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highlights

- Wind Turbine Blades
- Taiwanese Construction Industry
- Internal Combustion Engines
- Bio-Diesel processor

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Contents of the Volume

From the Chief Author's Desk

The research activities among different disciplines of natural science are backbone of system. The deep and strong affords are the demands of today. Sincere afford must be exposed worldwide. Which, in turns, require international platform for rapid and proper communication among similar and interdisciplinary research groups.

The Global Journal of Researches in Engineeringis to fulfill all such demands and requirements, and functions also as an international platform. Of course, the publication of research work must be reviewed to establish its authenticity. This helps to promote research activity also. We know, great scientific research have been worked out by philosopher seeking to verify quite erroneous theories about the nature of things.

The research activities are increasing exponentially. These great increments require rapid communication, also to link up with others. The balanced communication among same and interdisciplinary research groups is major hurdle to aware with status of any research field.

The Global Journals is proving as milestone of research publication. In view of whole spectrum of Knowledge, the research work of different streams may be considered as branches of big tree. Every branch is of great importance. Thus, we look after the complete spectrum as whole. Global Journals let play all the instruments simultaneously. We hope, affords of Global Journals will sincerely help to build the world in new shape.

Dr. R. K. Dixit
Chief Author
chiefauthor@globaljournals.org

Groundwater Management

Behzad Kalantari

GJRE -E Classification (FOR) 090509

Abstract-Groundwater plays a major life support to humanity. It is the major source to meet the domestic, irrigation and industrial demands. The discussion in this research paper begins with the definition of management as a general, and its importance to be applied to water resources. Then the ground water and ground water resources classifications are presented. Major threats to ground water resources are discussed in the following section. Also then the importance of ground water contamination and groundwater restoration as two of the vital elements in regard to groundwater managements are discussed. This discussion is followed by the protection of groundwater reservoirs under two topics. These topics cover the tools to manage and monitor the surface groundwater along with groundwater, with respect to their quantities and qualities. Recommendations and scientific sugges-tions throughout the paper are presented to save, properly used and protect the groundwater, and ground water basins.

I. INTRODUCTION

Before discussing groundwater management, it is essential to have a definition for management, which acts as a tool to handle the groundwater preservation and its related subjects. In general, management is the process of planning, handling, and controlling the use of resources to accomplish performances goals. The basic skills for managements are:

●Diagnostic: Visualizing the sources of problem

●Comunication: To exchange information and ideas affecting the problem with others

●Decision making: The ability to recognize and define prob-lems and oortunities correctly and then select an appropriate course of action to solve the problems.

Now, after management is being defined, it is time to continue with what ground water importance to human is and how it can be managed to fulfil our demand for future generations.

Actually, ground water plays a major life support to human being including all other living species. It is the major source to meet the domestic, irrigation (or agriculture) and industrials demands. Ground water represents the worlds largest freshwater storage and occurs in wide range of rock types and usually requires little or no treatment.Therefore, it is often the cheapest and simplest water supply option .It is not too far from reality to say that ground water is the most misunderstood and mismanaged resources available.

Ground water needs adequate protection and management. The role of ground water supply in total use of water is been increasingly rapid and with the rising of standard living will be more increased. It is estimated that there is four million cubic kilometres of ground water are stored in earth crust to a depth of 800 meters. As times goes on, the ground water reservoirs are considered for purposes other than water sup-ply such as use of deep wells for waste disposals and use of aquifers as a storage space.Therefore, such activities tend to affect the quality of groundwater.Actual objective of ground water management is to make sure that groundwater resources will be available in appropriate time with acceptable quantity and quality for the need of the society. The most important purpose of groundwater management is to reserve it for drinking supply, and then for other usages. Drinking water quality includes water used for all usual do-mestic purposes, including consumption, bathing and food usage. Fig. 1 shows the ground water usual distribution.

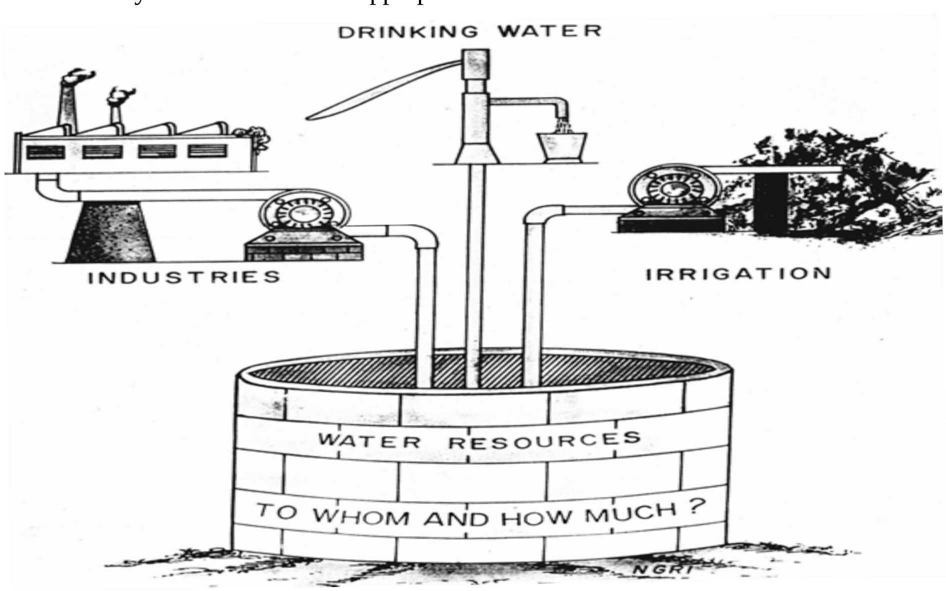

Fig. 1 Groundwater distribution

About-University of Putra Hormozgan, Bandar Abbas, Iran Email-behzad996@yahoo.com

II. Groundwater-Groundwater Resources

Water beneath the land surface in the saturated zone is hidden natural resources. Most of earth groundwater exists in reservoirs beneath the ground, which are called aquifers. Underground body made of layers of porous sand, gravel or fractured rocks that are saturated with water from above or from structures slopping toward it, and is capable of supplying useful quantities of water to a well or spring. Water in unconfined aquifers may have been collected recently by percolating in to the land surface, so they have young age. The top layers of unconfined aquifers are the ground water table. Unconfined aquifer often extends to the surface of land as river or lake. The source of groundwater (recharge) is through precipitation or surface water that percolates downward to the earth crest. Groundwater is part of the earth hydrological cycle that is the movement of water through the atmosphere, ocean, surface channels, and underground aquifers. Generally, ground water moves very slowly, typically from a few centimetres to about a meter per year depending on the intake or recharging amount of water in to the ground and also the soil type and texture. At one time, ground waters and its purity and availability were taken as for granted, but as with today's demand and scarcity of clean water, the contamination and availability of ground water are serious issues to consider.

In general, groundwater reservoirs that are the main source of water supplies are classified in four different groups, in these categories ground water reservoirs may be used or abused as are stated below.

- Natural uses
- Extraction of existing resources
- Land uses
- Subsurface uses

1) Natural Uses

Usually groundwater resources in their natural states are used for groundwater springs and base-flow contribution to surface water.

2) Extraction Of Existing Resources

Extraction of existing resources can be divided in to four different groups that are, extraction of water for purposes other than water supply, extraction of other naturally occurring fluids and also extraction of other natural resources.

3) Land Uses

Groundwater resources can be used as a host for specific uses conducted on land overlying the reservoir. This part may be the largest division of all classified uses of groundwater resources. These divisions are general construction, highways and roads, urban development,agriculture,excavation dewatering,drainage,solid waste disposals, salt or waste piling, agricultural developments, recreational development, incidental spills of harmful liquids, disposal of liquid waste by irrigation, waste retention ponds and lagoons, septic tanks, animal feed lots, and accidental breakage of sewers or pipelines.

4) Subsurface Uses

Also, ground water resources can be used as a host for specific uses inside the reservoir such as, artificial recharge, storage of fresh water in saline aquifers, natural gas storage, storage of storm run off and heat storage.

III. Threats To Groundwater

Threats to groundwater resources can be divided to two different groups; the first is the threat to quantity and second the threats to quality of groundwater resources. These two are discussed with details in the followings.

1) Threats To Quantity

An increase quantity of groundwater withdrawn from underground reservoirs for domestic purposes could be considered threats because the associated problem caused by this action may include overdraft, drawdown and subsidence. Overdraft occurs when groundwater is removed faster than recharge can replace it. This can result in:

- A permanent loss of a portion of its storage capacity
- A change that can cause water of unusual quality to contaminate good water
- In coastal basins, salt-water intrusion can occur Generally, any withdrawal in excess of safe yield (the amount that can be withdrawn without producing an undesirable result) is an overdraft.

Drawdown differs significantly from overdraft. Since, it results in a temporary lowered water table generally caused by pumping. In this situation, the water table recovers when supply is stopped. Subsid ence is one of the dramatic results from overpumping.As the water table declines, water pressure reduced. This causes the fine particles that held water to become compacted, and also permeability is reduced and so the soil will be consolidated under loads. Therefore the land above the aquifer can sink (from a few centimetres up to even a few meters) and causing a sinkhole. This can damage property and the field.

2) Threats To Quality

Inorganic compounds*, pathogens and organic compounds**, can harm water quality affecting the health of humans, and other living species as well.

IV. Groundwater Contamination or Pollution

Even, groundwater is in many regions a renewable resources, it may be locally limited. Therefore is vulnerable to damage, which in many cases, the damage may be irreversible, or if not irreversible, it may be very hard to restore the original conditions for it.

The man made contamination of groundwater is an undesirable phenomenon, whether it is groundwater contamination by a newly created, environmentally hazardous object or past and existing groundwater pollution by mismanagement of hazardous wastes, leakage, and emergency spills of chemicals. In many cases, once groundwater contamination has occurred, remediation of an aquifer would be expensive and technically difficult or infeasible. When estimating the importance of a groundwater contamination problem and developing water protection measures, it is helpful to be guided by at least two criterias.These criteria's are, risk to human health and threats to environments or so-called ecological risks. The most serious situation requiring intervention occurs when groundwater contamination is a source of risk to human health. Because the unconfined aquifers is hydraulically connected to the confined aquifers, the contaminated unconfined aquifer is a potential source of contamination of the confined aquifer below. The migration of the contaminated groundwater in the unconfined aquifer also carries radionuclide to the receiving rivers and surface waters. Thus, the three problem mentioned above are interconnected.The source of groundwater contamination is many and contaminants are numerous in developing countries. Common industrial solvents such as tri chloro-ethylene and carbon tetra chloride found in wide spread areas.Subrban areas usually have ground water with high levels of nitrate due to the use of lawn fertilizers found in groundewater.Landfills are known sources of contamination. Some of the more common contaminant transport in to groundwater includes; Accidental spills, Surface impoundments, Underground storage, Above ground tanks, Pipelines, Injection wells, Land application of waste and pesticides, Septic tanks, Radio active waste disposal, Salt water intrusion and acid mine drainage.

V. GROUNDWATER RESTORATION

As was stated before studies have shown that once ground water has been contaminated, it may take many years to remove the contaminants through natural process from an aquifer after the source of contamination has been eliminated. There are two broad categories of remedial measures for this problem. First, the source of contamination must be removed or isolated and second the groundwater has to be pumped or treated.

VI. PROTECTION OF GROUNDWATER RESERVOIRS

The protection of groundwater should include both its quantity as well as its quality. The quantity aspect of ground water protection is to regulate groundwater withdrawals in such a proper and calculated way that the water supply sources would not influence each other and that groundwater would not be permanently overdrawn. The quality aspect of groundwater protection is to eliminate or at least to minimize the wide range of contaminates and pollutions in to the groundwater reservoirs. Both of the mentioned parameters are interconnected and must be managed properly .In the following sections quantity aspect of ground water resources as well as its quality aspects with respect to managerial dimensions is being discussed. The emphasis is being put on water quality than the quantity, but their important relation is being taken to account and discussed. Fig 2 shows the groundwater resources distributed of the world

1) Groundwater Quantity Management

Water demand includes industrial, domestic and aqricultural.The studies show that the consumption of water will increase in the future due to growth of population, industry and agriculture. In some regions, the available water resources may not be adequate to meet the demands during short time perid.Therefore; problem of water scarcity will exist in those areas. A suitable strategy for the problem is to be adopted for the long term water supply augmentation to ensure groundwater recharge.Usually a small part of surface run off is stored in the form of streams and utilized as consumptive used, and most of the quantity of rainwater is being lost. Therefore, this heavy quantity surface runoff water should be stored properly for utilization by implementation of effective groundwater recharge techniques.Some of the programs that may be used in order to conserve rain water and facilitate additional recharge to the groundwater reservoirs and help to overcome the possible scarcity of ground water during dry seasons may include:

- ●Construction of retaining structures (to recharge aquifers artificially from rainfall waters)
- ●Water conservation (construction of retaining structures for percolation of water in to the ground from huge rain runoff water that is usually lost otherwise. This method is called artificially recharging aquifers)
- ●Irrigation efficiency project (improving the irrigation technology and engineering structures in the irrigation system)
- ●Water reclamation (recycling the water and reuse it for industries and possible plant watering and also recharging it to the underground resources)

One of the approaches to manage surface water in order to save groundwater from excessive discharge is called" the water shed management approach". In the following section, this type of approach is briefly being discussed.

2) Water Shed Management

The most critical components to water shed management approach is the involvement of all key stakeholders at each step of the process, the key components are:

- •Asses natural resources (soil, surface and ground water, air, plants, animals, and peoples)
- •Prioritizing the problem
- •Developing strategies for reaching objectives
- •Implement strategies and asses the result

3) Groundwater Quality Management

Groundwater pollution by human activities cannot be completely eliminated, but it can be minimized. The fact that pollution (in any form) is the price that the civilized world must pay to exist has to be admitted. On the other hand, it is essential that the problem should be countered by selecting effective and reasonable solutions for reducing groundwater pollution to an absolutes minimum. Control of ground water pollution necessarily begins with the development of strategies and guidelines to prevent future groundwater pollution and to maintain existing groundwater quality at the highest degree practicable. Strategies must include all aspects involved in the mechanism for achieving the objectives of the strategy. It may

*include all compounds that do not contain carbon, and those compounds that contain metals
**include volatile organic compound such as benzene, and some semivolatileslike pesticides

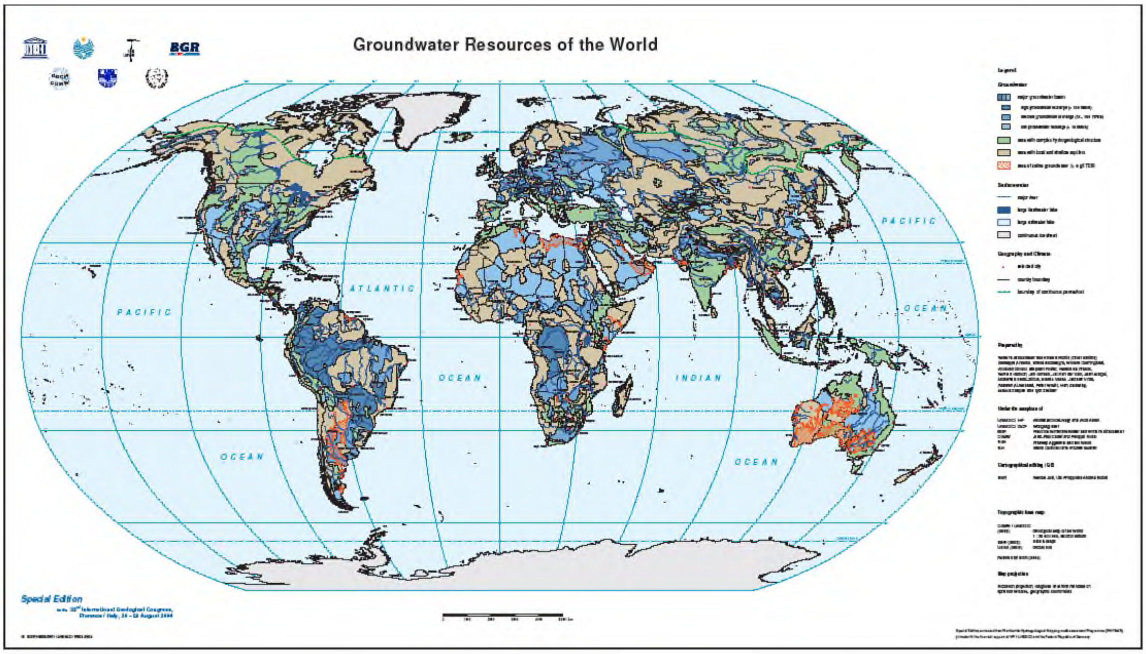

Fig. 2 Groundwater reservoirs of earth

be very difficult to find good solutions that would be accepted to all interest groups affected by the mechanism. Therefore, any strategy would include a compromise between what is theoretically desirable and what is practically can be achieved. Table 7.1 lists some of the methods available for achieving the objectives of a groundwater quality program. When groundwater is polluted, certain natural protection is provided by soil which water passes through. Pollutants in groundwater tend to be removed or reduced in concentration with time and distance travelled. Purification occurs in filtering action of earth materials and in chemical and biological process. However, the cleaning process by earth ability is not complete and has to be complemented by protective measures. In general, there are two basic approaches in dealing with groundwater quality problems.

The first is handling existing cases of pollution, and the second is preventing new incidents to happen. The most common approach toward existing problem is to start corrective action only after an occurrence of pollution is discovered. A major effort should be directed, by the responsible organizations toward defining extent and degree of severity of the groundwater-polluted area Equally pressing as the need to develop methods and strategies for dealing with existing problems of groundwater pollutions is the need to establish a program to prevent future problems.

One part of the program would be an inventory of all possible sources of pollution

and evaluation of their potential hazads.Groundwater protection can then be based on the same factors as surface quality water control.

Therefore reducing the pollution potential of source and eliminating some of those activities or uses of groundwater reservoirs that have the highest potential for introducing pollutants in to the groundwater. Another part of the prevention program is to evaluate the environment for accepting the degree of pollution, and identifying the most critical areas where the physical environment has the least capacity to protect groundwater from pollution. There are many alternatives for protective measures such as: setting groundwater standards, enforcing land use restrictions in critical areas, imposing limits on individual uses of groundwater reservoirs that may lead to pollution, and determining the protective zones for where there are intake water wells.

Monitoring process can not be considered as a protective measure for groundwater pollutions, rather it is just a detective measure of the groundwater quality problem.Monotoring is usually applied when there is need to determine groundwater quality at a particular location and its changes with time or it is necessary to determine if designed protective measures are working.One of the measures which is been practiced by most of European countries to limit pollution areas is called the" protective zone"The concept of protecting zone around the source of water supplies applies mostly to where there is a.populated region. The boundary of the zones may be set up considering the operational depression of water level, continuing of withdrawal and duration of exploitation. The protected area consists of several regions. Usually two or three and depending on the groundwater condition.

These zones can be described briefly as follows:

Zone I: Minimum zone protection that is confined to the immediate environment of the well or intake area includes protection against all kinds of influences. It is generally surrounded by barriers or fencing.

Table1 Groundwater protection alternatives

Natural protection		
	Purification	
Preventive actions (preventing pollution from occurring)		
	Inventory of pollution sources	
		Location of existing sources
		Identifying the potential sources
		Evaluation of potential hazards
		Land suitability studies
Control pollutions sources		
	Design and operation requirements	
	Management and inspection practices	
	Eliminating the dangerous sources	
Protective measures		
	Groundwater standards	
	Regulation of groundwater uses	
	Land use controls	
	Groundwater zoning	
	Law regulation enforcement	
Protection of water supply sources		
	Water- well construction	
	Sealing of abandoned wells	
	Protective zones	
Corrective measures (handling pollution after it occurs)		
	Soil removal Interception trenches	
	Pumping the affected area	
Monitoring the progress		

Zone II: This zone has the maximum boundary of the protected area and includes protection against wider reaching effects such as waste disposal pollution. Certain use of the area is allowed. For example, low capacity water supply, light housing development or small industries developments are allowed in this zone.

Zone III: All kind of uses in this zone are regulated and limited to a permit. In addition, an intermediate zone of protection may be established within this zone.

Another method to manage groundwater quality is called” regional groundwater quality management that also can be used in any of the mentioned protective zones.

In this method, procedures are to be taken for ensuring the sustainable and hazard free water resources for drinking, agriculture and industries. The following procedure also can be considered for any regional ground water basin:

•Remediation

•Planning to stop it from happening again or getting worst (prevention is far better than cure)

Some of the possible remedial measures may be considered as follows:

•Treatment of pollutants

•Improving lining of flow channels and discharge the wastes liquids in low permeability zones.

•Pumping of polluted groundwater, treating and recharging in to the system.

•Use of treated or partially treated groundwater in industry or agricultural sectors.

4) Management Plan To Protect Aquifer And Well Fields

Since groundwater resources are so vital in life cycle on earth, it is important to protect them from being polluted. Some of the procedures in this regard that are to be considered are listed below:

•Occurrence and distribution of pollutant sources

•Knowledge about pollutant sources

•Knowledge about hydrodynamics of aquifer system

•Knowledge about the behaviour of pollutants

•Data network and monitoring

•Regulation to limit and treat pollutants

It has been proven that industries are one of the main sources of pollutants for groundwater resources. Therefore, industries with out-dated technologies should be closed down and be replaced with eco-friendly technologies. Also it is found very difficult to remediate the aquifer, it is preferred to relocate the industries after studying the vulnerability of the area to the contaminants.

5) *Solid Waste Management*

The garbage generated in the urban areas including the industrial solid wastes disposed on the land surface also gives rise to groundwater pollutions. The most serious risk occur when sanitary landfill is practiced and where hazardous industrial waste including liquid effluents are disposed off at inappropriate sites. The municipal solid wastes are usually disposed in low-lying ground without any record or quantity and quality of wastes. Even the disposal is stopped, the site will represent a potential hazard to groundwater for future decades. Researches show that the solid wastes in developing countries generally are less toxic, having a high content of water and decaying vegetable matter, compared to typical solid wasted from different types of metals(lead, mercury) and synthetics organic compounds(solvents, phenol). Municipal wastes usually contain small quantities of hazardous materials, but the plume from the refuse site to the down gradient site will contaminate the drinking water and therefore a serious health hazard may be produced. Municipal towns will contaminate to grow rapidly and this in-turn will impose enhanced stress on groundwater resources.

The rapid development of industry, often small scale units and highly dispersed, is likely to produce wide spread contamination of groundwater by metals and chemicals. These types of contaminants from industries disposal to the ground or to surface water channels, where it may directly pollute the groundwater. Solution to this problem is the collection, treatment, and proper disposal of such solid wastes and liquid effluents

VII. SUMMARY AND CONCLUSION

Groundwater occurs in a wide range of rock types and usually requires little or no treatment; therefore, it is often the cheapest and simplest water supply option and is the main reserve of fresh water and a valuable natural resource. Therefore, it deserves all the care and attention that human can offer. How long human generation will enjoy the benefit of groundwater depends on the degree that these vital reservoirs are well managed and used. The space groundwater occupies underground, is susceptible to pollution, if improperly managed or protected. If this resource is polluted, cleanup process may be of long and expensive procedures.

One of the most important concerns is the contamination of underground waters by the industrial agriculture and domestic pollutants. Therefore, it is the responsibility of the governments to have an effective management plan to regulate, monitor and control the outcome of each sector wastes. Groundwater and surface water are fundamentally interconnected. It is often difficult to separate the two; because they feed each other. This is why one can contaminate the other, and if one is less available, the other will be in intense use. It is also important to understand that surface water management should be considered as a part of groundwater management in order to have an effective plan to use and to save this priceless reserve for ourselves and for the future generations.

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Procedural Perfection in Impulse Shape Generation for Indoor Type Impulse Test of Power Transformers

Sukanta Roy [1], Anjan Debnath [2]

GJRE -F Classification (FOR) 090699

Abstract **- In this paper we are to demonstrate the high voltage impulse test performed to testify the withstand capability of power transformer. Then the problems associated in practical wave generation will be stated which solutions are to be improved by the proposed method using PC tools. Then a simulation result will be presented for use in our practical lab test and the range of desired parameters should be compared.**

Key words: Impulse test, Surge protection, Power transformer indoor test, Mathematical modeling.

I. INTRODUCTION

The outdoor power transformers are highly at risk to receive heavy voltage surge from lightening. As to design the insulating capability a similar or even severe impulse wave, shaped with a defined rise/front time and tail time is applied in indoor to the leads of it [1]. Now to get the exact scenario, the correct type of wave shape generation is must which seems to be trial and error to get in practice. So a mathematical representation of the instrument with load effect and stray capacitances under concern, an automatic generation of the parameters (R, C, air gap) can be achieved to apply for some predefined wave shapes necessary for different kV level test and get the result in 1st try. For the preceding sections we are to do this with a simulated model as well as with the mathematical tools like Laplace.

II. PRINCIPLE OF OPERATION OF MARX-TYPE IMPULSE GENERATOR

A Marx-type impulse generator has the schematics like fig-1 which is commonly applied to the test.

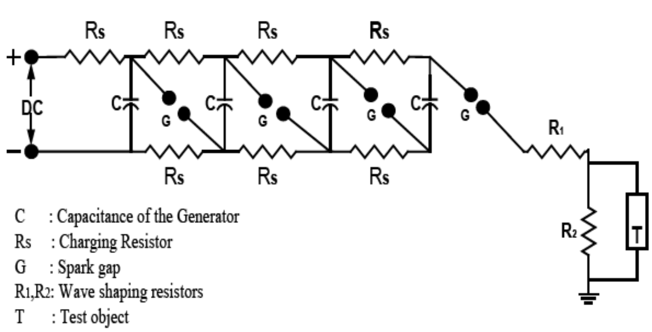


Fig 1: Marx type impulse voltage generators

The mainly generated impulse voltage waveform represents the following common incidents:
1) Standard lightening impulse waveform
2) Standard switching impulse waveform
3) Other special switching or uncontrolled impulses.

At the beginning of the operation a DC generator is used to charge the staged capacitors to its peak value. Normally the peaks of individual capacitors lie in 20 kV. Now when to test an insulator string (i.e) the air gap is made to break down by triggering the lowest air gap. The impulse capacitor is charged via a high charging resistance (R_o) to the direct voltage U_o and then discharged by ignition of the switching gap F (fig. 3). During this charging and discharging period, the desired impulse voltage U(t) appears across the load capacitor Cy.

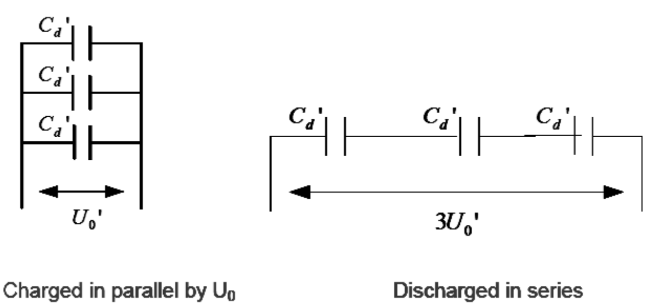


Fig 2: Capacitor orientation for charging/discharging phase

The discharging path then made the impulse to appear across the test object, as shown in the fig. 3.

Fig 3: A 3 staged b type IG s discharging

Now the waveform, generated has 3 major components to define before applied to [4]. These are:
1) Amplitude or % of amplitude 2) Wave front time,T_C
3) Wave trail time, T_S.
An acceptable Impulse [4] which can represent a lightening like waveform is defined by T_C, T_S & U_{max} and has the shape like fig. 4:

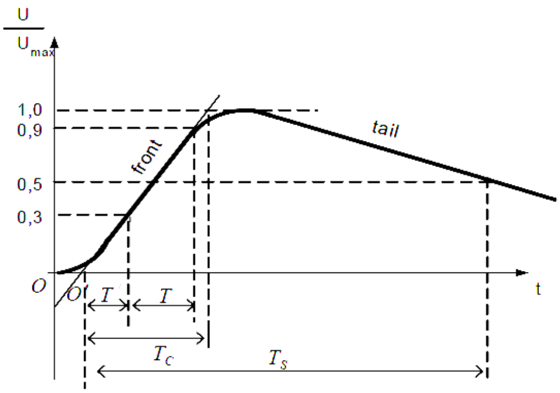


Fig 4: An ideal impulse wave's properties

Now we are going to create a signal which should be automatically generated with the given parameters of R, C, U_o and should fulfill the necessary T_C, T_S & U_{max}. For that we are to create a coding and simulate it in SPICE in the preceding sections. Then we are to apply it in a practical test, to get the real data and to verify its use in 1st time accurate try in impulse test.

III. SIMULATION AND ANALYSIS

1) *Spice simulation and no load analysis*

In this segment we have simulated the IG in spice (fig-5) with no transformer as load.

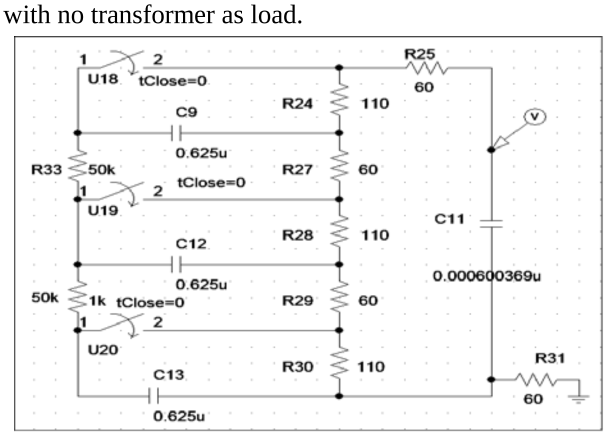


Fig 5: Spice schematic representing IG main circuit

The simulated waveform for the specific parameters appears as fig. 6 which has reported dissimilarities with our practical findings.

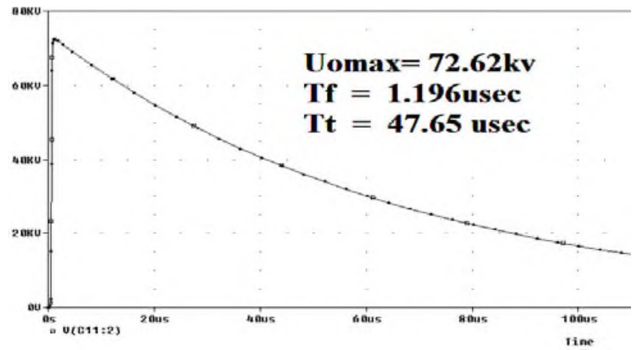


Fig 6: simulation result, V (C11) of the ckt of fig.5.

The granted wave shape in our Impulse lab appeared as fig.7 (which is made by trial and error basis): [1],[2],[4]

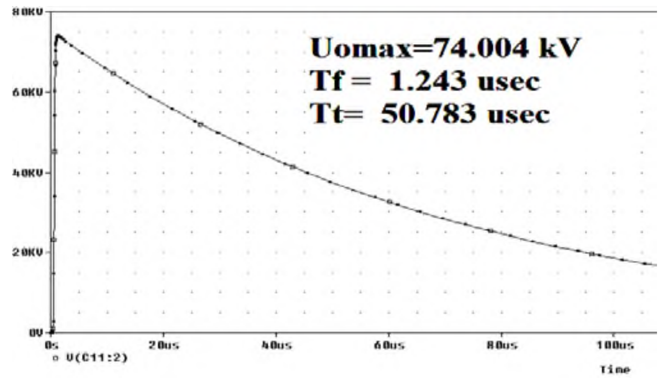


Fig 7: An industry granted impulse shape

Hence we are going to mathematically represent the system where, for the same value of front and tail resistor a multistage IG can be reduced to a single stage by using Laplace transform and it's inverse. As shown in fig. 8 the single stage is:

8: Single stage (reduced) equivalent of multistage IG during discharging phase

Then by using KCL, KVL and inverse Laplace we obtain the output parameter U(t) in time domain. We are here to present the equations, derived along with the constants only, where the detailed is given in appendix.
The output voltage in time domain is found as:
$U(t) = k\,[e^{s1t} - e^{s2t}]$
Here,
$k = A / (s1-s2)$ $\quad s1, s2 = -b \pm \sqrt{(b2-4ac)}\big/2a$

The output voltage in time domain is found as:

$U(t) = k\,[e^{s1t} - e^{s2t}]$

Here,

$k = A / (s1 - s2) \qquad s1, s2 = -b \pm \sqrt{(b2 - 4ac)}/2a$

$$a=1,\; b = \frac{1}{Rf*Cd} + \frac{1}{Rt*Cd} + \frac{1}{Rf*Cy},\quad c = \frac{1}{(Rf*Cy*Rt*Cd)}$$

$$A = \frac{Uo}{Rf*Cy}$$

The single staged parameters are defined for multistage as:
U_0 = n* per stage voltage of capacitor
R_f = n* per stage resistance of front resistor
R_t = n * per stage resistance of tail resistor
C_y = capacitance of divider/load capacitor
C_d = (1/n) * per stage capacitance of capacitor

Now, we have used MatLab coding to plot U(t). In practice we had to do the iterative process in fixing the suitable resistance and capacitance values for a defined waveform. By using the above equations and coding we can bring a more proximate waveform in a quicker and easier way which reduced the time, labor of handling weighty elements and chance, to decrease the durability of the transformer insulation.

3.2 Spice simulation with load and analysis

In this portion we have tested the spice model with a capacitive load representing a real equivalent transformer. But as found the tail time deviates from the practical test data for a 200KVA transformer. Moreover now in the schematics, we have added the stray capacitances which are inherited in the system. This caused a visible improvement in proximity with real test wave shape which is given in part IV of this paper.

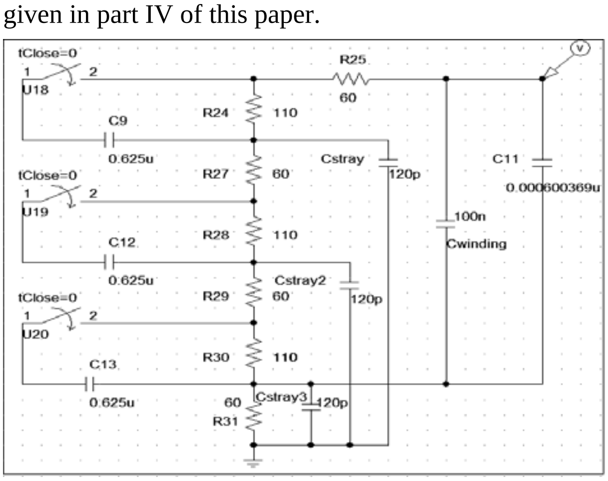


Fig 9: Spice schematic of IG main circuit with transformer model as load.

The generated wave shape across the capacitor divider can be found as fig. 10 which shows some definite deviation:

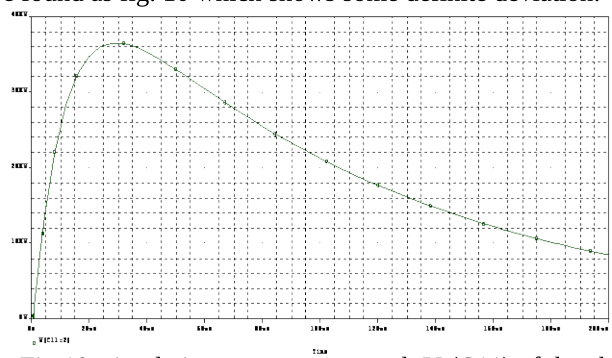


Fig 10: simulation result V (C11) of the ckt of fig. 9.

The main sources of this deviation are the non-calculated distributed capacitances that an original transformer winding has. If we can calculate it then we can measure the loading to use it in simulation and hence to produce the testable wave shape. [3], [5], [6].

For the exact R_f, R_t and U_o to find, we must then to have a calculated mathematical model which can represent a transformer's equivalent capacitance. For the tested circular disk wound transformer we have developed the total capacitance of a winding as: [5],[6],[7].

$C_{\text{winding}} = C_{\text{turn-turn}} + C_{\text{disk-disk}}$
$\qquad = C_{tt} + (C_{\text{dd due to key spacer}} + C_{\text{dd due to insulating oil}})$

C_{tt} exists as for the turns on a disk have paper insulation in between them and C_{dd} exists as for key spacer in some portion and insulating oil for the rest of the portion in between the disks consisting the turns. As shown in the

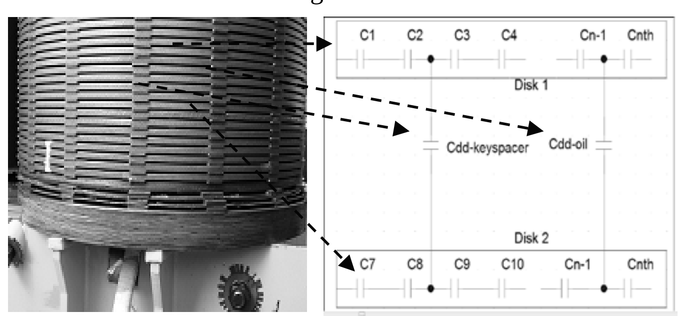


fig. 11 the two portions can be visualized clearly.

Fig 11: Two types of capacitances in a winding.

For the disk type transformer we have the developed equations. These are: [6], [7].

The turn-turn capacitance C_{tt} :

$$C_{tt} = \varepsilon_0 \varepsilon_p * 2 * \pi * R_{ave} * \frac{(h + 2\tau p)}{\tau p}$$

Where, R_{ave} = Average radius of the disk
h = Bare copper or conductor height
($h + 2\tau p$ = taking fringing effect into account)
ε_0 =Permittivity of air (vacuum)
ε_p= Relative permittivity of paper
R_{ave} = Average distance of the ring from center.

Now the disks are positioned one upon one using Key spacer which is paper or plastic type materials, in some portion. The rest of the gaps are filled with oil as insulating as well cooling media. So the disk-disk capacitance is expressed as: [6], [7].

$$C_{dd} = \varepsilon_0\pi * (R_{out}^2 - R_{in}^2)*[\frac{f_{ks}}{\tau_p/\varepsilon_p + \tau_{ks}/\varepsilon_{ks}} + \frac{(1-f_{ks})}{\tau_p/\varepsilon_p + \tau_p/\varepsilon_{oil}}]$$

Here, f_{ks} = Key spacer fraction (usually 1/3 in value)

Then we have the apprx. total capacitance of transformer as K:

$$K = \frac{27.8*D}{N}[\frac{\varepsilon_p(h+2\tau_p)}{2*n*\tau_p} + \frac{4}{3}*\frac{r+\tau_{ks}}{2\tau_p/\varepsilon_p + \tau_{ks}/\varepsilon_{ks}}]*10^{-12}\ F$$

Here, K = Apprx. total capacitance of transformer. [8]
D = Mean winding diameter
N = No of discs in winding
n = No of turns per disc
τ_p = Thickness of paper insulation
τ_{ks} = Thickness of key spacer

The tabulated data we had for our tested 28MVA, 33/11Dyn 11outdoor type transformer are given below: [1],[4].

Table 1: Tested transformer's properties to be concerned

Parameter	Value	Parameter	Value
R_{out}	453 mm	τ_p , τ_{ks}	0.5 mm,4.2mm
R_{in}	365 mm	h	12.2 mm
f_{ks}	1/3	ε_p	3.5
n	8	ε_{oil} , ε_{ks}	2.2, 4.5

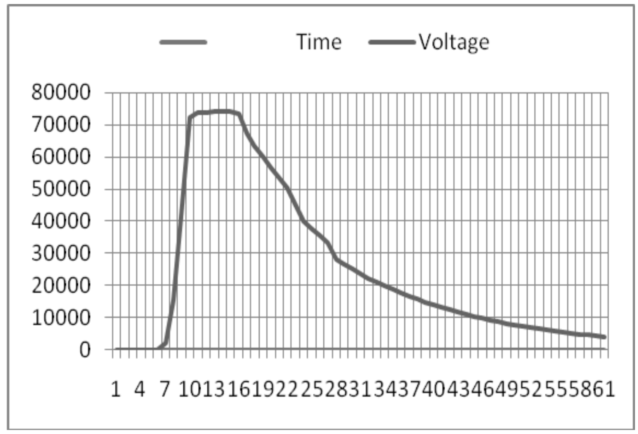
With these data we have calculated the approximate total capacitance of the transformer, K which is found as 33.7 e^{-12} Farad. Then we again use this value as $C_{winding}$ to find the desired impulse.

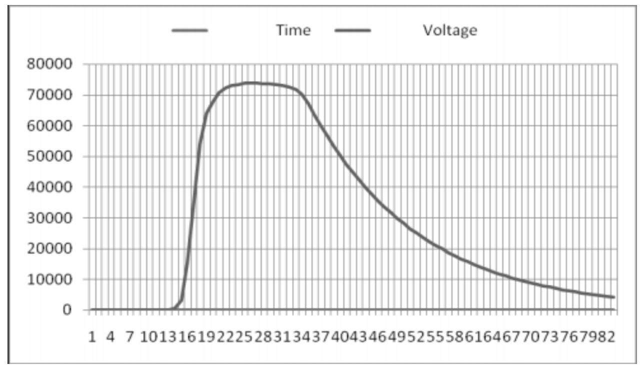
IV. REAL TIME INSTRUMENT & EXPERIMENTATION

We are to apply the stated method in a practical impulse test. The Impulse Generator is made by HUAGAO H.V. which has the rated voltage of 1600kv and rated energy storage of 100kJ. In our lab there are up to 7 stages of capacitor bank that can be used. As similar in spice model we have used 3 stages and take the various data over the monitoring system. By taking the all sampled data over the electronic monitoring panel, we have plotted them in excel worksheet. Then the parameters and design data are tabulated and the findings in wave shape in 1st try are compared. The findings are given here serially along with the referred part number.

1. IG output wave at lab for no load using R_f, R_t generated from simulation of fig.5 (reff. to part 3.1):

2. IG output wave found with stray capacitances included in order to get a generalized model for the IG itself (reff. to part 3.2):

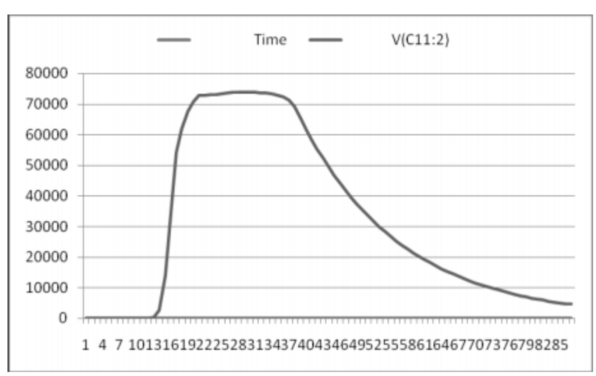




6) IG wave found in lab using R_f, R_t obtained from the simulation of both Spice and MatLab where stray capacitance and transformer winding's equivalent model are included (reff. to part 3.2):

Table 2: Front and Tail time found from simulated model, with load and stray capacitances included for comparing the characteristics of impulse

Lab found		Determined from simulation of part 3.2		Input parameters found from MatLab coding		Simulation model parameters	
T_f	T_t	T_f	T_t	R_f	R_t	C_{stray}	C_{load}
1.31 usec	49.89 usec	1.26 usec	50.97 usec	59	114	50pf	33.7 pf



In comparing between the values listed as in fig. 7 and lab result listed in table 2, here we see that we have gotten an acceptable wave shape in lab to test the insulation level effectively in first try.

V. CONCLUSION AND FUTURE WORKING PLAN

In our present work we have obtained a procedure where from a defined desired output we can calculate the value needed for the parameters to be set. For impulse test then we can get the test result in a quicker and safer way. This can reduce the error as well the durability of various precious equipments. In future we are going to work on low tension side. At low tension terminal as the voltage level is low, so the inductance plays a big role in creating required wave shape. The resultant wave has overshoots as well some high frequency transients. So we are planning to make a detailed model for LT IG test. From which, by means of software we should be able to get the correct wave shape at an instant at both side.

VI. APPENDIX

Reduction of 'n' stage impulse circuitry to a single stage and derivation of U(t) with constants:

The reduction can be made as:

Now in s domain analysis the represented ckt is:

Here, in loop 1:

$$\frac{Uo}{s} = I1(\frac{1}{sCd} + Rt) - I2 * Rt \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In loop 2:

$$I2(Rt + Rf + \frac{1}{sCy}) = I1 * Rt \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In outer loop:

$$U(s) = I2 * \frac{1}{sCy} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

We need to compute U(s) by putting I2.

(2)⇒

$$I1 = I2(Rt + Rf + \frac{1}{sCy}) \Big/ Rt = I2 + I2 * \frac{Rf}{Rd} + I2 * \frac{1}{sRtCy} \quad \ldots (4)$$

Putting (4) in (1) implies:

$$\frac{Uo}{s} = \{I_2 + I_2(\frac{R_f}{R_t}) + I_2 * (\frac{1}{s(R_t C_y)})\}\{\frac{1}{sC_d)} + R_t\} - I_2 * R_d$$

$$= I_2[\frac{1}{sC_d} + \frac{R_f}{s(C_d R_t} + \frac{1}{s^2(R_t C_d C_y)} + R_f - \frac{1}{sC_y}]$$

$$I_2 = (\frac{Uo}{s}) * [\frac{1}{\frac{1}{sC_d} + \frac{R_f}{s(C_d R_t)} + \frac{1}{s^2(R_t C_d C_y)} + R_f + \frac{1}{sC_y}}]$$

$$= (\frac{Uo}{sR_f}) * [\frac{1}{1 + \frac{1}{s}(\frac{1}{R_f C_d} + \frac{1}{R_t C_d} + \frac{1}{R_f C_y}) + \frac{1}{s^2(R_f R_t C_d C_y}}]$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Putting (5) in (3) implies:

$$U(s) = I_2 * (\frac{1}{sC_y})$$

$$= [\frac{Uo}{sR_f} * \frac{1}{1 + \frac{1}{s}(\frac{1}{R_f C_d} + \frac{1}{R_t C_d} + \frac{1}{R_f C_y}) + \frac{1}{s^2} * (\frac{1}{R_f R_t C_d C_y})}] * [\frac{1}{sC_y}]$$

$$= \frac{Uo}{R_f C_y} * [\frac{1}{s^2 + s(\frac{1}{R_f C_d} + \frac{1}{R_t C_d} + \frac{1}{R_f C_y}) + \frac{1}{R_f C_y} * \frac{1}{R_t C_d}}]$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Now we are to solve Eq^n (6) by taking the constants A,b and c

$$A = \frac{Uo}{R_f C_y}, b = (\frac{1}{R_f C_d} + \frac{1}{R_t C_d} - \frac{1}{R_f C_y}), c = (\frac{1}{R_f C_y} * \frac{1}{R_t C_d})$$

$$U(s) = A * \frac{1}{s^2 + bs + c} = \frac{A}{(s - s_1)(s - s_2)} = \frac{A}{(s_1 - s_2)}[\frac{1}{(s - s_1)} - \frac{1}{(s - s_2)}]$$

$$s_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Then, we shall apply inverse Laplace transform on U(s) to get U(t).

$$U(s) = \frac{A}{(s_1 - s_2)}[\frac{1}{(s - s_1)} - \frac{1}{(s - s_2)}]$$

$$= k * [\frac{1}{(s - s_1)} - \frac{1}{(s - s_2)}]$$

So,

$$U(t) = k[e^{s_1 t} - e^{s_2 t}]$$

Here,

$$k = \frac{A}{(s_1 - s_2)}, s_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a},$$

$$s_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

$$a = 1,$$

$$b = \frac{1}{R_f C_d} + \frac{1}{R_t C_d} - \frac{1}{R_f C_y}, c = \frac{1}{R_f R_t C_d C_y}$$

$$A = \frac{Uo}{R_f C_y}$$

. VII. ACKNOWLEDGMENT

We, the authors are grateful to EnergyPac engineering ltd of Bangladesh. Without the assistantship of their R&D dept. in using their Impulse Test Lab facilities, this work could not be completed.

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Analysis of Subsurface Contaminant Transport in Akaki Well Field and Surrounding Areas, Central Ethiopia

GJRE -E Classification (FOR) 090509

Leta Gudissa Shaqa

***Abstract*-This study generated a model and recommendations that allows decision makers to establish a framework for regulating contaminants that are likely to pose risks to drinking water in the well-field. The acute need for water calls for a development approach that considers environmental factors. It becomes more pressing as industrialization and development advances. In view of this, the current study aims to identify the pathways of pollutants and travel times of contamination. The well field provides more than 30 % of drinking water supply of Addis Ababa. The study area is a sub basin in the Awash drainage basin, particularly in southeast of the Akaki catchment. A groundwater flow model was constructed to indicate the existing flow condition. The model was then calibrated both under steady state and transient state flows, to prove that the model represents actual conditions. The Modeling tools have been eventually used by introduction of particles at contaminant sources upstream of wells and at the well field, then to identify the path lines, and travel times. The results revealed that the flow lines intersect with the Akaki River in numerous places. Furthermore, the flow lines converge towards Akaki well field, implying contaminated water from the upper part of the aquifer will be pulled into the wells. Therefore, there is a high risk of vulnerability of the well field to pollution. Hence, the following recommendations are helpful in cutting the risks posed. One should conduct contaminant transport analysis taking into account chemical reactions, attenuation and multiple layer aquifer; Manufacturing activities having pollution potential must be limited in special areas far from water wells; Industrial enterprises shall create closed–loop water supply systems involving effluent reuse; Environmental policy with regard to waste disposal and agricultural practices to be allowed in the area must be implemented with particular emphasis for the protection zones around the well field.**

Key words: Contaminant Transport: Pathways and Travel times, Groundwater flow model, Akaki well field, Ethiopia

I. Introduction

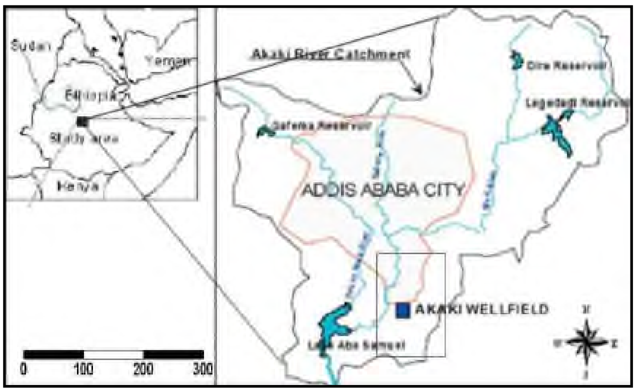
Water is the most essential nutrient for human existence. Therefore, the need for the management of water resources is crucial and even more pressing as industrialization and development advances. Monitoring and mapping groundwater movement and contaminant flow is important

About-Department of Civil Engineering and Architecture, School of Engineering and Information Technologies, Adama University, P.O.Box 5041, Adama, Ethiopia E-mail: Letagudissa@yahoo.com or letagudissa09@gmail.com

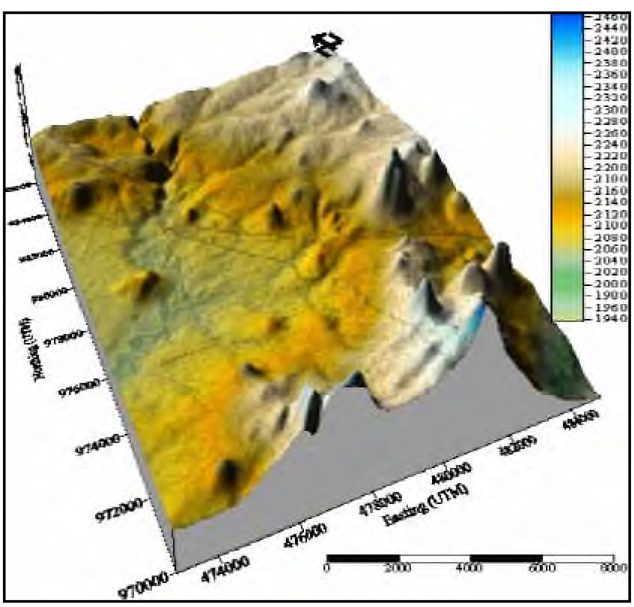
specifically for health care of the communities and generally for sustainable development. The ability to predict the rate and direction of groundwater flow and contaminant transport in the aquifer systems would be of great value in planning and implementing the remediation of contaminated aquifers. The Akaki well field provides 30% of the water supply of Addis Ababa and it requires a delicate aquifer management (Tamiru Alemayehu et al., 2005). This study intends to understand the travel time of contaminants as well as to delineate the path lines of contamination. As surface and groundwater are intimately linked to each other, there might be leakage from the highly polluted Akaki River. The quality of well water in such areas depends on the depth as well as pumping rate of wells. In the area, where large-scale industries have been expanding, pollution due to disposal of untreated industrial waste seems to be forthcoming. In addition, quarrying and agricultural activities that increase the influxes of solutes to water are widespread and locally increasing concentrations from harmless to toxic levels. The area is densely fractured by lineaments. As a consequence, permeability and transmissivity of rock matrix are high, facilitating accidental and/or deliberate introduction of contaminants into aquifer. Environmentally incompatible industries like skin and hide, chemical, metal and textile factories etc are unfavorably located along the Akaki road. In Akaki area, water resources have been investigated in terms of potential, flow models, and vulnerability by a number of investigators [e.g. Alemayehu , 1983; AAWSA and AESI, 1984; Vernier, et al., 1985; Tesfaye, 1988,1993; AAWSA and SEURECA, 1991; AAWSA et al., 1992; AAWSA et al., 1993 a, b; Anteneh, 1994; WWDE, 1996; AAWSA and COMPLANT, 1997; Eccleston, 1997; AAWSA, 1999; Aynalem, 1999; AAWSA et al., 2000; Gebrekidan, 2000; Alemayehu, 2001; Berhanu, 2002]. Although they vary in scope and degree of information, they have stressed that the quality of surface water is affected by waste disposal and these would have also potential impact on the quality of groundwater. Natural concentrations of contaminants are low in waters and soils but the problem aggravates when human activities locally upset the natural cycle. For instance, Sewage, garbage, and toxic pollutants are continually disposed into Akaki River. The contaminants may eventually enter into the aquifer system through porous, permeable media cut by numerous structures or clay materials that lose their filtration capacity. The results of current study can be applied in establishing preventive strategies and control further expansion of groundwater contamination, and in preparing a working model for solving similar problems elsewhere in the country. Therefore, analysis of transport of contaminants in a well-field which is clearly under threat by industrial wastes is not only a timely speculation but also a strong instrument in alleviating problems of drinking water.

II. Environmental Settings of the Area

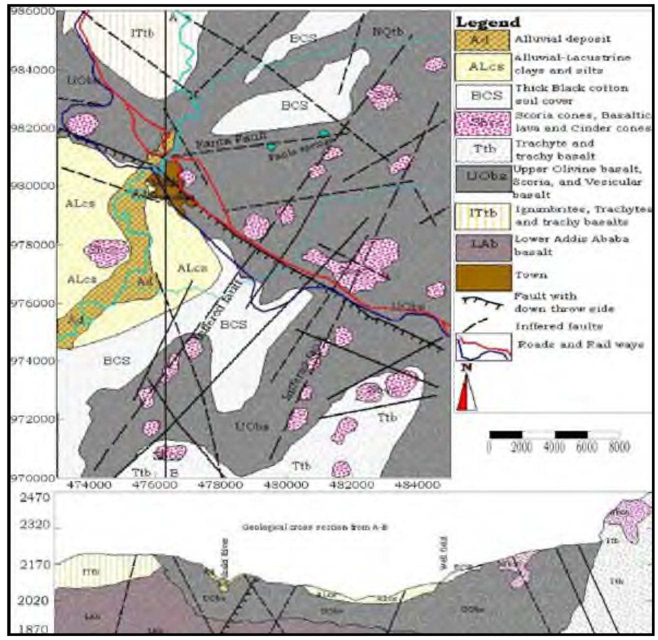
The project area lies within the Akaki river catchment (fig. 2.1). Fig.2.1. Regional location map of the Akaki catchment with major reservoirs, lakes, and rivers (modified after Shiferaw Lulu et al., 2005). The digital elevation model of the area shows a sharp topographic variation close to the ridge in the south, and east while the area is relatively flat towards center (fig. 2.3). Fig. 2.3 3D Digital Elevation Model of the study area constructed from a topographic map using surfer software.

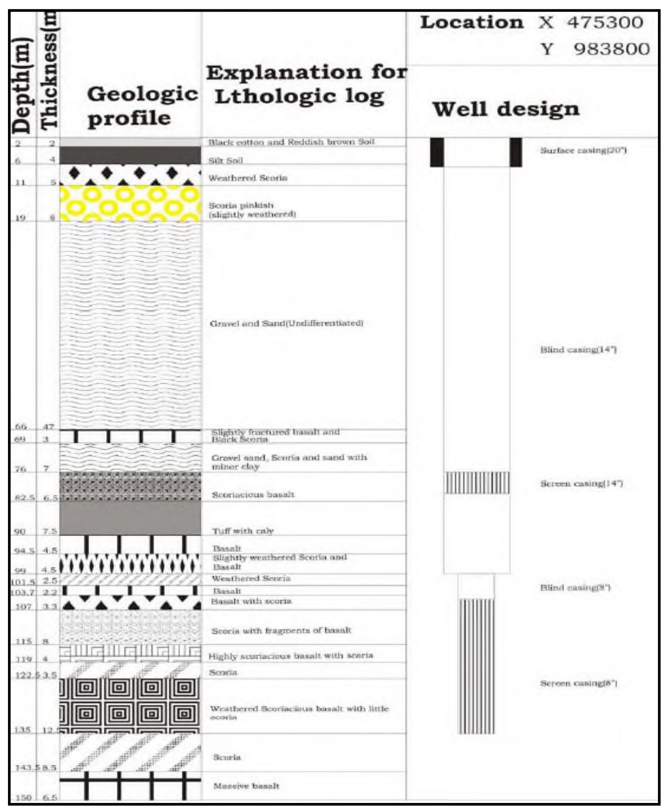


The lithology in the area form trachy basalt, Ignimbrites, tuff and volcanic ash, Akaki basalt, scoria and scoriaceous basalt, and recent alluvial deposits fig 2.5. Fig. 2.5 Geological map of the study area (modified after AG consult, 2004). Vertical exaggeration is 5x horizontal scale.



The rocks are subject to rift tectonics, as manifested in a number of faults having a general trend of the rift system Mixture of alluvial and lacustrine materials such as sand, clay, gravel, volcanic ash and tuffs are variably found at certain depths fig 2.6. Fig. 2.6. A Representative geological log of BH 06 in the well field showing the subsurface geology and thickness of the stratum. All soil types in the. (Berhanu Gizaw, 2002) Table 2.2





area have a relatively higher hydraulic conductivity

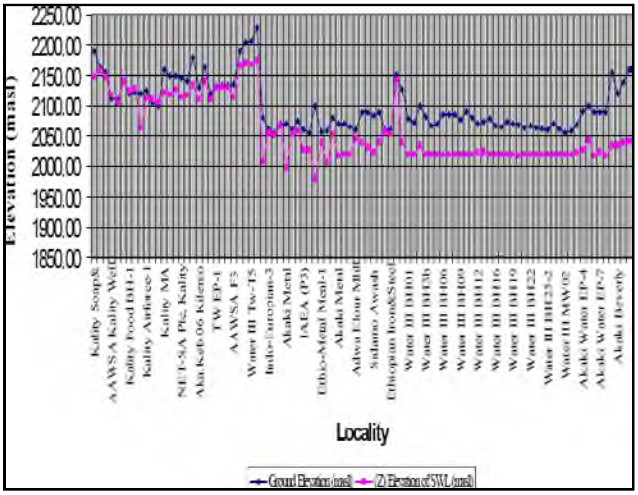
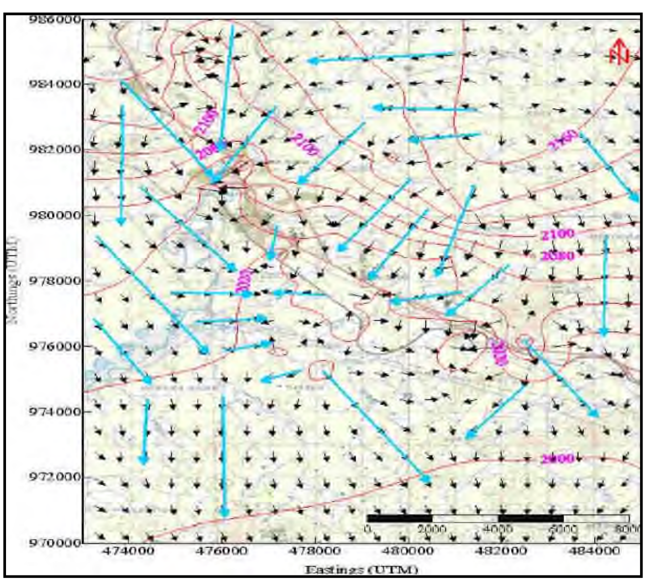


Fig.2.10. Comparison of ground surface elevation and elevation of SWL at respective wells location of the area that have spatial variations. It indicates the groundwater is in connection with the surface water in some localities. Fig.2.11. Map of local groundwater flow directions in the study area. The elevations of water level in boreholes are used to determine the general direction of groundwater flow in the study area. The groundwater movement is sub-parallel to the surface water flow direction and more or less controlled by the topography of the area. Convex contour lines at the northeastern and northwestern corners of the area (fig. 2.11) indicate regions of groundwater recharge, while concave contour lines at centre and along Akaki River are associated with groundwater discharge areas. The flow lines, sketched perpendicular to the contour lines, show the direction of groundwater flow. Land use pattern of the area is diverse but broadly classified into Urban, agricultural and open areas with rock exposures (grazing site). Scattered settlements are also found. Quarries are common near Tulu



Dimtu. Prospecting for new quarry sites and expansion of existing ones is going on.

III. Methodology

A MODFLOW package represented by matrix blocks, and an advection contaminant transport model known as PM PATH are used as tools. The analysis was conducted by constructing the groundwater model and performing flow simulations; by calibration of the model both under steady state and transient state flow conditions, and Introduction of particles at contaminant sources upstream of wells are conducted and observed for the path lines and how far the contamination moves using PMPATH. Finally, correlation coefficient, water budget analysis and calibrations were conducted to check the accuracy of the result for calculating the path lines and travel times of contamination by particle tracking method using the modeling tools. In pursuit of the overall objectives, the study followed scientifically approved procedures as Desk work that focused on literature review and assessment of previous works, Field work that include site observation and verification of previous geological map including structural features of the area and its hydrogeological setting, Post-field work that encompassed revision of geological and hydrogeological maps; evaluation of all data, borehole geologic logs and geophysical results from previous studies. A zonation approach is adopted where similar hydraulic conductivity, transmissivity and storage coefficient values are assigned to specific regions.

IV. Modeling Approach

The current model was to characterize flow in the study area by determining distribution of hydraulic head, flow velocity, and direction. A three-dimensional model grid was used to represent a two-dimensional aerial flow through a single layer. The following assumptions were used in simulation of the model. Fractures and weathered zones are considered as porous medium; Net recharge is not spatially uniform; Variation in geology and anisotropy impact the spatial distribution of hydraulic conductivity and Head dependent boundary condition is assumed on wet land of Akaki River, flux boundary is assumed at north, NE, and NW of the study area. The model simulates flow by the following governing equations thought to represent the physical processes that occur in the system.

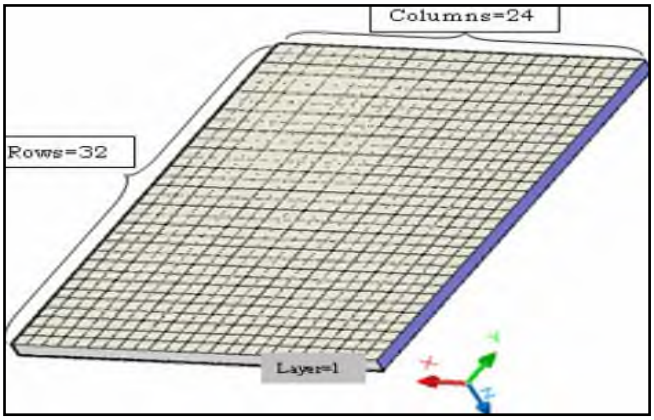
$$\frac{\partial}{\partial x}\left(kxx\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(kyy\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(kzz\frac{\partial h}{\partial z}\right)-w=0$$

……..Steady state condition (Eq.1)

$$\frac{\partial}{\partial x}\left(kxx\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(kyy\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(kzz\frac{\partial h}{\partial z}\right)-w=Ss\frac{\partial h}{\partial t}$$

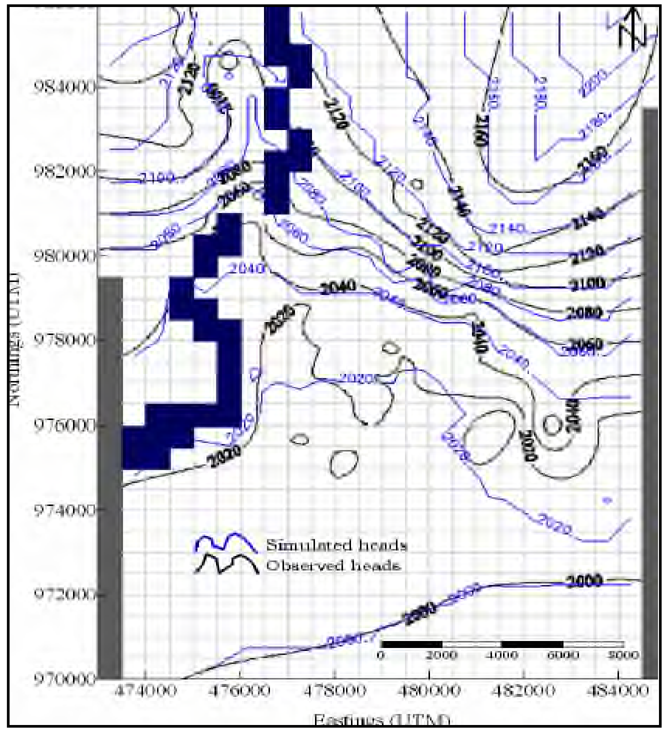
……Transient condition (Eq.2)

Where Kxx, Kyy, and Kzz are values of hydraulic conductivity along the x, y, and z, (LT^{-1}); h is the

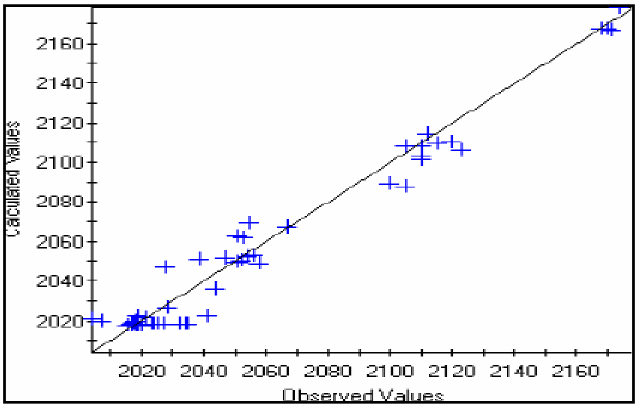


potentiometeric head (L); w is a volumetric flux per unit volume (T^{-1}); Ss is the specific storage of the porous material (L^{-1}); t is time (T).

An aquifer system is replaced by a discretized domain consisting of an array of nodes associated in finite difference cells fig. 3.1. Fig.3.1 a 3 dimensional conceptual geospatial model frame work. To use a finite difference approximation, a grid is superimposed over the topographic map of the study area, and aquifer hydraulic parameters are averaged over the area of cell and assigned. Spatial input parameters of the model are initial hydraulic head, horizontal anisotropy, horizontal and vertical hydraulic conductivities, transmissivity, recharge, discharge, storage coefficient, specific storage and effective porosity. They were assigned to each active grid cell. Temporal input parameters are number of stress periods, time steps and transport steps. Since flow can not take place parallel to the actual groundwater contour lines, no flow boundary has been assumed in the eastern and western boundaries of the study area. The boundary condition array contains a code positive 1-for active cell, negative 1-for constant head cell and 0-for inactive cell. Because there are no significant massive rocks that inhibit flow across them, most of the cells in the center of the study area are treated as flux boundaries. There are few cells along Akaki River and in wetlands near Aba Samuel Lake where hydraulic head is kept fixed at a given value all over the entire simulation time. By convention the area outside the model domain is deemed to be a "no flow". Since the area is a volcanic terrain, the scoria and scoriaceous basalt are not continuous laterally as observed from the geological map. Therefore, it is difficult to identify well-defined distinct units and the aquifer parameters are obtained as a cumulative effect of all layers. At this stage it was difficult to justify a multi-layer representation of the aquifer hence; the model layer was treated as a single layer. The aquifer structure had been determined by preparing DEM used to construct the top elevation of the aquifer and loaded to MODFLOW matrix. An average depth to static groundwater level in the study area (40m) obtained from well database is subtracted from each DEMs. The results of this calculation are used as initial prescribed hydraulic heads in each cell. But some of them are slightly altered later through calibration process particularly at borehole locations. Finally, these results are loaded to MODFLOW matrix and used in the modeling process. Initially a contoured hydraulic conductivity map was produced from the conductivity values of boreholes in the area. Then, the map is overlaid on the model grid, and the respective average values are assigned to each model cells. The recharge input was classified into two zones; a recharge of 74 mm/year in all areas except where black cotton soil is widely present and a recharge of 11.1 mm/year in black cotton soil cover. Mean value of the total porosity for medium gravel is 32 %, and for medium sand is 39 %. Therefore, an average effective porosity of 35 % was used in the model sine the black cotton soil and scoria of the area



constitute higher proportion of medium sand and medium gravel respectively. Calibration of the model developed is a process of changing values of model input parameters within some acceptable criteria to derive a close match between the observed water levels and calculated hydraulic heads. A graphical comparison between actually measured and model computed heads is shown in fig. 3.9. Fig3.9. Comparison of the actual head contours with that of simulated heads in transient state condition. The observed and calculated head values are well correlated with a correlation coefficient of 0.9699 in fig.3.8. Fig.3.8. a scatter diagram of calculated and observed heads in the study area. Observed heads in the study area. In addition to calibration, to check the accuracy of the simulation results, MODFLOW calculates volumetric water budget for the entire model at the end of each time step. The percent discrepancy of in- and out-flows for the model is calculated and acceptably small (0.11%) table 3.5. Table. 3.5. Water budget of the



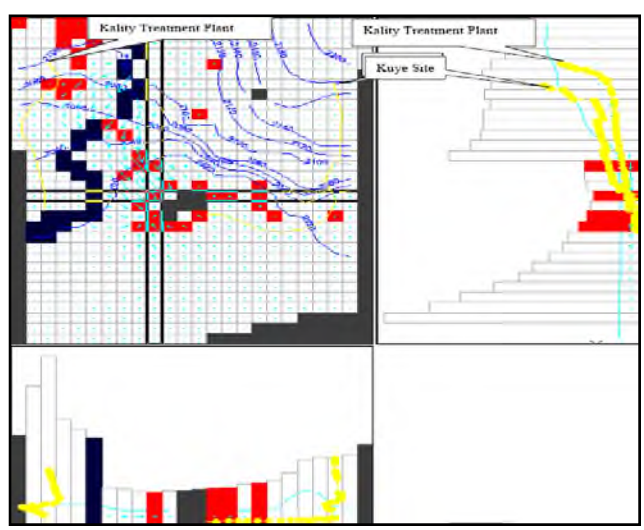
FLOW TERM	IN	OUT	IN-OUT
STORAGE	8.2467209E+01	8.1595268E+01	8.7194061E-01
CONSTANT HEAD	1.1303267E+00	1.1670703E+00	-3.6743522E-02
WELLS	0.0000000E+00	1.0639998E+00	-1.0639998E+00
RECHARGE	3.1726831E-01	0.0000000E+00	3.1726831E-01
SUM	**8.3914803E+01**	**8.3826340E+01**	**8.8462830E-02**
DISCREPANCY [%]		0.11	

model domain during time step-1 of stress period-1. (Flow terms: M^3/S)

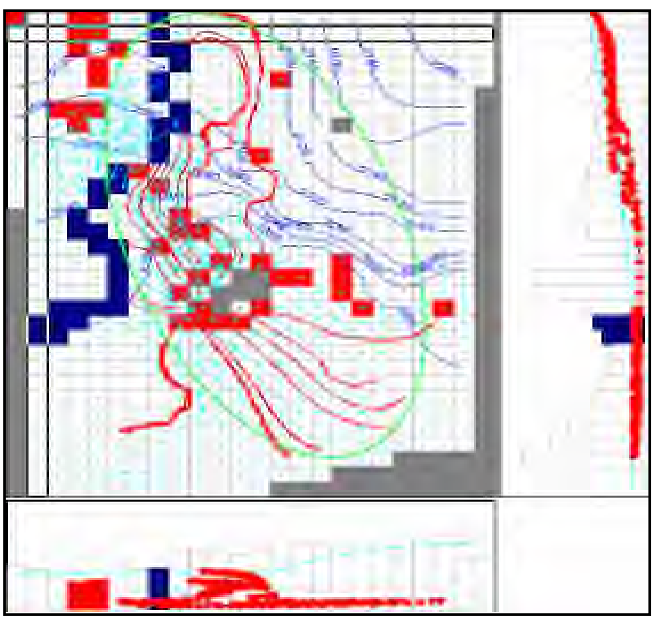
The water budget provides an indication of the overall acceptability of the numerical solution i.e. . the model equations have been correctly solved. Sensitivity analyses were used to refine initial estimates of input parameters during model calibration, and to determine which input parameters had the largest effect on simulated head values after model calibration. Sensitivity refers to sticking to the reference mode (to the actual flow pattern) even when key parameters are changed. Therefore the model was found to stick to the actual flow pattern with change in transmissivity and recharge except change in hydraulic conductivity. At the end of this phase it is assumed that the model has simulated the actual hydrogeological condition of the area making possible to simulate the behavior of the aquifer system as well as the contaminant transport.

V. CONTAMINANT TRANSPORT ANALYSIS

We have used PMPATH for contaminant transport analysis which is a component of Mudflow Model. It is assumed by PMPATH that fluid properties are homogeneous and concentration changes don't significantly affect fluid density or viscosity and hence fluid velocity. Rate of pollution attenuation depends on the geology, local hydrogeological situations (porosity, permeability and hydraulic conductivity), geochemical processes and the type of pollutants. The weathered rocks of the area and associated structures and their orientation would have facilitating contaminant migration. To identify the pathway and final destination of pollutants, it is necessary to describe the infiltration capacity of water in the black cotton soils. Contaminants move down with infiltrating water during the rainy season through the cracks formed in the previous dry season. Pollution of surface water can cause degradation of groundwater quality and conversely pollution of groundwater can degrade surface water. The Akaki River may temporarily become a losing stream. When the hydraulic gradient in the aquifer adjacent to the river is reversed due to draw down of water table during the dry seasons of the year and through increasing pumping rates in wells water flows from the river into the groundwater. Groundwater pollution is becoming a major threat particularly where the water table and the surface water coincide, around Kality (Berhanu Gizaw, 2002). Down Stream of Akaki Bridge up to Aba Samuel hydropower plant, the groundwater level is lower than the river bed level. Therefore, there is possibility of leakage through deep cutting fractures (AAWSA et al. (2000)). The pH, EC, TDS, and total coli form concentration in the groundwater also reflect the influence imposed by polluted surface water, implying the strong seepage of surface water into the groundwater system. Though the leakage is attenuated by the black cotton soil in places, the Akaki River could still have impact on the surrounding alluvial aquifer. Slope also determines the extent of runoff and the degree of settling sufficient time for infiltration. Areas with gentle slopes like the well field are highly vulnerable to groundwater contamination. All possible sources of contamination like steel, pulp, paper, pigments, caustic soda paint, pump, brewing, textile, food processing, and meat packing factories; dairy farms, open-air slaughtering, quarries, agricultural plots, grave yards, dense settlements, and open market areas are prevalent in the area. Few specific locations are selected to test for contaminant transport in the current study. These are Tulu Dimtu scoria: a highly fractured, porous and permeable rock sequence, located on elevated topography near the well field, the beds are tilted and; the site is being used as a grave site; Gelan metal industry: located on the way to Debrezeit road adjacent to Dengora stream. It is usually observed to release reddish effluents to the stream; the stream then crosses through the



center of the well field; Kality treatment plant: where highly polluted rivers, most sewerage lines, and sanitation systems are directed into it; and Akaki Mesfin Zelelew dairy farm in order to know the potential leakage of pollutants from the farm (bacteria, animal wastes, etc). The travel time for pollutants in the Akaki well field is calculated by considering lateral separation to be the velocity times travel time (Lawrence et al. (2001) cited in Tamiru Alemayehu et al., 2005). Hydraulic conductivity is considered as velocity in this case. For instance, the time required for bacteria to reach the groundwater level in the fractured scoriaceous basaltic aquifer ranges between 21/2 and 4 hours which could be effective during a single heavy rain period (Tamiru Alemayehu et al., 2005). Therefore, In the Akaki well field bacteria can easily move to a depth of 50 meters where the scoriaceous basalt is exposed on the surface (Tamiru Alemayehu et al., 2005). Particles are introduced at sources upstream in cells (21,18), (15, 20), (5, 3) and (7, 3) and the distance of travel of contaminants through the steady state flow field is observed for 120 days, 180 days, 5 years, and 10 years travel times, respectively (figures 4.8). Fig.4.8. Contamination introduced at cell (7, 3) upstream has arrived the well field after 10 years of travel time. The velocity is relatively higher in areas where there is high gradient as can be seen from the length of velocity vectors. They seem dots in most areas. Moreover, the cross-section in fig. 4.5 shows that the groundwater flows from Akaki River towards the well field. The particle at cell (5, 3) is initially injected



above potentiometeric surface; meanwhile moves within the aquifer but later comes on the surface of groundwater. However, contaminant at cell (7, 3) is injected at the potentiometeric surface and remains below the water surface entirely. Therefore, remediation may not be easy for contaminants at cell (7, 3). Contaminant sources which can affect the well field are then distinguished and capture zones of the pumping wells over different years have also been examined by running particles backward as observed in fig.4.10. The capture zone agrees with the results of protection zones delineated by Tamiru Alemayehu, et al. (2005) in groundwater vulnerability assessment. Contaminants from most of the study areas will be captured in 10 years time. Fig.4.10. Capture zone of the pumping wells in the well field in 10 years.

VI. RESULTS AND DISCUSSION

A constant withdrawal of water from the Akaki well field at optimum pumping rate of 30,000 m3/day will causes the highest draw down in the well field followed by Dalota site, and moderately for Upstream Dukem, Fanta and Downstream Dukem. According to AAWSA et al. (2000), discharge of Fanta spring which is situated upstream of the well field will be reduced and will even be dry after 10 years for most of the pumping situations. Even with suitable pumping rate, the drawdown in the well field will reach 20m after 17 years. In the same period, the wells would be affected with a drawdown of about 5m around Kality. Therefore, it is definite that contaminants will be attracted to highly pumped well, and eventually contaminates the well field before the estimated 20 years time. The shape of the iso-values is elliptical, with its long axis oriented along the northeast direction. This shape can be attributed to the fact that the main pumping wells (BH17, BH16, BH12, and BH09) are aligned along the northeast direction as well as the fact that the permeability of the reservoir is anisotropic following major tectonic line aligned in the same direction. Furthermore, the well field area with gentle gradient (wide water table contour spacing,) is characterized by higher hydraulic conductivity or permeability. All these together with the following factors facilitate the easy movement of fluids in the area. Factors like, intercalation of basalt flows separated by baked soils which form weak zones at the contact; the columnar joints of basalt; the inclined bedding of most scoriaceous basalts; intensive network of fractures and their close spacing allow easy groundwater circulation and contaminant migration in the area. In addition, the characteristics of soil influences the amount of recharge infiltrating into the ground, the amount of potential dispersion, and the purifying process of contaminants to move vertically into the vadose zone. In the Akaki well field, particle size distribution analysis done on black cotton soils and scoria indicates that the black cotton soils have relatively lower (10^{-5} to 10^{-4}m/s) hydraulic conductivity values followed by the residual soil (10^{-4} to 10^{-3}m/s) and scoria (assumed to be similar to the main aquifer of the Akaki well field, (10^{-3} to $5*10^{-2}$m/s) Berhanu Gizaw, 2002). As indicated in Table 2.2, higher proportion of the grain size distribution of all samples show sand for Akaki black cotton soils and gravel for Tulu Dimitu scoria. Therefore, even the black cotton soils which appear to be impermeable to infiltrations have of course relatively low permeability in the region but they are permeable to fluids. In addition, due to intensive erosional activities, there is poor soil development on most parts of the slope which proves the lack of defense line to hydrogeological system. Therefore, the danger zones are areas of rock exposures with no soil coverage and faulted zones. Thus, it is important to consider hydraulic conductivity of the scoriaceous basalt, which on average is 340m/day, and is very high if the rocks outcrop on the surface and if the spill occurs on fractures. In that case, there is a possibility of arrival of pollutant to the well field (Tamiru Alemayehu et al., 2005). The Big Akaki River shows wide channel and slow flow velocity that allows enough time for infiltration process near Akaki Bridge. The alluvial sediments of this area are also characterized by high water infiltration capacity. The recharging water is thus available to transport a contaminant vertically to the water table and horizontally within the aquifer. Hence there is higher danger of contamination in shallow wells from the Akaki River. The depth of water table gives an idea of the minimum distance that a pollutant has to travel to reach the saturated zone. The groundwater level in Kality and Fanta areas is shallow and is susceptible to contamination. In the long run, the lowering of the water level due to pumping will change hydraulic conditions at the bottom of the river in these areas increasing the degree of infiltration of polluted water. Groundwater monitoring in the area shall be conducted taking into account their spatial distribution and proximity to the well field and how long the contaminants take to arrive at the centre of the well field from their respective locations. At least half of the length of the travel time shall be assigned as the frequency of analysis. There fore, one can have at least half to quarter of its full travel time to control the contaminant before it pollutes the whole well field. In addition, if pollution is noticed in the highway area, the nearest wells (Ep-07 and BH-09) should not be stopped because they can be used to control the pollution. Stopping pumping of polluted wells will let contamination of the well field. Instead their discharge should be increased and the water should be disconnected from the system and discharged under a controlled mechanism out of the well field. Therefore, improper abstraction of water along with suitable Environmental setting of the area facilitates contaminant migration. Though the effect of contaminant migration is currently minimal, the model developed in this study clearly shows that contamination of the well field is forthcoming, unless strong environmental protection policy as well as aquifer management strategy is implemented. Groundwater quality monitoring not only help to know the current existing situation but also helps in building models and simulate changes in concentration of contaminants. Table 2.2 Grain size distributions of triplicate soil samples collected from various soil horizons and representative soil types in the area (modified from Berhanu Gizaw, 2002). Note: BCS-Black Cotton Soils, TuluD- Tulu Dimtu, Cl-Clay Si-Silt, Sa-Sand, Gr-Gravel. The soil was classified based on grain sizes: Clay (<0.002mm); Silt (0.002-0.06mm); Sand (0.062mm) and Gravel (2-60mm). The scoria, residual soils and black cotton soils of these types generally expected to have total porosity ranges of 25-50%.

VII. CONCLUSIONS AND RECOMMENDATION

This study indicated that the Akaki well field is highly vulnerable to contamination from surface waters and upstream groundwater. The Akaki River has direct impact on the nearby wells that tap water from alluvial layer as indicted by the intersection of contaminant path lines with the water level. In the study area, the groundwater flow lines converge towards Akaki well field, implying that any contaminants are carried to the well field from all directions. Therefore, the quality of the surface and groundwater up stream will determine the quality of water in the well field. The intensive pumping of groundwater from the Akaki well field will results in rapid decline of groundwater levels, leading to disturbance in the steady state flow system of the groundwater, eventually resulting in increased velocity of groundwater flow towards the depression zone. This process potentially facilitates the rapid flow of contaminated water from upstream sections of the aquifer to the well field. Currently, the degree of contamination of the groundwater is negligible giving certain time to avert the problem. However, the model indicates that water flow path lines with contaminated water injected at contaminant sources upstream will reach in the well field in less than10 years time. Flow is not linear through out the system; rather it is more rapid where porosity and transmissivity are high depending on the orientation of tectonic fractures. In view of tackling the actual and potential contamination risks of the Akaki well field more effort should be made to: conduct contaminant transport analysis taking into account chemical reactions, attenuation and multiple layer aquifer; effort should be made to create closed–loop water supply systems at industrial enterprises involving effluent reuse; to implement strict environmental policy with regard to industries and agricultural practices that have to be allowed in the area and set standards to discharges and penalties for non-observance of requirements; to limit activities having pollution potential in special areas far from water wells; and to Closely monitor the chemical quality of groundwater in the well field.

VIII. ACKNOWLEDGMENT

I wish to acknowledge the professional staffs of different institutions for their co-operation and data needed to

No	Sample	%							
		Cl	Si	Sa	Gr	Total	Cl+Si	Cl+ Si+Sa	Cl+Si +Sa+Gr
1	Akaki BCS 1	1.0	8.4	90.6	0.0	100.0	9.4	100.0	100.0
	Akala BCS 2	1.0	6.9	92.1	0.0	100.0	7.9	100.0	100.0
	Akaki BCS 3	0.9	8.9	90.1	0.0	100.0	9.8	100.0	100.0
	Aver.	**1.0**	**8.1**	**90.9**	**0.0**	**100.0**	**9.1**	**100.0**	**100.0**
2	TuluD1	0.0	0.0	21.7	78.3	100.0	0.0	21.7	100.0
	TuluD2	0.0	0.0	26.7	73.3	100.0	0.0	26.7	100.0
	TuluD3	0.0	0.0	22.7	77.3	100.0	0.0	22.7	100.0
	Aver.	**0.0**	**0.0**	**23.7**	**76.3**	**100.0**	**0.0**	**23.7**	**100.0**

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Optimization of Wind Turbine Blades Using Genetic Algorithm

GJRE -J Classification (FOR) 091508

G.B. Eke[1,] J.I. Onyewudiala[2]

Abstract -**This paper presents a design tool for optimizing wind turbine blades. The work considers optimizing the blade of wind turbines with respect to maximizing the energy yield of a wind turbine. The design variables are the shape parameters comprising the chord, the twist and the relative thickness of the blade. Genetic algorithm was used to illustrate the optimization technique; two wind turbines of different sizes are subjected to analysis. The results obtained are in good agreement with other published results.**

*Key words***:** Optimization of blades; energy cost; wind turbine design; Genetic Algorithm

I. Introduction

For wind energy to become competitive with respect to other sources of energy, the initial consideration must be to reduce the cost of energy from wind power. In modern wind power researches, how to minimize the cost of a wind turbine per unit of energy is an important task. The shape of the rotor blades plays a decisive role in determining the overall aerodynamic performance of a horizontal axis wind turbine (Fuglsang and others, 1995; Giguere and others, 1999; Benini and others, 2002). Thus, aerodynamic optimization of the blade shape is a very important stage in the design and manufacturing of wind turbines. In earlier days, the Glauert and Wilson methods were mostly used for blade design (Spera, 1994). The objectives of these methods were to obtain the maximum power coefficient of each blade section at the design wind speed. Because the time variation characteristics of wind speed are not taken into account, blades designed by these methods cannot achieve the maximum annual energy output. Furthermore, design results from these methods must be substantially corrected to get smooth chord length and twist distributions (Spera, 1994). Because the corrected results already deviate from the design points, effectively controlling design results poses problems. Conventional search algorithms, such as the feasible direction method and the complex method, are often prone to converging on the local optimal point (Gen and others, 1999). For some complicated problems, it is difficult to obtain a global optimal result and user interference must be carried out. For example, changing the design parameters or shifting the initial feasible domain to execute multiple search processes is needed to get the best local optimal result as the global optimal one. This prevents the designer from concentrating on the problem itself and guaranteeing that the designed result is globally optimal. Several researches have been carried out on the viability of the wind turbine for power generation. These researches cover the entire design of a wind turbine from the blade design to the intricate control systems which allow for optimum performance. On the note-able work on the theory of wind machines, using Betz equation shows a mathematical approach for evaluating various parameters involved in the design of the wind turbine (Ragheb, 2008). Philip, (2004), research covered wind resources, the Origin of the wind. He showed how to estimate available wind power and how a horizontal axis wind turbine (HAWT) works. Through the use of relevant equations, he obtained the power coefficient using the Betz relation. Other aspects covered by his research which are essential to the wind turbine technology are the aerofoil concept, Blade Element–Momentum theory, brakes, gearbox, generators and aesthetic considerations. There are a number of recently published papers dealing with the optimization of wind turbines. Fuglsang and others, (1999), develop optimization methods for wind turbine rotors. Stiesdal, (1999), developed the wind turbine, components and operation. Hansen, (2000), worked on aerodynamics of wind turbines. Fuglsang and others, (2001), developed site-specific design optimization of 1.5-2.0 MW wind turbine. Benini and others, (2002), developed optimal design of horizontal axis wind turbines using blade-element theory and evolutionary computation. Slootweg and others, (2003), worked on inside wind turbines, fixed versus variable speed. Grauers, (2003), worked on efficiency of three wind energy generator systems. Jureczko and others, (2005), developed optimization of wind turbine blades. In an attempt to achieve optimization and power analysis of a wind turbine, Afolami, (2007), improved the operation of a wind turbine through replacement of some components of the wind turbine in other to collect data over a period of time thereby analyzing the amount of power generated within a given wind direction, speed and location. The data obtained from the power analyses was compared with that obtained from the wind data logger. Michael, (2007), showed that modern wind turbines have become an economically competitive form of clean and renewable power generation. Optimizing wind turbines for specific sites can further increase their economic competitiveness. In his study, he carried out an economic optimization analysis of a variable speed, three

About- Department of Mechanical Engineering, Faculty of Engineering, University of Port Harcourt,
Port Harcourt, Nigeria.
e-mail: onyewudialajulius@yahoo.com
Tel. +2348037316672 ; +2348063314201

blade, and horizontal-axis wind turbine. This work presents design tool for optimizing wind turbine blades. This considers optimizing the blade of wind turbines with respect to maximizing the energy yield of a wind turbine. To achieve the optimization in this work, the genetic algorithm code in MATLAB is written for the turbines and this code can be used for any type of wind turbine provided that the objective function is the same.

II. PROBLEM FORMULATION AND SOLUTION

As the costs from operation and maintenance often can be accounted as a small percentage of the capital cost, the reduction of the capital cost becomes an essential task for designing wind turbines. Moreover, a well designed wind turbine with a low cost of energy always has an aerodynamically efficient rotor. Therefore, the rotor design plays an important role for the whole design procedure of a wind turbine. In the current study, the objective function is restricted to the cost from the rotor. Thus the objective function is defined as

$$Minimize\ Z = \frac{C_{rotor}}{AEP} \quad (1)$$

where Z is the cost of energy of a wind turbine rotor; C_{rotor} is the total cost for producing, transporting and erecting a wind turbine rotor and AEP is annual energy production. Therefore the total cost of a rotor, C_{rotor}, is a relative value defined as (Wang and others, 2009).

$$C_{rotor} = b_{rotor} + (1 - b_{rotor})W_{rotor} \quad (2)$$

where W_{rotor} is the weight parameter of the rotor. The fixed part of the cost for a wind turbine rotor b_{rotor} is chosen to be 0.1 (Wang and others, 2009). In this work, the weight parameter is calculated from the chord and mass distributions of the blades. Supposing that a blade can be divided into n cross-sections, W_{rotor} is estimated as

$$W_{rotor} = \sum_{i=1}^{n} \frac{m_i C_{i,opt}}{M_{tot} C_{i,or}} \quad (3)$$

where m_i is the mass of the $i-th$ cross – section of the blade; $C_{i,opt}$ is the averaged chord of the $i-th$ cross section of the optimized blade; $C_{i,or}$ is the averaged chord of the $i-th$ cross section of the original blade; M_{tot} is the total mass of the blade. The power curve is determined from the Blade Element Momentum (BEM) method (Hansen, 2000). In order to compute the annual energy production (AEP), it is necessary to combine the power curve with the probability density of a wind (i.e. the Weibull distribution). The function defining the probability density can be written in the following form:

$$f(V_i < V < V_{i+1})\ \exp\left(-\left(\frac{V_i}{A}\right)^k\right) - \exp\left(-\left(\frac{V_{i+1}}{A}\right)^k\right) \quad (4)$$

where $A[-]$ is the scale parameter, $K[-]$ is the shape factor and $V[m/s]$ is the wind speed. Hence the shape factor is chosen to be $K = 2$ corresponding to the Rayleigh distribution. If a wind turbine operates about 8760 hours per year, its AEP can be evaluated as (Wang and others, 2009).

$$AEP\ \sum_{i=1}^{N-1} \frac{1}{2}\left(P(V_{i+1}) + P(V_i)\right).f(V_i < V\ \ V_{i+1}).8760 \quad (5)$$

or

$$AEP = \sum_{i=1}^{N-1} \frac{1}{2}\left(P(V_{i+1})\ P(V_i)\right).exp\left(-\left(\frac{V_i}{A}\right)^k\right)\ exp\left(-\left(\frac{V_{i+1}}{A}\right)^k\right).8760 \quad (6)$$

where $P(V_i)$ is the power at the wind speed of V_i.
The expression for power P is given by

$$P = \frac{1}{2}\dot{m}V_0^2 = \frac{1}{2}\rho A_0 V_0^3 \quad (7)$$

where $\dot{m}[m^3/s]$ is the mass flow rate; $V_0[m/s]$ is the wind speed; $\rho[kg/m^3]$ is the density of the air; and $A_0[m^2]$ is the area of the wind speed.

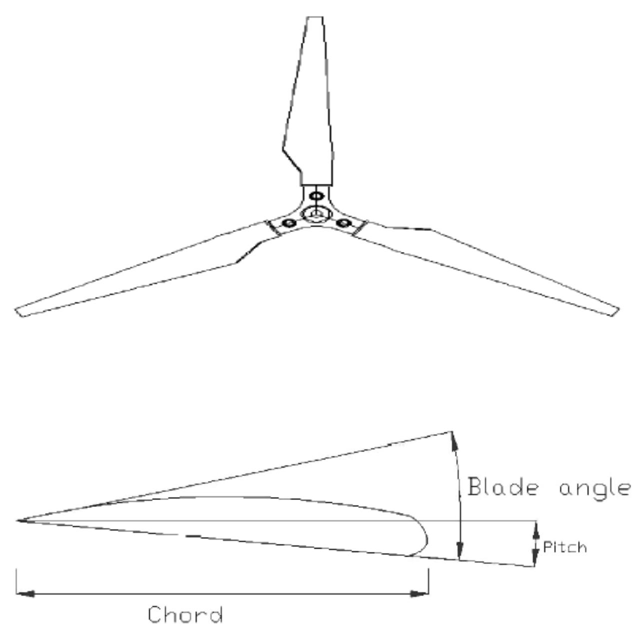


Figure 1 The wind turbine blade.

To obtain a reliable optimization of a wind turbine blade, the geometry of the blade needs to be represented as much as possible. This requires a great number of design variables. On the other hand, the selection of more design variables in the optimization procedure requires more complex solution algorithm and computational time. The design variables are often chosen to be the parameters controlling the rotor shape, airfoil characteristics, rotational speed and pitch angle. The rotor shape is controlled by the rotor diameter, chord, twist, relative thickness and shell thickness. The airfoil characteristics are the lift and drag dependency on the angle of attack. Based on a general chord distribution, a cubic polynomial is used to control the chord distribution. Because of the multiple distribution characteristics, a spline function is used to control the distributions of twist angle and relative thickness. The constraints of the design variables are

$$X_{i\,min} \leq X_i \leq X_{i\,max} \quad i = 1,2,3 \qquad (8)$$

where $X_{i\,min}$ is the lower limit and $X_{i\,max}$ is the upper limit for chord, twist angle and relative thickness of the blade respectively. As a usual procedure for optimization problems, we have one objective function and multiple constraints. To achieve the optimization, the genetic algorithm code in MATLAB is written for the turbines and this code can be used for any type of wind turbine provided that the objective function is the same.

III. RESULTS AND DISCUSSION

As a first consideration of the optimization, the Mexico $25kW$ experimental rotor is chosen (Wang and others, 2009). Table 1 shows the input data.

Table 1 Input data for Mexico $25kW$ experimental rotor and Tjaereborg 2MW wind turbine rotor.

Parameter	Units	Mexico 25kW experimental rotor	Tjaereborg 2MW wind turbine rotor
Number of blade	–	3	3
Air density	kg/m^3	1.19	1.19
Radius of the rotor	m	2.25	30.56
Total mass of the blade	kg	4.62	9321.7
Lower limit for chord	m	0	0
Lower limit for twist	°	0	0
Lower limit for relative thickness of the blade	%	18	12.2
Upper limit for chord	m	0.24	3.3
Upper limit for twist	°	20	8
Upper limit for relative thickness of the blade	%	100	100
Scale parameter	–	6.8	6.8
Shape factor	–	2	2
Power coefficient	–	0.59	0.59
Coefficient of lift	–	0.7	0.7
Fixed part of the cost for a wind turbine rotor	–	0.1	0.1
Tip speed ratio	–	4	4
Angle of attack	°	5	5
Wind Speed	m/s	16	2

From Figure 2, it can be seen that the chord keeps closely to the original distribution for most of the blade except that it narrows down significantly near the blade tip. The reason for this is that this section of the blade does not contribute much to the power and thus is not required to have a thick chord. The relative thickness distribution does not change during the present optimization. The AEP of the optimized rotor is reduced by about 0.8%, whereas the cost of the optimized rotor comes down by approximately 1.9%. Thus the cost of energy for the Mexico rotor can be reduced by approximately 1.15%. However from the trend and pattern of the graphs in Figures 2 and 3, it is seen that genetic algorithm is in line with other published results.

As a second test case of the optimization techniques, the Tjaereborg 2MW rotor is chosen (Wang and others, 2009). In Figures 4 and 5, the chord and twist angle distributions of the optimized Tjaereborg rotors are shown. From Figure 4, it is seen that the optimized blade has a much smaller value of chord in the region between 10 m and 23 m. From the position at a radius of 23 m to the position at a radius of 28 m of the blade, the chord keeps the original distribution. This is because the axial and tangential forces on this part of the blade contribute significantly to the power. Again the chord reduces significantly in the region near the tip. The change in the twist angle is not very significant because of the constraint on the maximal thrust from which a bigger thrust would shorten the blade life and increase the cost.

Figure 2: The chord distribution of the optimized rotor using genetic algorithm

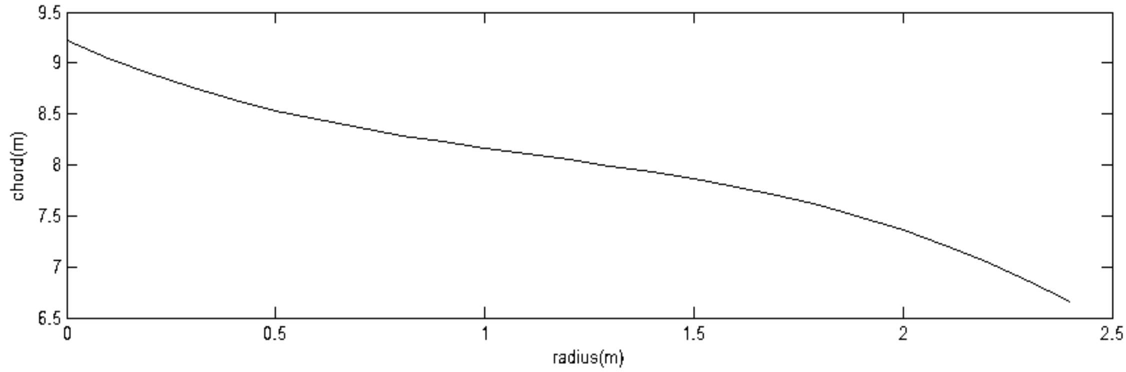
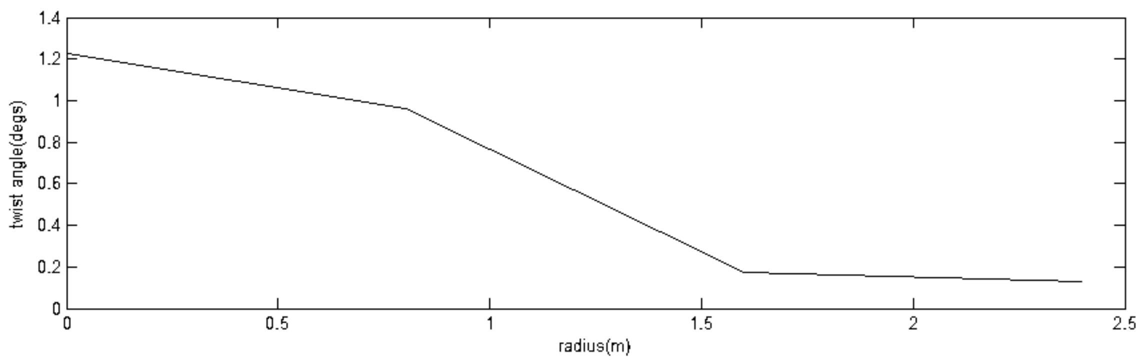


Figure 3: The twist angle distribution of the optimized rotor using genetic algorithm



The AEP of the optimized rotor is reduced by about 4% whereas the cost of the optimized rotor comes down by approximately 7.1%. Thus the cost of energy for the Tjaereborg rotor can be reduced by approximately 3.4%.

However from the trend and pattern of the graphs in figures 4 and 5, it is seen that genetic algorithm is in line with other published results.

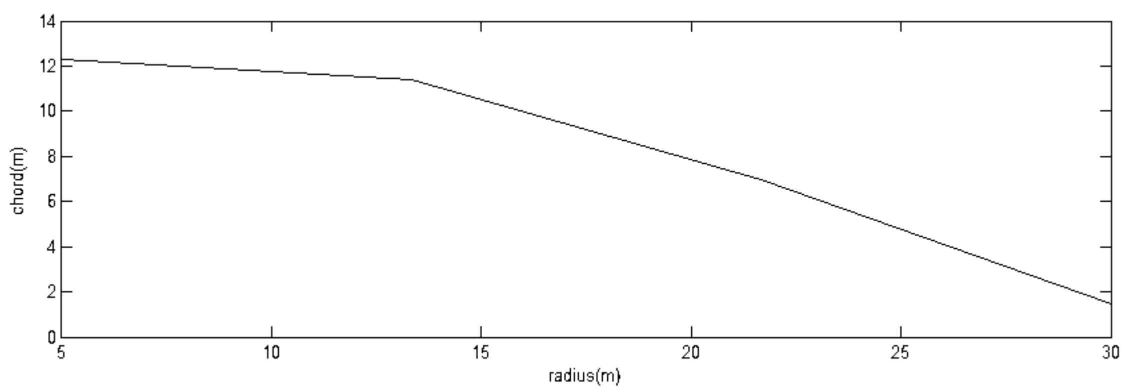


Figure 4: The chord distribution of the optimized Tjaereborg 2MW rotors using genetic algorithm

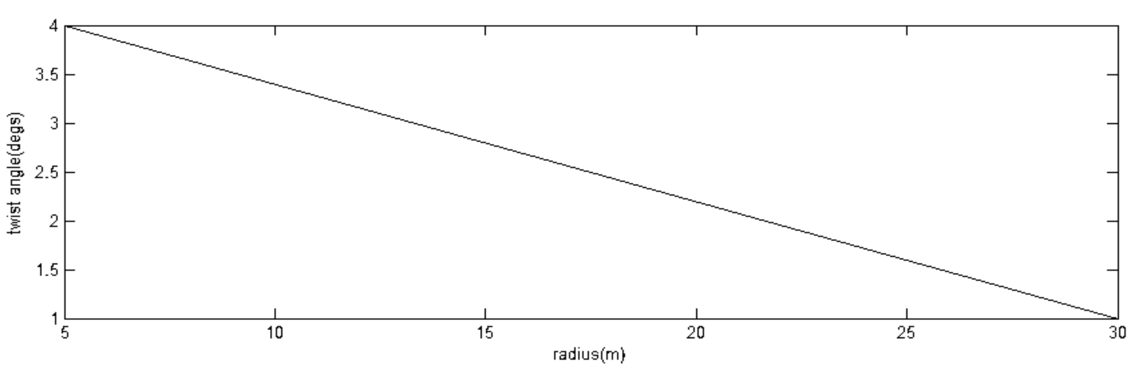


Figure 5: The twist angle distribution of the optimized Tjaereborg 2MW rotors using genetic algorithm.

IV. Conclusion

An optimization model for rotor blades of horizontal axis wind turbines that accounts for the minimum cost of energy which is defined as the ratio of the cost of rotor to the annual energy production is presented. To develop a generalized optimization program, genetic algorithm is used as the search algorithm. Utilizing the developed program, two different blades of 25KW and 2MW wind turbine are optimized. The results obtained are in good agreement with other published results.

V. Acknowledgement

Am grateful to Engr. Dr. C.O.C Oko for his assistance and motivation in making this work a reality.

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A Survey of the Potential for I-Build Technology in Improving the Effectiveness of Construction Management in the Taiwanese Construction Industry

GJRE -E Classification (FOR) 120201

Hung-Ju Chien

Abstract- i-Build technology is a state-of-the-art business integration tool, which includes all the functions of construction management for the enterprise and its partners. i-Build applications include electronic document management (EDM), customer relationship management (CRM), sub-contractor management (SCM), e-Procurement and financial management (FM) etc. The aim of this paper is to examine the current awareness of i-Build and to identify its potential for improving the effectiveness of construction management in the Taiwanese construction industry. This paper reports on the findings obtained from a questionnaire survey conducted between November 2009 and January 2010, with contributions received from 50 organisations representing Taiwanese main contractors, construction companies, architects, engineering companies and clients. The results revealed that 5% of Taiwanese construction professionals have experience of using i-Build. It also indicated that applications of i-Build offered significant potential in improving the effectiveness of construction cost management (CM), project information management (PIM), electronic document management (EDM) and programme management (PM).

Keywords: Construction Management, Information and Communication Technology, i-Build Technology.

I. Introduction

Construction is usually a temporary multi-organisation process, which is heavily dependent on the exchange of large complex data and information. The successful completion of the project depends on the accuracy, effectiveness and timing of communication and the exchange of information and data between the project team (Tam, 1999; Rojas & Songer, 1999; Akinsola et al., 2000; Barker, 2001). According to research by Professor Hans Bjornsson (2001), former director of Stanford University USA, 65% of mistakes in the construction industry are due to a misunderstanding among architects, contractors and subcontractors over information. A further study carried out by Coopers & Lybrand (2001) showed that 15% of all documents are misplaced and 7% are lost for good. In the study, the average cost of the search for the missing documents was £85 per item in staff time / salary equivalent. Great strides have been made over recent years to improve productivity through the design and construction process. The introduction of non-adversarial approaches such as 'lean thinking' and 'partnering' has contributed significantly to cutting down on wasted time and money, making the UK construction industry far more efficient. Construction Best Practice Programme (CBPP, 2003) as an example, stated that during 2002 construction organisations that engaged in Best Practice increased profitability by £56 million, an average of £15,000 per company. Companies implementing Best Practice have seen profits increase by 50% relative to those not applying these principles. A key contributor to this process improvement is the sharing of project information. Huge savings can be made simply by ensuring that all members of the project team receive accurate drawings and everyone is working to the same, up to date, information (Kernon, 2000). This paper investigates the extent of the current use of i-Build by Taiwanese construction professionals. It also reports on the findings obtained from the questionnaire survey conducted by the authors between November 2009 and January 2010, with contributions received from fifty respondents representing Taiwanese main contractors, construction companies, architects, engineering companies and clients.

1) *Aim Of This Research*

The aim of this research is to explore the potential for i-Build technology in the Taiwanese construction industry which will enable companies to improve their corporate business performance.

2) *Rational for the hypothesis*

As previously mentioned there could be potential improvements in the construction industry through the implementation of the i-Build technology. Such improvements have only recently come to the attention of the Taiwanese construction industry because ICT implementation is changing construction in many ways as part of a general drive towards best practice. It improves the capability and efficiency of many aspects of the construction process. Integration of the construction process through the Internet and effective information exchange is not widespread at present but it is a major area of opportunity waiting to be exploited. The following hypothesis is based on this rationale.

3) *Hypothesis*

The Taiwanese construction companies utilising i-Build will improve communication, extend information support and enhance business performance.

II. Challenges Facing Project Management Now and in the Future

Traditional project management practices have evolved over time as the requirements for managing and controlling construction projects unfolded. However, with the advances of management techniques and Information and Communication Technology (ICT), traditional practices have proven to be insufficient in meeting the new project requirements (Alshawi & Ingirige, 2002, p.5). Indeed, productivity analysis by Howarth (2002) has concluded that the industry, on average achieves less than 50% productivity. At present the UK government, industry and clients are all seeking to bring about change in the construction industry to improve quality, competitiveness and profitability and finally increase value to clients (Alshawi & Ingirige, 2002, p.2). Implementation is carried out through initiatives such as the Strategic Forum for Construction (2002), the activities of the Construction Best Practice Programme (CBPP) and the Movement for Innovation (M4I). These initiatives are seeking to secure a culture of co-operation, teamwork, and continuous improvement in the performance of the industry. According to the report, 'Project Management and Computers in the Year 2010' Froese and Waugh (1991), argue that there are three major roles relating to future trends in computers for project management. These are a supplier of more and better information, a tool for multimedia communication, and an advanced decision support and information-processing device. They conclude that: "Since the computer technology to support these roles will undoubtedly exist, the challenge facing the industry is to develop the information technology foundations – such as representation standards and project models." In the report, 85% of the respondents believed that in 2010, the success of companies offering project management services would depend on their computer and information technology capabilities. In fact 92% of respondents believed that everyone in the project management team would be using a computer in 2010. Another similar survey carried out by Froese et al. (2001) revealed that almost all respondents (96%) believed that information technology will be more important for project managers in 2020 compared with today (two-thirds said 'much more important'). A further 94% of respondents responded that new computer technologies would have a positive impact on the market potential/competitive advantage and the effectiveness in managing projects. From the two survey results, it is easy to accept the fact that ICT will have a vital role to play in the execution and management of projects in the future. The changing project management environment is also influenced by other factors. Alshawi & Ingirige (2002, p.6) identified these factors as:

- Globalisation of the marketplace; many industries are facing a lot of pressures due to this factor.
- Economic forces; this factor may significantly affect the client organisation and subsequently can impact on the initial objectives of their projects.
- Increases in project complexity; project complexity has increased due to their being much wider scope, and fragmented parties around the world are having to communicate with one another for efficient project execution.
- The need to achieve faster results with the given resources; this factor places severe time pressures on the entire project team.
- New procurement practices; the emergence of new procurement practices change the way the team members are interrelated. For example procurement schemes such as Private Finance Initiative (PFI) and partnering have impacted upon construction project management.
- Client sophistication; this has become a major driver for productivity improvements in construction.

One of the real challenges in implementing change in the construction industry is the highly fragmented nature of the industry that results in a large number of participants, even on a small construction project. The transition of the construction industry to the computer-integrated era requires the development and acceptance of collaboration technologies for all phases of a construction project from design, through the construction process planning, and project execution and management (Veeramani et al., 1998).

III. Limitations of the Current Project Management Practices

1) *Lack of Adequate Communication*

Construction is one of the most information-dependent industries. Timely and accurate information is therefore important for all project participants as it forms the basis on which decisions are made and physical progress is achieved. Scanlin (1998) points out that communication consumes about 75% to 90% of a project manager's time and Biggs (1997) lists communication problems as the root cause of most project failures. Deng et al (2001) further points out that the extensive physical distance between project participants, extending over national boundaries is the main communication barrier to achieve timely and accurate information transfer. Thus, improving communication among project participants is always the key factor leading to the success or failure of a construction project. The inefficiency of the current communication practice has become a barrier to the innovative construction processes that have been developed for the industry over the past four decades (Akinsola et al., 2000). Dennison (2000), consultant for Druid commented, "There is so little communication between the different elements of the construction process. Even internally between regional offices, everybody is doing things a different way." Communication problems typically lead to additional project expenditure due to reworking. According to Egan (1998) up to 30% of construction is rework. The problems of reworking occur due to conflicting information and information not received in time to the parties concerned. The main cause is the lack of consistency in the flow of information between the different parties involved in the construction project (Alshawi & Ingirige, 2002, p.7).

Figure 1: Typical project environment – chaotic and inefficient
Source: Hogan, 2001, Appendix 1

E-mail is now a popular tool of communication in the construction industry, so most professionals will be familiar with using it for sending messages and attaching drawings and documents. A survey carried out by the Construction Confederation (CC, 2001) revealed that the majority of contractors make full use of e-mail with 100% of companies that employ over 250 employees using it. The survey also predicts that by 2002 all companies with over 30 employees will use it consistently. However, it does have its limitations, first of all, e-mail is not ideal for sending large documents or drawings as there is no guarantee that the whole thing will be delivered intact. Secondary, e-mail messages sit on a server belonging to a third party - the Internet Service Provider (ISP) - before they are collected, so there is also the potential for a security breach (Kernon, 2000).

2) *The Duplication of Project Information*

The construction professionals that participate in the project all have specific functions to carry out a number of discrete activities. Examining the activities carried out by various members of the project team lead to the conclusion that different entities often deal with similar information (Table 1). Project information therefore needs to be passed along the project chain from one member to others. This is often done in practice by paper transfer of, for example, drawings and reports etc. Recently, information has started to be transferred electronically (Murray et al., 2001). On examining table 1 it can be seen that very similar items of information are used by most of the role players during the project cycle; the two, which stand out are drawings and cost data. Table 1 for example also illustrates how both the quantity surveyor and the contractor need to prepare priced bills of quantities; these professionals may, however, use different and incompatible software for taking off quantities, preparing a bill, pricing the bill and for calculating interim and final measurements. The duplication of information here is evident.

3) *Lack of Collaborative Design and Construction*

The current practice of design and construction in industry can be described as a stage controlled process. The life cycle of a project is divided into many isolated stages such as design, tender, construction, maintenance, etc. Each stage has a predefined output that is considered to be the main input for the next (Alshawi & Faraj, 2002). This can result in several disadvantages. Veeramani et al. (1998) identified such disadvantages as:

- Firstly, some problems with the facility design may not be recognised until the actual construction of the facility has begun. This can lead to redesign or design modifications during the construction stage, and this not only impacts upon the productivity but also the cost and completion lead-time of the project.
- Second, since a lesser amount of design flexibility is available once the construction phase has begun, this can result in less-than-optimal design changes in order to overcome the construction problem. For example, a typical building consists of several types of subsystems that may need to be accommodated within the available space. The current practice of design of these subsystems is typically

performed by separate groups of people within an organisation or by different organisations. This can often lead to conflicting space requirements or difficult-to-construct configurations for certain subsystems. Due to the expense associated with delaying construction projects, the typical tendency is to make local modifications to the affected subsystems so that they can be made to fit within the spatial constraints. But this can create longer-term problems for maintenance and upgrade of these subsystems.

Table 1: Information – role player matrix for a typical project chain

Information	**Role Players**										
	P	PM	A	QS	E	C	S	FM	LA	B	L
Drawing	○	○	●	○	●	●	○	○	○	○	
Specifications	○	○	●	○	●	○	○	○	○		
Bills of quantities		○	○	●	●	○	○				
Budget	○	○	○	●	○	○	○			○	○
Contracts	○	○	○	●	●	●				●	●
Planning	○	●	○	●	●	●	●		○	●	
Personnel control		●		●	○	●	●				
Materials control		●		●	○	●	●				
Equipment control		●		●	○	●	●				

Key:
● - Initiation ○ - Information
P – Promoter PM – Project Manager/principal agent
A – Architect S – Subcontractors, suppliers, plant hire companies etc
QS – Quantity Surveyor E – Engineers
C – Contractor FM – Facilities Manager
LA – Local Authorities B - Bankers
L – Lawyers

Source: Murray *et al*., 2001, p. 39-4

4) *Projects Still Rely On Hard Copy Documentation To Complete The Endorsement Procedure*

Although many construction organisations are using ICT to improve specific processes/applications, the construction industry still traditionally continues the practice of issuing hard copy documentation as against electronic forms for auditing and record purposes (Alshawi & Ingirige, 2002, p.7). Multiple copies of these documents of course would be printed off and distributed using mail or courier services. Every time a drawing gets revised - however simple the revision - new sets of the full drawing have to be printed and dispatched around the country to various members of the project team (Kernon, 2000). Deng et al. (2001) argue that communication in the construction industry is complicated by its structural problems. They conclude that: “When drawings are amended, the revised drawings or instructions need to be in hard copy form confirmed with the architect’s chop (authorisation stamp) or signature and the receipt of the drawings be acknowledged by the contractors in writing. Therefore, sending project information in an electronic form cannot complete the endorsement procedure.” Indeed, the mixing of electronic and hard copies in projects makes it difficult for project managers to process the right information as and when required.

5) *Lack Of Standard Processes For Project Management*

Projects are normally managed according to the experience of the project managers who are specifically appointed for this task. Each project manager, even within the same organisation, prefers to follow his/her own experience, which has been developed over a long period of time. These practices lead to large variations in management practices and therefore can create a significant impact on the capability of co-ordinating and controlling project information (Hunt, 1995).

IV. FEATURES AND FUNCTIONAL REQUIREMENT OF THE I-BUILD

i-Build can have four main constituent parts that are needed to run a successful construction business (See Figure 2).

1. Process management
2. Document management
3. Electronic commerce
4. Security

With i-Build, information can be aggregated from multiple sources, consistently analysed and then communicated

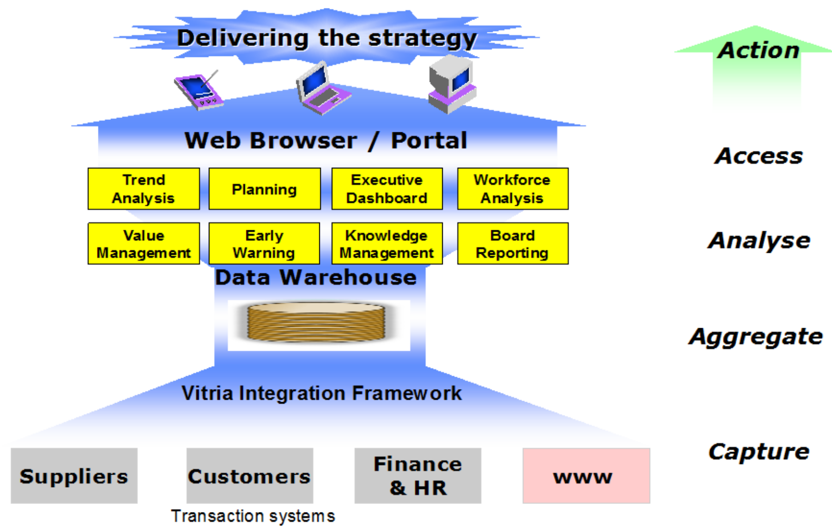

Figure 2: i-Build framework

Source: Hogan, 2001 (adapted by the authors)

1) *Opening Viewing*

The opening view is a project directory or an individual project web site depending upon how the service is provided (Graig, 2006). i-Build allows a single point of access for managing multiple documents and programmes. All information pertaining to the users' role will be delivered to their computer. It also indicates whether users have documents for review in their associated projects. For a single project, the access will be controlled at a project Web page or beneath it. For example, the project web site could have a public side on which general information about the project can be viewed by anyone. (See Figure 3)

2) *Security*

The Internet makes companies more vulnerable simply because it allows more entry points to their business. Using i-Build is also the case. ICT security is becoming an increasingly important issue since no system can be 100% secure (Hamilton, 2002a). There can be a number of security levels to guard against unauthorised third-party access to sensitive information. For example, every user has a unique username and password (Figure 4). For added security, Secure Socket Layering (SSL) can be added. All of the data is held on servers in physically secure premises, data is backed up regularly and servers monitored constantly for hackers, viruses and overall performance.

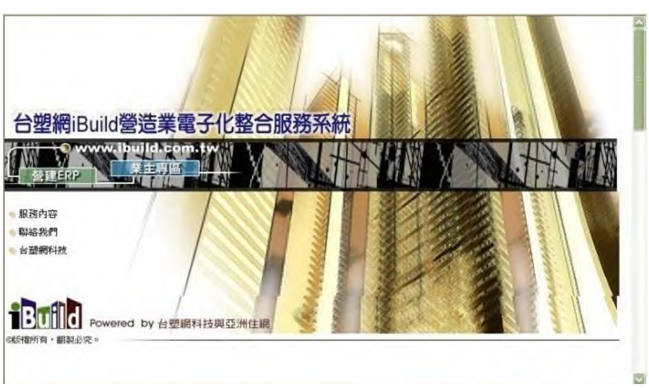

Figure 3: Open view page Source: i-Build, 2009 with permission

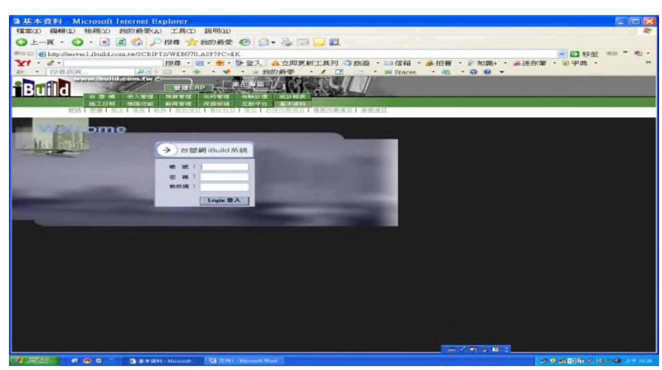

Figure 4: Log in page Source: i-Build, 2009 with permission

3) *Requests For Information (RFI)*

The RFI facility can be used to raise and answer questions, resolve issues of request information (BuildOnline, 2002). Individual users should need the appropriate permissions from the construction company to create an RFI. The construction company may also be able to configure routing rules for resolution, review, information and forwarding (Hamilton, 2002b, Figure 5). The actual workflow routing used for RFI and submittals is likely to vary with the delivery model. For example, in the design-build model, there may be only isolated cases where it is necessary to route an RFI or a submittal through an owner (Graig, 2006).

Figure 5: Requests for information Source: i-Build, 2009 with permission

4) *Document Management*

A significant amount of information is exchanged between various members in a construction supply chain. Poor communication and co-ordination, resulting in misunderstanding, misinterpretation and ignorance of information may seriously affect the performance of the project in terms of quality, time, cost and value (Cheng et al., 2001). Document management provides all the features needed to allow the construction company to share and collaborate on project related documents as well as being able to route them to the right project participants for action and follow-up. Document management also allows the construction company to upload, download and revise documents as well as view and redline online. All activities are audited so that the enterprise is aware of all the history relating to a document (Figure 6).

5) *Contracts Management*

The contract section manages multiple prime contracts, subcontractor contracts and professional service agreements. The contract profile can be used to create the actual contract and display it within the i-Build system to authorised users. Change orders, purchase orders, back-charges, work orders and contract closeout documents can all be prepared and managed in the i-Build system (Graig, 2006). Furthermore, contractor invoices can be issued from the i-Build, just using a customised workflow process (Figure 7).

Figure 6: Document management
Source: i-Build, 2009 with permission

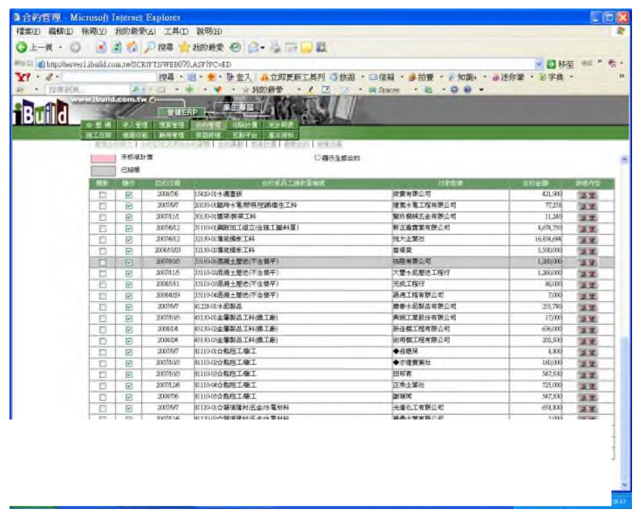

Figure 7: Contracts management
Source: i-Build, 2009 with permission

6) *Cost Management*

Today, Internet enabled customers have more information and more choice than ever. The one-size-fits-all days are gone, customers have high expectations and are increasingly demanding more tailored and customised services to suit their specific needs. Cost management provides all the features needed to allow the construction company to assess their cash flow. It also simultaneously issues the daily report of 'cash-in' and 'cash-out' of the project. Therefore, the enterprise could assess the cash flow of the project at any time (Figure 8).

7) *Management Reports*

The management report within the i-Build system includes management reports and field reports. In general, the primary contract requires these features to keep the client and other members of the team apprised of the overall status of the project including schedule budget, significant issues, photographic progress and other items (Figure 9).

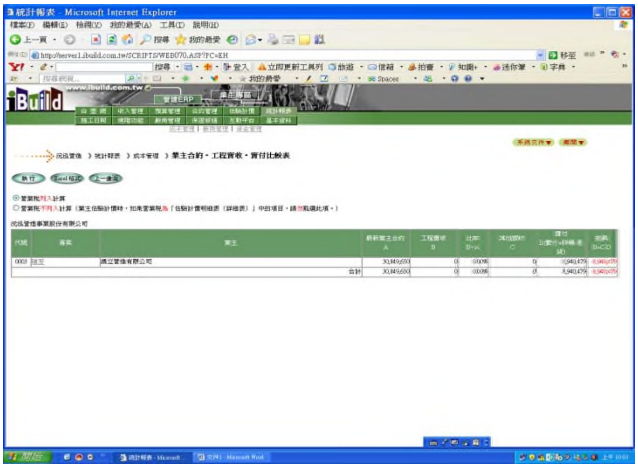

Figure 8: Cost management Source: i-Build, 2009 with permission

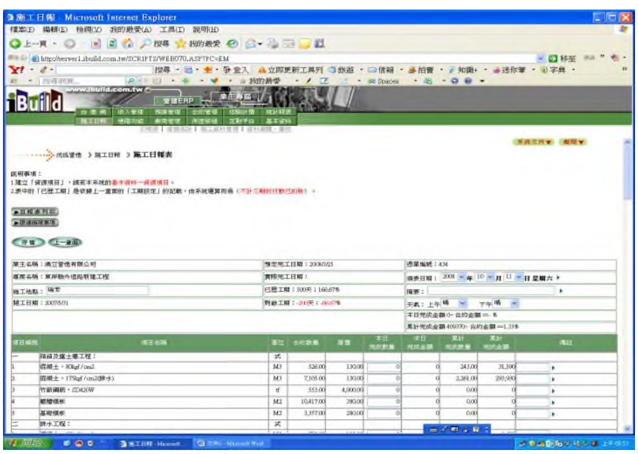

Figure 9: Management reports
Source: i-Build, 2009 with permission

8) *E-Procurement*

In the traditional supply chain, buying and selling materials means establishing long-term relationships with suppliers, distributors and retailers, with multiple distribution centres, long lead-times and fixed margins. Now, all of the business activities are being re-innovated. Companies can buy and sell across a wide Internet-enabled marketplace – the virtual marketplace. Conditions such as challenging time-to-market, service response times and product lifecycles – are all factors that are key to market success. i-Build e – procurement solution offers another model for efficient Internet purchasing. With e – procurement, enterprises can streamline entire purchasing operations from item selection through to approvals to payment and offers real-time interactivity with trading partners, dramatically reducing purchasing costs, and boosting efficiencies to realise a rapid return on investment.

Furthermore, e – procurement also offers flexible functionality to cater for the different needs of first time, repeat and power users, allowing the user to select based on the user's business model. e - Procurement was therefore designed to:

- Provide new, industry leading search capabilities, which include text search, parametric search and categorisation, and perform as people think (Figure 10).
- e – Procurement also provides a 'Smart Search' for supplier link-outs, so users can more easily find and link out to these external supplier sites.
- e – Procurement caters for frequent or experienced users, so they can complete their transactions quickly and handle checkouts in one step.

Figure 10: e – Procurement
Source: i-Build, 2009 with permission

V. RESEARCH METHODOLOGY

The aim of this research is to explore the potential for i-Build technology in the Taiwanese construction industry which will enable companies to improve their corporate business performance. To determine the current use of state-of-the-art i-Build technology by Taiwanese Architectural, Engineering and Construction (AEC) companies, a questionnaire was conducted, which was designed and based upon a review of current literature and the research objective. In addition, this questionnaire was also used to test the veracity of the hypothesis: The Taiwanese construction companies utilising i-Build will improve communication, extend information support and enhance business performance. A number of stages were involved in questionnaire survey process; these are:

- Sample selection;
- Questionnaire design;
- Pilot questionnaire;
- Questionnaire main distribution and analysis.

1) *Sample Selection*

Once the technique has been decided for collecting data, selecting the research sample is very important and great care must be taken in order to provide representative and reliable evidence. Naoum (1998, p.60) suggests that there are two main criteria that need to be taken into account when selecting the research sample. First, what do you want to know? Second, about whom do you want to know it? Following the general recommendations provided by Naoum, this questionnaire was sent to a wide range of professionals within the Taiwanese construction industry. A total of 50 construction professionals were selected as the sample for the questionnaire survey. The name and contact information of the sample respondents were obtained from the authors' network of contacts and also from organisations such as the Taiwan Construction Research Institute (TCRI), Chinese National Association of General Contractors (CNAGC), Construction Magazine and Contractor Development Foundation (CDF). Although some of the sample respondents were obtained from the author's network of contacts, not all free random selection. However although they can in no way be considered to representative of the industry as a whole they do provide important indications.

2) *Questionnaire Design*

Two types of questions were used in the questionnaire; closed-ended questions and open-ended questions. Almost all the questionnaires have closed-ended questions to ensure consistency of respondent feedback. As it is not possible to design all questions as closed-ended, some questions were left open-ended, to obtain numerical data or to solicit some written comment. A total of 10 multiple-choice questions were included in the questionnaire. From the above hypothesis, the author constructed the questionnaire with five sections as shown below:

1. General information
2. Build applications
3. The appropriate level of cost and charging structures
4. The noticeable benefits that have been gained from using i-Build
5. The barriers that discourage the construction industry from utilising i-Build

3) *Pilot Questionnaire*

Before the main survey was undertaken, a draft version of the questionnaire was piloted with one Taiwanese construction company (turnover between TWD 2 – 5 billion (USD 61- 305 million)) and one Taiwanese engineering company (turnover between TWD 2 – 5 billion (USD 61- 305 million)). This pilot study was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguous questions, and also provide an indication of the time to complete the questionnaire. Some of the comments and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

4) *Questionnaire Main Distribution*

During November 2009 and January 2010, the authors conducted 50 telephone interviews with potential users of i-Build technology. Interviewees were drawn from 50 different companies and comprised of main contractors, construction companies, architects, engineering companies and clients. Only 5 percent of the interviewees had used i-Build technology on construction management. The data obtained from the authors' survey were analysed according to the type of profession, which was distinguished by five categories as indicated in Table 2.

Table 2: Categories of interviewees

Categories	**Annual Turnover**					**No. interviewed**
	Below TWD 0.1 billion	Between TWD 0.1 – 1 billion	Between TWD 1 – 2 billion	Between TWD 2 – 5 billion	Above TWD 5 billion	
Main Contractor	8	11	7	2	0	28
Construction Company	2	4	0	4	0	10
Architect	1	0	0	0	0	1
Engineering Company	5	2	0	1	0	8
Client	1	0	0	1	1	3
SUM	**17**	**17**	**7**	**8**	**1**	**50**

VI. Data Analysis Using SPSS

Statistical Package for the Social Sciences (SPSS) is a very powerful and user friendly program for statistical analysis (Gaur & Gaur, 2006; Green & Salkind, 2008). The data obtained from the authors' survey was analysed in SPSS.

1) *Scale Reliability*

Scale reliability is one of the SPSS techniques, has to be tested for validity and reliability. Proper validity and reliability testing can be done using Confirmatory FactorAnalysis (CFA). However, researchers commonly use the Cronbach alpha coefficient for establishing scale reliability. The Cronbach alpha coefficient is an indicator of internal consistency of the scale. A value of Cronbach alpha above 0.70 can be used as a reasonable test of scale reliability. (Gaur & Gaur, 2006) The analysed results are shown in Table 3 where the Cronbach alpha value was calculated to be 0.914 (larger than 0.70).

Table 3: Reliability statistics

Crohbach's Alpha	N0. of Items
0.914	8

2) *The Two-Way Anova Analysis*

An analysis of variance (ANOVA) exercise was undertaken to test the null hypothesis that there is no significant difference between the mean values of the groups. This enabled the authors to clarify whether or not the opinions of the separate construction professional groups were the same on the various issues dealt with in the survey. A probability value of 'F significant' (Sig.) below 0.05 indicates that the null hypothesis can be rejected, suggesting that there is a high degree of difference of opinion between groups in relation to that factor. The ANOVA results are shown inTable 4 where the 'type of profession' has a significant effect on the 'reasonable monthly price' (Sig.=0.003 <0.05). However, the 'annual turnover' does not affect the 'reasonable monthly price' (Sig.=0.102 >0.05). Furthermore, the interaction of the type of profession and annual turnover also does not affect the reasonable monthly price significantly (Sig.=0.579>0.05). A further analysis is therefore necessary to localise whatever differences there may be among the individual treatment means. Table 5shows the differences between means (Mean Difference (I-J)), their standard errors, p-values (Sig.) and 95% Confidence Interval for each pair. Inspection of the p-values shows that the 'engineering company group' differs significantly (p<0.05) from the 'client group' in relation to the 'reasonable monthly price' factor, but the engineering company group does not differ significantly from the architect, the main contractor and the construction company groups (p>0.05).

3) *Chi-Square Test*

The chi-square test of independence is used to test the hypothesis that two categorical variables are independent of each other. A small chi-square statistic indicates that the null hypothesis is correct and that the two variables are independent of each other (Gaur & Gaur, 2006). Table 6 reveals that the *Pearson Chi-Square* (2-sided significance reported in the last column) is 0.008<0.05, we can therefore

Table 4: Tests of between subject effects

Dependent variable: reasonable monthly price

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected model	19.702[a]	12	1.642	2.232	0.035
Intercept	65.226	1	65.226	88.657	0.000
Type of profession	12.503	3	4.168	5.665	0.003
Annual turnover	6.228	4	1.557	2.116	0.102
Type of profession* Annual turnover	2.828	5	0.566	0.769	0.579
Error	23.543	32	0.736		
Total	146.000	45			
Corrected total	43.244	44			

a. R Squared= 0.456 (Adjusted R Squared=0.251)

Table 5: Post Hoc Tests – Multiple Comparisons

Dependent variable: reasonable monthly price						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value Sig.	95% Confidence interval	
					Lower bound	Upper bound
Client	Engineering company	-1.00	0.577	0.023	-3.264	-0.653

relationship at 5% significance level between the professional group and annual turnover.

Table 6: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	32.823a	16	0.008
Likelihood Ratio	25.372	16	0.064
Linear by Linear Association	0.049	1	0.825
N of Valid Cases	50		
a. 23 cells (92.0%) have expected count less than 5. the minimum expected count is 0.02.			

VII. Survey Results and Discussion

The results have been classified under the following headings:

a). i-Build applications

b). The appropriate level of cost and charging structures

c). The noticeable benefits that have been gained from using the i-Build

d). The barriers that discourage the construction industry from utilising the i-Build

1) *I-Build Applications*

There are many specialised i-Build applications that are designed specifically for use in construction. The respondents were invited to rate the level of usefulness in improving the effectiveness of construction management from the various i-Build applications. Mean ratings on the level of usefulness were calculated, (on a scale of 1-5) which revealed that Project Information Management (3.90), Cost Management (3.84) and Electronic Document Management (3.84) were considered to be the most useful in improving the effectiveness of construction management. The applications of Programme Management (3.82) and Sub-contractor Management (3.70) ranked fourth and fifth respectively (Table 7).

2) *Appropriate Level Of Cost And Charging Structures*

The i-Build provider charges a flat monthly rate for the users. The price of such applications range is depending upon the level of functionality, the number of users and an estimation of the data storage required. The authors' survey results revealed that the majority of respondents (70.5%) indicated that a reasonable monthly price for 10 Gb (Giga bites) data storage space and up to 100 system users is between TWD 6,000 and TWD 7,999. A further 15.9% reported that a reasonable level of monthly rate is between TWD 8,000 and TWD 9,999, only a small share of respondents (9.1%) believed that an appropriate level of monthly price is between TWD 10,000 and TWD 13,999. (See Figure 11)

Table 6: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	32.823a	16	0.008
Likelihood Ratio	25.372	16	0.064
Linear by Linear Association	0.049	1	0.825
N of Valid Cases	50		
a. 23 cells (92.0%) have expected count less than 5. the minimum expected count is 0.02.			

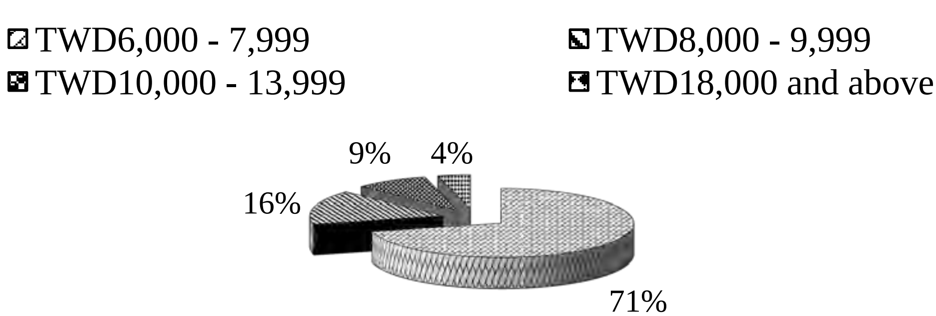

Figure 11: Reasonable monthly price of i-Build response analysis

3) *The Noticeable Benefits That Have Been Gained From Using I-Build*

i-Build technology is now a state-of-the-art business collaboration tool in the Taiwanese AEC industry with 5% of Taiwanese construction professionals in the authors' survey indicating that they have experience of using the i-Build technology. Although 5% of responses seems a low figure at present, in reality, some respondents gained noticeable benefits from using i-Build. Some respondents commented that "In fact, with i-Build the return on investment is enormous", "Simple to implement in stages, meets our needs, we do not have to adapt our business processes to use them." and "i-Build is providing a platform for improved assessment within the value chain, and simultaneously issues the daily report of 'cash-in' and 'cash-out' of a project, it is easy for an enterprise to assess the cash flow of the project." 65% of mistakes in the construction industry are due to a misunderstanding among architects, contractors and subcontractors over information, according to Bjornsson (2001). Oliver (2002) further commented, "The general statistic is that 80% of mistakes stem from not using the most up-to-date information." The authors' survey has identified that one of the main advantages of using i-Build is that it ensures that all members of the project team have access to the most up-to-date versions of the various project documents. This means that traditional mistakes generated from someone working from an old document or drawing are in theory removed or at the very least reduced.

4) *The Barriers That Discourage The Construction Industry From Utilising I-Build*

The barriers discouraging the effective implementation of i-Build in the Taiwanese AEC industry have been identified in the authors' survey. The results are illustrated in Table 8, and indicate that the three most significant barriers are:

- Data may be altered in transit and delivery
- System reliability concerns
- Appropriate charging structures

The findings in the authors' survey are similar to those from the research conducted by Ng *et al*. (2001), White (2001), Goodwin (2001), Alshawi & Ingirige (2002), Oliver (2002), Sturley (2002) and Barthorpe & Chien (2003) who identified the reasons for the low level of ICT usage by construction professionals as:

- Software problems
- Confidential information getting into the wrong hands
- Legal disputes arising

However the order of importance of the various barriers has slightly changed.

Table 8: Dependence levels of barriers – response analysis

Factors	Main contractor	Construction company	Architect	Engineering company	Client	Average
Appropriate charging structures	3.94	4.00	2.00	2.83	3.00	3.61
Confidential information getting into the wrong hands	3.25	3.50	3.00	4.00	4.00	3.46
Speed of information transfer and delivery	3.67	3.50	3.00	3.17	3.00	3.48
System reliability concerns	3.80	4.25	2.00	3.17	3.00	3.63
Data may be altered in transit and delivery	4.00	3.25	2.00	3.83	4.00	3.78
Legal disputes arising	3.07	3.50	2.00	3.50	4.00	3.23

Footnote: In a rating of 1 to 5 where 5 is most important, 1 is least important.

VIII. LIMITATION OF THE SURVEY

According to Olle Samuelson (2008) '*IT – Barometer 2007 survey*' stated that "Three criteria were set up for the survey tool. It should:

1. Be repeatable and comparable over time.
2. Be comparable between countries.
3. Cover all categories in the construction industry."

Although the purpose of this survey is to examine the current state of i-Build technology usage by Taiwanese AEC companies, there are several limitations and constraints that have influenced the response obtained in this survey:

- Unfamiliarity of i-Build applications: i-Build is a relatively new technology, particularly by Taiwanese AEC companies and therefore some interviewees were unfamiliar with the i-Build applications available or even the esoteric terminology used.
- Constraints of conducting structured interviews: Although a substantial empirical study was conducted using the questionnaire survey, the expense and time-consuming nature of conducting structured interviews limited the number that were able to be carried out. However although 50 structured interviews can in no way be considered to be

representative of the industry as a whole they do provide important indications.

- Analysis constraints: Some difficulty was experienced in analysing some of the survey interviewee's comments, due to their subjectivity.

IX. CONCLUSIONS

This paper has presented the findings of a questionnaire survey conducted by the authors among a sample of 50 construction organisations based in Taiwan. The survey results demonstrate that only 5% of the survey respondents have experience of using i-Build. The three most significant barriers that discourage the AEC industry from utilising the i-Build have also been identified in this paper as:

- Data may be altered in transit and delivery
- System reliability concerns
- Appropriate charging structures

From the survey, the majority of respondents (70.5%) indicated that a reasonable monthly price for 10 Gb (Giga bites) data storage space and up to 100 system users is between TWD 6,000 and TWD 7,999. Furthermore, the respondents indicated that the three i-Build applications that were the most useful in improving the effectiveness of construction management in the Taiwanese AEC industry are:

- Project Information Management
- Cost Management
- Electronic Document Management

The Taiwanese construction industry output is annually worth around Taiwan Dollar (TWD) 469 billions, roughly equivalent to 5-6% of the Gross Domestic Product (MOI, 2004). According to the MOI report there were 12,012 construction companies in 2008. Only 5% of these organisations have so far implemented i-Build system, therefore a 95% potential construction market for i-Build system exists in this sector alone.

The ICT technology infrastructure is now available for construction in enhancing business performance and future growth. i-Build applications are just one of several possible solutions that can be used to streamline construction processes, form closer client/subcontractor/supplier relationships and operate more effectively in the global market place.

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Investigation of Oil Retention in Vapor Ompression Systems: A Case Study

GJRE -A Classification (FOR) 091308

G. B Eke[1], K. P Okpara[2]

Abstract- **In air conditioning and refrigeration systems a small amount of oil is carried along with the refrigerant and is retained in the system components. Oil retention characteristics in the condenser, evaporator, liquid and suction lines were studied and are presented and discussed here. Refrigerant R22 with miscible lubricant was considered to investigate oil retention physics in the widest possible range of transport properties. A parametric analysis was performed in the suction line and it showed that oil retention depends on the oil mass fraction, vapor refrigerant mass flux, mixture viscosity ratio and orientation of the pipe. Computational method and correlations were used with the input data gotten from a 10KW rated compressor with five passes of inlet and outlet cross flow. In the evaporator and condenser, Premoli's and Chisholm's correlated void fraction models were used. In the suction line, an increase in mixture viscosity of about 55% caused a rise in oil retention in the range of 50%, depending on the oil mass fraction. Oil retention in the upward vertical suction line is about 50% higher than in the horizontal line at similar conditions. Results agreed with other published works in the same subject.**

Keywords: Oil retention, Refrigerant R22, Vapor compression systems

I. INTRODUCTION

In a refrigeration plant, a small portion of the oil circulates with the refrigerant flow through the plant components, while most of the oil stays in the compressor. The compressor in a refrigeration system needs oil for the following reasons: to prevent surface-to-surface contact between moving parts, to remove heat, to provide sealing, to keep out contaminants, to prevent corrosion, and to dispose-off debris created by wear (Vaughn, 1971). Most of the screw compressor mechanical failures are due to improper oil management that leads to lack of proper lubrication inside the compressor. The circulating oil can form a fairly homogeneous mixture with the refrigerant or it can exist as an oil film on the tube wall, the thickness of which is affected by the system conditions (Mehendale, 2001). Each plant component that is - condenser, evaporator, suction and liquid lines has different amounts of oil retention. Large amounts of oil retention cause a decrease in heat transfer and an increase of pressure drop which in this case is an undesirable effect. As a result, the performance of the air conditioning system and the reliability of the screw compressor depend on how much oil is circulated and retained in each component of the system (Arora, 2000; Lee, 2002). Mehendale and others in 2001 estimated liquid film thickness in an upward vertical suction line and verified this model with experimental data, and later used a similar model to compute oil retention volume in the suction line of CO_2 air-conditioning system. A new correlation was obtained for Reynolds numbers varying from 16×10^4 $R_{eg} < 35 \times 10^4$, which was the range of gas core Reynolds numbers in CO_2 air-conditioning systems. The liquid film thickness ranged from $0.02 \leq \delta \ /D < 0.10$ and the suction line was horizontal. Lee in 2002 conducted experiment to investigate oil retention in carbon dioxide air-conditioning system hence computing the volume of oil retained in a micro-channel evaporator and developed a model to estimate oil retention volume in the headers of the heat exchanger, as well. A critical summary of the influence of oil on refrigerant heat transfer and pressure drop was given by Shen and Groll (2003). They described one possible approach for evaluating the properties of liquid refrigerant and oil mixtures, summarized the most common heat transfer correlations used during evaporation and condensation processes, and proposed pressure drop correlations depending on oil mass fraction in the mixture. Then, in 2005 Cremaschi and others measured oil retention in the evaporator, condenser, liquid and suction lines of R-22 and R-410A air conditioning systems. He plotted the cumulative oil retention in each component and measured the increase in pressure drop due to oil retention. Thome who was one of the pioneers in this area, proposed a comprehensive thermodynamic approach to modeling the behavior of refrigerant and oil mixtures (Thome, 2006). His theoretical and experimental investigations provided useful insights about the physics involved in the evaporation of a mixture. Sarntichatsak and others in 2006, performed simulation and experimental evaluation of the effects of oil circulation in an inverter air conditioning system using refrigerants R-22 and R-407C. Their simulation and experimental model, based on minimum gas velocities, introduced the concepts of void fraction, oil entrainment, and liquid film thickness for oil– refrigerant mixtures. Choi and others in 2008 conducted experiments in order to determine the quantity of oil in smooth and micro-fin tubes during evaporation and condensation of refrigerant–oil mixtures. They showed that the parameters that affect oil retention were mass flux, oil mass fraction, mixture viscosity, evaporator exit conditions (i.e. vapor quality at the evaporator outlet), and evaporation pressure. In this paper, new semi-empirical correlations were used to model oil retention characteristics in the suction line for refrigerant-oil mixtures. The results gotten are verified with experimental data presented in Cremaschi's (2004) PhD thesis and with previous experimental results available in the literature. Oil retention in a tube-fin evaporator using conventional refrigerant is also computed using the

Premoli's (1971) void fraction model. Hence, the objective of this research among other things is to investigate the volume of oil retained in each component of the air-conditioning system using various correlations and void fraction models, and to quantify the effects of refrigerant mass fluxes on oil retention using the model developed at the suction line and for the heat exchangers.

II. Problem Formulation and Solution Method

Oil is required in the compressor crankcase of a screw compressor, but refrigerant present in the compressor (except in the motor compartment, suction plenum, cylinders, and heads) might be considered a contaminant. Liquid refrigerant is always a contaminant in the screw compressor system because it usually dissolves in the oil, thereby changing its viscosity and interfering with lubrication. During the off period of the screw compressor in eleme Petrochemical, both liquid refrigerant and oil are in the crankcase of the compressor. Immediately after the compressor starts up, liquid refrigerant boils and the oil-refrigerant mixture is flung onto the cylinder walls and possibly into the cylinder. Then, there is a significant rise in the rate at which the oil is pumped from the compressor thereby forcing the lubricant to accumulate in bends and pockets of the system components such as the condenser, evaporator, accumulator, and suction line as shown in Figure 1. Therefore, the oil level in the crankcase of the compressor decreases to a level that is not sufficient enough to guarantee proper lubrication of its components. In order to have a satisfactory theory for oil charge management, we considered the oil distribution in the entire system with conditions similar to those of the real applications. Hence the input parameters for this research was gotten from a 10KW rated compressor with five passes of inlet and outlet cross flow. In the model studied, the oil charged into the compressor, the number of the components in a vapor compression system, the geometry and configuration of each component, and the interaction between refrigerant and oil are only some of the variables upon which the oil retention amount depends. Thus, a proper oil charge needs to consider that there is a certain amount of oil circulating outside the compressor crankcase. Thus, this volume of oil that resides outside the screw compressor is referred to as the oil retention volume. Based upon system geometries, operating pressures and temperatures, and refrigerant and oil flow rates, the amount of oil in each component changes. The amount of oil carried over with the refrigerant in a vapor compression system is referred to as the oil mass fraction (OMF):

$$OMF = \frac{\dot{m}_{oil}}{\dot{m}_{ref} + \dot{m}_{oil}} \times 100 \qquad [wt\%] \qquad (1)$$

where, $\dot{m}_{oil}$ is mass flow rate of oil (kg/s); $\dot{m}_{ref}$ is mass flow rate of refrigerant (kg/s). Some investigators refer to oil mass fraction as "oil concentration" or "oil circulation ratio" (in mass %). OMF and oil concentration are used interchangeably throughout this paper and they are both defined by Equation (1). The pressure drops in the connecting lines and in the heat exchangers, such as the condenser, evaporator, and suction line heat exchanger (SLHX), depend on the refrigerant flow rate and on the amount of oil that exists in each component. When oil is either retained or circulated in system components, the pressure drop increases and the heat transfer generally decreases. On the other hand, oil caused the pressure drop to double in the evaporator compared to a similar oil free system.

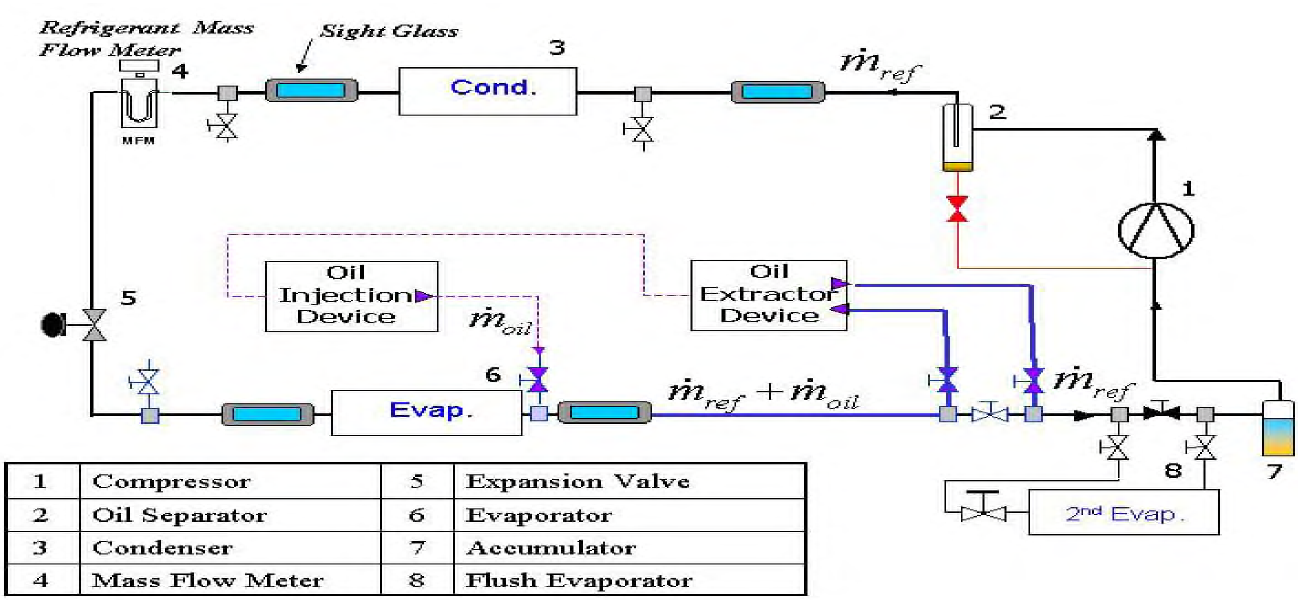

Figure 1 Lab-view schematics of air-conditioning system in Eleme Petrochemical ltd

1) Oil Retention In The Condenser Of An Air-Conditioning System

The oil retention volume in the condenser was investigated, and the convective condensation heat transfer, pressure drops, and void fraction model in the condenser was computed using various correlations. The convective condensation heat transfer was calculated using the correlation below;

If $\mathrm{Re}_{ref,vap} < 24000$

$$Nu = 15.9\,\mathrm{Pr}_{mix,liq}^{1/3}\left[\frac{h_{fg}}{c_{p,mix}(T_s - T_w)}\right]^{1/6}\mathrm{Re}_{ref,vap}^{0.15}\exp(-5\omega_o)$$

If $\mathrm{Re}_{ref,vap} > 24000$

$$Nu = 0.084\,\mathrm{Pr}_{mix,liq}^{1/3}\left[\frac{h_{fg}}{c_{p,mix}(T_s - T_w)}\right]^{1/6}\mathrm{Re}_{ref,vap}^{0.67}\exp(-\omega 5_o)$$

where $\mathrm{Pr}_{mix,liq}$ is the liquid mixture prandtl number and ω_o is the local oil mass fraction. In this work the temperature T_s was set to $T_{bubble,mixture}$ since T_w can be higher than the saturation temperature in the first segments of the condenser. The thermodynamic proprieties of the oil and liquid refrigerant mixtures in the condenser were evaluated with the same approach described for the evaporator in section 2.3. The sub-cooled region was separated from the two-phase region. As a first approximation, the liquid refrigerant and the lubricating oil were considered completely miscible and uniformly mixed in the condenser sub-cooled region. Thus, oil retention in this portion of the condenser, was estimated with the same method adopted for the liquid line described in section 2.2. Based on a critical literature review of other research works in the same subject, it is reported that the influence of oil on heat transfer degradation during the condensation process increases with oil mass fraction and that the lubricant reduces the mean convective condensation regardless of oil mass fraction, mass flux, and tube geometry. Since the presence of the lubricant does not alter the condensation mechanism significantly, it is suggested that it is feasible to use a correlation for pure refrigerant to predict the heat transfer coefficient of the refrigerant-oil mixture by replacing pure refrigerant proprieties with the mixture proprieties. It has been computed according the same correlation used for the evaporation processes in section 2.3. Thus, pressure and temperature were read from Table 1 and local mixture vapor quality x_{mix}, was calculated from equation (5).

2) Oil Retention in the Liquid Line of an air-conditioning system

Homogenous model was applied in the liquid line because the refrigerant is in the liquid phase. Thus, since the OMF is known, oil retention was simply obtained by equation (2)

$$OR\ [ml] = \omega_o A_{tube} L_{tube} \frac{\rho_{mix}}{\rho_{oil}} 10^6 \qquad (2)$$

where, ω_o is the absolute oil mass fraction in the liquid line calculated according to equation(4), ρ_{mix} is the mixture density which was calculated from equation (7), and ρ_{oil} is α in each segment of the heat exchanger tube. The void fraction, α at any given cross section is defined as the ratio of the area occupied by the vapor phase $A_{ref,}$ to the total area available to the mixture. Thus, the definition of void fraction, α is

$$\alpha = \frac{A_{ref,vapor}}{A_{cross\ actual}}$$

and for the evaporator studied, the geometric ratio of the actual over the nominal inner cross sectional area was computed as follows;

$$\omega_o\ [wt.] = \frac{\dot{m}_{oil}}{\dot{m}_{oil} + \dot{m}_{ref}} = \frac{OMF}{100} \qquad (4)$$

After the expansion device, the local vapor quality ranged from 0.10 to 0.30 and oil mass fraction in the liquid phase increased. Along the evaporator, oil mass fraction continued to rise as the refrigerant evaporates into the vapor phase. The local mixture quality x_{mix} was defined as the mass of refrigerant vapor divided by the total mass of fluid:

$$x_{mix} = \frac{m_{ref,gas}}{m_{ref,gas} + m_{ref,liq} + m_{oil}} \qquad (5)$$

where, $m_{ref,gas}$ is mass flow rate of refrigerant vapor (kg/s), $m_{ref,liq}$ is mass flow rate of liquid refrigerant (kg/s) and m_{oil} is mass flow rate of pure oil (kg/s).

The vapor pressure of oil is negligible in comparison to that of refrigerants and consequently, the lubricants were assumed to have no effect on the mixture vapor pressure. From the conservation of mass of the two components, and assuming no oil entered the vapor phase, the following expression relates local oil mass fraction ω_{local} to local vapor quality x_{mix} and inlet oil mass fraction ω_o . Hence local oil mass fraction was calculated according to equation (6),

$$\omega_{local} = \frac{\omega_o}{1 - x_{mix}} \tag{6}$$

Equation (6) is based on steady state flow of the mixture through the system, i.e., no local oil hold-up in the heat-transfer tubes. Since the oil is assumed non-volatile, the maximum exit vapor quality that can be achieved in the evaporator is

$$x_{mix,\max} = \frac{m_{ref,gas}}{m_{ref,gas} + m_{oil}} = 1 - \omega_o \le 1$$

If the refrigerant and oil mixture reached maximum, $x_{mix,\max}$ then the heating fluid increased the mixture temperature without increasing the mixture quality, as occurred in single phase heat transfer processes. Even though the mixture quality was less than one, this situation is referred to as superheating of refrigerant, because all liquid refrigerants has been evaporated and superheated. Moreover, according the exit pressures and temperatures, a minimum amount of refrigerant remained dissolved in the oil and does not participate in the evaporation process. Therefore, the mixture density as given by Jensen and Jackman (1984) was obtained from

$$\frac{1}{\rho_{mix}} = \frac{\omega_{local}}{\rho_{oil}} + \frac{1 - \omega_o}{\rho_{ref,liq}} \qquad \left[kg / m^3\right] \tag{7}$$

This was calculated, since the local oil mass fraction ω_{local}, the inlet oil mass fraction ω_o and liquid refrigerant and oil densities are known.

Finally, since the velocity slip ratio is known, the void fraction α was computed according to equation (8)

$$\alpha = \left[1 + S\frac{\left(1 - x_{mix}\right)}{x_{mix}}\frac{\rho_{ref,vap}}{\rho_{mix,liq}}\right]^{-1} \tag{8}$$

Since the liquid fraction in each segment is simply obtained by (1- α), the oil retention mass in each segment was computed according to equation (9):

$$ORM_{segment}\ \left[kg\right] = \omega_{local} V_{segment} \left(1 - \alpha\right)\rho_{mix,liq} \tag{9}$$

where, $V_{segment}$ is the actual internal volume of each segment (m^3). Since mass is conserved, the oil retention mass in the whole evaporator was simply the summation of oil retention in each segment of the heat exchanger:

$$ORM_{tot}\ \left[kg\right] = \sum_{tube}\left(\sum_{segment}\left(ORM_{segment}\right)\right) \tag{10}$$

The oil retention volume (*OR*) in the entire heat exchanger was obtained by dividing the ORM_{tot} by the average oil density in the evaporator.

3) Oil Retention In The Suction Line Of An Air-Conditioning System

Oil entrainment is a complex function of refrigerant and oil velocities, densities, mutual solubility, and miscibility. In vapor compression system pipe flows as described in Figure 2, the core region is usually the refrigerant-rich phase while the liquid film at the pipe wall is the oil-rich phase. Figure 2 depicts a force balance on the vapor refrigerant core region of an air-conditioning system. It is assumed that oil film thickness δ uniformly covers the inside tube wall while the gas flows through the core. When the force balance applied to the gas core is drawn,

$$\frac{dp}{dz} + \rho_g g_z + \frac{\tau_i \pi D_c}{A_c} = 0$$

where, D_c is the outer vapor core diameter and A_c is the vapor core cross sectional area. The void fraction α is defined as follows:

$$\alpha = \frac{A_c}{A} = \left(\frac{D - 2\delta}{D}\right)^2 \tag{11}$$

The previous force balance equation can be written as:

$$\frac{dp}{dz} = -\frac{4\tau_i}{D - 2\delta} - \rho_g g_z \tag{12}$$

Consequently, the pressure gradient of the core is a function of oil film thickness δ (or the void fraction α) and interfacial shear stress τ_i .

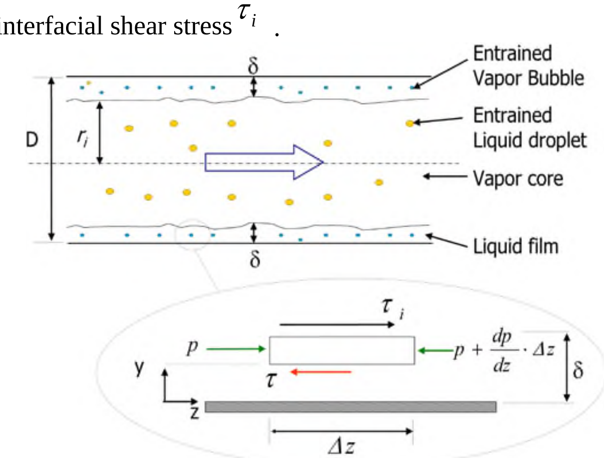

Figure 2 Oil entrainment simple models in an air-conditioning system.

The refrigerant core mass flux acts on the liquid film by transmitting axial momentum outward in the radial direction. The interfacial shear stress exerted by the gas core on the liquid film is given by

$$\tau_i = \frac{1}{2} f_i \rho_c \left(u_c - u_f\right)^2 \quad (13)$$

In case of gas-liquid two-phase flow, the velocity of the gas core is much larger than the oil film surface velocity. Hence, the interfacial shear stress was approximated as

$$\tau_i = \frac{1}{2} f_i \rho_c u_c^2 \quad (14)$$

The interfacial friction factor f_i in equation (14) is one of the most important parameter in estimating oil distribution and hence retention. For example, Wallis (1969) proposed the following correlation valid for annular two-phase flow with thin liquid film in smooth pipes:

$$f_i = 0.005\left(1 + 300\frac{\delta}{D}\right) \quad (15)$$

Similarly, Newton and others (1999) investigated two-phase flows of air with different liquids: water, kerosene, and Propar-22, which is light machine oil and proposed two different friction factors depending on interface roughness:

$$f_i = 6.5\times10^{-4}.\mathrm{Re}_g^{0.3} \quad \text{for a smooth interface}$$

$$f_i = 0.003.\mathrm{Re}_g^{0.2} \quad \text{for a wavy interface} \quad (16)$$

Refrigerant Side				Air Side				
Ref.	R22	Evap. Out	Super	Indoor			Outdoor	
MFR [g/s]	Charge [kg]	Pressure [kPa]	Heat [°C]	T [°C]	RH [%]	AFR [m³/h]	T [°C]	RH [%]
42	6.3	530	24	26.7	50	1800	27.8	56
46	6.1	561	18	24.5	50	1470	27.8	56
51	6.3	612	16	26.7	50	1800	27.8	56
53	5.5	640	16	28.5	50	2100	27.8	56
59	6.3	658	0	26.7	50	1800	27.8	56

Table 1 Operating conditions in the Suction line and Evaporator of an air-conditioning system in eleme petrochemical ltd

4) Analytical Model For Gas-Liquid Annular Flow In The Suction Line

The following assumptions simplified the problem of investigating oil retention in the suction line of a vapor compression system: this includes,

- Axisymmetric flow.
- Steady state, adiabatic, and fully developed flow.
- Oil droplets entrainment is neglected.
- The proprieties of the oil and liquid refrigerant mixtures are uniform along the liquid film thickness. The oil film has some refrigerant dissolved in it and therefore the oil properties are not the same as those of the pure oil, properties of oil with refrigerant solution were estimated based on the solubility data from the manufacturers as well as the refrigerant and oil properties. The oil retention volume ratio in the suction line was calculated by the integration of oil film thickness with respect to the cross sectional area as well as the entire length of the suction line tube, as shown in equation (17)

$$\text{Oil Retention Volume Ratio } \overline{\overline{\delta}}\, L.A\left[1-\left(1-\frac{}{R}\right)^2\right].\frac{1}{V_{ini}} \quad (17)$$

where L is total suction line length [m]; A is tube inner cross sectional area [m^2]; R is inner tube radius [m]; δ is oil film thickness [m]; V_{ini} is oil volume initially charged into the compressor [m^3]. The properties of fluids change from section to section along the pipe, and the suction line consists of horizontal as well as vertical sections. The oil film thickness δ in the suction line is a function of refrigerant pressure and temperature of the system which are read from the process chart. Therefore, the problem of estimating oil retention in the suction line reduced to the problem of finding the oil film thickness δ, in the pipe at given refrigerant pressures and temperatures.

III. Results and Discussion

Oil retention was calculated in the evaporator, condenser, liquid line, and suction line as summarized in Figure 3. The liquid line was quite simple to model and oil retention was computed to be 146.3 ml at oil mass fraction of 5 wt% representing 9.8 % of oil retained. Also in the liquid line, the model assumed homogeneous mixture with average bulk properties uniformly distributed in the entire tube. The problem of computing the oil retention in the evaporator and condenser was not trivial however, the mechanisms of evaporation and condensation of refrigerant-oil mixtures is quite different from that of pure refrigerants. Hence in the evaporator, pure liquid refrigerant proprieties were substituted by oil and liquid refrigerant mixture proprieties. Since oil's vapor pressure is negligible compared to refrigerants, lubricants was assumed to have no effect on the mixture vapor proprieties and thus computed as pure refrigerant vapor proprieties with the lowest oil retention of about 46.8 ml or 3.8 % at oil mass fraction of 5 wt%. In the condenser, correlations were used to predict the pressure drop; but the heat transfer correlation during condensation process was different from that used to estimate the heat transfer coefficient in the two-phase region during evaporation.

However in the evaporator, the maximum oil retained is always at the end part of the heat exchanger, while in the condenser a local maximum of oil retention was observed in between inlet and outlet tubes. Results as presented in Figure 3 agreed with the experiment performed at the Center for Environmental Energy Engineering at the University of Maryland by Cremaschi (2004) with an estimated deviation of ± 2.5 ml in the suction line, ± 2.1 ml in the evaporator, ± 0.8 ml in the liquid line and ± 1.2 ml in the condenser. Figure 3 depicts the comparison of oil retention in the suction line, evaporator, liquid line and the condenser of an air-conditioning system. From the graph, oil retention increases with the increase in oil mass fraction which is the only independent variable. At maximum oil mass fraction of 5 wt%, the oil retained in the condenser is 413 ml or 33 % hence local maximum of oil retention occurred at the inlet tubes. As the refrigerant-oil mixture entered the condenser, it cooled down and the oil retention increased as exemplified in Figure 3. The evaporator has the lowest amount of oil retained amounting to about 70 % reduction when compared with the condenser. The most sensitive component of the air conditioning system is the suction line since it contains both the vertical and horizontal lines with high refrigerant mass flux. Higher refrigerant mass flux reduces the amount of oil retained in the suction line. Refrigerant mass flux is the product of refrigerant density and velocity.

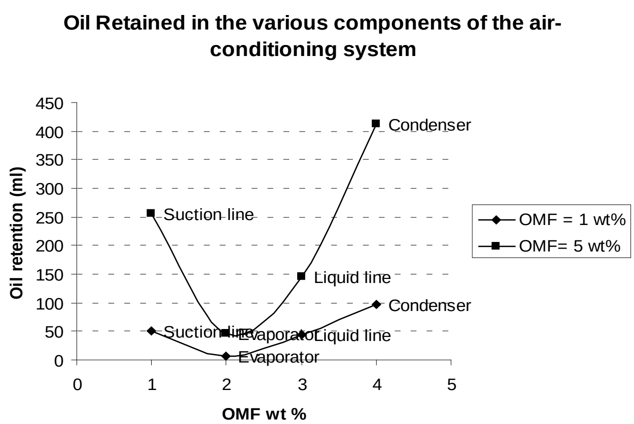

Figure 3 Oil Retention in various components of the air-conditioning system using Refrigerant R22/Mineral oil

The latter directly affects the shear stress gradient inside the flow. This refers to the vertical upward suction line of refrigerant R22 and mineral oil mixture. The mass fluxes were G = 145 kg/($m^2 s$) and G = 207 kg/($m^2 s$) for oil mass fraction of 1 wt% and 5 wt% respectively and the corresponding Reynolds numbers were 20 $\times 10^4$ and 25 $\times 10^4$. At G = 145 kg/($m^2 s$), refrigerant velocity changed from 6.8 m/s to 8.4 m/s while at G = 207 kg/($m^2 s$), the refrigerant velocity changed from 10.0 m/s to 12.1m/s.

By comparing the two series at G = 207 kg/($m^2 s$), it seems that the highest refrigerant velocity of 12.1 m/s, led to lower oil retention when refrigerant velocity was equal to 10.0 m/s. At G = 145 kg/($m^2 s$), the difference on oil retention was less than 7 % if the refrigerant velocity increased from 6.8 m/s to 8.4 m/s. The general trend in the fore-going analysis as described in Figure 4 seemed to suggest that if vapor velocity increases, oil retention will decrease slightly.

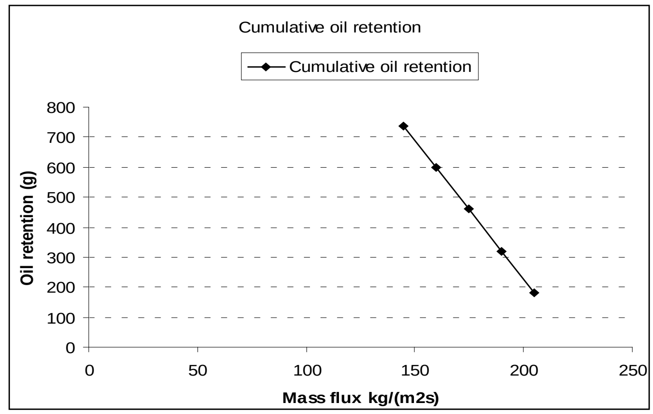

Figure 4 Effect of Refrigerant Mass flux on Oil retention in an air-conditioning system

IV. CONCLUSION

The objective of this paper was to investigate the oil retention characteristics of refrigerant and oil mixtures in various components of the vapor compression systems. Computational method and correlations were used with the input data gotten from a 10KW rated compressor with five passes of inlet and outlet cross flow. For the suction line, where the flow type is annular flow, interfacial friction factor correlations were developed and used. In the evaporator and condenser, Premoli's and Chisholm's correlated void fraction models were used. In the liquid line, the homogeneous model predicted the oil retention quite satisfactorily. These research objectives were accomplished with the conclusions summarized below. Oil retention is proportional and very sensitive to the oil mass fraction (OMF) of the refrigerant-oil mixture in each component of the system and the suction line is the most critical component for oil retention due to high liquid film viscosity and low inertia force from the vapor refrigerant core, which is the driving force for oil transport hence, higher refrigerant mass flux reduced the amount of oil retained in the suction line. A reduction of pipe diameter promotes oil transport but also increased the frictional pressure drops along the pipe. Thus, the suction pipe diameter should be a compromising value to minimize the pressure drop and to reduce oil retention. In the evaporator, oil retention volume reached a maximum value at the end part of the heat exchanger since the local liquid film viscosity is higher.

The liquid viscosity depends on the mixture temperature and local oil mass fraction in the liquid film furthermore, in the condenser, a local maximum of oil retention occurred at the inlet tubes. As the refrigerant-oil mixture entered the condenser, it cooled down and the oil retention increased. The drop of the mixture temperature increased the liquid film viscosity until the local oil mass fraction reached about 65 wt. %. Then, the dissolved refrigerant decreased the liquid film viscosity and oil retention reduced. Near the liquid phase region, the void fraction decreased sharply with mixture quality and oil retention increasing again. It eventually reached a maximum value in the sub-cooled region of the condenser.

V. Acknowledgement

I sincerely wish to express my profound gratitude and appreciation to OKO, C.O.C (PhD) for his tireless and unquantifiable advice. I believe that in the future, that advice will be as precious as it is now, if not more so.

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A Novel Device to Measure Instantaneous Swept Volume of Internal Combustion Engines

MURUGAN. R.

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Abstract- **In this paper a new method of measuring instantaneous swept volume of internal combustion engine is discussed. The instantaneous volume of reciprocating IC engines change at a predictable rate as a function of crank angle. In this work a new novel device is used for measuring the instantaneous swept volume of SI engine. The volume measurement system consists of a cam mounted on the crankshaft and a suitable device to measure the cam profile. The profile of the cam was designed such that the radius of the cam is a measure of the instantaneous cylinder volume of the engine. To measure the instantaneous swept volume, the instantaneous radius of the cam is required. For this purpose, a non-contact laser displacement sensor is used. The Laser Displacement Sensor (LDS) was positioned firmly in such a way that laser beam continuously traces the profile of the rotating cam. The Laser displacement sensor measures precisely the distance between the cam surface and itself and converts this distance into an equivalent voltage. The cam profile was made according to the kinematic relationship between crank radius, connecting rod and crank angle for the test engine. The cam was made of Acrylic because it is strong, light and easy to cut on a CNC milling machine. The cam surface exposed to the Laser spot has to be made opaque to reflect the laser beam. To improve the data acquisition accuracy balancing of the cam was done by shifting the centroid of the cam near to its rotating centre. It was done by removal of mass on the heavier side and addition of mass on the lighter side. The mass removal was performed by drilling holes taking care that the strength of the cam is not sacrificed. An experimental setup is created to validate the measurements obtained by this method by comparing with measurements performed with a crank angle encoder.**

Keywords: Instantaneous swept volume, cam, laser displacement sensor, balancing.

I. INTRODUCTION

As the objectives of improvement in efficiency and decreased emissions of IC Engines are pursued, there is an increasing need for direct measurement of engine cylinder data. Measurement of pressure and volume is essential to study the various processes taking place in an engine during its operation. This would provide us important information about the engine performance that could be utilized for improving the specific problems encountered during the operation and efficiency in general. High-speed engines require an accurate system for acquiring the Pressure-Volume trace. Many of the present systems use the crank angle encoder for obtaining the instantaneous cylinder volume. Lancaster et al. (1) presented the methods in detail for acquiring IC engine cylinder pressure data. The encoder employed generate electrical signal, which is converted to the volume by inbuilt electronic units. The crank angle measuring devices are delicate equipment and need precise alignment with the Top Dead Center (TDC) of the cylinder. The fitting of the crank angle-measuring device to the reciprocating IC engine often requires a fixture or modification of the existing engine. Hohenberg et al. (2) performed heat release analysis with an improved measurement and evaluation system. The combustion pressure diagram was recorded and processed by means of a low speed computer. It was well known that the motion of the piston is repetitive in a reciprocating machine. Hence, the instantaneous volume of an IC engine changes at a predictable rate as a function of crank angle. Accordingly Pannirselvam et al. (3) used a novel device for measuring the instantaneous swept volume of reciprocating air compressors. The Volume measurement system consisted of a cam and a suitable device to measure the cam profile. The profile of the cam was designed such that the radius of the cam was a measure of the instantaneous in-cylinder volume of the engine.

About-Professor, Department of Mechanical Engineering, M.I.E.T. Engineering College Tiruchirappalli-620 007, Tamil Nadu, India
E-mail: murugan3212000@yahoo.com

II. EXPERIMENTAL FACILITY

In this research, measurement of the instantaneous cylinder swept volume of the chosen SI engine was done using a cam and a Laser Displacement Sensor (LDS) following the approach given by Pannirselvam et al. (3). The cam was fitted to the crankshaft of the IC engine and a laser displacement sensor was used to measure the profile of the cam, which produces a voltage signal proportional to the distance between the cam and the sensor. This voltage was thus, a measure of the instantaneous volume of the cylinder. The cam can be made of any material, the only constraint being the strength to withstand the high centrifugal forces developed during the engine operation. The single cylinder 4 Stroke SI engine was connected to an AC alternater through a torque transducer (Staiger Mohilo 0160DM "L"). The torque transducer measures the torque and speed. The loading device employed was a set of incandescent lamps of 200 Watts each connected through switches to the alternator. The cam was fitted in between the torsionally rigid coupling of the torque transducer and the crankshaft the engine as shown in Fig.1. The maximum radial position of the cam with minimum distance between sensor and cam surface mounted on the engine output shaft was fixed such that it represent volume measurement corresponding to TDC of the engine.

Fig.1. Engine Test Facility with Cam Arrangement

1) Laser Displacement Sensor

To measure the instantaneous swept volume, the instantaneous radius of the cam is required. For this purpose, a non-contact laser displacement sensor is used. The Laser Displacement Sensor (LDS) was positioned firmly in such a way that laser beam continuously traces the profile of the rotating cam. The Laser displacement sensor senses the distance between the cam surface and itself and converts this distance into a proportional voltage. The LDS of Model: LD 1605, Type 100 was used with a Laser Frequency Response of 40 KHz.

2) Construction of the Cam

The cam profile was made according to the relationship given by

$$r = r_b + K * V(\theta) \qquad \text{(I)}$$

Here, K was chosen such that the cam radius was within the measuring range of the displacement sensor. The base radius r_b , was given to avoid sharp changes in the cam profile and also constrained by the space available for mounting of the cam. Thus it was the base radius that restricts the size of the cam. The cam was made of Acrylic because it was strong, light and easy to cut on a CNC milling machine. The cam surface exposed to the Laser spot has to be made opaque to reflect the laser beam.

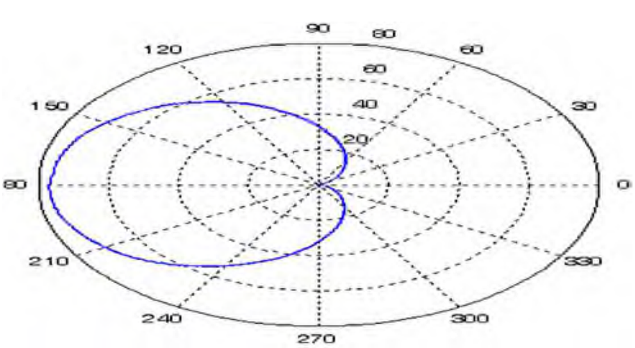


Fig. 2. Cam profile without base radius

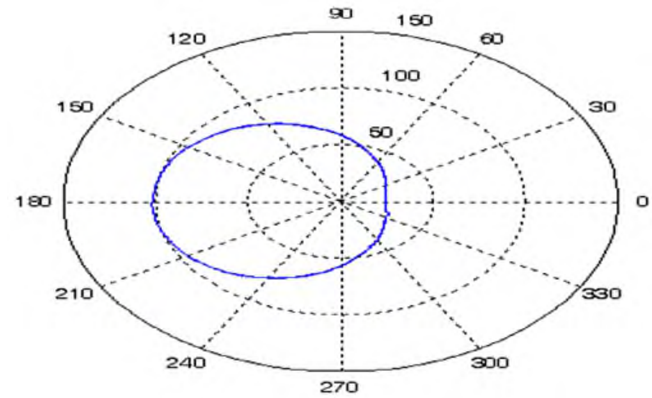


Fig 3. Cam profile with base radius

3) Balancing of the Cam

The cam as shown in Fig.4. was asymmetrical about the centre of rotation. Initially it was fitted on the crankshaft of the test engine, which rotates at speeds of the order of 3200rpm. If left unbalanced; it causes vibrations in the system, which may introduce considerable errors in the measurements. Further, the high centrifugal forces on the cam may even lead to its failure. Hence the cam has to be balanced dynamically to avoid these problems. In this study, partial balancing of the cam was done by shifting the centroid of the cam near to its rotating centre. Because of the geometric constraints imposed by the engine-torque transducer- generator assembly the size of the cam could not be increased to achieve perfect balancing. However the cam was modified to minimize the unbalanced force to fullest extent. Hence some residual centrifugal force, within the safe limits, still exists.

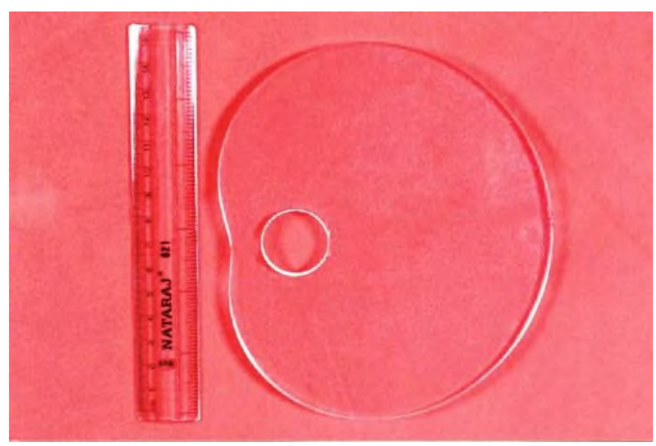


Fig. 4 Unbalanced cam

The partial balancing was done by removal of mass on the wider side of the cam and addition of mass on the opposite side. The mass was removed by drilling sufficiently large holes to remove considerable mass but at the same time without weakening the cam. On the opposite side (thinner side with reference to the shaft axis) discs made of mild steel were fixed to the cam with screws and a strong adhesive as shown in Fig. 5. Mild steel was chosen because of its high density and therefore discs of lesser thickness could be employed for the purpose. Only about 25mm wide gap was available for the cam to be mounted on the crankshaft between the engine and the coupling so the thickness of the cam was also an important practical constraint. In the present study, the maximum local shear stress was calculated and found to be within safe limits.

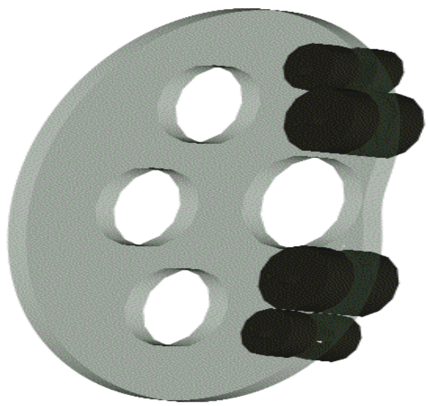


Fig. 5 Partially Balanced cam

The comparison of the balanced and the unbalanced cam is summarized in theTable 1.0.

Table 1.0: Comparison of Unbalanced and Balanced Cams

Feature	Unbalanced Cam	Partially Balanced cam
Material	Acrylic	Acrylic cam and MS discs
Mass	74.7gm	239.4 gm
Mass Centroid (X, Y, Z)(mm)	-33.2, 0, 0	-2.5,0,0
Resultant Centrifugal Force (N) (at 3500 rpm)	333.3	80.3
Max. Local Centrifugal Force (N) (at 3500 rpm)	360.6	206.8
Max Local Shear Stress (at 3500 rpm)	2.48MPa	1.37MPa
Shear Strength of the material	35MPa	35Mpa

III. EXPERIMENTAL PROCEDURE

The cam, LDS and the DSO were arranged as shown in the Fig.1. The cam was mounted carefully on the engine crankshaft and the LDS was focused onto the cam surface. As the lamp load remained constant under steady state conditions, the instantaneous volume $V(\theta)$ calculated from the time data given by the Digital storage oscilloscope along with speed recorded by the torque transducer was considered as the base value fore this study. The time is converted to crank angle using the engine speed indicated by the torque transducer. By employing the kinematic relation (equation.2) of piston - connecting rod - crank linkage the instantaneous volume were calculated.

$$V_i(\theta) = \frac{\pi}{4} D^2 \left(l + aCos\theta - \sqrt{l^2 - a^2 Sin^2\theta} \right) \quad (2)$$

$$V(\theta) = V_i(\theta) + V_c \quad (3)$$

Where, V_c = Clearance Volume.

$V_i(\theta)$ = Instantaneous displacement Volume.

D = Cylinder Bore.

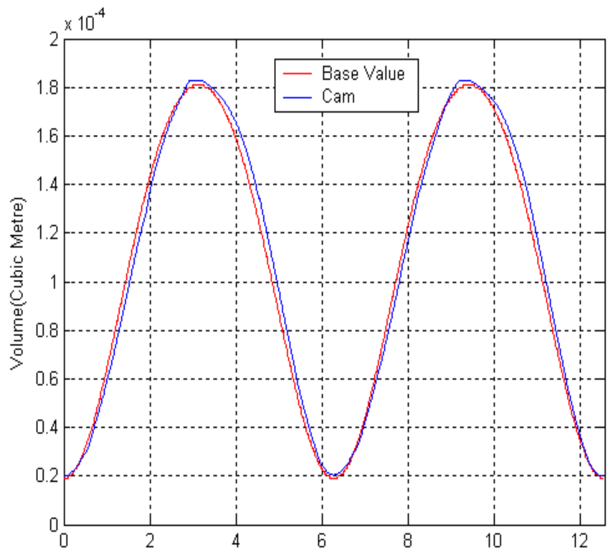
l = Length of Connecting Rod.

a = Crank Radius.

During the experiment, the reflected light from the cam surface sensed by the LDS was passed through a signal amplifier and converted to voltage. This voltage was recorded in a digital storage oscilloscope. The raw data acquired by the oscilloscope was averaged over 64 cycles to minimize cycle-to-cycle variations during the engine operation. The range of the Voltage obtained is equated to the cam displacement. For the cam used in the present work the base radius was maintained as 25mm and the cam displacement (range) is 77mm. The Instantaneous volume in the engine cylinder was calculated using Equation (1) with the voltage obtained from the Laser Displacement Sensor based on engine geometry and the cam base circle. The value of K for the cam used is 0.472 To verify the instantaneous volume measurement using cam with standard procedure a crank angle encoder is fitted on the other side of the crankshaft. The crank angle encoder provides an electrical pulse for every degree of crank angle rotation and a single TDC reference pulse for every revolution. The shaft of the encoder is fitted to the crank shaft of the engine. To match the TDC position of the piston and TDC pulse of the encoder, the following procedure is adopted. The piston is positioned at TDC within +1 µm accuracy using an electronic comparator. Then the body of the encoder is turned with reference to its shaft till corresponding TDC slot of the encoder matches the photodiode position and thus produces an electrical pulse.

IV. RESULT AND DISCUSSION

In the present study, comparison was made between the volume data acquired using the LDS equation (1) and the base volume data calculated using the engine kinematic relationship Equation (2). The base volume is determined using the engine bore, stroke and connecting rod length. The swept volume measurements indicated by kinematic relationship equation (2) are compared with crank angle encoder measurements. Fig.6 shows the cylinder volume–time trace obtained for both cases. The engine was operated at 3200 rpm and the lamp load was steadily maintained as 200 W. As seen in the Fig.6 the volumes measured using the cam agrees well with the base values during most part of the engine cycle. However, close to the TDC some differences were observed between these two quantities. In the present case the maximum error in volume measurements using LDS is 2cc or approximately 3% of stroke volume. As seen in Fig.7 instantaneous volume measured by crank angle encoder agrees well with base values during most part of the engine cycle. In the present case the maximum error in volume measurements using crank angle encoder is 1cc or approximately 1%. Hence the additional maximum error introduced when the cam is employed for measurement of stroke volume is about 3%.



Crank Angle (Rad)

Fig. 6 Comparison of Volume obtained by the Cam with the Base Value.

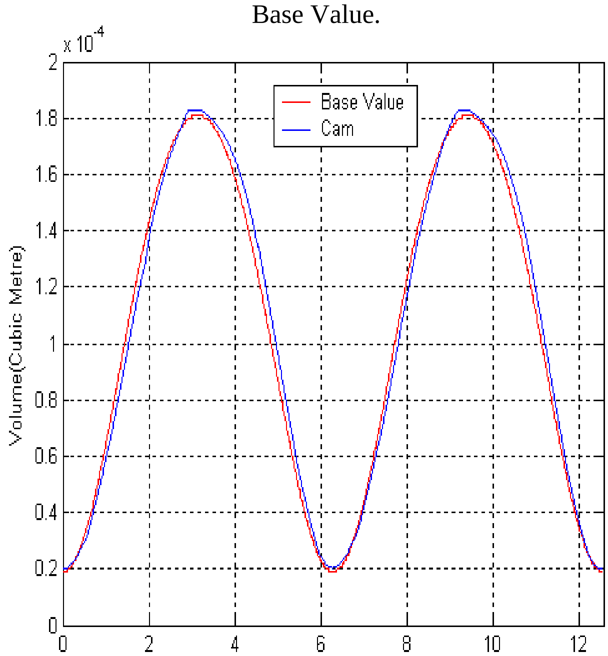
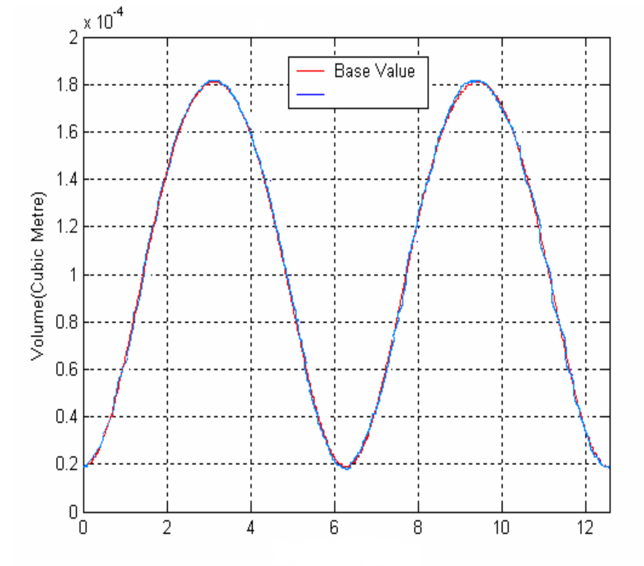


Fig. 6(a) Error Percentage in Volume vs Crank Angle.



Crank angle (Rad)

Fig.7 Comparison of Volume obtained by the Encoder with the Base Value

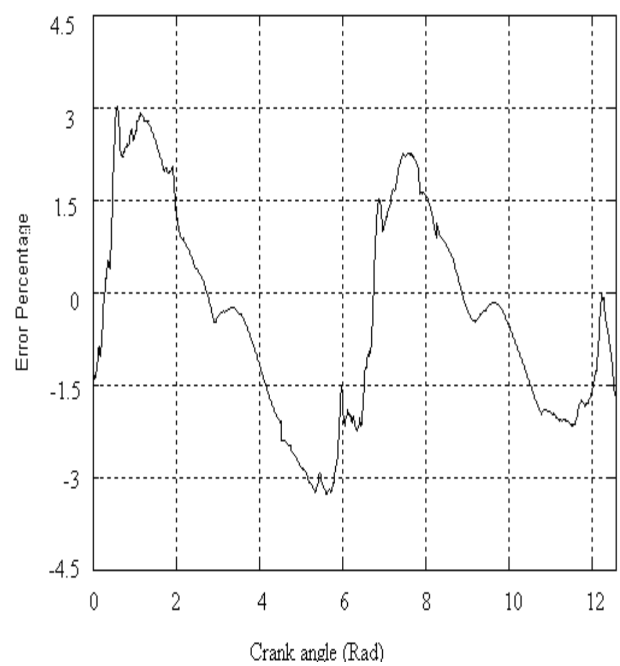


Fig.(7a) Error Percentage in Volume vs Crank Angle

V. CONCLUSION

In this work, a cam has been specially made and employing a Laser Displacement Sensor, the measurements were made to determine the instantaneous volume. The cam (along with the LDS) is a potential device that can replace the crank angle encoder. The cam could also be made an integral part of the engine by locating it along with the fly wheel with TDC position matched for both cam and engine, so that periodically engine combustion related parameters could be measured and calculated. This could go a long way in improving the understanding of engine indicated parameters at the field level and effect necessary maintenance activities to maintain the engine in prime operating conditions. For the test engine the errors in the calculated volumes are 1 % (min) and 3 % (max).

VI. NOMENCLATURE

TDC	Top Dead Center
CA	Crank Angle
D	Cylinder Bore
a	Crank Radius
l	Length of the connecting rod
V_c	Clearance volume
θ	Crank angle
$V_i(\theta)$	Instantaneous displacement volume
LDS	Laser Displacement Sensor
DSO	Digital Storage Oscilloscope

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Design of Compact Rectangular Slot Micro strip Antenna for Mobile Communication

Vinod K. Singh[1], Zakir Ali[2], Dr Shahanaz Ayub [3]

GJRE -F Classification (FOR) 090609

***Abstract*-This paper presents novel coaxial feed compact rectangular slot microstrip antenna for linear polarization. A narrow C shaped microstrip antenna is fed at the corner using a coaxial feed to obtain a LP operation. The compactness of the antenna is easily obtained by inserting a slot. Wide LP radiation is achieved simply by making the C-shaped slot symmetrical. The simple rectangular and compact C shaped microstrip antenna is simulated with IE3D and MATLAB and their corresponding result is compared.**

Keywords-Rectangular, C shaped microstrip antenna.

I. INTRODUCTION

Microstrip patch antennas (MPAs) have attracted widespread interest due to their small size, light weight, low profile and low cost as well as to the fact that they are simple to manufacture, suited to planar and non planar surfaces, mechanically robust, easily integrated with circuits, allow multifrequency operation to be achieved [1] Linearly polarized microstrip antennas (LPMAs) are widely used in many wireless communication applications. The classification of the LPMAs is based upon the single-feed or dual-feed types. Single-feed wideband LPMAs are currently receiving much attention. Recently in [2], another design was proposed. In this design, LP operation was accomplished by using the U-slot of unequal lengths for a square microstrip antenna using a coaxial feed. The symmetrical U-slot cut microstrip antenna structure can generate two orthogonal modes for LP radiation; therefore no extra stubs, notches or chamfering at corners of the rectangular patch are necessary. The patch radiator was fabricated from the copper sheet and mounted on a duroid substrate. However, the patch radiator on the duroid substrate is mechanically unstable. Moreover, the coaxial feed in this antenna makes it unsuitable for a low-cost antenna array design. A LPMA with combining slots and patch has been proposed for dual-band operation [3]. They had used a power divider to excite the four slots for LP operation. In this paper, we propose a new compact, coaxial feed, linear polarized, C-shaped microstrip antenna. The antenna consists of a C-shaped patch radiator and a coaxial feeding structure. By cutting a slot in the patch radiator, the excited surface current of the fundamental TM_{10} mode on the patch is significantly lengthened to make the fundamental resonance frequency lower. The C-shaped dimensions are optimized to radiate wide linearly polarized waves. The results are compared with the results obtained by EM simulator software, IE3D.

II. ANALYSIS OF PROPOSED ANTENNA

In the first step we had analyzed the rectangular microstrip patch antenna by most popular method transmission line model and then analysed proposed antenna as same model "equation.1-11". The side view of rectangular antenna geometry is shown in "Fig.1", the patch is feed by coaxial probe. The feed position is calculated by using by modal expansion cavity model theory [4] for a 50Ω co-axial cable. The shaped has been cut along the patch width in such a way that it lies at a symmetrical distance from both length edges of the path. According to the cavity modal theory [5], a normal microstrip patch antenna can be modeled as parallel RLC circuit. The current flows from the feeding point to the top and bottom edges of the patch. Values of L and C are determined by the currents path length: The patch width, effective dielectric constant, the length extension and also patch length are given by

$$W = \frac{c}{2f\sqrt{\varepsilon_r}} \tag{1}$$

where **c** is the velocity of light, ε_r is the dielectric constant of substrate, f is the antenna working frequency, W is the patch nonresonant width, and the effective dielectric constant is ε_{eff} given as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r+1)}{2}\left[1+10\frac{H}{W}\right]^{-\frac{1}{2}} \tag{2}$$

The extension length Δ is calculates as,

$$\frac{\Delta}{H} = \frac{(\varepsilon_{eff}+0.300)\left(\frac{W}{H}+0.262\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{H}+0.813\right)} \tag{3}$$

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta \tag{4}$$

About[1]- Assistant Professor,E.C.E, C.S.E., Jhansi U.P. INDIA. singhvinod34@gmail.com
About[2]- Assistant Professor,E.C.E, I.E.T.,B.U. Jhansi U.P. INDIA. zakirali008@rediffmail.com
About[3]- Reader, B.I.E.T., Jhansi U.P. INDIA. shahanaz_ayub@rediffmail.com

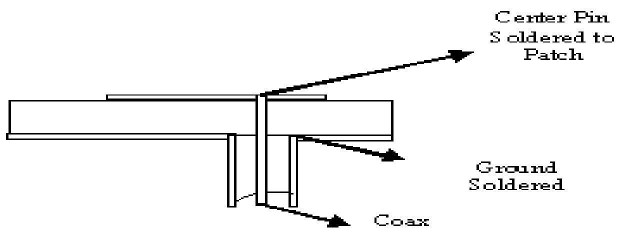

Figure 1. Side view of rectangular microstrip antenna

III. PROPOSED ANTENNA GEOMETRY AND DESIGN

The cross-section of the proposed coaxial feed, linearly polarized,C-shaped microstrip antenna with dielectric cover is shown in "Fig. 2". W is the width and L is the length and h is the thickness of rectangular microstrip patch antenna. The rectangular Microstrip patch with a C-shaped has a side length l_s and width w_s and thickness is s of the proposed antenna. The co-axial feed is located at the corner of the C-shaped rectangular microstrip antenna. A parametric analysis is conducted to optimize the proposed antenna for good LP operation. Now we have taken small value of substrate thickness is 1.6 mm then after calculation we got width and length of the patch are 62.02 and 48.40 at 1.5 GHz operating frequency of proposed antenna.

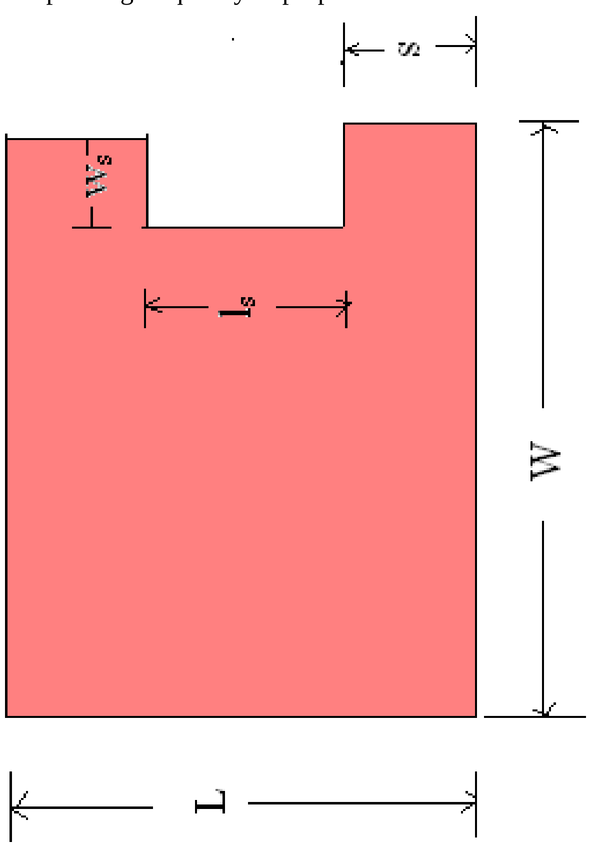

Figure 2. Geometry of c shaped rectangular microstrip antenna

IV. ANTENNA FABRICATION AND RESULTS

The C shaped microstrip patch antenna designed on EM simulator software IE3D and after simulation reflection coefficient S_{11} is obtained. It is mounted on a RT duroid substrate of dielectric constant 4.2. We have operating frequency at 1.5 GHz but after simulation resonance frequency shifted at 1.44GHz which is shown in "Fig.4,5&6".

Figure 3.. Geometry of c shaped of proposed antenna on IE3D

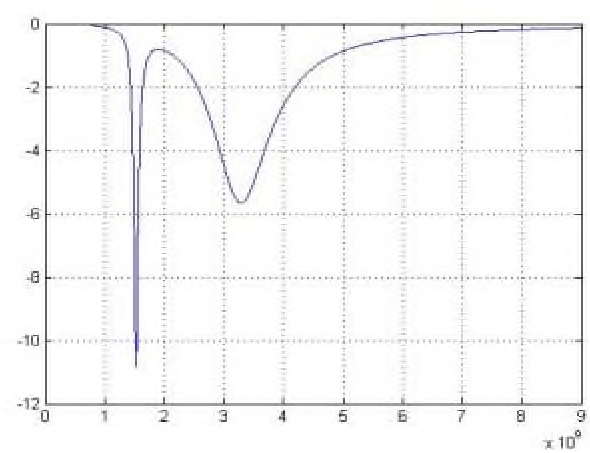

Figure 4. Return loss Vs frequency plot of c shaped on MATLAB.

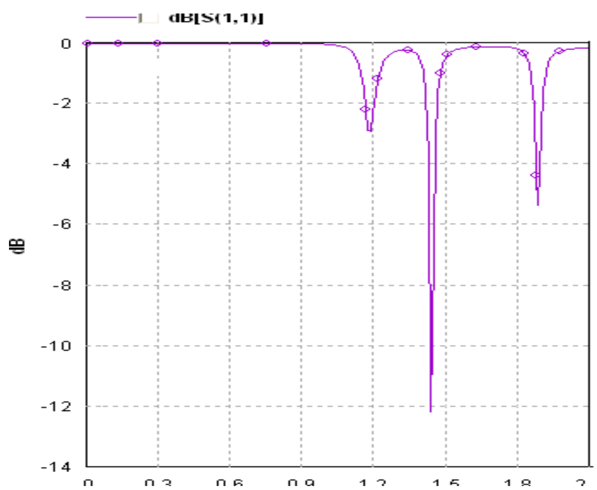

Figure 6. Return lossVs frequency plot of c-shaped on IE3D.

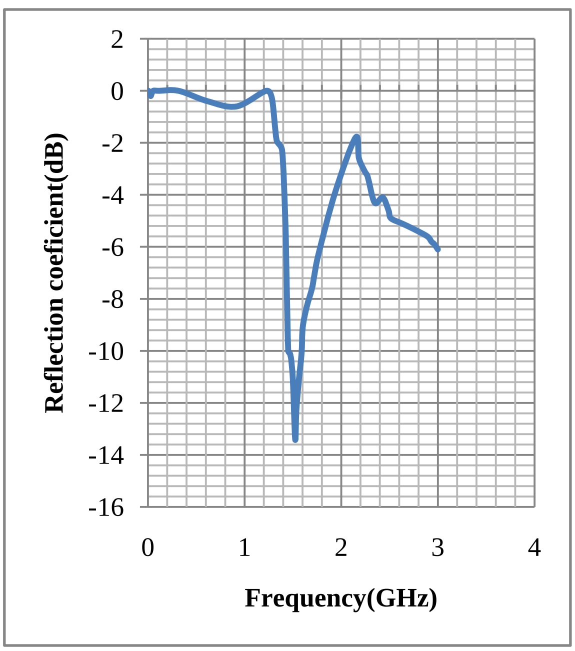

Figure 7. Experimental return loss Vs frequency plot of c-shaped

V. CONCLUSIONS

A compact, coaxial feed, linear polarized, compact rectangular microstrip antenna has been designed, and simulated using IE3d and matlab. After comparison the proposed antenna gives better results as compared normal rectangular microstrip antenna. The proposed shaped microstrip antenna is suitable for implementing it in mobile communication compact arrays, thus achieving even higher gain and good LP over a large bandwidth. The performances of antenna is investigated for the application in wireless local area network and mobile communication using IE3Dand matlab software and the computed results are verified by measurement. Results show that the antennas have moderate gain and may be used as small, compact antennas mobile communication.

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Modeling and Construction of Bio-Diesel processor

R.Murali Manohar[1], M.Prabhahar[2], Dr.S.Sendil velan[3]

GJRE -A Classification (FOR) 091399

***Abstract*- Bio-Diesel the word itself defines almost all the features of the Bio-Diesel literary. In the Era of this Global warming where the people are making their living more and more comfortable and they are deteriorating the environment also. The uses of the automobiles with the conventional source of fuel leads to the production of the toxic gaseous substances like carbon monoxide, carbon dioxide, oxides of nitrogen, oxide of sulphur, hydro-carbons etc. The limitation comes with the rise in the price of the fuel as well as the produce of the green house gases as the exhaust gas. In the present study, a new method has been employed to produce Bio-Diesel. The production of the Bio-Diesel is done by using Bio-Diesel processor. It requires the used vegetable oil, methanol and the lye with the accurate proportionate. The objective of this paper is modeling and construction of Bio-Diesel processor and produces the Bio-Diesel by using the Bio-Diesel processor.**

Keywords: Bio-Diesel, Vegetable oil, Bio-Diesel Processor, modeling, construction.

I. INTRODUCTION

With the exhaustion of fossil fuel in the near future, the need to find a renewable energy sources becomes more and more important all over the world. Bio-diesel originating from vegetable oils and animal fats has characteristics similar to petroleum-derived diesel oil and has received considerable attention in recent years as a substitute fuel for diesel engines [Gui et al]. Currently, about 84% the world bio-diesel production is met by rapeseed oil. The remaining portion is from sunflower oil (13%), palm oil (1%), soybean oil, and others (2%) [Themes P].The major hurdle of widespread bio-diesel industrialization is the high cost of feedstock oil [. Kulkarni M.G et al]. One way of reducing the cost of biodiesel production is to employ waste oil as feedstock, such as waste cooking oil, oil deodorizer distillates, stale non-edible oils, and so on[Canakci M.]. The technologies for converting waste oil to bio-diesel are well established, which include alkali [Hass M.J et al],acid[Canakci M et al], or no catalytic reaction in supercriticamethanol [Kusdiana D.et al]. Due to the presence of considerable free fatty acids (FFAs) in such feedstock, the alkali-catalyzed process is not recommended because a large amount of soap byproduct is formed during reaction, which creates a serious problem of product separation and ultimately lows the yield substantially [Canakci M et al]. Bio-diesel can be Produced from non-edible oils[Murugesan A.,et al] The bio-diesel yield can achieve 85.6 – 97.1 % under the following operating conditions: used vegetable oil to methanol molar ratio 1:9, reaction temperature 60°C, and reaction time 4 hours. The effects of several crucial variables in a packed column reactor were also studied, such as reaction temperature from 40°C to 80°C, molar ratio of oil/methanol from 1:3 to 1:15, and reaction time from 2 to 6 h. [Lui yun et al]. The impurities, excess methanol, and glycerin all eventually settle to the bottom of mixing tank after the batch is properly mixed under certain condition like constant. Before the production of Bio-Diesel, the Bio-diesel processor is to be designed and constructed. This paper investigates the modeling and construction of the Bio-diesel processor and the properties of produced Bio-Diesel by using Bio-Diesel processor.

About[1]-Research scholar,St.Peters Universty,Avadi , Assistant Professor,Aarupadai veedu Institute of Technology,Paiyanoor, INDIA .
E-Mail:muralimanohar04@gmail.com,Tel+919841935219.
About[1]-Research scholar,St.Peters Universty,Avadi , Assistant Professor,Aarupadai veedu Institute of Technology,Paiyanoor, INDIA .
E-Mail: mprabhahar@gmail.com, Tel +91 9444310236.
About[1]-Principal, Aksheyaa college of Engineering, Chennai., INDIA
E-mail: sendilvelan63@yahoo.com, Tel +91 9710925886

II. EQUIPMENT AND PROCEDURE

1) Bio-Diesel processor

The fig1 shows the schematic diagram of Bio-Diesel processor (BDP) has a reservoir tank which is having the 30 liters capacity. Put 15 Liters of used vegetable oil that has been strained into the 30 Liter drum set up on Frame 1. Hook up the mixer unit in Frame 2 which has the mixing tank with stirrer.. Turn on heater which is under the reservoir tank at Frame 1 and get the oil heated up to 135̊F. The Digital thermometer is used to check the temperature. Heating the oil will melt any partially hydrogenated vegetable oil in the batch and will allow for a more thorough chemical reaction to take place. When the batch of oil, is heated to the required temperature then turn off the heater and drain the Used Vegetable Oil from 30 Liter drum Reservoir Tank after opening the check valve. The UVO will be gravity feed down to the Methanol, Lye and UVO Mixing Tank. Then the filtered and the heated Used Vegetable oil are mixed with the Methanol and Lye (Sodium Hydroxide) in the mixing tank. The speed of the motor fitted in the mixing tank can be controlled with the help of the regulator. The stirring of the mixture need vigorously fast so that the chemical reaction should take place with effect.

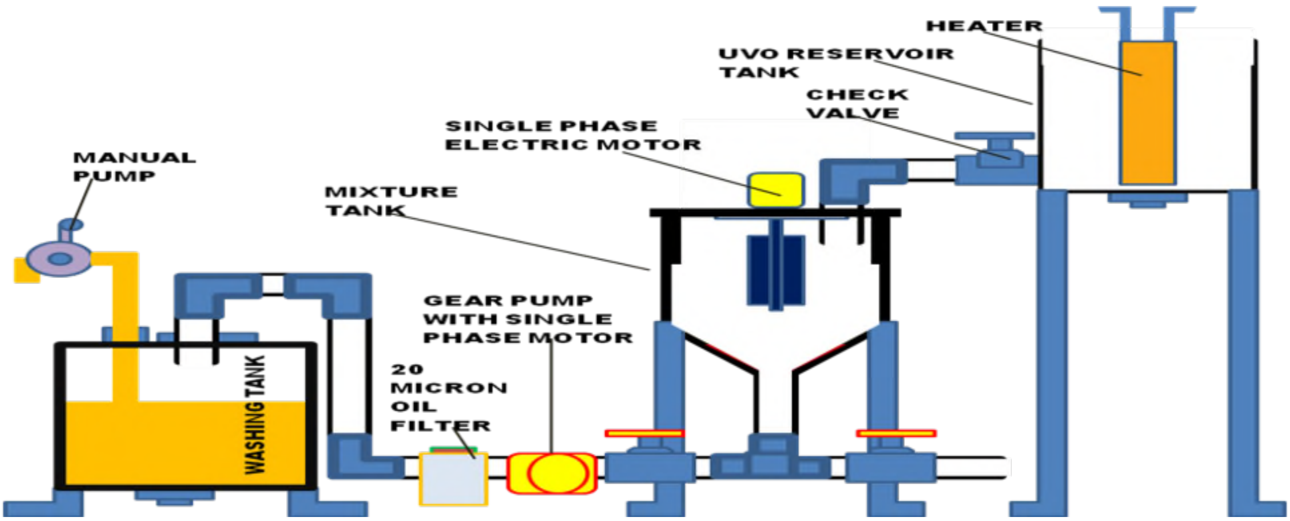

Fig 1.Bio-diesel processor

The mixture is kept to the mixing tank for the period of 4-6 hour at least, at a constant temperature of 40-50˚C below the boiling point which is maintained with electric bulb of 500W connected with Variable resistance of the methanol that is 60˚C, but the result can be far better if the mixture in mixing tank is kept for one day. The glycerin produce because of the chemical reaction takes place inside the mixing tank will be settled down at the bottom of the tank and the Bio-diesel produce will be remain over the glycerin as Bio-diesel is lighter than Glycerin. The glycerin can be drained off using the check valve fitted at the bottom of the mixing tank to the drain line or some collecting tank as the Glycerin can be used further to produce soap and extract the methanol back using the destructive distillation process. The check valve which opens the port of the pipe to the Washing Tank should be open now and the pump connected to the pipe is started to give the Bio-diesel a pressurize flow to the filter of 20 micron so that the Glycerin left on the Bio-Diesel must be filtered off. And the produced Bio-Diesel needs to wash. After washing and drying the Bio-Diesel is ready for the use directly to the C.I. Engine.

III. Modeling and Construction

1) Isometric view of the Bio-Diesel processor:

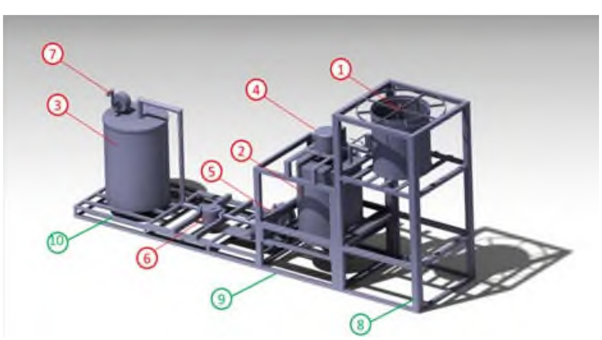

Fig.2.Schematic diagram of Bio-Diesel processor with support frame in isometric view

Table.1. Details of schematic diagram of Bio-Diesel processor with support frame in isometric view

Feature no.	Description
1.	Used vegetable oil reservoir tank with heater.
2.	Lye, Methanol and Used vegetable oil mixture tank with motor.
3.	Washing Tank washes the produced BIO-DIESEL.
4.	Electric Motor to stir the mixture in the mixing tank.
5.	Assembly of pump and the motor to pump the oil to the filter with pressure.
6.	Filter to filter the produced oil.
7.	Manual Pump which will pump out the stored Bio-diesel to the Diesel vehicle directly or to the other storage jar.
8.	Frame 1 fabricated with slotted angle to give support the Reservoir Tank of UVO.
9.	Frame 2 fabricated with slotted angle to give support the Methanol, Lye and UVO Mixing Tank and the Motor.
10.	Frame 3 fabricated with slotted angle to give support the assembly of the Oil Pump, Motor, filter and the Washing Tank.

Before to construct the Bio-Diesel processor, the model of the Bio-Diesel processor is done by using the CAD software CATIA-V5. The figure 2 shows the schematic model of Bio-Diesel processor with support frame and the table 1 shows the description of the Bio-Diesel processor.

2) *Pipe line connection from reservoir tank to mixing tank*

B .Pipe line connection from reservoir tank to mixing tank

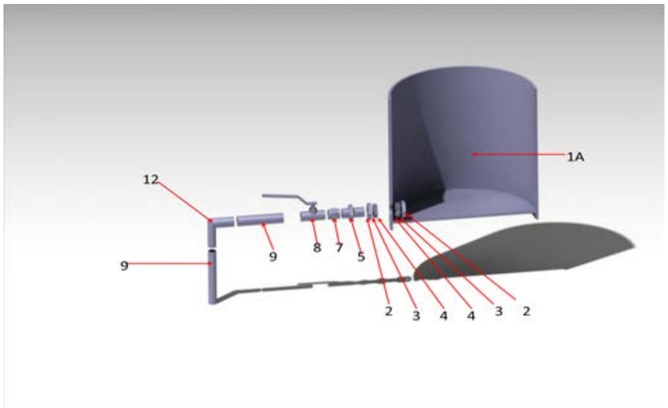

Fig3.Schematic pipe line connection from UVO reservoir to mixing tank

The figure 3 shows the pipe line connection from the UVO reservoir to mixing tank of Bio-Diesel processor and the table2 shows the description of the pipe line connection from the UVO reservoir to mixing tank.

Table 2. Details of pipe line connection from UVO reservoir to mixing tank

Feature no.	Description
1A	UVO reservoir
2	Check nut of drain plug 12mm
3	Steel washer 12mm
4	Anti oil rust rubber washer
5	Drain plug head 12mm
7	Nipple 12mm
8	Check ball valve 12mm
9	G.I. pipe 12mm
12	Elbow 12mm

3) *Pipe line connection from mixing tank to washing tank*

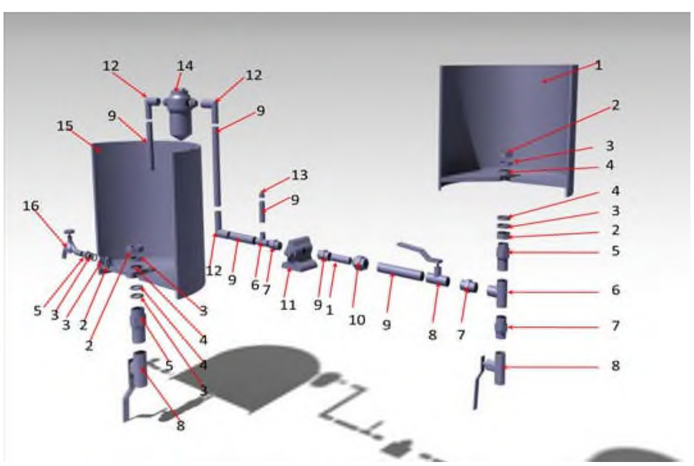

Fig4. Schematic pipe line connection from mixing tank to washing tank

The figure 4 shows the pipe line connection from the mixing tank to washing tank of Bio-Diesel processor and the table3 shows the description of the pipe line connection from the mixing tank to washing tank.

Table 3. Details of pipe line connection from mixing tank to washing tank

Feature no.	Description
1	Methanol, lye and UVO mixing tank
2	Check nut of drain plug 12mm
3	Steel washer 12mm
4	Anti oil rust rubber washer
5	Drain plug head 12mm
6	Tee 12mm
7	Nipple 12mm
8	Check ball valve 12mm
9	G.I. pipe 12mm
10	Union
11	Pump
12	Elbow 12mm
13	End cap
14	Filter 12mm
15	Washing tank
16	Steel tap

4) *Electrical circuit used*

The Fig 5 shows the schematic circuit of electrical component used in bio-diesel processor and the table 4 shows the details of schematic circuit of electrical component used in bio-diesel processor.

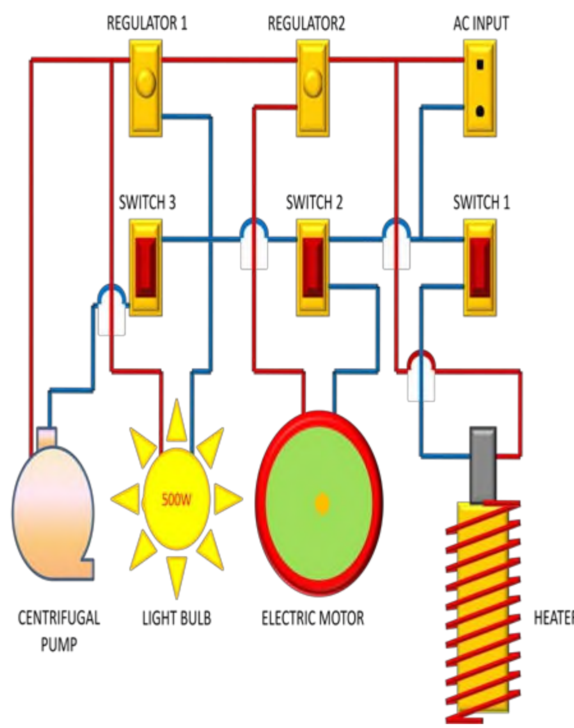

Fig 5.Schematic circuit of electrical component used in Bio-diesel processor

Table 4. Details of schematic circuit of electrical component used in bio-diesel processor.

Feature no	Description
Ac input	Takes the supplies the AC of 230V from the workshop.
Regulator 1	Controls the intensity as well as heat of the 500W Electric bulb, which will help to maintain the temperature of the mixing tank to take place the chemical reaction precisely.
Regulator 2	Controls the r.p.m. of the Electric Motor fitted to the Mixing Tank.
Switch 1	Switch On/Off the Heater fitted to the Reservoir Tank.
Switch 2	Switch On/Off the Electric Motor fitted to the Mixing Tank.
Switch 3	Switch On/Off the Centrifugal Oil Pump.
Heater	Heats the Used Vegetable Oil inside the Reservoir Tank.
Electric motor	Mixes the mixture in the Methanol, Lye and UVO Mixing Tank.
Electric bulb	Helps to maintain the temperature in the mixing tank to take the chemical reaction very precisely between Lye, Methanol and UVO.

IV. RESULTS AND DISCUSSION

1) *Front view of the Bio-Diesel processor*

After the model of the Bio-Diesel processor had been done by using the CAD software CATIA V5, the frames are assembled and the Bio-Diesel processor is constructed. The fig 6 clearly shows the model of the front view of the Bio-Diesel processor and the fig 7 shows the original photograph of the Bio-Diesel processor as front view. The Description of the feature of Bio-Diesel processor is as described in table 5 for front view.

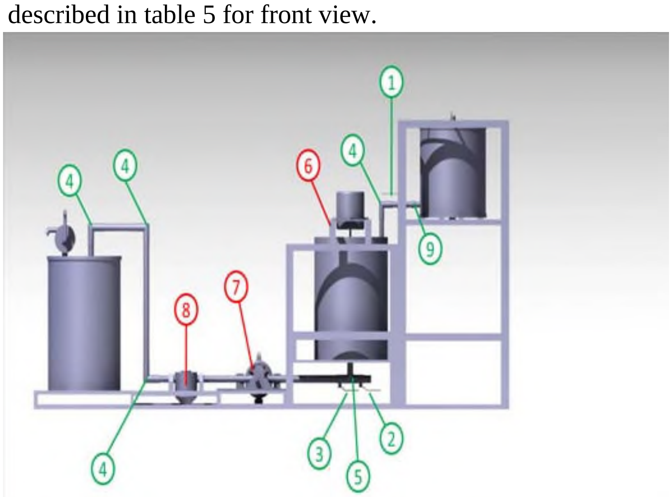

Fig.6.Schematic model of Bio-Diesel processor Front view

Table 5. Details of .Schematic model of Bio-Diesel processor Front view

Feature no	Description
1.	Check valve: - Opening the port from UVO Tank to the Mixing Tank
2.	Check valve: - Opening the port to the drain or any collector tank.
3.	Check valve: - Opening the port towards the Pump, filter and to the Washing Tank.
4.	Elbow: - Joints the pipes to the right angle.
5.	TEE: - Opens to port from one.
6.	Frame: - Frame which can be dissemble easily for the regular inspections.
7.	Pump and electric motor assembly: - Assembly of Pump and Motor.
8.	Filter: - Filters the Processed Bio-Diesel.

Fig 7. Front view of Bio-Diesel processor

2) *Top view of the Bio-Diesel processor*

The fig 8 and fig 9 shows the top view of the Bio-Diesel processor in CAD model and in original photo respectively. The Description of the feature number 1 of Bio-Diesel processor as shown in fig 8 is the Assembly of electric motor and oil gear pump: - The assembly of the Electric Motor and The Oil Gear Pump is done on the Frame 3 using Coupling in between the two spindles.

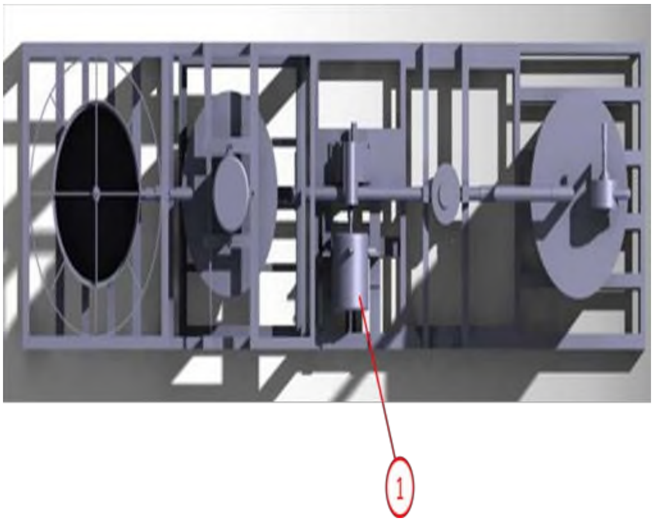

Fig.8. Schematic diagram of Bio-Diesel processor top view

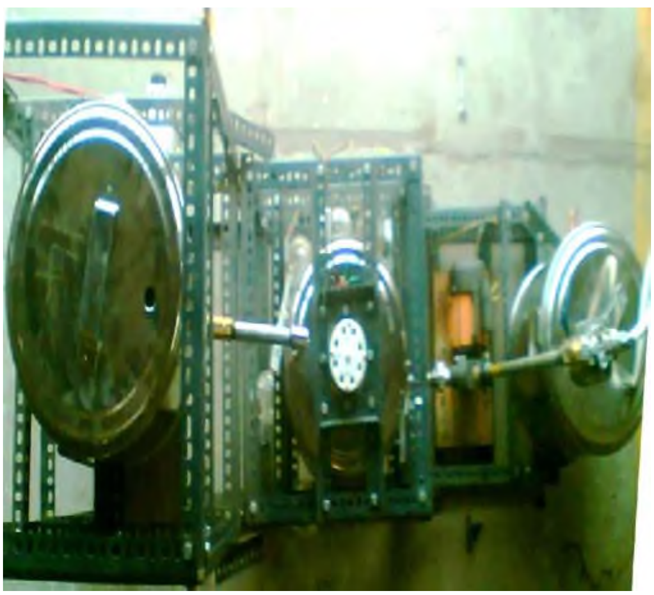

Fig 9.Original photograph of the Top view of the Bio-Diesel processor

3) *Properties of produced Bio-Diesel and blends*

The properties of produced Bio-Diesel are found by appropriate testing process and they are compared with the properties of Diesel is shown in table 6.The Fig10 and Fig11 shows the comparisons of the properties of the produced Bio-Diesel with Diesel. The values of cetane number, kinematic viscosity at 40^{0}C, flash point of produced Bio-Diesel are greater than the values of Diesel. Fig 11 shows in constant heating value, the value of specific gravity at 15^{0}C of produced Bio-Diesel is greater than the value of Diesel and the value of Stochiometric Air/ Fuel Ratio of produced Bio-Diesel is less than the value of Diesel**.**

Table 6. Characteristics of Diesel and produced Bio-diesel

Characteristics	Diesel	Bio-diesel
Specific gravity @ 15 Degree Celsius	0.82	0.88
Heating Value MJ/kg	43.0	43.0
Cetane Number	40-55	48 – 60
Kinematic viscosity at 40 Degree Celsius	1.3 - 4.1	1.9 – 6.0
Flash Point, Degree Celsius	60 – 80	100 – 170
Stochiometric Air/ Fuel Ratio	15	13.8

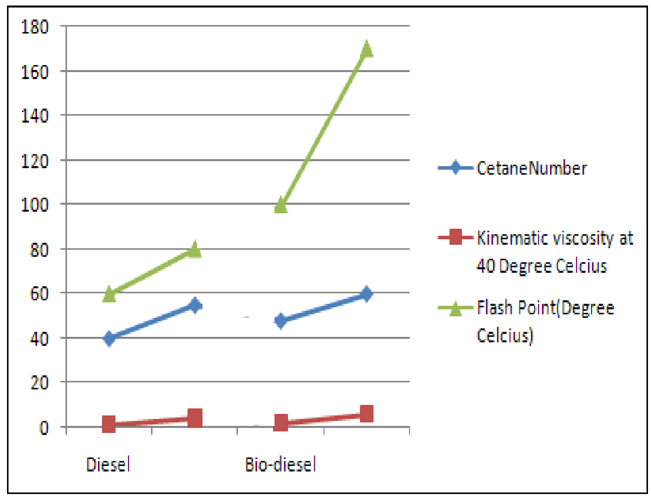

Fig10.Comparision of properties of Diesel Vs Bio-Diesel (Cetane Number, kinematic viscosity, Flash point)

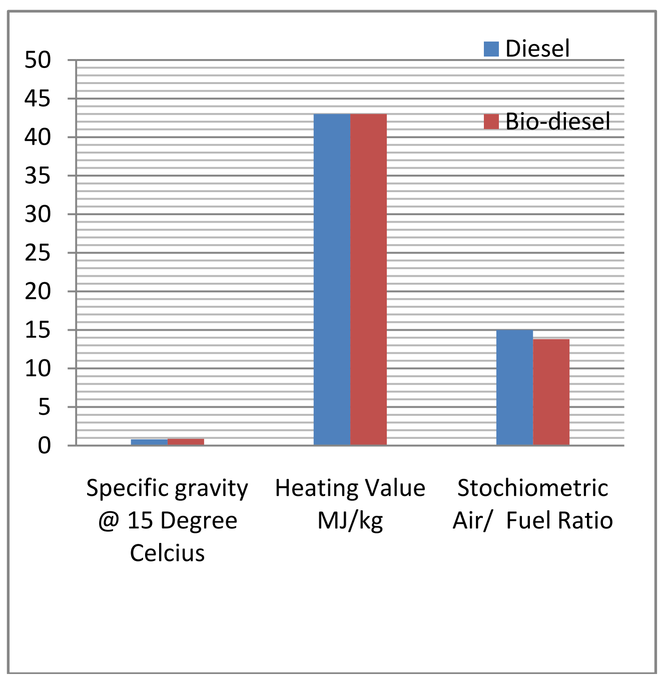

Fig11.Comparision of properties of Diesel Vs Bio-Diesel (specific gravity, Stochiometric Air/Fuel Ratio with constant heating value)

V. Conclusion

This work clearly shows that the modeling and construction of Bio-Diesel processor and the Bio-Diesel production from used vegetable oil by using Bio-Diesel processor shows the promise in applications. When the properties of Bio-Diesel are compared with the Diesel properties, the values of cetane number, kinematic viscosity, flash point of produced Bio-Diesel are greater than the values of Diesel and the value of specific gravity of produced Bio-Diesel is greater than the value of Diesel and the value of Stochiometric Air/ Fuel Ratio of produced Bio-Diesel is less than the value of Diesel**.**

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Design and Analysis of Low Pass FIR & IIR Filter and Find Optimum Result Using Neural Network

Awadhesh Gupta[1], Girish Chandra Tripathi[2]

GJRE -J Classification (FOR) 100508

***Abstract*-This paper is only based on the computational analysis. First of all taking window method for designing low pass FIR filter and the window equation for the different window is coded in the Matlab and find out the result by changing filter order randomly 21 to 54 and find out there results the width of main lobe and number of side lobes 0.4330 to 0.7500 and 4 to 15 respectively. But our goal to find out the width of main lobe is 0.4000 and minimum sides lobes, and then using same parameters for IIR filter we design an IIR filter and then we compare the FIR and IIR filter to find the best result, so for this optimization all data is coded in the Matlab and then by the help of Neural Network we find out the best result after simulation.**

Index Terms-FIR filter, IIR filter, Neural Network.

I. INTRODUCTION

Digital filter design techniques are widely used in different areas. The digital filters consist of software and hardware. The input and output signals in the digital filter is digital or discrete time sequence. Basically, digital filters are linear time invariant (LTI) systems which are characterized by unit sample response these filters are highly flexible and portable and it has minimum/negligible interference noise and other effects. Digital filters are easier in storage, maintenance and reduced failure time. The digital filters are classified in two categories as FIR (Finite impulse response) filter and IIR (Infinite impulse response) filter. The FIR filters have greater flexibility to control the shape of their magnitude response over the IIR filters [1-2].As there is much software for the designing of the digital filters but we are using the Matlab due to reason that the MATLAB is a high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation [3].

II. FILTER SPECIFICATIONS

For the designing of the low pass filter we choosepassband cutoff frequency 150 Hz and stop band frequency 250 Hz. It is safe to choose passband ripple of 1 dB and the minimum stopband attenuation of 40 dB.

Table.1 Filter specifications

Parameters	Value
$F_{passband}$	150 Hz
$F_{stopband}$	250Hz
$\alpha_{passband}$	1dB
$\alpha_{stopband}$	40dB
$F_{sampling}$	1000Hz

As we have

$$\alpha p = -20\log(1-\delta p)dB \qquad (1)$$

$$\alpha s = -20\log(\delta s)dB \qquad (2)$$

So we have

The Pass band ripple is given by:

$$rp = 1 - 10^{-\alpha p/20} = 0.1087 \qquad (3)$$

The Stop band ripple is given by:

$$rs = 10^{-\alpha s/20} = 0.01 \qquad (4)$$

$$wp = 2\pi * \frac{fp}{f} = 0.3\pi \qquad (5)$$

$$ws = 2\pi * \frac{fs}{f} = 0.5\pi \qquad (6)$$

$$wc = \frac{(wp+ws)}{2} = 0.4\pi \qquad (7)$$

III. FIR FILTER DESIGN

1) *Hamming Window*

We analysis the filter using Hamming window or fixed widow by coding in the Matlab and the response of the filter is given in figure 1, 2&3 respectively at the order 21,36& 54.

About -Department of Electronics and Communication Engineering B.S.A.College of Engineering and Technology, Mathura, U.P. (India)
E-Mail- awadheshkandu@yahoo.co.in,girish5111@gmail.com

2) *Blackman Window*

We analysis the filter using Blackman window by coding in the Matlab and the response of the filter is given in figure 4,5 and 6 respectively at the order 21,36 and 54.

3) *Kaiser Window*

We analysis the filter using adaptive window or Kaiser window By coding in the Matlab and the response of the filter is given in figure 7,8 and 9 respectively at the order 21,36 and 54.

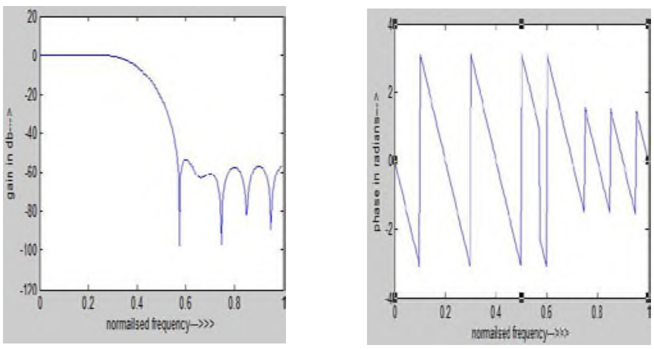


Figure.1 FIR Hamming window (n=21)

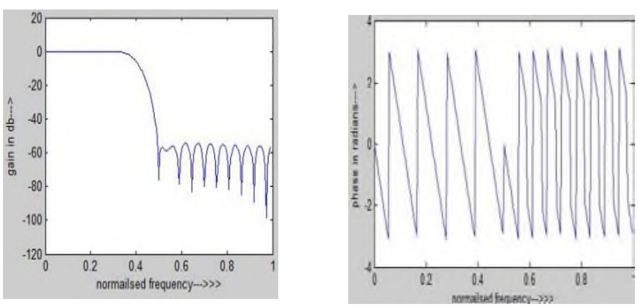


Figure.2 FIR Hamming window (n=36)

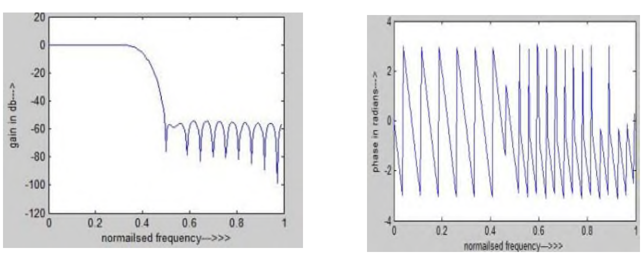


Figure.4FIR Blackman window (n=21)

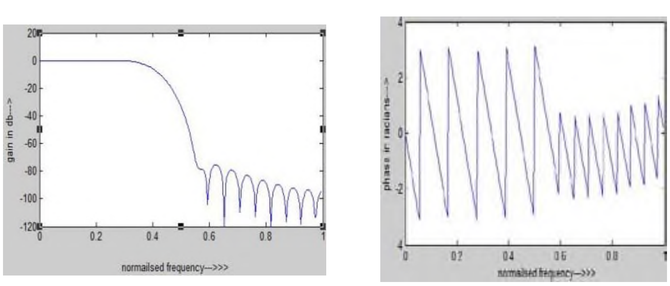


Figure.5 FIR Blackman window (n=36)

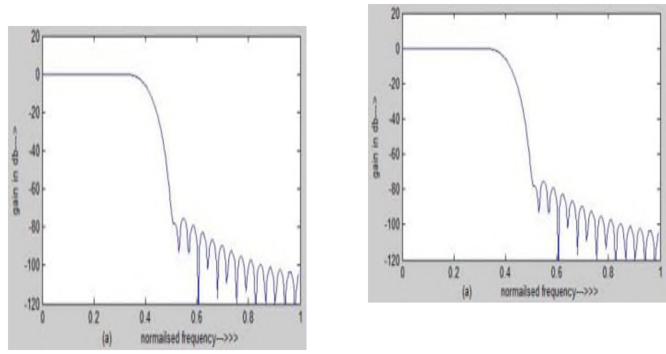


Figure.6FIR Blackman window (n=54)

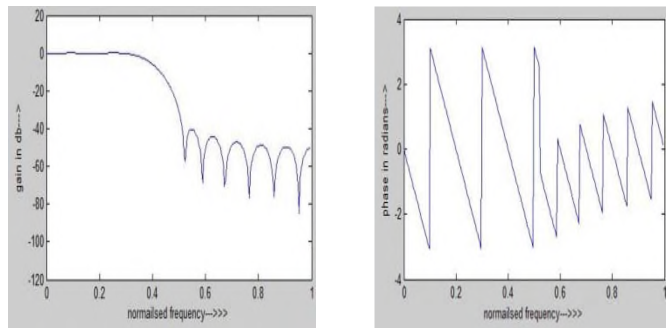


Figure.7FIR Kaiser Window (n=21)

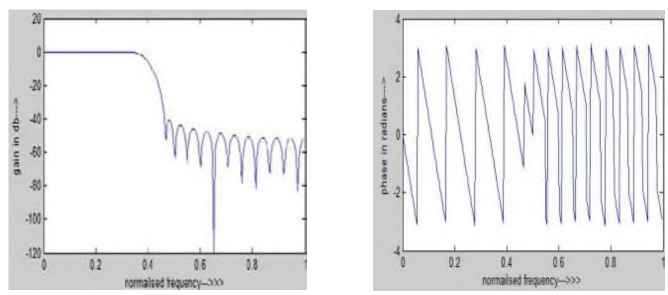


Figure.8FIR Kaiser Window (n=36)

IV. IIR FILTER DESIGN

We use three different approaches for the designing of the IIR filter. First we estimate the order of the filter, and then we design the filter by the help of the Matlab functions provided in Matlab Signal Processing toolbox.

1) *Elliptic*

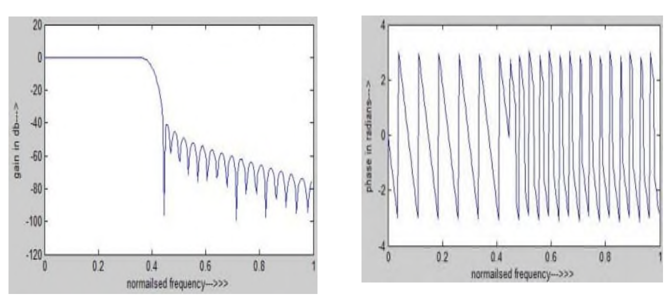


Figure.9 FIR Kaiser Window (n=

We design the elliptic filter on taking order (n = 4).The corresponding response is shown in the figure 10.

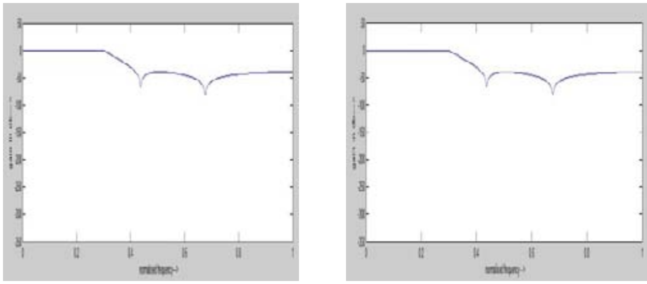


Figure.10 IIR Elliptic (n=4)

2) *Chebyshev*

We design the chebyshev filter on taking order (n = 5).The corresponding response is shown in the figure 11.

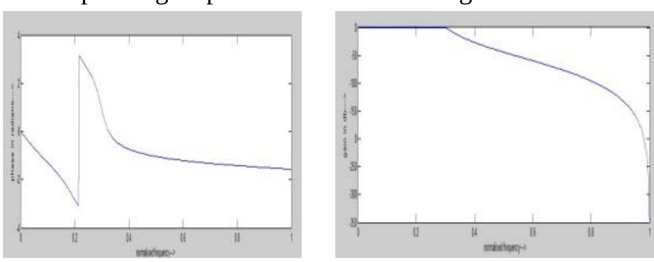


Figure.11IIR Chebyshev (n=5)

3) *Butterworth*

We design the Butterworth filter on taking order (n = 8).The corresponding response is shown in the figure 12.

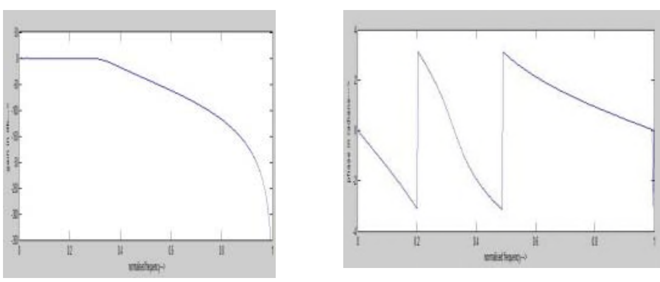


Figure.12IIR Butterworth (n=8)

VII. RESULT

1) *Fir Filter*

Table.2 Comparison between different window techniques

Window technique	Order of the filter	Width of main lobe	No. of side lobes
Hamming Window	21	0.5703	4
	36	0.5000	9
	54	0.4648	14
Blackman Window	21	0.7500	3
	36	0.5938	7
	54	0.5273	13
Kaiser Window	21	0.5195	5
	36	0.4687	10
	54	0.4330	15

We can see that as the order of the FIR filter increases the number of the side lobes also increased and width of the main lobe decrease that it is tending to sharp cut off that is the width of the main lobe decreased. If we want to reduce the width of the main lobe then the number of the side lobes gets increased. So there should we a compromise between attenuation of side lobes and width of main lobe. The Blackman has the smallest side lobes compare to all methods at any order but the width of the main lobe is increased. As in the Kaiser window we can see that at the lower order the width of the major lobe is less than the other approaches and the number of the sides lobes are also less. The Kaiser window provides the flexibility to designer and it gives best result. Therefore it is most commonly used window for FIR filter design.

2) *Iir Filter*

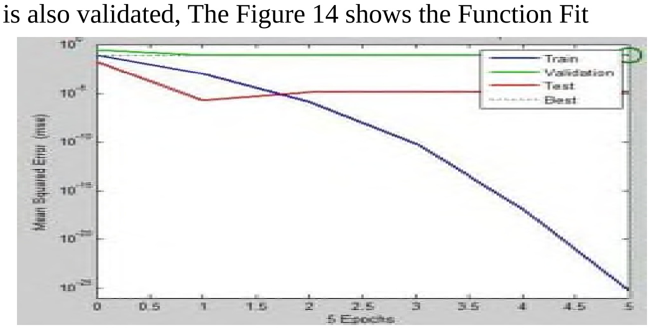
From Figure 10 to 12 we can say that for frequency response, the Butterworth and Chebyshev both the filter have flat response in the passband and it smoothly decreases in the stopband. Elliptic Filter has the ripples in both the passband and stopband, and it also provides us a narrow transition bandwidth.

3) *Comparison Between Fir And Iir Filter*

On comparing the FIR and IIR Filter for the same filter specifications, the IIR filter can achieve the requirement in much lower order, so it is more efficient .But when we want the filter to be linear phased, FIR filter is preferred because it automatically achieves linear phase. The gain response of IIR filter will keep decreasing in the stop band while most FIR will have ripples in stopband.

4) *Neural Network*

The plot obtained by the help of the neural network is shown below. The Figure 13 shows the best validation performance is 0.466 for the FIR filter and for the IIR filter is also validated, The Figure 14 shows the Function Fit



curve for the differentstates and Figure 15 shows the Regression plot.

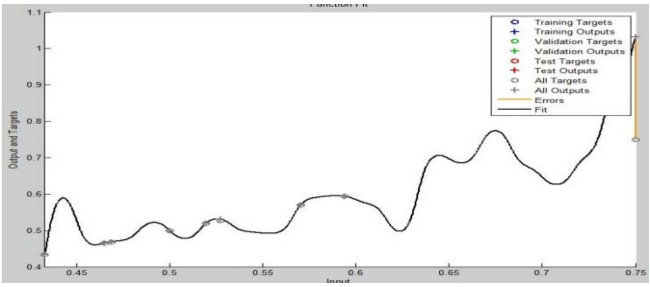


Figure.14 Function Fit graph

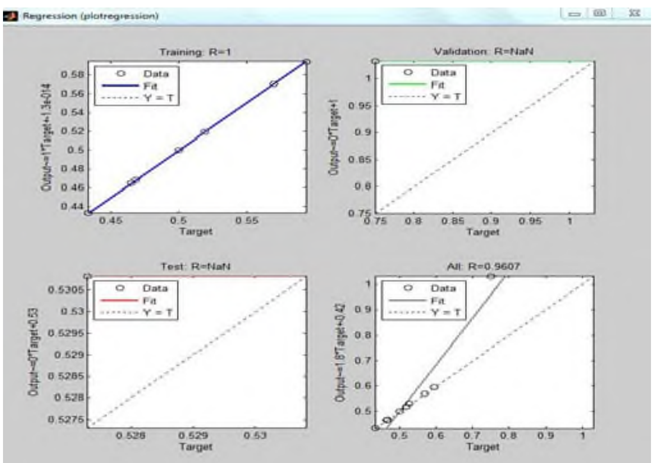


Figure.15 Regression plot

VI. Conclusion

We use the neural networks for verification of the coded value and find the best result. From both of the results we found that IIR filter can give best result in lower order. So by the help of the neural network we can say that the for designing the lower order digital filters IIR filter is best and for the linear phase response FIR filter is used.

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Experimental Analysis of Porosity in Gray Iron Castings

GJRE -E Classification (FOR) 091308

C. Umezurike[1], W.O. Onche[2]

***Abstract-* This paper presents the experimental analysis of porosity in gray iron castings poured with cores prepared with Phenolic urethane no-bake binders. The data for analysis were obtained by altering the casting parameters such as binder ratio, binder level, casting temperature, section size, mixing effect, metal composition, addition of Titanium, Zirconium, Iron oxide, core washes and core post-baking on porosity formation in gray iron castings. Results obtained showed that pouring temperature above 1482°C, poor binder dispersion and use of binder ratio favouring higher level of poly-isocyanate component of the binder promotes porosity. However the additions of 0.25% red iron oxide (Fe_2O_3), 0.025% Titanium and 0.05% Zirconium were also effective in eliminating porosity just as core post-baking and the use of core coating modified with red iron oxide. This result will help metal casters to reduce porosity defects in gray iron castings when they are poured with cores prepared with Phenolic urethane no-bake binders.**

Keywords: Porosity, Castings, Gray iron, Phenolic urethane no-bake binders.

I. INTRODUCTION

Monroe (2005) in his work described porosity as the most persistent and common complaint of casting users. Forgings, machined parts and fabrications are able to avoid porosity with ingot cast feedstock, mechanical processing and automated inspection of simple shapes. Controlling porosity depends on understanding its sources and causes. Significant improvements in product quality, component performance, and design reliability can be achieved if porosity in castings can be controlled or eliminated. Porosity in castings is due to bubbles or gases being trapped during solidification. Porosity sources include entrapped air during filling, centerline shrinkage that occurs during the final solidification, blowholes from unvented cores, reactions at the mould wall, dissolved gases from melting and dross or slag containing gas porosity (Bates et al, 1980). In addition, due to a decrease in the solubility of gases during solidification, gases dissolved in a molten alloy are rejected from the solid to the liquid, resulting in an increase in the gas concentration in the remaining liquid. As a result, the last liquid to solidify can have relatively high dissolved gas content and exceed the limit of solubility. Dissolved gases in molten irons may come from various sources, but charge materials containing high amounts of nitrogen, oxygen, and hydrogen, and decomposing organic mould binders during pouring are the most common sources. Volume contraction during solidification creates shrinkage in castings. Some of the factors contributing to shrinkage are the density differences of liquid and solid, the viscosity of the liquid, the solidification range, the solidification rate, and the permeability of the mushy zone (Coble, 1971). Since the pioneering work of Pellini (1953) on solidification shrinkage, there have been a number of studies to understand the mechanisms of gas and shrinkage porosity formation and to develop models to predict porosity formation, particularly in Al alloys. Using hydrodynamic principles, several workers such as Fang and Granger (1989) developed models to predict shrinkage which correlated well with experimental data in some cases. The relationship between porosity and surface tension in ductile irons was presented in Henych (1998). Niyama et al (1982) investigated the effect of casting size and temperature gradient in castings on shrinkage porosity. There has also been a thermodynamic approach to the porosity problem. Authors such as Poirier et al (1987) calculated the effect of the segregation of gases in the liquid on porosity formation. These studies have yielded useful information on topics such as the level of gas pressure required to form gas porosity in a few alloys under various conditions. The above works describes porosity defects and the metallurgical practices that promote the occurrence and treatment of such defects, relatively little experimental work had been conducted in the area of effect of chemical binder induced porosity defects especially with Phenolic urethane no-bake binders. This work investigates the influences of casting variables on porosity formation in gray iron castings poured with cores prepared with Phenolic urethane no-bake binders. In a bid to achieve these objectives there was the need to design a well balanced experiment that promotes and prevent porosity formation in gray iron.

II. MATERIALS AND EXPERIMENTAL PROCEDURE

The materials and equipment used for this investigation were sourced and provided by the foundry department of Delta steel company. These includes; No-bake furan binder, Phenolic urethane no-bake binder, washed and dried silica (W/D) sand, Cast iron of varying grade, Assorted inoculants, Pt-Pt pyrometer, Strip chart recorder, Electronic weighing scale, Magnifying glass, Strip chart recorder, Gas furnace, Ladle, Patterns, Core and mould boxes, Mould boards, Crucible, Wooden rammer, Electric saw, Emery cloths, Vice, Ingot mould. The experimental program used in this investigation was divided into two phases. First phase was devoted to the development of suitable tests having the capability to produce porosity defects. The

About[1]- Department of Mechanical Engineering, University of Port Harcourt, P.M.B. 5323 Port Harcourt, Rivers State, Nigeria..
Email address: *umezurikechukwumah@yahoo.com*
Tel: +2348066004141

cylindrical test casting shown in Figures 1 was developed for these tests to observe the extent of porosity formation under various test conditions. This "stepped cone" configuration was selected because its design was such that core decomposition gases would be generated rapidly while the casting was still in the molten state and for the study of how section size affect porosity formation.

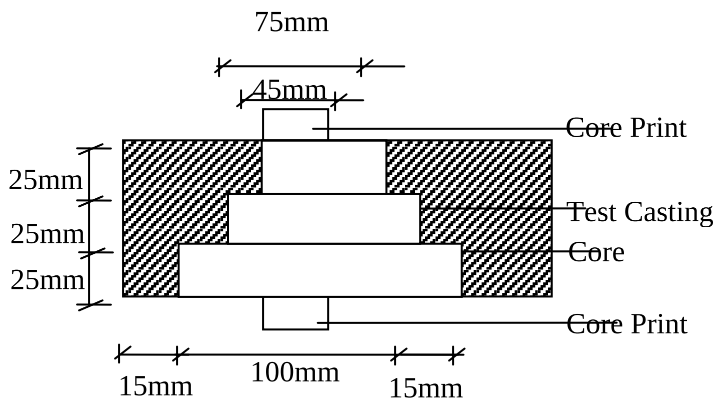

Figure 1: Schematics of cylindrical test casting showing the core and core print

The moulds used for the production of test castings were made with a zero nitrogen no-bake furan binder. The base core sand mix used for the experimental work consisted of the phenolic urethane no-bake binder (PUN) mixed with a high purity, washed and dried, round grained, silica (W/D) sand. The core making procedure used throughout this work consisted of adding the phenolic polyol resin component (Part I)** to 4.0x10-4m3 of the core sand and mixing for two minutes, followed by the addition of the polyisocyanate component (Part II)** and mixing for an additional two minutes. The mix was immediately hand rammed into the core box and the stepped cone cores were stripped after five minutes. The melts were poured at selected temperatures as measured with a Pt-Pt 10% Rd immersion pyrometer and a high speed, strip chart recorder. Variables investigated in this phase includes binder ratio, binder level, pouring temperature, sand type, mixing effects, metal composition and core age. Within each series of tests, the conditions were controlled as carefully as possible and individual variables altered to determine their effect on porosity. The second phase depends upon the first phase of the work in that conditions that were found to promote porosity were used exclusively to developing remedial techniques to prevent porosity. The same melting and core making procedures previously described were likewise used at this time. Techniques studied in attempt to eliminate defects included; use of various grades of iron oxide, additions of ferrotitanium, as well as titanium and zirconium based ferroalloy inoculants, use of core sand additives, core baking, and a study of experimental core coatings. The extents of porosity formation in all the castings were determined by careful sectioning at several locations. The porosity extent was rated 1 Nil-6 Very severe. i.e (1-Nil, 2-Nil-Trace, 3-Trace, 4-Moderate, 5-Servere and 6-Very severe.

III. Results and Discussion

Below are the results obtained from tests carried out to determine the effects of casting parameter in the formation of porosity in test castings poured with cores prepared with Phenolic urethane no-bake binder. Figure 1 below shows the effect of binder ratio on porosity propensity. The ratio of Part I to Part II resin components for PUN binders was varied at constant binder level of 1.5%. Test castings made with binder ratio of 60:40 (Part I: Part II) were without porosity defects. As this ratio became balanced (50:50), trace amounts of porosity were found in a few test castings. As the binder ratio was unbalanced again in favour of excess Part II (40:60 and 35:65), greater amounts of subsurface porosity formed in the test casting. The types of defects observed varying in intensity from nil to very severe. The severity of the porosity defects increases as the binder level was increased at constant Pt I: Pt II ratio, as shown in table 1. These results show that if sufficient amounts of evolved hydrogen and / or nitrogen decomposition gases are made available to the solidifying irons, porosity will generally occur even with favourable binder ratios of 60:40 (Part I: Part II) and using relatively high pouring temperatures. The result also demonstrated the temperature dependency of porosity formation with PUN binders. The test Castings poured at temperatures of 1482^{o}C and higher produces severe subsurface defects when unbalanced binder ratios in favour of Part II were used. However, test castings poured at temperatures between 1371^{o}C and 1400^{o}C show little or no trace of porosity.

Table 1: Effect of Binder Level on Porosity Formation

BINDER LEVEL (%)	RATIO PT. I : PT II	POROSITY EXTENT
3.0	60 : 40	Nil to Trace
3.0	50 : 50	Moderate
3.0	40 : 60	Severe
3.0	35 : 65	Very Severe
1.8	60 : 40	None
1.8	50 : 50	Trace
1.8	35 : 65	Severe
1.5	60 : 40	None
1.5	50 : 50	None to Trace
1.5	35 : 65	Severe
1.25	50 : 50	None
1.25	35 : 65	Moderate

TEST CONDITIONS:
PUN on W/D silica sand.
Iron Chemistry: 4.3 C.E. Gray Iron
Binder Ratio: Part I: Part II ratio varied.
Pouring Temperature: 1482°C

Porosity occurred in section thickness ranging between 10mm-24mm in the test castings containing porosity. It occurred in preferential locations. Deep seated, subsurface porosity was usually located adjacent to the 90° re-entrant angle or step. These locations act as localized hot spots since a small volume of the core is heated from both sides by the solidifying iron. In thinner sections, varying degrees of surface porosity were often found. Results obtained with typical lake sand and washed and dried silica sand incorporating unbalanced binder with Part I : Part II ratio held constant at 35:65 and pouring temperature of 1482°C shows that sand type has significant effect on porosity formation. Severe subsurface porosity was very prevalent with washed and dried silica sand cores while castings made with Lake Sand cores were entirely sound. The behaviour of lake sand in eliminating gas defects may possibly be attributed to either its significantly larger quantity of surface impurities, bulk impurities or greater permeability. Comparisons of casting results obtained with acid-treated versus untreated Lake Sands showed that the removal of surface impurities by acid leaching was not effective in promoting porosity and no porosity was observed in the test castings.

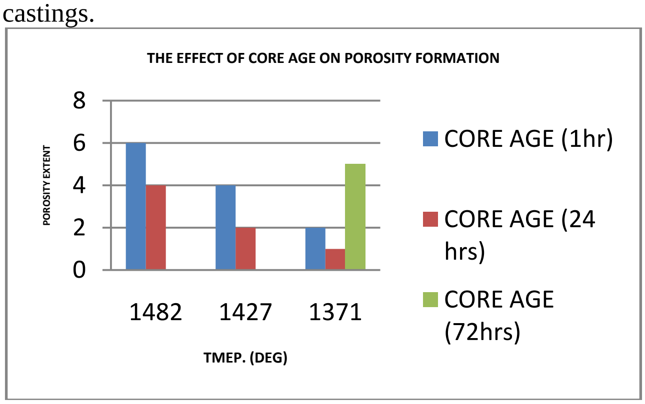

Figure 2. The effect of core age on Porosity Propensity in test casting poured at three different temperature regimes

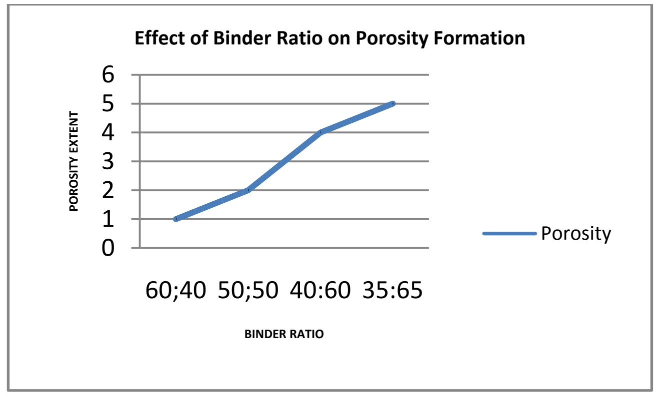

Figure 3. Effect of Binder Ratio on porosity formation in test castings poured at four different Binder Ration

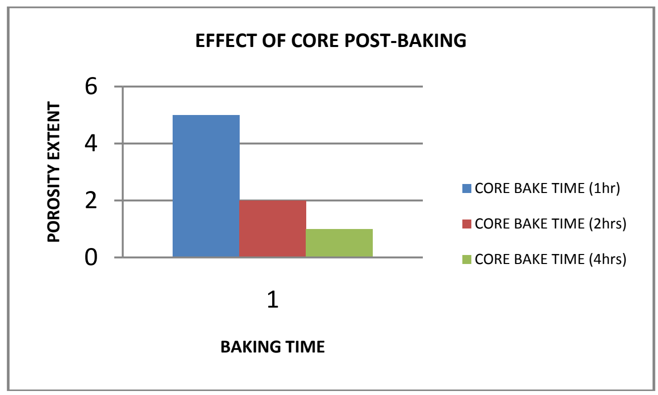

Figure 4. Effect of core post-baking at 1, 2 and 4hrs on porosity formation in test castings

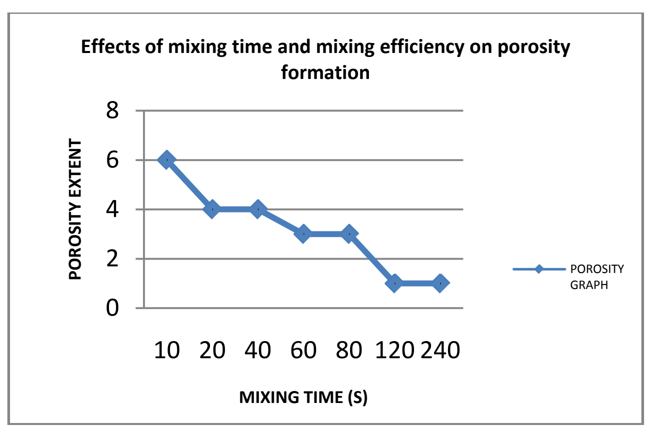

Figure 5. Effect of binder dispersion on porosity formation

Experimental test cores were made using mixing times of 5, 10, 20, 30 and 60(s) for each component (double for actual total mix cycle). The result as shown in Figure 5 demonstrated that, short mix cycles of 10 to 40 (s) total times tended to promote the formation of both surface and subsurface porosity. Only trace amounts of subsurface porosity were found in the remaining castings made with cores mixed for intermediate times of 60 to 80(s). Sound castings were obtained when total mixing times ranged from

120 to 240(s). Results obtained from core age tests poured at three pouring temperatures of 1371oC, 1427oC and 1482oC incorporating unbalanced binder with Part I : Part II ratio held constant at 35:65 is as shown in Figure 2. The cores were allowed to age for 1, 24 and 72hours after stripping. The effect of test core age within the first 24 hours after strip had no effect on porosity formation. Test castings poured with cores used immediately after strip or after overnight aging performed in a similar manner. Susceptibility to porosity formation reduces with the core age within 24hours after stripping. However, with test cores aged over three days under ambient conditions, the severity of the defects increased slightly. This phenomenon appears to be related to moisture from atmospheric humidity combining with unreacted 'NCO' groups in the Polyisocyanate and forming urea structures. Dawson et al (1962) reported in their work that the porosity forming tendencies of this latter group of substances is well known. They are reported to readily break down into ammonia derivatives at high temperatures that later dissociate into nascent hydrogen and nitrogen, both of which are highly soluble and dissolve very readily in molten irons.

Metal composition of the castings poured had a significant effect on porosity formation as shown by result obtained. The tests results indicate that the porosity forming tendencies seemed to be greatest for the low carbon equivalent iron followed by High carbon equivalent iron and least for ductile iron. Ductile iron castings seemed to be far less susceptible to defect formation than either composition of gray iron. Further tests incorporating the use of proprietary inoculants containing carefully controlled additions of surface active elements as well as elements that neutralize nitrogen were examined and are reported herein. Titanium (Ti) and zirconium (Zr) were added to the molten metal prior to pouring. The results obtained from these tests showed that in almost all cases, the addition of small amounts of titanium was effective in eliminating subsurface porosity in castings made with cores bonded with excessive (Part II) polyisocyanate levels. In the case of 70% ferrotitanium additions, titanium additions of 0.05% as were effective in removing subsurface porosity defects. No porosity was found when titanium addition levels of 0.025% were employed with Inoculant B (- 75% Si, 11% Ti, 5.5% Ba, 3.5% Mn, 1.25% Ca, 1.0% Al, Bal – Fe). Ferrosilicon zirconium was almost as effective in eliminating porosity but somewhat higher levels of 0.05% zirconium had to be added. With zirconium additions of 0.025%, trace to no subsurface porosity was found. The effect of controlled addition of zirconium and selenium in mould are listed in Table 3.

Table 2: Effect of Selenium and Zirconium Additions on Porosity Formation

% ADDITION	BINDER LEVEL (%)	RATIO PT. I TO PT. II	POROSITY EXTENT
None – Standard 75% FeSi	1.5%	35 : 65	Very Severe
Inoculant Tablet D. 0.0048% Zr	1.5%	35 : 65	Severe
Inoculant Tablet E. 0.0048% Zr and 0.0019% Se	1.5%	35 : 65	Severe

TEST CONDITIONS:

PUN Binders applied to Washed and Dried Silica sand, Iron Chemistry: 4.3 C.E. Gray Iron, Pouring Temperature: 1482^{o}C

Standard Inoculant - Foundry grade 75% FeSi with 0.75% Calcium, 0.33% addition rate

INOCULANT D - 9 gram inoculant tablet containing 27.7% Si, 28.41 oxy-sulfide forming elements plus 8.0%Zr, Bal - Fe

INOCULANT E - 9 gram inoculant tablet containing 25.6% Si, 26.88% oxy-sulfide forming elements plus 8.0%Zr and 3.3% Se, Bal - Fe

The result shows that castings made with either zirconium by itself or with both selenium and zirconium contained subsurface porosity. The of additions of varying amounts of red iron oxide (Fe2O3 or hematite) to PUN core sand mixes showed that the additions of as little as 0.25% red (hematite) iron oxide were sufficient to inhibit the formation of all traces of porosity in test castings poured under adverse testing conditions. Furthermore, the casting tests run comparing hematite (Fe2O3 -red) to magnetite (Fe3O4 - black) shows clearly the effects of iron oxide mineralogy and chemistry. The red iron oxide (hematite) clearly outperformed the black iron oxide (magnetite) in preventing porosity in gray iron castings. Proprietary red iron oxide (Fe2O3) bearing core washes provided very slight or no reduction in porosity defects. Experimental washes composed of aluminum powder and titanium powder provided similar performance. However, a 100% red iron oxide (Fe2O3) wash, and another prepared with sodium silicate and iron oxide (Fe2O3) completely prevented the formation of porosity.

To determine the effect of core baking on porosity elimination, several test scores were subjected to post-baking or curing for three different times. The result in Figure 4 indicates that castings made with test cores baked at 232oC but for only 1 hour contained severe porosity defects. Intermediate times of 2 hours significantly reduced the extent of porosity. Baking for 4 hours at 232oC produced a distinctive core colour change to chocolate brown and had a significant effect on porosity elimination.

Baking might be effective in reducing overall binder level in the core surface layers and demonstrates that some free hydrocarbons are undoubtedly volatilized and nitrogen components from the Part II resin may undergo further reactions to form more stable compounds. Although several variables have been identified that either exaggerate or promote the formation of porosity defects in PUN binders, these variables are in one way or another related to the gaseous decomposition products generated by the resin during casting. Decomposition gases consisting of both hydrogen and nitrogen are readily liberated during casting pouring and during subsequent solidification. High pouring temperatures further enhance both the breakdown rate and amount as well as favour increased gas solubility in the liquid metal. High pouring temperatures also have a significant effect on liquid metal surface tension, which is known to have a significant effect on porosity formation. Because both hydrogen and nitrogen are readily available and extremely soluble at the casting temperatures employed, their effect on potential porosity defects is often additive. From the results obtained during this investigation it is believed that considerable pickup of both hydrogen and nitrogen occurred in the immediate subsurface layers when conditions favouring porosity were employed. At depths of 6mm and more below the cored surface, hydrogen and nitrogen levels tended to be quite low and representative of the base metal. It is probable that just before solidification, momentary super saturation of both hydrogen and nitrogen exist just under the casting surface. Furthermore, if a considerable amount of nascent nitrogen is dissolved in a casting from unbalanced binder ratios favouring excessive polyisocyanate components, the presence of even a small amount of hydrogen will serve to lower the overall solubility of nitrogen. Stated another way, hydrogen may be exerting a catalytic effect on nitrogen to enhance porosity formation. The same effect of alloying elements on gas solubility is well known and acts in a similar manner. To further aggravate conditions, if the melt initially has a high gas content resulting from the use of poor charge metallics or carbon additives, then the tolerance for additional solution of nascent mould or core gases is reduced considerably and porosity formation becomes extremely favourable.Gas holes formed were located just underneath the surface, and most extended no more than 6mm into the casting, a few castings contained gas fissures almost 12.6mm long. Incorporation of proprietary nitrogen stabilizing elements or "scavengers," which include both titanium and zirconium based ferroalloys, offered additional possibilities for treating binder induced porosity defects. Likewise, inmould inoculating tablets incorporating zirconium for nitrogen control and small amounts of selenium for hydrogen control also offer promise for defect elimination. It is not well understood how small amounts of red iron oxide (0.25% addition rates) were so effective in eliminating subsurface porosity in the test castings. It has been suggested that the red iron oxide is exerting some type of "catalytic effect" on binder decomposition products that minimize or alter the generation of nitrogen and hydrogen gases. One such theory is that when exposed to the sudden high temperatures of iron casting, red iron oxide (Fe_2O_3) readily releases oxygen. This released oxygen immediately reacts with nitrogen decomposition products from the binder to form stable NO_X compounds. Since hematite (red iron oxide) has a much higher concentration of oxygen compared to magnetite (black iron oxide), and based on the improved performance of red iron oxide compared to black, this mechanism certainly appears to be very feasible.

IV. Conclusions

This work has successfully showed the causes and the prevention of porosity defects in gray iron castings poured with cores prepared with Phenolic urethane no-bake binders. The results of this investigation lead to the following conclusions: Unbalanced PUN systems favouring excess Part II or polyisocyanate promote the occurrence of both surface and subsurface gas defects. High binder levels also tended to slightly increase defect propensity even when balanced ratios were employed. Inadequate mixing that result in poor distribution of the binder components in the mix was also found to promote porosity formation. The temperature of the molten iron as it contacts the core surface was found to have a significant effect on porosity formation when castings were poured under conditions favouring their formation. Severe porosity defects were formed at 1482^{o}C and higher. As the temperature was gradually reduced, these defects became fewer in number and intensity until none formed at 1399^{o}C. Porosity formation was found to be very sensitive to core sand type. Lake sands were relatively insensitive to defect formation while high purity, round grained white silica sands were found to be very sensitive.

Cast iron composition had an effect on porosity formation. Ductile iron was least susceptible to defect formation while low carbon equivalent irons were most susceptible. Addition of Titanium and Zirconium was effective in eliminating porosity defects. Incorporation of ferrosilicon zirconium into proprietary inoculants was also found to reduce the incidence of defects.

The addition of small amounts of red iron (Fe_2O_3) oxide (82% minimum purity) to silica sand mixes was extremely effective in eliminating porosity. Sound castings were obtained with additions as small as 0.25% red iron oxide. Black iron oxides were not anywhere as effective as red iron oxide. Porosity defects tended to form in geometric hot spots or re-entrant angles on the test casting. The location seems to indicate that localized heating of the core re-entrant angles creates a condition that results in a momentary super saturation of the surface layers. The table below gives the summary of conclusions and recommendation for producing sound castings poured with cores prepared with Phenolic Urethane no-bake binder.

Casting Variables	Recommendation for Sound Castings Poured with PUN-B		
Binder Ratio (Pt I : Pt II)	60:40	50:50	40:60
Binder Level (%)	1.25-1.8	1.25	1.5
Pouring Temperature (^{O}C)	1371-1400	1371-1400	1371
Sand Type	W/D silica Sand, Lake Sand	W/D silica Sand, Lake Sand	W/D silica Sand, Lake Sand
Binder Dispersion (Sec)	120-240	120-240	120-240
Metal Composition	High Carbon Equivalent Iron/Ductile Iron	Ductile Iron	Low carbon Equivalent Iron/ Ductile Iron
Core Age (Hours)	< 24	< 24	< 24
Titanium and Zirconium Addition (%)	0.025-0.50	0.025-0.50	0.025-0.50
Zirconium & Selenium In Mould Addition	----------	---------	----------
Iron Oxide Addition	0.25 and Above	0.25 And Above	0.25 And Above
Core Wash application	100% Fe_2O_3 **wash** /With Sodium Silicate and Fe_2O_3	100% Fe_2O_3 **wash** /With Sodium Silicate and Fe_2O_3	100% Fe_2O_3 **wash** /With Sodium Silicate and Fe_2O_3
Core Post-Baking (H@ ^{O}C)	2-4 @ 232 ^{O}C	2-4@ 232 ^{O}C	2-4 @232 ^{O}C

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Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.

- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the *Harvard scheme* of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Color Charges: It is the rule of the Global Journals Inc. (US) for authors to pay the full cost for the reproduction of their color artwork. Hence, please note that, if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a color work agreement form before your paper can be published.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

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Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

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Informal Tips for writing a Engineering Research Paper to increase readability and citation

Before start writing a good quality Engineering Research Paper, let us first understand what is Engineering Research Paper? So Engineering Research Paper is the paper which is written by professionals, engineers or scientists who are associated to the field of engineering from all over the world. If you are novel to this field then you can consult about this field from your supervisor or guide.

Techniques for writing a good quality Engineering Research Paper:

1. Choosing the topic- In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to the field of Engineering. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: At a first glance, this point looks obvious but it is first recommendation that to write a quality research paper of any area, first draft your paper in Microsoft Word. By using MS Word, you can easily catch your grammatical mistakes and spelling errors.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.

You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.

- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.

Written Material: You may discuss with your guides and key sources.

- Do not copy or imitate anyone else paper. (Various Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation)
by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

Z

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