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Mechanical & Mechanics Engineering

Highlights

- Reduce Generators Noise
- Modified Absorption Silencer
- Design of Reconfigurable
- Algal Biodiesel from Spirulina

Discovering Thoughts, Inventing Future

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Energy Analysis of Simultaneous Charging and Discharging Concrete Bed Storage System

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Abstract- One of the major challenges with the use of solar thermal energy is the intermittent nature. As such, present day research is geared towards energy storage systems in which thermal energy is stored during the day for later use. However, in many engineering applications there is a continuous steady demand for energy.

Experiments were conducted using concrete mix of 1: 1.2: 1.1 of cement, sharp-sand and limestone, respectively, plus 20g of 5cm length steel fibers which has a thermal conductivity of 2.46 W/mK and storage capacity of 3.24×10^6 J/m^{3}K.

A laboratory packed bed prototype was built and test conducted for simultaneous charging, storage and discharging for an intermittent energy input. From the experimental results, the energy transfer of the packed bed system was analyzed and it was discovered that energy stored, charged and discharged increases with airflow rates.

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Keywords: *energy analysis, simultaneous charging and discharging, concrete bed.*

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ENERGYANALYSISOFSIMULTANEOUSCHARGINGANDDISCHARGINGCONCRETEBEDSTORAGESYSTEM

Strictly as per the compliance and regulations of:

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Adeyanju A.A [α] & Manohar K [σ]

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This is an indication that there was continuity of energy delivered for usage during charging and none charging.

Keywords: energy analysis, simultaneous charging and discharging, concrete bed.

I. Background of the Study

A thermal energy system can be considered as being made up of charge, storage and usage (discharge) as shown in Figure 1.0.

Thermal energy can be stored by three major methods:

As sensible heat in liquids

As sensible heat in solid materials

As latent heat in phase transition of materials

A thermal storage unit in which particulate material is contained in an insulated vessel is known as a packed bed (pebble bed or rock pile) storage unit. It uses the heat capacity of a bed of loosely packed particulate material to store energy. A fluid, usually air, is circulated through the bed to add or remove energy. The most commonly used solid is rock.

A thermal-storage unit in which particulate materials contained in an insulated vessel is known as packed bed (pebble bed or rock pile) storage unit. It uses the heat capacity of loosely packed particulate materials to store energy. Fluid, usually air, is circulated through the bed to add or remove energy. The most commonly used solids are rocks, concrete, clays and walls (Adeyanju 2009a, Ataer 2006). The materials are invariably in porous form and heat is stored or extracted by the flow of a gas or a liquid through the pores or voids. Typically, the characteristics size of the pieces of rock used varies from 1 to 5cm (Ataer 2006). An approximate rule of thumb for sizing is to use 300 to 500kg of rock per square meter of collector area for space heating applications. Rock bed storages can also be used for much higher temperatures up to 1273K. The difficulties and limitations relative to liquids can be avoided by using solid materials for storing thermal energy as sensible heat. But larger amounts of solids are needed than using water, due to the fact that solids, in general exhibit a lower storing capacity than water. The cost of the storage media per unit energy stored is, however, still acceptable for solids. Direct contact between the solid storage and a heat transfer fluid is necessary to minimize the cost of heat exchange in a solid storage medium (Adeyanju 2009b, Ataer 2006).

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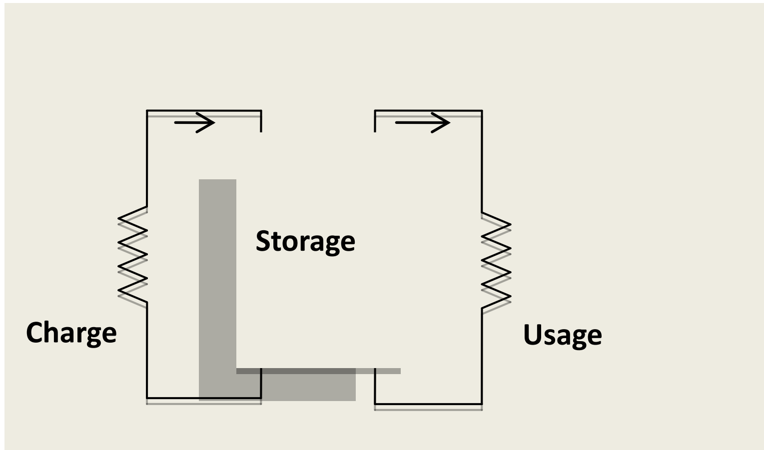

Figure 1.0 : Schematic of thermal energy Storage System

Thermal energy storage is very important to many engineering applications. For example, there is a need for waste heat recovery systems for systems where the waste heat availability and utilization times are different. Similarly, for systems such as solar heat collectors, there needs to be an effective medium in which to store the energy for night usage or even on cloudy days. An effective review on some of the main storage mediums can be found in Hasnainet al. (1998).

As expected, there are two main types – sensible and latent systems. Sensible systems harness the specific heat of materials, which include both liquid and solid materials. Latent systems store thermal energy in the form of a change in phase, and do not require vast temperature differences to store thermal energy, and can be stored in a variety of Phase Change Materials.

The first-law efficiency of thermal energy storage systems can be defined as the ratio of the energy extracted from the storage to the energy stored into it where mC is the total heat capacity of the storage medium and T, T_o are the maximum and minimum temperatures of the storage during discharging respectively, and T_∞ is the maximum temperature at the end of the charging period.

$$\eta = \frac{\mathrm{mC}\left(\mathrm{T} - \mathrm{T_O}\right)}{\mathrm{mC}\left(T_\infty - T_O\right)} \tag{1}$$

Heat losses to environment between the end of discharging and the beginning of the charging periods, as well as during these processes are neglected. The first law efficiency can have only values less than one.

Two particular problems of thermal energy storage systems are the heat exchanger design and in the case of phase change materials, the method of encapsulation. The heat exchanger should be designed to operate with as low a temperature difference as possible to avoid inefficiencies.

If one tries to get an overview of heat storage systems one would be overwhelmed by the large number of possible technical solutions and the variety of storage systems. Latent heat thermal energy storage systems, using phase change materials to store heat or coolness, have many applications.

The specific application for which a thermal storage system is to be used determines the method to be adopted.

Some of the considerations, which determine the selection of the method of storage and its design, are as follows:

- The temperature range, over which the storage has to operate.
- The capacity of the storage has a significant effect on the operation of the rest of the system. A smaller storage unit operates at a higher mean temperature. This results in a reduced heat transfer equipment output as compared to a system having a larger storage unit.
  The general observation which can be made regarding optimum capacity is that "short-term" storage units, which can meet fluctuations over a period of two or three days, have been generally found to be the most economical for building applications.
- Heat losses from the storage have to be kept to a minimum. Heat losses are particularly important for long-term storage
- The rate of charging and discharging
- Cost of the storage unit: This includes the initial cost of the storage medium, the containers and insulation, and the operating cost.

Other considerations include the suitability of materials used for the container, the means adopted for transferring the heat to and from the storage, and the power requirements for these purposes. A figure of merit that is used occasionally for describing the performance of a storage unit is the storage efficiency, which is defined by Equation (1). The time period over which this ratio is calculated would depend upon the nature of the storage unit. For a short-term storage unit, the time period would be a few days, while for a long-term storage unit it could be a few months or even one year. For a well-designed short-term storage unit, the value of the efficiency should generally exceed 80 percent.

Table 1.0 : Overview of Thermal Energy Storage Methods

Type of Thermal Energy Storage	Functional Principle	Phases	Examples
Sensible Heat	Temperature change of themedium with highest possible heat capacity	Liquid Solid	Hot water, organic liquids, molten salts, liquid metals
Latent Heat	Essentially heat of phase change	Liquid – Solid Solid - Solid	Nitrides, Chlorides,Hydroxides,Carbonates,Fluorides,Euc tectics and Hydroxides

In latent heat storage the principle is that when heat is applied to the material it changes its phase from solid to liquid by storing the heat as latent heat of fusion or from liquid to vapour as latent heat of vaporization. When the stored heat is extracted by the load, the material will again change its phase from liquid to solid or from vapor to liquid.

The latent heat of transformation from one solid phase into another is small. Solid-vapor and liquid-vapor transitions have large amounts of heat of transformation, but large changes in volume make the system complex and impractical. The solid-liquid transformations involve relatively small changes in volume. Such materials are available in a range of transition temperatures.

Heat storage through phase change has the advantage of compactness, since the latent heat of fusion of most materials is very much larger than their enthalpy change for 1 K or even 0 K. For example, the ratio of latent heat to specific heat of water is 80, which means that the energy required to melt one kilogram of ice is 80 times more than that required to raise the temperature of one kilogram of water one degree Celsius.

Any latent heat thermal energy storage system should have at least the following three components: a suitable phase change material (PCM) in the desired temperature range, a containment for the storage substance, and a suitable heat carrying fluid for transferring the heat effectively from the heat source to the heat storage.

Furthermore, the PCMs undergo solidification and therefore cannot generally be used as heat transfer media in a solar collector or the load. Many PCMs have poor thermal conductivity and therefore require large heat exchange area. Others are corrosive and require special containers. Latent heat storage materials are more expensive than the sensible heat storage media generally employed, like water and rocks. These increase the system cost. Due to its high cost, latent heat storage is more likely to find application when:

1. High energy density or high volumetric energy capacity is desired, e.g., in habitat where space is at a premium, or in transportation where either volume or weight must be kept to a minimum.
2. The load is such that energy is required at a constant temperature or within a small range of temperatures, or
3. The storage size is small. Smaller storage has higher surface area to volume ratio and therefore cost of packing is high. Compactness is then very important in order to limit the containment costs. Similarly, heat losses are also more or less proportional to the surface area. Compactness is also an important factor to limit the heat losses in storages of small capacities.

Latent TES systems have become much more viable for a high volumetric heat capacity. Usually, latent systems can store much more thermal energy for a given volume, require less of a temperature gradient, and can be used for both hot and cold thermal energy storage, depending on the material.

A comprehensive review of the various types of systems can be found in Sharma and Sagara (2007) where various applications and PCM innovations are discussed. Briefly, some of these applications include space heating and cooling, solar cooking, greenhouse upkeep, solar water heating and waste recovery systems. However, it is the design, control and analysis of these systems which researchers are most concerned with.

As examples, a solar water heating system utilizing encapsulated PCM, an ice-on-coil laboratory unit and an encapsulated ice industrial refrigeration system are presented, as well as past and present methods for system optimization.

Latent solar-water heating systems are a perfect example of the advantage of thermal energy stored in

PCMs. Nallusamy *et al*. (2006) study the performance of a solar collector, coupled with a storage tank filled with encapsulated PCMs, which in this case is paraffin. Water is used as the heat transfer fluid, and the inlet temperature to the storage tank was varied to study the effects of bed porosity and flow rate on overall system performance. It was found that the latent storage system drastically reduced the size of the solar heat storage system, and that these systems are best used for intermittent usage where the latent heat can be best used.

Lee and Jones (1996) studied an ice-on-coil TES unit perfect for residential and light commercial conditions. The chiller, a vapor compression refrigeration cycle using Refrigerant R22, freezes the water inside the evaporator tubes during charging, for the purpose of extraction during peak energy times. The unit was tested varying both evaporator and condenser temperatures, and parameters such as the ice-building rate, the compressor power, cooling rate, heating rate, energy efficiency ratio and power consumption factor are studied. The results indicate that, among other things, the energy efficiency increased with a decreased condenser temperature. The energy efficiency is also readily calculable and heat transfer rates are easily obtainable, which is an encouraging aspect of many TES systems when attempting to minimize energy losses.

An encapsulated ice refrigeration system is studied in Cheralathanet al. (2007). Henze (2003) presents an overview of the control for central cooling plants with ice TES. The control algorithms target the minimization of energy usage and minimizing demand costs, to name a few. Fully optimal control, based on full system knowledge, is also introduced. The main arguments here state that depending on the specific objectives of the system, a control algorithm can be utilized which optimizes the objectives in a concise manner. Henze (2005) furthers this by investigating the relationships between cost savings and energy consumption associated with the conventional control of typical TES systems. Items accounted for in these optimizations include varying fan power consumption, as well as chiller and storage coefficient of performance.

The results indicate that buildings can be operated in such a manner as to reduce overall costs, with only a small increase in total energy consumption.

Another interesting application of PCMs is the regulation of indoor temperatures when rapid changes occur in the surrounding outdoor temperature. Khudhair and Farid (2004) discuss, among other latent TES applications, the advantages of PCMs installed in concrete, gypsum, wallboards, ceilings and floors to limit the effects of outdoor temperature swings on indoor temperatures. These PCMs can act as a heat source while solidifying during cooler indoor temperatures, or a heat sink when melting during warmer indoor temperatures, by having a fusion point close to that of room temperature. Latent TES by means of solar energy and peak load shifting by running a refrigeration cycle are also discussed, as are many other advantages and typical drawbacks of these systems.

It has been conventional, as has been done in the above works, to use energy consumption, energy efficiency and cost minimization as the main benchmarks in determining optimal system configurations. However, in recent years, a new approach has been exercised which simultaneously reduces both energy and cost inputs. These exergy analyses have been the preferred method of late to better analyze the performance of these systems, as well as the location and severity of energy losses. Dincer and Rosen (2002) discuss the usefulness of exergy analysis in the performance and optimization of various TES systems. During exergetic analyses of aquifer, stratified storage and cold TES systems, appropriate efficiency measures are introduced, is the increasing importance of temperature, especially during cold TES.

Rosen et al. (1999) provide detailed exergy analyses of many types of cold TES systems. They consider full cycles of charging, storage and discharging in both sensible and latent systems. The results indicate that exergy clearly provides a more realistic and accurate measure of the performance of a cold TES system, since it treats “cold” as a valuable commodity. This is in contrast to the energy analysis, which treats cold as an undesirable commodity. In addition, it was summarized that the exergy analysis is substantially more useful than the energy analysis. Furthering this study, Rosen et al. (2000) examine an industrial sized encapsulated ice TES unit during full charging, discharging and storage cycles. The results indicate that in addition to energy analyses being incomplete for cold TES, they also achieve misleadingly high efficiency values.

For the system in question, the overall energy efficiency was 99.5%, while the exergy efficiency was calculated to be 50.9%. This solidifies the fact that exergy analyses allow for a more complete diagnostic of cold TES systems and the locations of their shortfalls.

This study utilized spherical shaped concrete imbedded with copper tube as the storage medium. Thermal storage in concrete relies on sensible heat storage where the stored thermal energy is defined by the heat capacity of the concrete and the temperature difference between the charged and the discharged states.

II. Methodology

a) Test and Equipment

The schematic diagram of experimental set up is shown in Figure 2.0. A photograph of the components is presented in Figure 3.0.

For indoor experimentation, air duct with an electric heater was used (Singh, Saini and Saini, 2005). The size of the duct was 3 x 0.5 x 0.0254m. The packed bed storage system consists of packed spherical shaped concrete imbedded with copper tubes, inlet plenum chamber and outlet plenum chamber. The copper tube was of type L and of 0.00635m standard size. The outside diameter of the copper tube was 0.02223m, the inside diameter was 0.01994m, wall thickness of 0.01143m, length 1.32m, number of copper tubes was 4 of two passes with radius 0.115m. The spherical shaped concrete was made of ratio 1:1.2:1.1 of cement, sand and gravel, respectively.

The entry and exit lengths were 0.65 and 0.96m respectively, including the inlet plenum and outlet plenum height of 0.3 m each. The heating section was 2 x 0.5 x 0.0254 m. Electric heater having size of 2 x 0.5 m was fabricated by combining series and parallel loops of heating wire wound on an asbestos sheet. In order to minimize the heat losses, the backside of the heater was insulated with fiber glass.

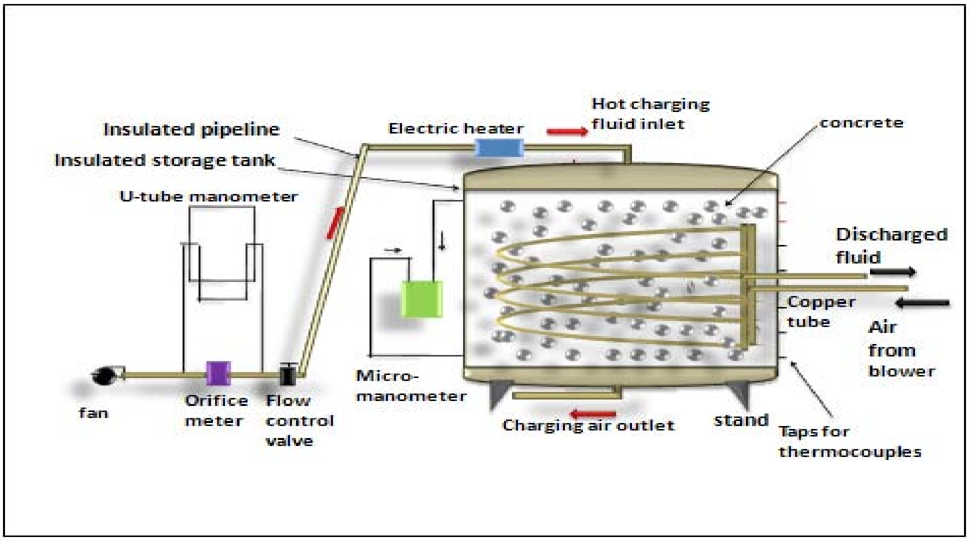

Figure 2.0 : A diagrammatic sketch of simultaneous charging and discharging packed bed energy storage system components

The heater was fixed on the top of the duct between entry and exit lengths. Electric supply to heater was controlled by a variac.

Air duct was well insulated from outside. A centrifugal blower was used to force hot air from air duct to storage tank through a 0.051m diameter orifice. The blower motor range is from 1-5 horsepower and maximum blower revolution per minute is 3800.

Flow was varied by controlling the blower speed using the variable transformer which could supply any voltage from 0 to the rated voltage of 120 V. This blower produced a flow of 0.047m^3/s at a pressure of 13699.9 N/m^2 at standard conditions.

A 3m long pipe of 0.15m inside diameter made of plastic connected with a 0.53m long barrel pipe made of galvanized steel was used between the blower and the electric heater. The length of the pipe was important to provide a fully developed air velocity distribution inside the pipe in order to accurately measure the air flow rates with an orifice meter.

Storage tank having 0.70 m diameter was made of MS sheet of 3.00 mm thickness. The tank was 1.07 m high, including lower and upper plenums of height 0.25 m each resulting to packed bed height of 0.47 m. Tank was insulated with fiber glass to minimize the heat losses. It was mounted in hanging condition on a rigid stand made of MS angles, with the tilting provision to make it trouble-free for attaching and detaching the union joint in the pipe line at entry to the bed and also for easy loading and unloading of storage material. To make air supply from air duct to storage tank, a pipeline of 0.082 m diameter, well insulated with fiber glass, was used. A flange with 0.64m inside diameter and 0.7m outside diameter was installed with the tank cover. Silicone rubber was used for sealing the joint connections in order to avoid air leakage.

Figure 3.0 : A photograph of simultaneous charging and discharging packed bed energy storage system components before and after insulation

An arrangement was provided in order to ensure uniform distribution of air into the bed. A circular MS sheet of 3.00 mm thickness with number of holes was placed on MS angles inside the tank to support the storage material above the lower plenum. All joints of the experimental apparatus were sealed properly to avoid any air leakage. Hole was drilled at different cross sections of the tank in order to insert the thermocouple wires. An air velocity meter was used for the measuring of air flow rate in the pipeline. This meter simultaneously measure and data log the air parameters using a single probe with multiple sensors. The model measure velocity, temperature and calculate flow. It has a telescopic articulated probe.

Figure 4.0 : A photograph of spherical shaped concretes and those imbedded with copper tube

An orifice meters with a U-tube manometer was installed along the pipeline for pressure drop measurement.

A control valve was provided in the pipeline for adjusting the flow rate of air. Micro-manometer was attached with the taps at top and bottom of the bed for measuring pressure drop through the bed. Temperatures of air and solid at different points along different cross sections in the bed were measured with thermocouples.

The temperature of the flowing air through the packed bed, the surface and core of the spherical shaped concrete, the concrete/copper tube contact and also the surface of the copper tube together with air flowing inside the copper tube were measured at interval of ten minutes at several locations. These temperatures were measured by means of thermocouples. At each location, a thermocouple was positioned at the center of the horizontal plane of the packed bed for measuring the air temperature, the surface and the center of the concrete material and copper tube. Air temperatures were also measured at the inlet and outlet of the storage tank and also at the inlet and outlet of the copper tube through the thermocouples.

The thermocouples were then connected to three data loggers which have its software installed on the computer for the temperature readings. The data loggers have 8-channel each. Input from thermocouples of types B, E, J, K, R, N, S, or T could be recorded using the instrument. Each of the 8-channels are independent of each other, and can be independently enabled or disabled. Type J thermocouples were used for all tests performed. This Pico instrument was capable of 0.1°C resolution with readings displayed in °C and capable of continuously recording and exporting data to a remote computer.

A centrifugal fan with a control valve was installed to provide air at varied flow rates through the copper tube in the storage tank.

b) Test Procedures

The experimentation involved testing of the thermal performance of energy stored in a packed bed storage system in which the inlet air temperature to the packed bed were generated from the discharge air temperatures of a simulated air type flat plate solar collector. The second phase of the experiment involved studying the pressure drop, energy loss, air passage through the packed bed and the fan energy used for optimization of the packed bed storage system.

Before a test was conducted on the packed bed which contains partly spherical shaped concrete of a specific size and the spherical shaped concrete imbedded with a copper tube of same size. The spherical shaped concrete of three different sizes with diameters 0.065m, 0.08m and 0.11m were casted and several of its physical properties such as weight, density and compressive strength were determined. The void fraction (ε) was calculated using the relationship between porosity and concrete bulk density (ρ_b) which is given by the following equation:

$$\varepsilon = 1 - \frac{\rho_b}{\rho_c} \tag{2}$$

The bulk density of the spherical shaped concrete was determined from the volume of the storage section of the packed bed and the weight of the concrete filling the volume.

Tests were carried out with spherical shaped concrete of diameter 0.11, 0.08 and 0.065m, respectively. The spherical shaped concrete imbedded with copper tube was then dropped into the storage section of the tank and the remaining concrete without copper tube was dropped and arranged in the storage tank to maintain space volume between particles within very close limits. Moreover, different porosity could be obtained.

Before packing of storage material, thermocouples were fixed in small sized grooves in material particles. During packing these were placed at different points in different cross sections of the bed along with thermocouples for measurement of air temperature at the same points.

At each location, a thermocouple was positioned at the center of the horizontal plane of the packed bed for measuring the air temperature, the surface and the center of the concrete material and copper tube. Holes were drilled at different locations across the height of the storage tank where twenty two thermocouples were inserted. Four thermocouples were inserted to measure the air temperature within the void of the packed bed at different height of the tank. Four thermocouples each were also inserted to measure the surface and internal temperature of the spherical shaped concrete and another four each for the copper tube surface and internal air temperature at different height.

One thermocouple each was also inserted at the entry and exit of the copper tube and at the entry and exit of the storage tank respectively.

Three runs of air flow rates were conducted for the 0.11, 0.08 and 0.065m diameter spherical shaped concrete at the normal drop. The designed air flow rates were 0.0094m^3/s, 0.013m^3/s, and 0.019m^3/s per square meter of total cross sectional area of the storage tank.

The corresponding superficial velocities were approximately 0.1m/s, 0.15m/s and 0.20m/s.

As soon as the air enters the storage tank into the packed bed, temperature measurements of air, concrete surfaces, copper tube surfaces, concrete core and inside of the copper tube were recorded at four levels via a data logger connected with the computer. These four levels were located at different heights above the base, 117.5cm, 235cm, 352.5cm, and 470cm.

Temperatures were measured at the storage tank inlet and outlet and copper tube inlet and outlet via a data logger connected to a computer. The measurements were taken automatically at an interval of 10 minutes for between 10 to 12 hours.

In order to test the storage capacity of the spherical shaped concrete and the copper tube, the measurements were also taken during the night period when the simulated heat was no longer in supply to the packed bed.

Upon analysis of all measuring equipment, the error calculated for these experiments was found to be ±5%.

The second phase of the experimentations involves studying the air resistance through packed bed and the blower and also through the copper tube. The pressure drop measurements were taken at varying air flow rates of 0.0094, 0.012, 0.014, 0.017, 0.019, 0.021, 0.024, 0.026, 0.028, and 0.031m^3/s.

The pressure drops were taken for spherical shaped concrete of diameter 0.11, 0.08 and 0.065m.

The following measurements were taken:

Pressure drops of air across the pipe (barrel) leading to storage tank inlet

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Pressure drops of air across the pipe entry the copper tube inlet

Pressure drops of air across the packed bed

From this experimentation blower characteristics performance and the power used for the operation were established. The volume flow rate handled by the blower expressed the inlet conditions. The blower total pressure is expressed as follows:

Blower total pressure = Outlet blower total pressure –Inlet blower total pressure (3)

The blower total pressure calculated from equation (3) represents the pressure drop across the blower.

The blower efficiency can also be expressed as follows:

$$\eta_{blower} = \frac{\text{power output}}{\text{power input}} \quad (4)$$

III. Results and Discussion

This is the results of the experimentation which involved the determination of the thermal performance of packed bed energy storage system using a heater.

The ambient air temperature; fan inlet and outlet temperature; pressure drop across blower, barrel and pipe; and blower power input at air flow rates of $0.0094m^3/s$, $0.013m^3/s$, and $0.019m^3/s$ for spherical shaped concrete of size 0.065, 0.08 and 0.11m, respectively, were shown in Tables 2.0 to 4.0.

Table 2.0 : Average values of Air Flow Measurements for the Spherical shaped Concrete of size 0.11m diameter

Air flow rate m^3/s	Ambient air temp. (°C)	Fan inlet air temp. (°C)	Fan outlet air temp. (°C)	Pressure drop across barrel orifice (N/m^2)	Pressure drop across pipe orifice (N/m^2)	Atmospheric pressure (N/m^2)	Pressure drop across blower (N/m^2)	Blower power input (watt)
0.0094	24.30	24.40	26.40	89.7	9.96	101320.7	122.5	490
0.013	24.30	24.20	26.60	176.9	19.9	101320.7	220.7	510
0.019	24.40	24.20	27.00	331.3	34.87	101320.7	392.3	530

The energy analysis of the simultaneous charging and discharging storage system at airflow rates of 0.0094, 0.013, and $0.019m^3/s$ for spherical shaped concrete of size 0.11m, 0.08m and 0.065m, respectively, were shown in Tables 5.0 to 7.0.

It can be seen from Figures 5.0, 6.0, 7.0 and 8.0 that at airflow rates of 0.0094 m^3/s; 494.95, 504.50 and 526.80 watts of energy were supplied to charge the packed bed contain spherical shaped concrete of diameter 0.11m, 0.08m and 0.065m, respectively. 201.60, 118.62 and 77.82 watts of energy were stored in the packed bed contain spherical shaped concrete of diameter 0.11m, 0.08m and 0.065m, respectively, while 132.90, 217.78 and 255.78 watts of thermal energy were conducted through the concrete imbedded with copper tube making a total energy in packed bed to be 334.52, 336 and 333.6 and the storage efficiency to be 40.7, 23.5 and 14.8%, respectively.

298.25, 304.3 and 296.49 watts of energy were delivered from copper tube for usage through a simultaneous charging and discharging arrangement per packed bed contain spherical shaped concrete of diameter 0.11m, 0.08m and 0.065m, respectively.

Table 3.0 : Average values of Air Flow Measurements for the Spherical shaped Concrete of size 0.08m diameter

	Ambient air temp. (°C)	Fan inlet air temp. (°C)	Fan outlet air temp.(°C)	Pressure drop across barrel orifice (N/m^2)	Pressure drop across pipe orifice (N/m^2)	Atmospheric pressure (N/m^2)	Pressure drop across blower(N/m^2)	Blower power input (watt)

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Air flow rate m^3/s								
0.0094	24.00	24.20	26.00	92.16	12.46	101320.8	122.59	490
0.013	24.00	24.15	26.20	176.85	22.42	101320.8	220.66	510
0.019	24.20	24.40	27.50	323.82	34.87	101320.8	380.51	530

Likewise, an amount of 663.4, 675.14 and 712.1 watts of energy were supplied to charge the packed bed contain spherical shaped concrete of diameter 0.11m, 0.08m and 0.065m, respectively at airflow rates of 0.013m^3/s; 401.40, 346.4 and 249.67 watts of energy were stored while 127.58, 192.74, and 247.6 watts of thermal energy were conducted through the concrete imbedded with copper tube making a total energy in the packed bed to be 529, 512.97 and 497.27 and the storage efficiency to be 60.5, 51.3 and 35.06%, respectively.

Table 4.0 : Average values of Air Flow Measurements for the Spherical shaped Concrete of size 0.065m diameter

	Ambient air temp. (°C)	Fan inlet air temp. (°C)	Fan outlet air temp. (°C)	Pressure drop across barrel orifice. N/m^2	Pressure drop across pipe orifice (N/m^2)	Atmospheric pressure (N/m^2)	Pressure drop across blower (N/m^2)	Blower power input (watt)
Air flow rate m^3/s								
0.0094	23.30	24.80	27.20	87.18	9.96	101862.6	124.60	490
0.013	23.40	24.65	26.90	174.36	22.42	101320.7	245.18	510
0.019	23.60	24.90	28.00	328.80	34.87	101930.3	392.28	530

406, 423.65 and 412.7 watts of energy were delivered from copper tube for usage through a simultaneous charging and discharging arrangement per packed bed contain spherical shaped concrete size of diameter 0.11m, 0.08m and 0.065m, respectively.

934, 944.71 and 1005.73 watts of energy were supplied to charge the packed bed contain spherical shaped concrete of diameter 0.11m, 0.08m and 0.065m, respectively at airflow rates of 0.019m^3/s; 536.85, 473.90 and 405.55 watts of energy were stored while 125.55, 187.70 and 244.55 watts of thermal energy were conducted through the concrete imbedded with copper tube making a total energy in the packed bed to be 662.4, 661.6 and 650.1 and the storage efficiency to be 57.5, 50.2 and 40.3%, respectively.

Table 5.0 : Energy analysis for the 0.11m spherical shaped concrete storage system at airflow rates of 0.0094, 0.013, and 0.019m^3/s

	Energy input to bed (W)	Energy output of bed (W)	Energy conducted through copper tube/ concrete (W)X	Energy store (W) Y	Total Energy in bed (W) X+Y	Energy input to copper tube (W)	Energy delivered from copper tube for usage (W)	Storage Efficiency (%)
Air flow rate m^3/s								
0.0094	494.95	160.43	132.90	201.6	334.52	39.40	298.25	40.7
0.013	663.40	134.40	127.58	401.40	529.00	76.50	406.00	60.5
0.019	934.13	271.60	125.55	536.85	662.40	73.14	388.80	57.5

388.8, 525.9 and 510.2 watts of energy were delivered from copper tube for usage through a simultaneous charging and discharging arrangement per packed bed contain spherical shaped concrete size of diameter 0.11m, 0.08m and 0.065m, respectively.

These analyses indicated that it is possible to charge a packed bed, store thermal energy and discharge the energy simultaneously.

Table 6.0 : Energy analysis for the 0.08m spherical shaped concrete storage system at airflow rates of 0.0094, 0.013, and 0.019m^3/s

Air flow rate m^3/s	Energy input to bed (W)	Energy output of bed (W)	Energy conducted through copper tube/ concrete(W)X	Energy store (W) Y	Total Energy in bed (W) X+Y	Energy input to copper tube (W)	Energy delivered from copper tube for usage (W)	Storage Efficiency (%)
0.0094	504.50	168.00	217.78	118.62	336.00	32.31	304.30	23.5
0.013	675.14	162.16	192.74	346.41	512.97	61.14	423.65	51.3
0.019	944.71	283.10	187.70	473.90	661.60	115.40	525.90	50.2

Table 7.0 : Energy analysis for the 0.065m spherical shaped concrete storage system at airflow rates of 0.0094, 0.013, and 0.019m^3/s

Air flow rate m^3/s	Energy input to bed (W)	Energy output of bed (W)	Energy conducted through copper tube/ concrete(W)X	Energy store (W) Y	Total Energy in bed (W) X+Y	Energy input to copper tube (W)	Energy delivered from copper tube for usage (W)	Storage Efficiency (%)
0.0094	526.80	193.25	255.78	77.82	333.60	21.07	296.49	14.8
0.013	712.10	214.83	247.60	249.67	497.27	60.52	412.70	35.1
0.019	1005.73	355.6	244.55	405.55	650.10	128.22	510.20	40.3

The energy analysis for discharging only (when no energy is supplied during night time) indicates that energy delivered from copper tube for usage at airflow rates of 0.0094m^3/s were 236.7, 233.7 and 225.9 watts for spherical shaped concrete size of diameter 0.11m, 0.08m and 0.065m, respectively while that of airflow rates of 0.013m^3/s were 257.5, 296.3 and 285.4 watts for spherical shaped concrete size of diameter 0.11m, 0.08m and 0.065m, respectively whereas at airflow rates of 0.019m^3/s it was 298.5, 293 and 277.1watts.

This is an indication that there was continuity of energy delivered for usage during charging and none charging.

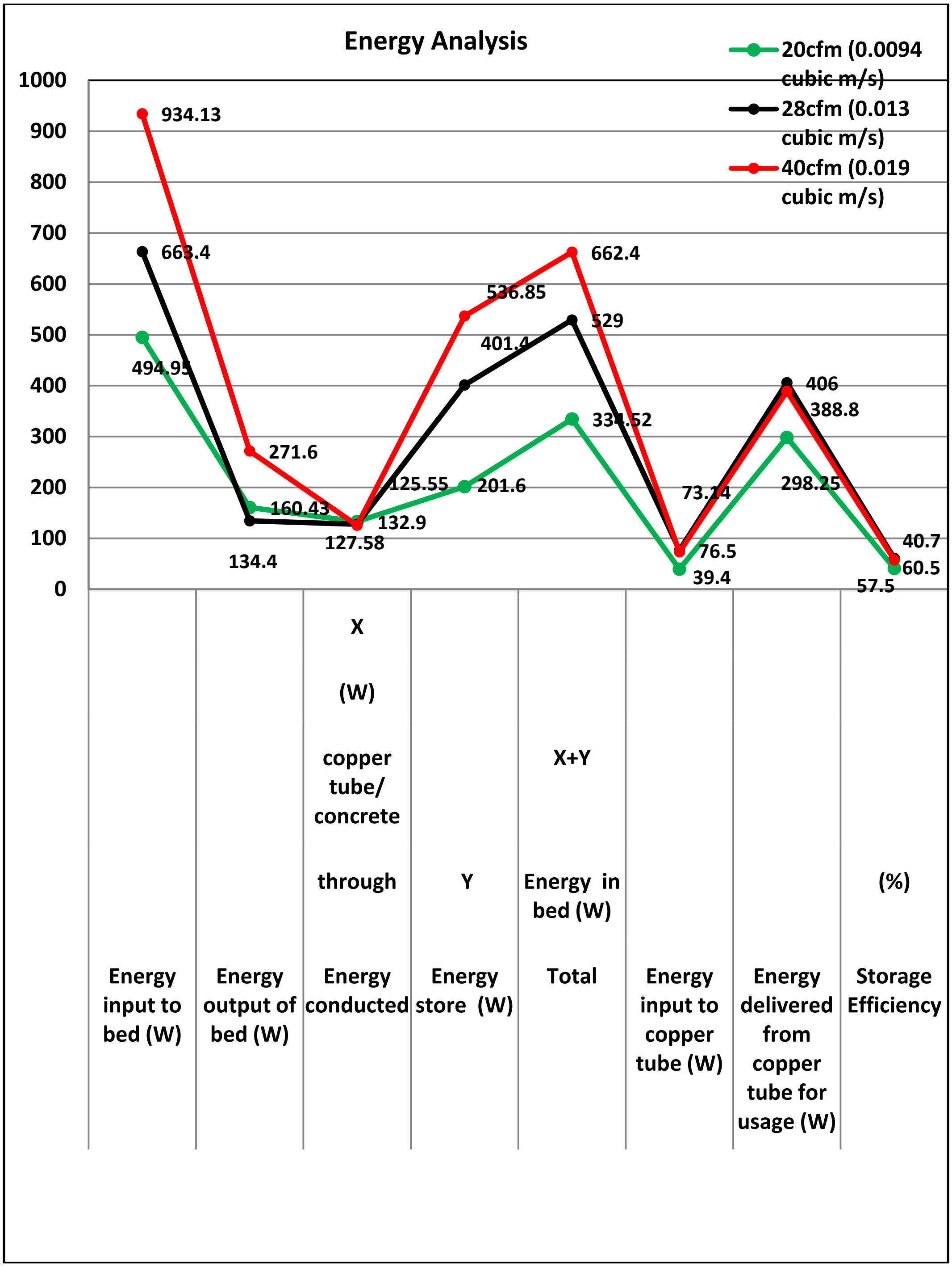

Figure 5.0 : Energy analysis of simultaneous charging and discharging packed bed storage system at airflow rate of 0.0094, 0.013, and 0.019m^3/s for 0.11m diameter spherical shaped concrete

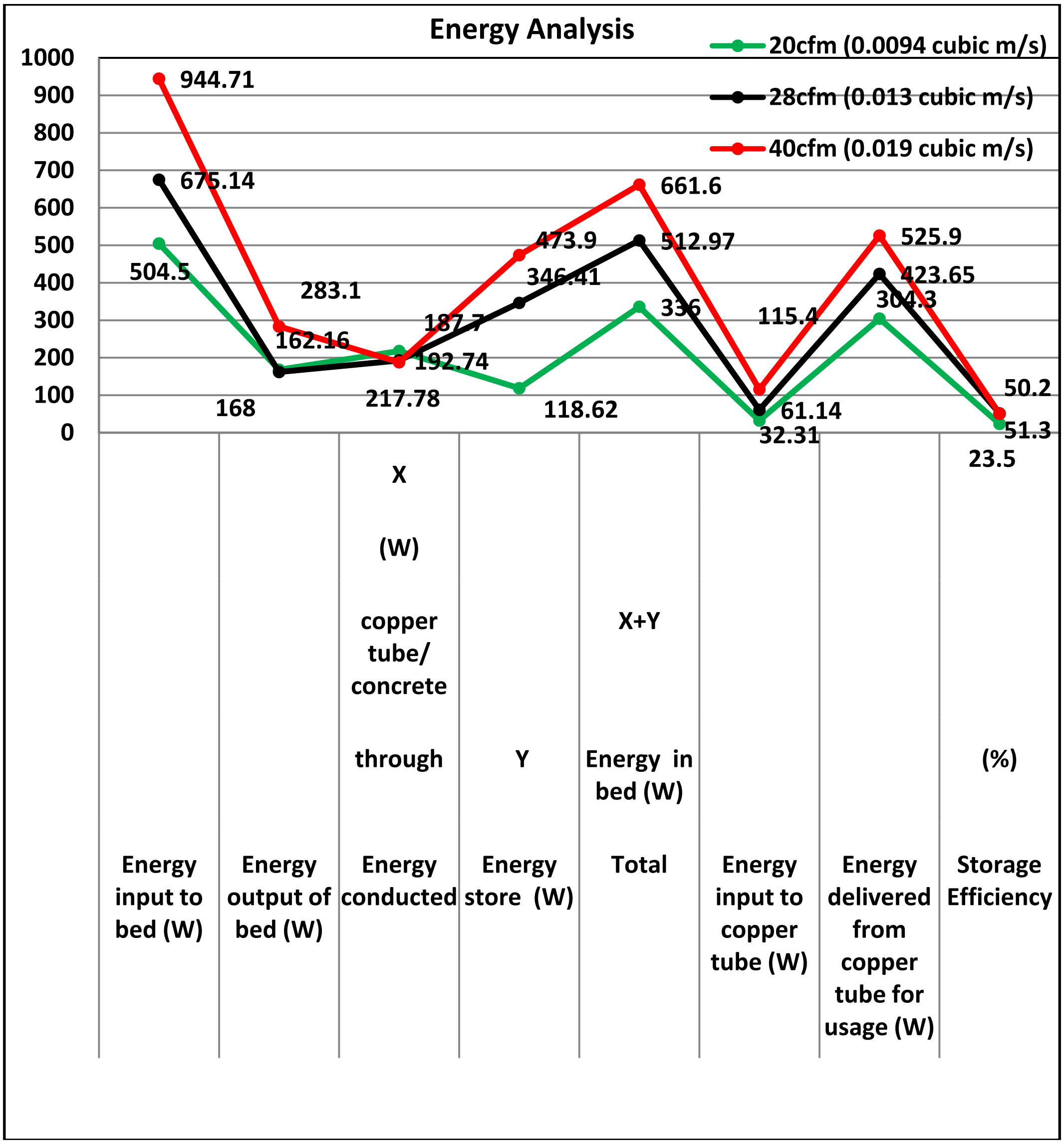

Figure 6.0 : Energy analysis of simultaneous charging and discharging packed bed storage system at airflow rate of 0.0094, 0.013, and $0.019 m^3/s$ for 0.08m diameter spherical shaped concrete

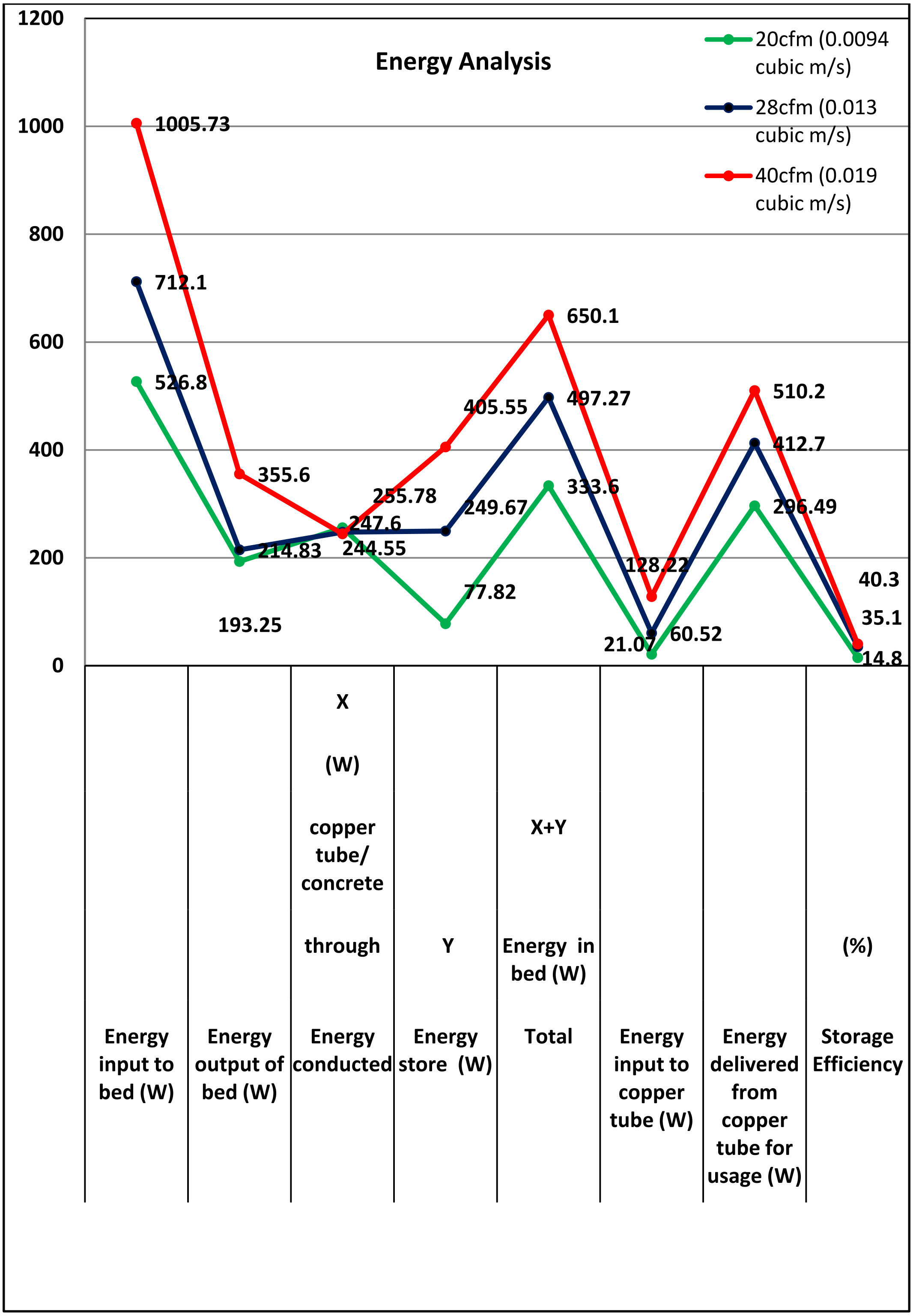

Figure 7.0 : Energy analysis of simultaneous charging and discharging packed bed storage system at airflow rate of 0.0094, 0.013, and 0.019m^3/s for 0.065m diameter spherical shaped concrete

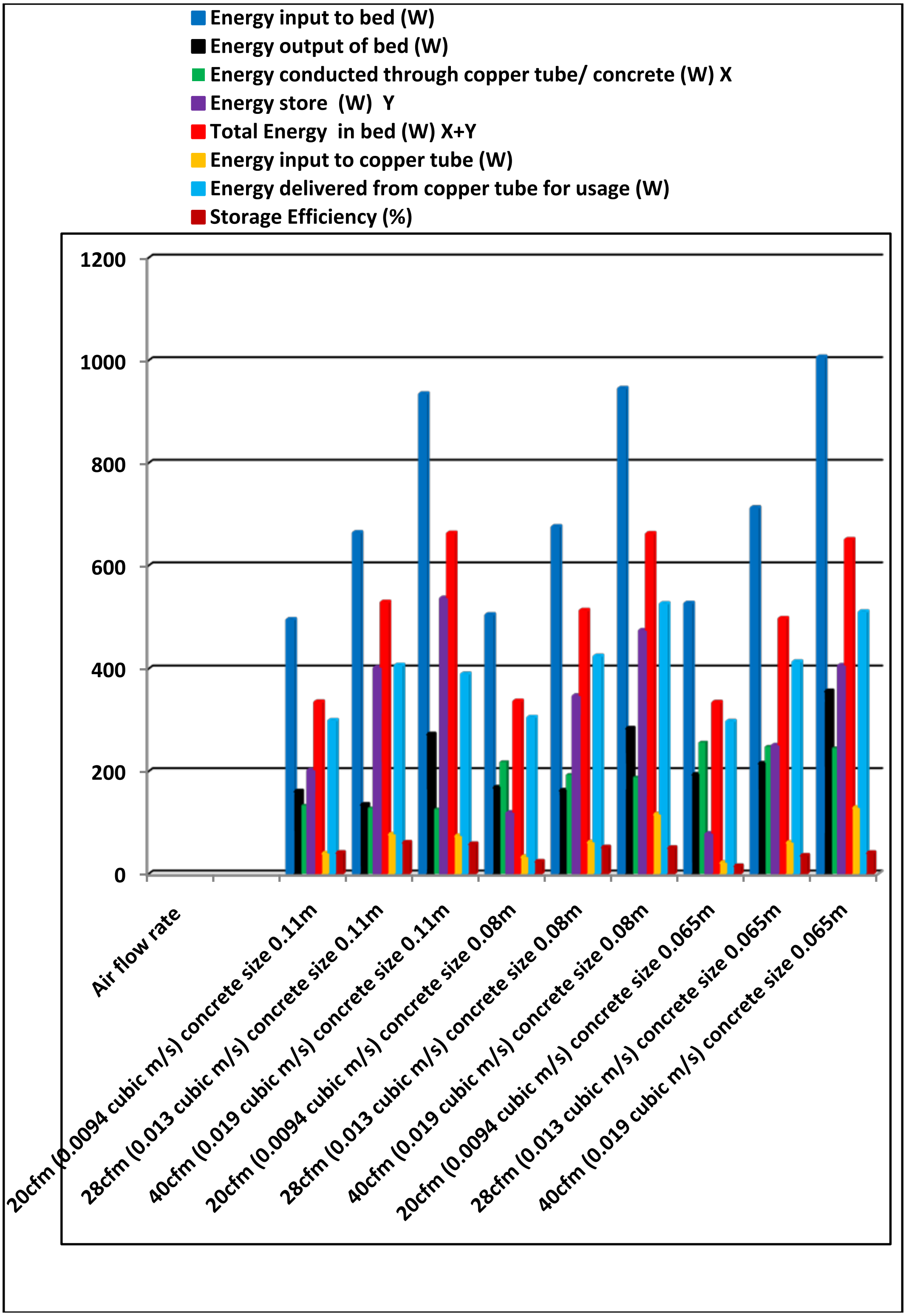

Figure 8.0 : Energy Analysis of Simultaneous Charging and Discharging Packed Bed Storage System for Spherical Shaped Concrete of diameter 0.065, 0.08, 0.11m and Air Flow Rate 0.0094, 0.013, and 0.019m^3/s

IV. Conclusion

Packed bed in a solar heating system does not operate with constant inlet temperature, during the day the variable solar radiation, ambient temperature, collector inlet temperature, load requirements, and other time-dependent conditions result in a variable collector outlet temperature and sinusoidal temperature discharged from the bed. This study further looks into converting this ntermittent solar radiation into continuous form.

Experiments were conducted on conventionally used thermal storage materials and concrete. Precast concrete showed to have superior thermal storage properties than natural stones. Research and laboratory testing on concrete showed that a mix 1: 1.2: 1.1 of cement, sharp-sand and limestone, respectively, plus 20g of 5cm length steel fibers exhibited a high thermal conductivity of 2.46 W/mK and storage capacity of 3.24 x 10^6 J/m^3 K.

Further experimental studies were carried out to investigate the thermal performance of simultaneous charging and discharging packed bed energy storage system and it was discovered that the energy analysis shows a positive results (i.e. energy input = energy output + storage)

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Economicheat Exchanger Is?

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Abstract- Heat exchanger is one of devices that are convenient in industrial and house hold application. These include power production, chemical industries, food industries, electronics, environmental engineering, manufacturing industry, and many others. It comes in many types and function according to its uses. So what exactly heat exchanger is? Heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluidat different temperatures and in thermal contact. There are usually no external heat and work interactions. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In this report I will discuss about the uses and application of shell and tube heat exchanger, type of heat exchangers, and shell and tube heat exchanger.

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Strictly as per the compliance and regulations of:

Economicheat Exchanger Is?

Alok Shukla [α] & Dr. Bhumendra Kumar [σ]

Abstract- Heat exchanger is one of devices that are convenient in industrial and house hold application. These include power production, chemical industries, food industries, electronics, environmental engineering, manufacturing industry, and many others. It comes in many types and function according to its uses. So what exactly heat exchanger is? Heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluidat different temperatures and in thermal contact. There are usually no external heat and work interactions. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In this report I will discuss about the uses and application of shell and tube heat exchanger, type of heat exchangers, and shell and tube heat exchanger.

I. Uses and Applications of Heat Exchanger

Heat exchangers are used to transfer heat from one media to another. It is most commonly used in space heating such as in the home, refrigeration, power plants and even in air conditioning. It is also used in the radiator in a car using an antifreeze engine cooling fluid. Heat exchangers are classified according to their flow arrangements where there are the parallel flow, and the counter flow. Aside from this, heat exchangers also have different types depending on their purpose and how that heat is exchanged.

But the fact is that there are heat exchangers even in the circulation system of fishes and whales. The veins of these animals are intertwined such that one side is carrying cold blood and the other has cold blood. As a result, these species can prevent heat loss especially when they are swimming in cold water. In some whales, the heat exchanger can be found in their tongues. When it comes to the manufacturing industry, heat exchangers are used both for cooling and heating. Heat exchangers in large scale industrial processes are usually custom made to suit the process, depending on the typeof fluid used, the phase, temperature, pressure, chemical composition and other thermodynamic properties. Heat exchangers mostly can be found in industries which produce a heat stream. In this case, heat exchangers usually circulate the output heat to put it as input by heating a different stream in the process. The fact that it really saves a lot of money because when the output heat no longer needed then it can be recycled rather than to come from an external source as heat is basically recycled. When used in industries and in the home, it can serve to lower energy costs as it helps recover wasted heat and recycle it for heating in another process. Typically, most heat exchangers use fluid to store heat and heat transfer can take the form of either absorption or dissipation. For instance, heat exchangers are used as oil coolers, transmission and engine coolers, boiler coolers, waste water heat recovery, condensers and evaporators in refrigeration systems. In residential homes, heat exchangers are used for floor heating, pool heating, snow and ice melting, domestic water heater, central, solar and geothermal heating. Of course, heat exchangers have different designs which depend on the purpose it is intended for. Brazed heat exchangers, a collection of plates which are brazed together, are used for hydronic systems like swimming pools, floor heating, snow an dice melting. The shell and coil heat exchanger design is best for areas with limited spaces as it can be installed vertically. Of course, for the highly industrial process, the shell and tube heat exchanger is the perfect solution.

II. Types of Heat Exchangers

In industries, there are lots of heat exchangers that can be seen. The types of heat exchanger can be classified in three major constructions which are tubular type, plate type and extended surface type.

a) *Tubular Heat Exchangers*

The tubular types are consists of circular tubes. One fluid flows inside the tubes and the other flows on the outside of the tubes. The parameters of the heat exchanger can be changed like the tube diameter, the number of pitch, tube arrangement, number of tubes and length of the tube can be manipulate. The common types of heat exchangers lie under these categories are double-pipe type, shell-and-tube type and spiral tube type. The tubular heat exchangers can be designed for high pressure relative to the environment and high pressure difference between the fluids. These exchangers are used for liquid-to-liquid and liquid-to-vapor phase. But when the operating temperature or pressure is very high or fouling on one fluid side, it will used gas-to-liquid and gas-to-gas heat transfer applications.

i. *Double-Pipe Heat Exchanger*

A double-pipe heat exchanger consists of smaller and larger diameter pipe where the smaller pipe

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fitted concentrically into the larger one in purpose to give direction to the flow from one section to another shown in Figure 1. One set of these tubes includes the fluid that has to be cooled or heated. The second fluid runs over the tubes being cooled or heated in order to provide heat or absorb the heat. A set of tubes is the tube bundle and it can be made up of several types of tubes such as longitudinally plain, longitudinally finned, and more. If the application requires an almost constant wall temperature, the fluids may flow in a parallel direction. It's easy to clean and convenient to disassemble and assemble. The double-pipe heat exchanger is one of the simplest. Usually, it is used for small capacity applications because it is so expensive on a cost per unit area basis.

Figure 1 : Double-Pipe Heat Exchanger

ii. *Shell-and-Tube Heat Exchanger*

This exchanger is built of a bundle of round tubes mounted in a large cylindrical shell with the tube axis parallel to the shell to transfer the heat between the two fluids shown in Figure 2.The fluid flows inside the tubes and other fluid flows across and along the tubes. But for baffled shell-and-tube heat exchanger the shell side stream flows across between pairs of baffles and then flows parallel to the tubes as it flows from one baffle compartment tothe next. This kind of exchanger consists of tubes, shells, and front-end head, rear-end head, baffles and tube sheets. The different type of Shell-and-tube heat exchangers depend on different application. Usually in chemical industry and process application, it is used asoil-coolers, power condensers, preheaters in power plants and also steam generators in nuclear power plants. The most common types of shell-and-tube heat exchanger are fixed tube sheet design, U-tube design and floating-head type. Cleaning this heat exchanger is easy. Instead of easily cleaning, it is also low in cost. But among all tube bundle types, the U-tube is the least expensive because it only needs one tube sheet. Technically, because of its construction in U shape, the cleaning is hardly done in the sharp bend. An even number of tube passes only can be achieved.

Figure 2 : Shell-and-Tube Heat Exchanger

iii. *Spiral-Tube Heat Exchanger*

A spiral heat exchanger is a helical or coiled tube configuration shown in Figure 3. It consists of spirally wound coils placed in a shell or designed as co-axial condensers and co-axial evaporators that are used in refrigeration systems. The heat transfer coefficient is higher in a spiral tube than in a straight tube. Since the cleaning is impossible, the spiral tubes are suitable for thermal expansion and clean fluids. The biggest advantage of the spiral heat exchanger is its efficient use of space. A compact spiral heat exchanger can lower costs, while an oversized one can have less pressure drop, higher thermal efficiency, less pumping energy, and lower energy costs. Spiral heat exchangers are frequently used when heating fluids that have solids and therefore often foul the inside of the heat exchanger. Spiral heat exchangers have three types of flow arrangements.

Firstly, the spiral flow and cross flow has one fluid in each. The spiral flow passages are welded at each side and this type of flow is good for handling low density gases which pass-through the cross flow. This can be used for liquid-to-liquid applications if one fluid has a much greater flow rate than the other. A second type is the distributed vapor and spiral flow. The coolant moves in a spiral and exits through the top. The hot gases that enter will leave as condensate out of the bottom outlet. The third type is the counter current flow where both of the fluids will flow in opposite directions and are used for liquid-to-liquid applications. The spiral heat exchanger is good for pasteurization, heat recovery, digester heating, effluent cooling, and pre-heating.

Figure 3 : Spiral-Tube Heat Exchanger

b) Plate Heat Exchangers

A second type of heat exchanger is a plate heat exchanger. It has many thin plates that are slightly apart and have very large surface areas and fluid flow passages that are good for heat transfer. This can be a more effective heat exchanger than the tube or shell heat exchanger due to advances in brazing and gasket technology that have made this plate exchanger more practical. Large heat exchangers are called plate and frame heat exchangers and there allow for periodic disassembly, cleaning, and inspection. There are several types of permanently bonded plate heat exchangers like dip brazed and vacuum brazed plate varieties, and they are often used in refrigeration. These heat exchangers can further be classified as gasketed plate, spiral plate and lamella.

i. *Gasketed Plate Heat Exchangers*

A gasketed plate heat exchanger consists of a series of thin plates that have wavy surface which function as separating the fluids shown in Figure 4. The plates come with corner parts arranged so that the two media between which heat is to be exchanged flow through interchange exclaim spaces. Appropriate design and gas keting permit a stack of plates to be held together by compression bolts joining the end plates. Gaskets prevent leakage to the outside and direct the fluids in the plates as desired. The flow patern is generally chosen so that the media flow countercurrent to each other. Since the flow passages are quite small, strong eddying gives high heat transfer coefficients, high pressure drops, and high local shear which minimizes fouling. These exchangers provide a relatively compact and lightweight heat transfer surface. Gas keted plate is typically used for heat exchange between two liquid streams. This type can be found in food processing industries because of the compatibility to be cleaned easily and sterilized as it completely disassembled.

Figure 4 : Gasketed Plate Heat Exchangers

ii. *Spiral Plate Heat Exchanger*

Spiral heat exchangers are formed by rolling two long, parallel plates into a spiral using a mandrel and welding the edges of adjacent plates to form channels shown in Figure 5. The distance between the metal surfaces in both channels is maintained by means of distance pins welded to the metal sheet. The two spiral paths introduce a secondary flow, increasing the heat transfer and reducing fouling deposits. These heat exchangers are quite compact but are relatively expensive due to the specialized fabrication. The spiral heat exchanger is particularly effective in handling sludge's, viscous liquids, and liquids with solids in suspension including slurries. The spiral heat exchanger is made in three main types which differ in the connections and flow arrangements. Type has flat covers over the spiral channels. The media flow countercurrent through the channels via the connections in the center and at the periphery. This type is used to exchange heat between media without phase changes such as liquid-liquid, gas-liquid, or gas-gas. One stream enters at the center of the unit and flows from inside outward. The other stream enters at the periphery and flows towards the center. Thus the counter flow is achieved. Type is designed for cross flow operation. One channel is completely seal-welded, while the other is open along both sheet metal edges. The passage with the medium in spiral flow is welded shut on each side, and the medium in cross flow passes through the open spiral annulus. This type is mainly used as a surface condenser in evaporating plants. It is also highly effective as a vaporizer. Two spiral bodies are often built into the same jacket and are mounted below each other. Type, the third standard type is in principle similar to type with alternately welded up channels, but type is provided with a specially designed to cover. This type of heat exchanger is mainly intended for condensing vapors with sub-cooling of condensate and no condensable gases. The top cover, therefore, has a special distribution cone where the vapor is distributed to the uncovered spiral turns in order to maintain a constant vapor velocity along the channel opening.

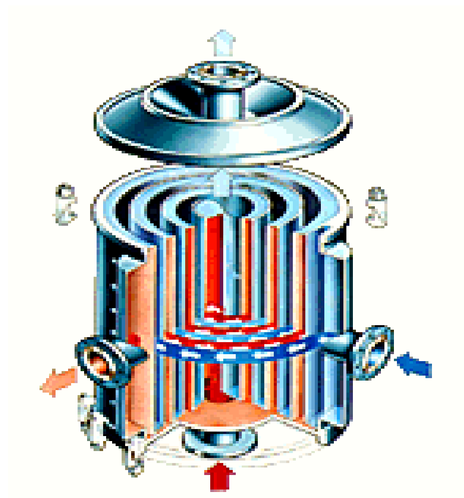


Figure 5 : Spiral Plate Heat Exchanger

iii. *Lamella Heat Exchangers*

The lamella type of heat exchanger consists of a set of parallel, welded, thin plates channels are lamellae placed longitudinally in a shell. It is a modification of the floating-type shell-and-tube heat exchanger. These flattened tubes, called lamellae are made up of two strips of plates, profiled and spot- or seam-welded together in a continuous operation. The forming of the strips creates space inside the lamella and bosses acting as spacers for the flow sections outside the lamellae on the shell side. The lamellae are welded together at both ends by joining the ends with steel bars in between, depending on the space required between lamellae. Both ends of the lamella bundle are joined by peripheral welds to the channel cover which at the outer ends is welded to the inlet and outlet nozzle. The lamella side thus completely sealed in by welds. At the fixed end, the channel cover is equipped with an outside flange ring which is bolted to the shell flange.

III. Design Considerations

For most economic small and simple units operating at moderate pressure and temperatures. Standard heat exchanger designs may be used for industrial applications, individually designed units may be required for a large variety of applications, the criteria for optimization depends on the minimum weight, minimum volume of heat transfer surface, minimum initial cost, minimum operating cost, maximum heat transfer rate, minimum pressure drop for a specified heat transfer rate, minimum mean temperature difference, and so on. The initial step in the optimization process is the solution of the rating and the sizing problems.

The rating problem is concerned with the determination of the heat transfer rate, the outlet temperature and the pressure drop on each side. The following quantities are generally specified in the rating problems: type of heat exchanger, surface geometries, flow arrangement flow rates, inlet temperatures and the overall dimensions of the matrix.

The sizing problems is concerned with the determination of the matrix dimensions to meet the specified heat transfer and pressure drop requirements. The designer's task is to select the type of construction, flow arrangements and surface geometries on both sides. The following quantities are generally specified fluid inlet and outlet temperatures, fluid pressure drops, and heat transfer rate.

Apart from the heat transfer requirements an important consideration in the heat exchanger design, as cited earlier, is the pressure drop or pumping power. The size of the heat exchanger can be reduced by forcing the fluids through it at higher velocities there by increasing the overall heat transfer coefficient. But higher velocities will result in large pressure drops (∞u^2) and so large pumping costs. For a given flow rate, the smaller diameter pipe may involve less initial cost but higher operating or pumping cost. For an incompressible fluid, $\Delta P_{\infty}\, m^2$ and pumping power $\alpha\, \dot{m}^3$, where $\dot{m}$is the pumping cost increases considerably with higher velocity a compromise between the large overall heat transfer coefficient and the corresponding velocities will have be made. The cost of the materials and the floor space occupied by the heat exchanger may impose limitation on the physical size of the heat exchanger.

IV. Selection of heat Exchanger

The proper selection depends on several factors as explain below.

1. *Heat Transfer Rate:* This is most important quantity. A heat exchanger should be capable of transferring heat at the specified rate in order to achieve the desired temperature change of the fluid at the specified mass flow rate.
2. *Cost:* Budgetary limitation often restricts the selection of the heat exchanger. An off-the-self heat exchanger has a definite cost advantage over those made to order. However, in many cases, the standard available heat exchanger is not satisfactory. It is then needed to undertake the expensive and time-consuming task of designing and manufacturing a heat exchanger from scratch to suit the needs. The operation and maintenance cost of the heat exchanger are also required to consider for assessing the overall cost.
3. *Pumping Power:* In a heat exchanger, both fluids are usually forced to flow by pumps or fans that consume electrical power. The annual cost of electricity associated with the operation of the pumps and fans can be determined from

Operating cost = {Pumping power, kW X Hours of operation, h X Price of electricity, Rs. /kWh]

Where the pumping power is the total electricity consumed by the motors of the pumps and fans.Minimizing the pressure drop and the mass flow rate of the fluids will minimize the operating cost of the heat exchanger, but it will maximize the size of the heat exchanger and thus the initial cost.

1. *Size and weight:* Normally, the smaller and lighter the heat exchanger, the better it. Important consideration factor is space availability
2. *Type:* The type of heat exchanger to be selected depends primarily on the type of the fluids involved, the size and weight limitations, and the presence of phase-change process. A heat exchanger is suitable to cool a liquid by a gas. On the other hand, a plate or shell-and-tube heat exchanger is very suitable for cooling a liquid by another liquid.
3. *Materials:* The materials used in the construction of the heat exchanger have an important effect on the selection. The thermal and structural stress effects need not be considered at pressure below 15 atmosphere or temperature below 150°C. Differential thermal expansion problems need be considered be it a temperature difference of 50°C or more exists the tubes and the shell.
4. *Other Considerations:* Heat exchanger should be leak-tight particularly for toxic or expensive fluids. There should be ease of servicing, low maintenance cost, safety, reliability and silence in operation.

V. Observation

a) Material appearance

Copper : Red in appearance
Brass : Yellow in appearance
SS : White in appearance
MS : Black in appearance

b) Dimensions conversion

1”	25.4 mm
1cm	10 mm
1ft	304mm

c) Copper & Copper Alloy Tubes

Condition: Half hard / Annealed / Hard.
Coil form straight in length)
Standard: BS: 2871, C101 copper,
CZ 111 Admirable Brass IS: 1545
Theoreticalwt.:$[0.785\ X\ (OD^2 - ID^2)X\ \rho\ X\ L\ X\ Qty]/1000$
(OD & ID in mm,$\rho = 8.96\ kg/cm^2$, L in mm)
Visual check: Surface marks/ pitting, cracks, Dent, Ovality.
Dimensional: OD, thickness range, length range, Qty.,
Weight (Weight = Actual / Theoretical)
Spectro Analysis

d) MS plate

Make: Bhilai /Bokaro / Rourkela / Jindal
Quality: Prime / Test / Boiler Quality
Theoretical wt. : $[L\ X\ B\ X\ thickness\ X\ \rho]$
(L & B in m,$\rho = 7.86\ kg/cm^2$, thickness in mm)
Standard: IS: 2062, SA: 285 Gr C, SA: 515 Gr 60/70, SA: 516 Cr 60/70 or any other.
Visual check: a) Edge should be perpendicular each other.
b) Corner Rounded: Not Accepted
Rectangular: Accepted
c) Pitting / Lamination: Not Accepted
d) Fatness of plate ± 1: Accepted
e) Plate should be radish and not bluish in color.
(Indicated proper heat treatment)
Dimensional: Thickness range, length range, Width, Qty.,
Weight (Weight = Actual / Theoretical)

e) Expanding Tool

- Make, Model No., Tube OD, Thickness, Hole size, Expanding length.
- Make, Model No., Min & Max dia. of the cage when in and out respectively.
Spare Mandrel – Model No.
Spare Roller set – Model No.

f) Electric Motor

Make: H.P., Phase, RPM, voltage, frequency, and insulation
Type: squirrel cage.
Visual check: a) Dent on fan cover.
b) Crack on motor pedestal.
c) Smoothness of rotation of shaft.

Name plate marking: Motor S. No., Installation, H.P., frequency, volts, RPM.
Test certificate enclosed or not.
Verify: RPM,
No load current - a) R
b) Y
c) B
No load voltage – a) RY
b) RB
c) YB

g) MS, ERW Pipes

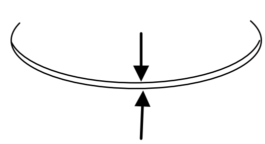
NB/OD, Thickness: mm / class / light / medium / heavy
Length & Qty.:
Make:Jaindal& Tata
Inspection: a) Pitting below black painting
b) Dents
c) Cracks
d) Ovality
Dimension: OD, thickness, L, Qty.
Marking: up to 6” NB Hot stamping and beyond paint marking.

h) Dished End

Shape: Tori Spherical / Elliptical / Hemispherical.
(NB /OD), thickness, straight face, Knuckle radius, crown radius,
wt. / piece, Quantity
Standard: Plate confirming to MS (IS: 2062) / Boiler Quality (IS: 2002)
Visual check: a) No pitting, hammer mark also: Not Accepted
b) Crinkle: Not Accepted
c) Cracks: Not Accepted
Tolerances:-

a) On crown radius

a) 1.2% of ID Over dishingshown in Figure 6.

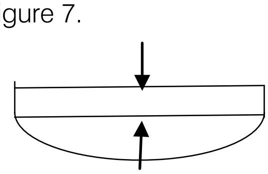


Gap between require and actual = 1.25% of ID

Figure 6 : Over dishing

b) ½ % of

b) ID under dishing shown in Figure 7.



Under dishing

Figure 7 : Under dishing

Knuckle radius = Nil
Weight: Actual / Theoretical

i) HP sheet

Make:
Dimension: Length, Width, thickness, Qty.
Visual check: a) Edge should be perpendicular: Not Accepted
b) Pitting / Lamination: Not Accepted
c) Waviness on the sheet: Not Accepted

j) Integral Finned Tube

Dimension: OD, thickness, Length, Qty., Material, Plain end (L) on each side,
No. of fins/inch
Condition: Hard / Half Hard / Annealed
Standard: BS: 2871 Pt. -3,
Theoretical wt.:$[0.785\ X\ (OD^2 - ID^2)X\ \rho\ X\ L\ X\ Qty]/1000$
Fin depth – 19/26
Visual check: a) Fins have to be formed and the material is not to be remove from the surface.
b) Size of OD is not exceed tube any case.
c) Groove depth
d) Dent
e) Surface cracks, pitting
f) Ovality

k) S.S. Plates Circles

Dimension: OD, thickness, Qty.
Theoretical wt .:$[0.785\ X\ (OD^2)X\ \rho\ X\ L\ X\ Qty]/1000$
Visual check: a) Surface flat width in 1mm
b) Gas cut edges should be perpendicular with in 2mm.
c) Manufactures test certificate required along with supply.
d) Weight
Spectro analysis

l) Working fluid with compatible materials

Working Fluid	Temperature	Compatible Materials
Water	50°C – 200°C	Copper
Freon	Up to 50°C	Aluminum
Diphenyle oxide	Up to 300°C	Steel
Organic fluid	Up to 300°C	Steel
Liquid metals like sodium	Up to 600°C	Stainless steel
Liquid oxygen	-200°C	Cryogenic
Liquid nitrogen	-200°C	Cryogenic
Niobium	Up to 1500°C	Inconel or refractory
Tantalum	Up to 1500°C	Inconel or refractory

An alternate to refractory metals is ceramic tubing. Ceramic such as silicon carbide and alumina have excellent corrosion and erosion resistance. Working fluid can be nontoxic, non-corrosive, less viscous, high surface tension of high latent heat and chemically compatible with the heat exchanger.

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A Mechanism Concept and Design of Reconfigurable Robot for Rescue Operation

By Md. Nasir Uddin, Md Ahbabur Rahman, M. M. Rashid, N A Nithe & JI Rony

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Abstract- There seem to be a lot of robots that have been built up until today. Basically, the creation of robot is supposed to be a helper for a human. Robot will replace human whenever the task is really difficult or dangerous to be done by human. Recently, the robots that have been created were made reconfigurable. The purpose is to make the robot to function in more type of surroundings rather than only one surrounding. With this ability, the robot can be more useful to human, and less number of robot is required to complete a certain task. This report emphasizes on the reconfigurable robot project, where in this report, the robot that has been created is using the walking motion. It presents a description with pictures and construction drawings of a four-leg reconfigurable robot.

Keywords: robot, mechanism, reconfigurable, rescue, controller.

GJRE-A Classification : *FOR Code: 091399*

AMECHANISMCONCEPTANDDESIGNOFRECONFIGURABLEROBOTFORRESCUEOPERATION

Strictly as per the compliance and regulations of:

A Mechanism Concept and Design of Reconfigurable Robot for Rescue Operation

Md. Nasir Uddin α, Md Ahbabur Rahman σ, M. M. Rashid ρ, N A Nithe ω & Jl Rony¥

Abstract- There seem to be a lot of robots that have been built up until today. Basically, the creation of robot is supposed to be a helper for a human. Robot will replace human whenever the task is really difficult or dangerous to be done by human. Recently, the robots that have been created were made reconfigurable. The purpose is to make the robot to function in more type of surroundings rather than only one surrounding. With this ability, the robot can be more useful to human, and less number of robot is required to complete a certain task. This report emphasizes on the reconfigurable robot project, where in this report, the robot that has been created is using the walking motion. It presents a description with pictures and construction drawings of a four-leg reconfigurable robot.

Keywords: robot, mechanism, reconfigurable, rescue, controller.

I. Overview

It is believed that a mechanism must be designed with a cosistent structure and invariant functions during operation. However, as the knowledge for mechanism design was surprisingly promoted in the past century and new design ideas are continuously evolutionary and born, people started to realize that a mechanism may be elegantly structured so that its configuration can be manipulated. The manipulation should be with multiple operation modes in order to collectively fulfil multiple tasks based on a sole mechanism. Because of the problem faced, people start to search to another alternatives, and the alternatives lead to creation of robot which can be reconfigured to adjust itself to suit to the environment. Such mechanism, which can change its configuration during operation, is normally so-called the reconfigurable mechanism.One of the objectives in the field of mobile robot is so that it can replace man to achieve a task whenever man are not capable of doing it. The building systems of a robot are created to operate in natural environment which are dramatic, unstructured and hazardous, which is very difficult for human. Nowadays, the reconfigurable mechanism have caught so many attention among people. It has also found excellent applications in various industries [1-3].

The study on reconfigurable mechanisms especially in structural design and kinematics has not been noticed even until the middle 1990s. From then on, some pioneering researches were started to surface.

After that, the attentions onto this topic gradually increase. Until today, the results of its relevant work have show progressing succesful work around this new mechanism concept.

Several new studies such as kinematotropic linkage, metamorphic mechanisms, mechanism with variable chains, and etc are leading the reconfigurable mechanism studies into a new level.

According to Merriam-Webster Dictionary, "configuration" is defined as "relative arrangement of parts or elements." Basically, the configuration looks at the relative arrangement. The relative arrangement that we discuss may be relative distance, relative angle, relative position, etc. The "parts or elements" are the links and joints of the mechanism and the "relative arrangement" are the relative positions, or further the relative motions, among the links and joints. Since the movement of the mechanism is depend not only by the arrangement of the joints but also their kinematic types, the configuration of the mechanism is described together by geometric arrangement and the kinematic types of its all kinematic joints [1-5].

a) Reconfigurable to robots

In our times today, we can see a lot of handful of commercially available mobile robots, wether used in industry factory, house, or for research in the laboratory. Most of all cases, the robot get around on wheels, or perhaps tracks. For example, the remote-controlled bomb disposal robot. It cannot be denied that the wheels are definitely the most sensible choice for the environments that these robots run in. Wheels are very easy to control since it act predictably given a flat surface to run on. Other than cheap in cost, the power systems behind the locomotion are very well developed and understood. Besides, the wheel's speed can be easily configured just by controlling the amount of torque applied to the shaft connected to the wheels. Thus, it can make the robot to run faster[3-6].

However, wheels may not fully function in some cases. There are environments in which wheels become useless such as getting up to stairs. Although today's large buildings that have uses for robot have uses lift to accomodate the robot, it is not practical to implement it to the outside world. Some estimates suggest that half

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of the earth's surface is presently inaccessible to wheeled vehicles[4-6].

Thus, engineers take the idea of using the walking leg as another alternatives to overcome this problem. Plus, the legs can be reconfigured to adjust itself to the environment. It is quiet difficult for a wheeled robot to suddenly change the tyres to a different direction compared to walking leg robot[5].

b) History

Starting from 1960's, most of legged machines have used a degree of computer control. Since its advent, this system technique has become greatly compacted and also be applied to the small machine.

Table 1 : Research issue concerning reconfigurable robot

Research issue concerning self reconfigurable robot	
The part and the whole diversity	Self-similar structure, boundary of a system, flexibility, multifunctionality; adaptable to change according to environment.
Morphogenesis	Logic of growth from homogeneity to heterogeneity; computational complexity
Robustness	Self-repair, graceful degradation, scalability
Self-reproduction evolution	Driving force of evolution, novel method of production co-evolution betweenmorphology and motion; acceleration of evolution
System architechture	Centralized/decentralized, homogeneous/heterogenous, local/global communication

The idea of building systems by homogeneous components comes from von Neumann's "Theory of self reproducing cellular automata". His model assumes complete homogeneity of initial modules. This is an analogy to biological systems. In the system, the cell division from a single cell after fertilization produce the differentiated cells. However, the biological system has it's own weakness as it need a large number of cells in order to form their bodies[4-7].

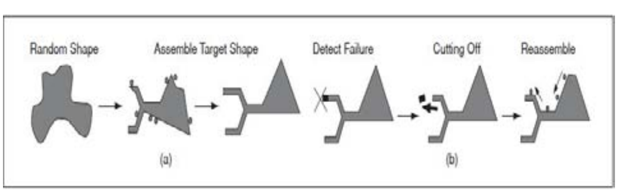


Figure 1.1 : shows self-assembly and self-repair. (N.Inou etal, 2003)

In 1988, a robot called CEBOT (Fukuda etal, 1990) was created and this is the first self-reconfigurable robot designed based on heterogenous components. It is composed of several different module. The module include transportation, rotational joint, telescopic arm, and grasping modules. Because of these modules combination, the CEBOT was able to perform a lot of different tasks[3].

Following the heterogeneous module, the study of reconfigurable robot with homogeneous module takes place. In the homogeneous system, all the modules are identical. A set of common rules should sufficiently describe the differentiation and behaviour of each module. Any module can be replaced with another module as soon as this is realized. This property makes the self-repair and self-reproduction schemes become easier.

c) Problem statement

People nowadays normally use a lot of help from the robot to do something that they cannot do by themselves. A lot of robot that we see in the market today have their own programme to do a task, but ufortunately every robot have their own limitation. As we can see today, the normal robot may be able to move into a certain direction only. Most of them cannot adapt to sudden change in environment. Whenever the surrounding change, such as from a floor to the staircase, the robot will become completely useless. In the end, people need to replace that robot with another robot that is built only for that task. This makes the time taken to complete the task become very slow. It such a waste of timeand a bit tiring.

d) Objectives

This paper approach four central challenges-

To develop a robot that will be able to reconfigure if it stuck in a changed environment. To design the mechanical system for the robot. To design the control system so that the robot can move efficiently without any problem. To test the performance of the robot.

II. Introduction

Reconfigurable robot is a robot where it can modify their shape and size in order to accomplish difficult mission. This capability is very desireble in many tasks. Such reconfigurable robot is very useful to overcome obstacles during doing the task. Reconfigurable robots offer a new approach in robotics.

The applications can be applied in many areas such as urban search and rescue, military reconnaisance and civil exploration [5-7].

This late few years, considerable progress has been made in the field of reconfigurable robotic systems. Normally, it would compromise with several segments that are connected with joint. The kinematic modes that we commonly see are multiple legs, wheeled and chain-track vehicle. According to study, the robot with multiple legs kinematic is less adapted compared to wheeled and chain-track vehicle robot. The multiple legs was said to be too complex since the structure has so many degree of freedom. Robots with wheeled and chain-track vehicle are usually portable since the adaptability to unstructured environment is high[6].

Usually for reconfigurable robot with multiple legs, the robots are facbricated based on modularity. Modularity consists of any number of identical interconnected units or modules. This system have advantages in term of manufacturing and robustness because of their homogeneity and redundancy. However in this type of kinematics, there are many degree of freedom (D.O.F) which make it complex and difficult to build. For example, a 14 degree of freedom (D.O.F) reconfigurable manipulator robot has been developed as a part of the Dockwelder EU project to perform in ship manufacturing industry.

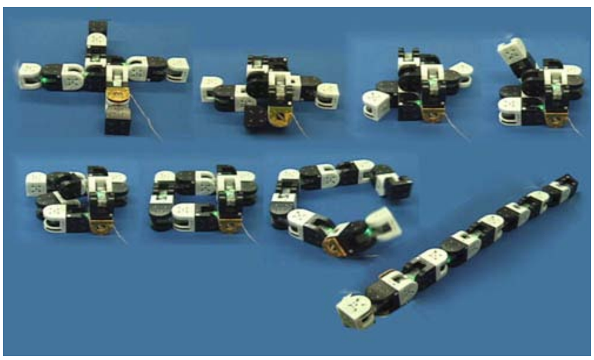
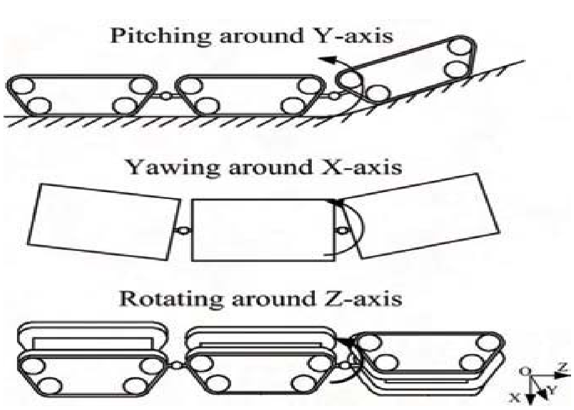


Figure 2.1: Picture of modular reconfigurable robot.



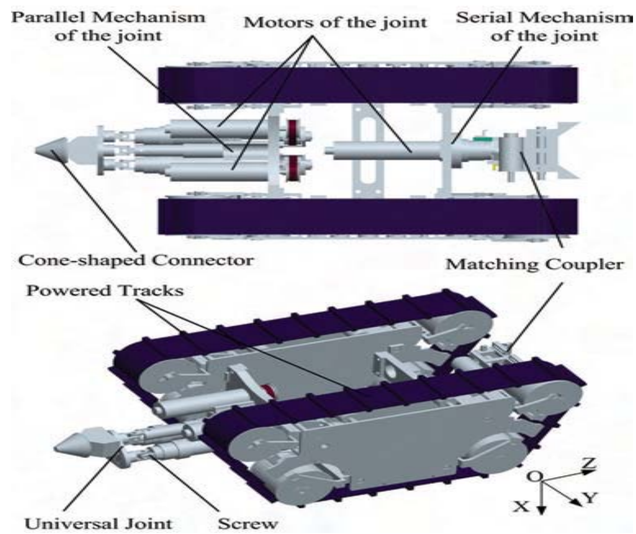


Figure 2.3 : Picture of wheel and chain-track vehicle

Nowadays, we can see a lot of robots designed by engineers to make it walk with four legs and even six legs.

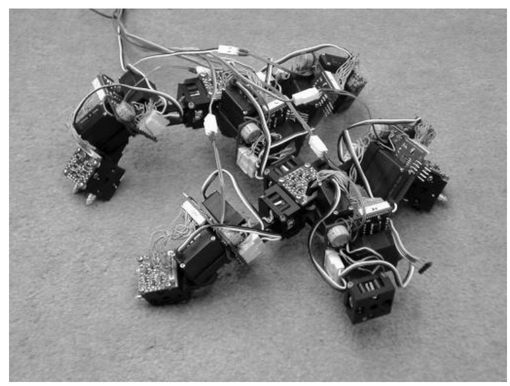


Figure 2.4 : Multi legs Robot

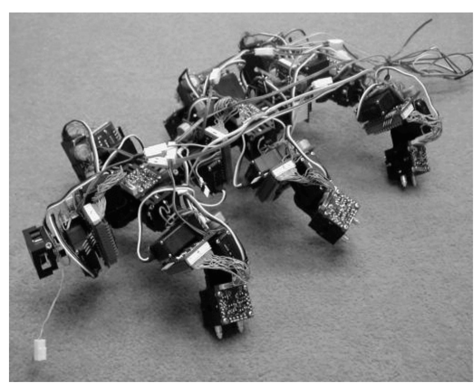


Figure 2.5 : Multi legs Robot

However, there are not much on focusing the reconfigurable legs. The objectives of this project is to improve the capability of the robots by making the legs of the robot to be adjustable according to the environment. The motor plays important role to realize this objective.

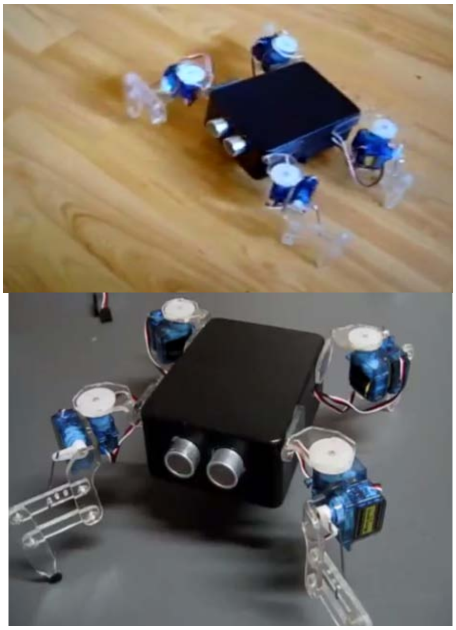


Figure 2.6 : Four legsrobot

This paper emphasizes the reconfigurable robot with four legs. It would not be complex enough since it will have several degree of freedom only. Each of the leg contain two link which will be connected through a servo motor. The principal of the movement of this robot is simple enough to understand. The servo motor will act as a joint and the movement of the legs will be based on the servo motor rotation or translation move.

Figure 2.7 : Servo motor

a) *A chronological development of self reconfigurable robot*

i. *Cebot (1988)*

CEBOT is the first modular self- reconfigurable robot that have been ever created in history. The modules were considered cellular in structure[7].

ii. *Fracta (1994)*

This robot (Murata etal,1994) is capable of reconfiguration, transportation in 2 dimensions, and self-repair[8,9].

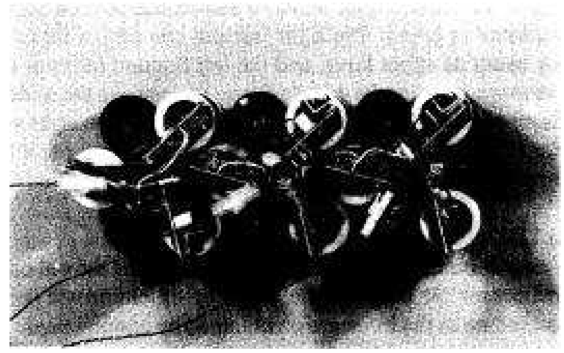


Figure 2.8 : Fracta modules

iii. *Metamorphic (1996)*

Metamorphic robots (Pamecha etal, 1996)are homogenous, 2 dimensional, and lattice-based reconfigurable robots. It has square or hexagon-shaped modules. Figure below illustrated the metamorphic robot.

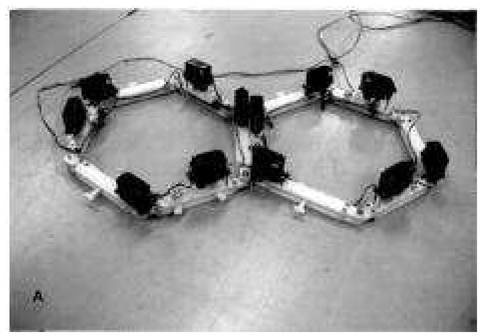


Figure 2.9 : Metamorphic robot with hexagon-shaped

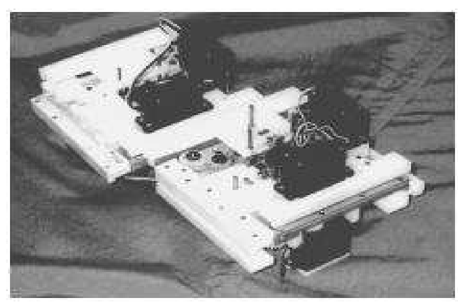


Figure 2.10 : Metamorphic robot with square-shaped

iv. *3D-Unit (1998)*

3D-Unit (Murata etal,1998) is the first robot 3 dimensional robot that have been prototyped. The shape is taken from common hexagon-based. The modules are homogeneous type. They can change their local connection, communicate with neighbours, and process information. The figure below shows the illustration of the robot[9].

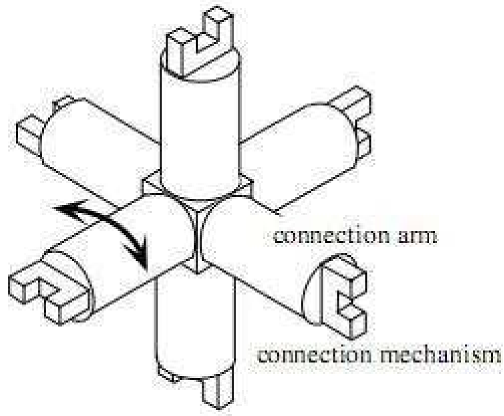


Figure 2.11 : 3D-Unit module

v. *Molecule (1998)*

The Molecule (McGray etal, 1998) is a robot based on 3D lattice. The modules comprised of two atoms connected by a bond while the modules are connected by electromagnets. Figure below shows the picture of molecule robot that was created[10,11].

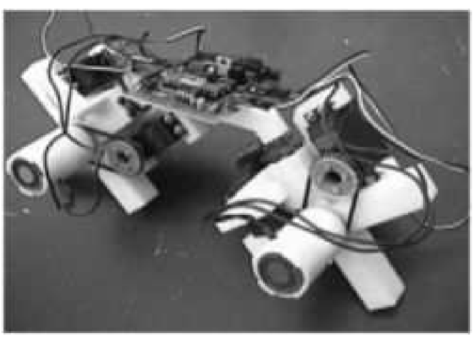


Figure 2.12 : Molecule robot

vi. *Vertical (1998)*

This robot (Hosokawa etal,1998)has climbing stairs-like structures and have a capability to reconfigure against gravity. This robot also has potential to be used as to build a bridge structure for transporting cargo across a gap. There were four prototype modules that have been built[11-13].

vii. *I-Cubes (1999)*

As we can see in the figure below, these type of robots (Unsal etal,1999)consist of active link and passive cube. The cubes can be rotated, translated simultaneously in two direction, and also act as pivot joint for a moving link. These type of robots are very ptential to move over obstacles, climb stairs, traverse through tunnels and pipes, manipulate objects, formbridges and towers, and be utilized for space applications [12-14].

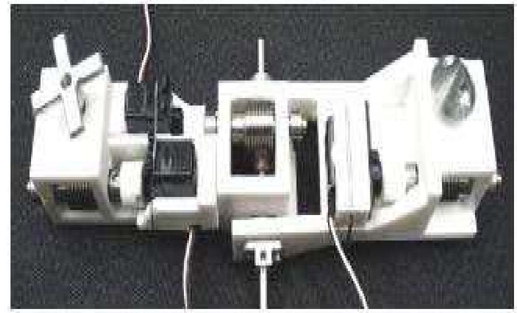


Figure 2.13 : I-cube link structure(Murata etal, 1998)

viii. *Crystalline (2000)*

Crystalline robots (Rus etal, 2000)are homogeneous square modules. Similar to muscles, this type of robot perform locomotion using expansion and contraction movements. Using a key and lock (channel) mechanism, the connection between the modules can be performed[14].

ix. *Polybot (2000)*

This robot, polybot (Yim etal, 2000) was built from a chain structure consisting of segment and node modules. The structure make the robot capable of several types of locomotions, including rolling, earthworm motion, and spider-like motion.

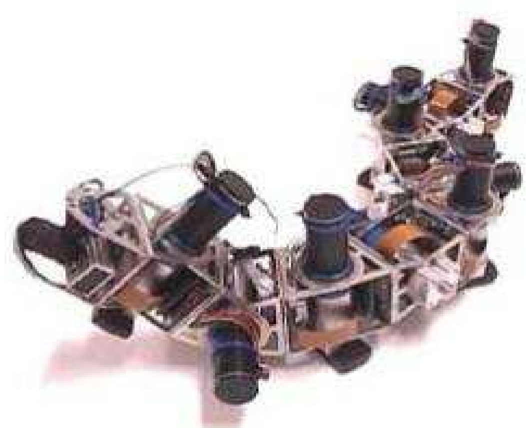


Figure 2.14 : Polybot modules in a snake-like structure

x. *Conro (2000)*

The name CONRO was taken from the (CONfigurable RObot)(Castano etal, 2000). The modules are self-sufficient, homogenous, autonomus, three-dimensional, and form into chain-like structures.

The modules are connected by using a pin/hole mechanism[13-15].

xi. *Pneumatic (2002)*

The pneumatic (Inou etal, 2002) was inspired by animals such as worms and caterpillars with hydrostatic skeleton. The pneumatic modules are homgeneous, cubic-shaped structures with pneumatic actuators consisting of flexible bellows[15-20].

xii. *Telecubes (2002)*

This type of robot (Vassilvitskii, 2002) perform motion by expanding and contracting the sides of the cube. Permanent switching magnet is used for the connection mechanism[14-17].

xiii. *Chobie (2003)*

This robot, Chobie (Koseki etal, 2004) can reconfigure by means of slide motion and successive cooperative movements. This robot is potential in cooperative transportation, collection, and construction [15-18].

xiv. *Deformatron (2006)*

It is a homogeneous 3D modular robot (Stoy, 2006)with modules. The modules can form in two structures which are rigid lattice and flexible chain. This robot has limitations which are no communication between modules and the modules do not contain power source. Therefore, it need to be controlled externally[15,16].

xv. *Odin (2007)*

It is a hierarchical lattice-based robot (Stoy etal, 2007). It is built with two different types of modules which are cylinder-shaped and sphere-shaped. The link modules are able to communicate with neighbours, performing computation, and power sharing among modules[16,17].

xvi. *Morpho (2008)*

Morpho robot is based on deformation and transegrity model of cellular structure. The cells exert expansion and contraction forces on the entire structure. There are four types of modules where this robot can be assembled. They are active link, passive link, surface membrane, and interfacing cubes[18].

xvii. *Anatomy-based catomns (2008)*

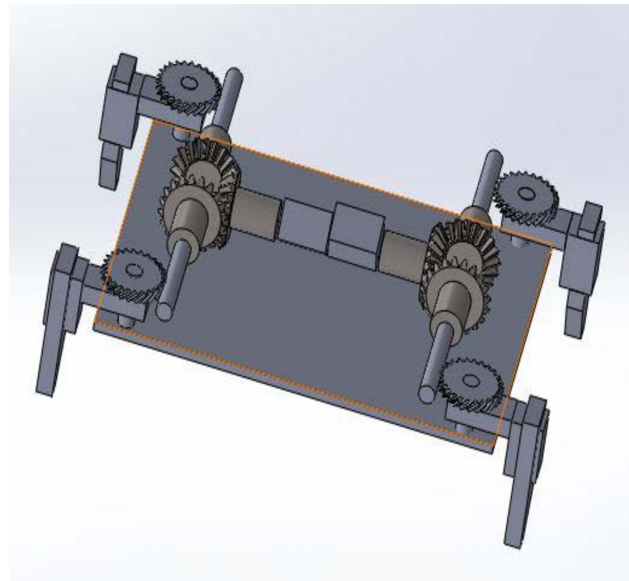
The claytronics project (Goldstein etal, 2004) is an inspiration for this anatomy-based catomns (Christensen D.J., 2008) robot being built. Truthfully, this type of robot has not been physically created yet. However, several promising simulations have been done using Open Dynamics Engine. This type of robot is expected to be able to performing computation, sensing points of contact with neighbours, sensing the gravity direction and local actuation. This robot can assemble a muscle-actuated arm, and grasping objects by using whisker feedback [17-20].

xviii. *Swarmorph (2009)*

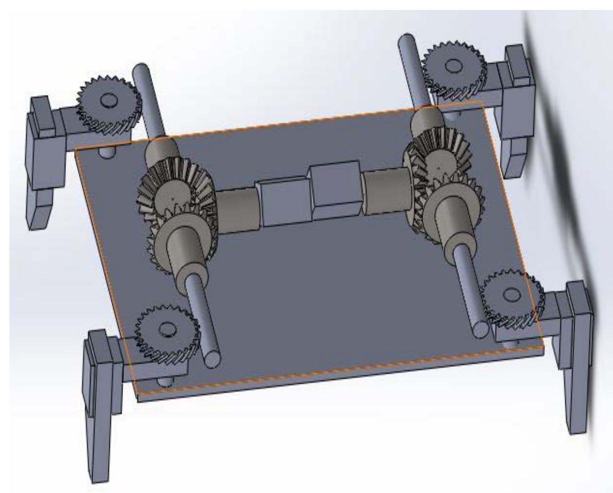
The SWARMORPH (O'Grady etal, 2009) project involves the development of a distributed scheme forgenerating morphologies using autonomous self-assembling mobile robots[18,19].

This technique is applied to the swarmrobot (s-bot) platform. However, there is a limitation of this self-assembling mobile robots. There is little control over the structure of the formed robot assembly. This work proposes a mechanism for control of the growth of morphological structures based on self-assembly. One by one, individual robots connect to the forming assembly.

III. Drawing of the Robot

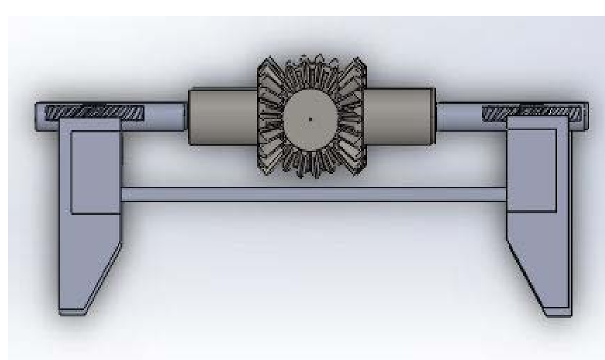


(a)



(b)

Figure 3.1 : (a) and (b) show thethe 3D robot design in solidworks



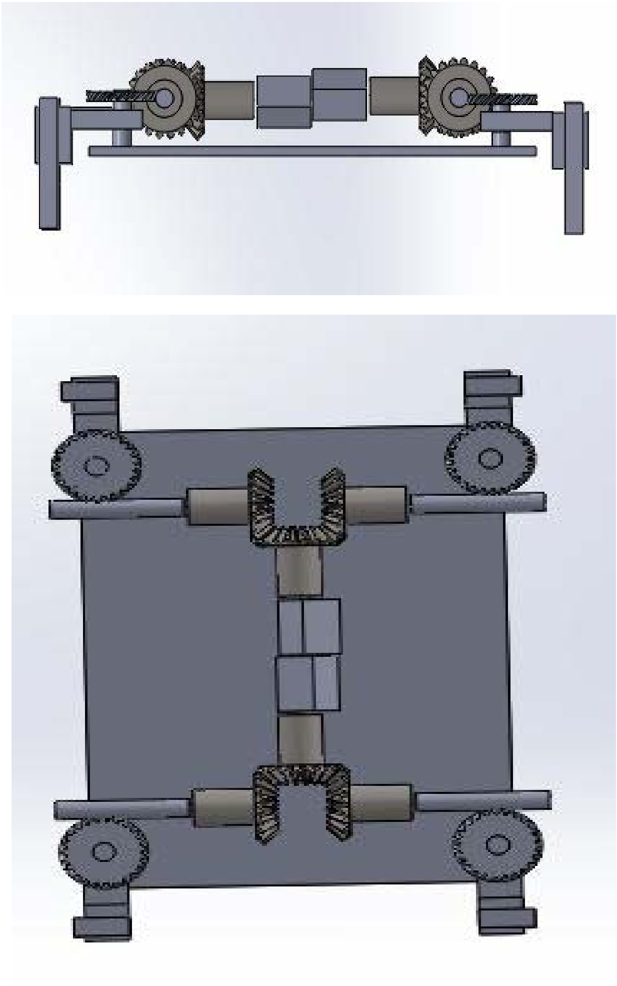


Figure 3.2 : show the robot in front,side, and top view

a) *Design analysis*

The main thing that should be consider when doing this project is about how the motion of the robot would be. In this project, after consulting with the supervisor, we agreed on building a robot with walking leg for this type of reconfigurable robot. A servomotor is a crucial part to determine the direction of the robot to move, wether forward or backward. The servo motor can be placed into the robot once the code have been made and have been transferred through arduino board. For the robot to turn the leg, we also need a motor to turn the bevel gear. The rotation motion from the bevel gear will be tranferred to a worm gear. Since the leg is attached to the worm gear, it will automatically turn the direction of the leg once the worm gear start rotating.

The robot also consists of inertial sensor that will detect when the robot fall or flip, so that the robot will be able to reconfigure and walk again.

b) *Force division between the legs*

The whole body of the robot will stand on two legs while it is taking forward motion. Thus, the whole weight will be divided between these two legs equally so that the robot will stand balanced.

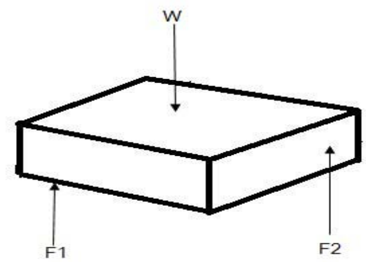


Figure 3.3

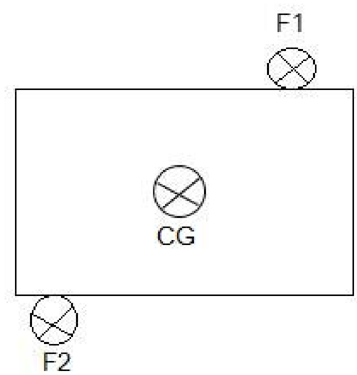


Figure 3.4

Figure 3.2 and 3.3 show the forces that are equally divided between the two sides of the frame.
By using the formula :

$F1 + F2 = W$

$F1 = F2 = W/2$

c) *Bill of materials*

Table 2 : Bill

Materials	Price (1 unit)	Quantity	Total
DC Servo motor	USD10	6	USD60
Worm gear	USD2	4	USD8
Bevel gear	USD3	6	USD18
Plastic	USD10	1	USD10
Inertia sensor	USD67	1	USD67
			USD163

d) Selection of components

i. Servo motor

Figure 3.5 : dc servo motor, model/SKU E0695

General specifications

Storage temperature range : -20°C ~ 60°C

Operating temperature range: -10°C ~ 50°C

Operating voltage : 4.8V ~ 6V

Mechanical Specification:

Description	Specification
Overall dimension	40 x 20 x 37.5mm
Limit Angle	360°±10°
Weight	38±1g
Connector wire gauge	#28 PVC
Connector wire length	320±5mm
Horn gear spline	25T/ψ5.80
Reduction ratio/td>	240:1

Electrical Specification:

Description	5V	7.2V
Operating speed (at no load)	0.14sec/ 60°	0.12sec/ 60°
Running current (at no load)	20mA	25mA
Stall torque (at lock)	3kg.cm	3.5kg.cm
Stall current (at lock)	300mA	350mA
Idle current (at stopped)	4mA	5mA

Control Specification:

Description	Specification
Operating frequency	50Hz
Operating angle	90° (from 1000 to 2000 usec)
Neutral position	1500 usec
Dead band with	4 usec
Rotating direction	Counter clockwise (from 1500 to 2000 usec)
Pulse width range	From 800 to 2200 usec

Figure 3.6 : Specification

ii. Set of worm gear

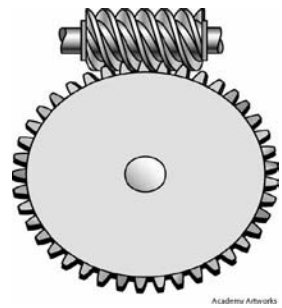


Figure 3.7 : worm gear

iii. Bevel gear

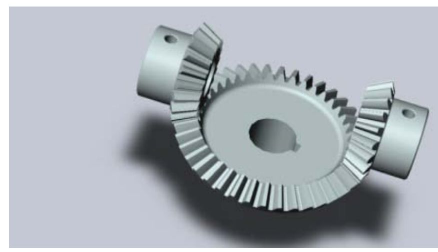


Figure 3.8 : bevel gear to transmit the rotation motion

IV. Conclusion

The design of the robot for this project is not achieved just by thinking once. The redesign and the development of this reconfigurable robot is always challenging. In the process of making this project, some fundamental design principles which are applicable to all components of the system became more clear. The very first important step that we should be aware of before beginning the implementation of a robot systemis to go through a thorough design, analysis and also the specification. It is crucial in order to verify wether the implementation will work or not.

Upon completing this project also, I also learned that the simplicity of the design should not be overlooked. As an engineer, it is our job to make something which is easy for humankind to handle but at the same time give a maximum output. In designing, creativity and experimentation are two of the most valuable design tools available until today. From the research that have been made, it can be concluded that the reconfigurable robot is one of the most desirable technology that people need today.

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Production and Characterization of Algal Biodiesel from *Spirulina Maxima*

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Abstract- Biodiesel is renewable; reduce the greenhouse gas emission and potential as a substitute of fossil fuel. The aim of the current investigation is to produce biodiesel and compare physiochemical properties of spirulina maxima biodiesel (BD) with diesel fuel (DF). Soxlet apparatus was used to extract oil from algal body. Transesterification process was carried out to produce BD by adding potassium hydroxide (KOH) and methanol. Different properties of BD were determined. The physical properties includes density, viscosity, flash point, Higher Calorific Value (HCV), Cetane Number (CN), PH, moisture content, carbon residue, ash content, acid value, etc., and chemical properties include fatty acid composition; fourier transform infra-red (FTIR), elemental analysis. All the fuel properties were ASTM standard and close to those of DF. FTIR results revealed that BD was like diesel like hydrocarbon.

Keywords: *spirulina maxima, biodiesel, diesel, tranesterification, properties.*

GJRE-A Classification : *FOR Code: 091399p*

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Md. Atiqur Rahman [α] & Kamrun Nahar [σ]

Abstract- Biodiesel is renewable; reduce the greenhouse gas emission and potential as a substitute of fossil fuel. The aim of the current investigation is to produce biodiesel and compare physiochemical properties of spirulina maxima biodiesel (BD) with diesel fuel (DF). Soxlet apparatus was used to extract oil from algal body. Transesterification process was carried out to produce BD by adding potassium hydroxide (KOH) and methanol. Different properties of BD were determined. The physical properties includes density, viscosity, flash point, Higher Calorific Value (HCV), Cetane Number (CN), PH, moisture content, carbon residue, ash content, acid value, etc., and chemical properties include fatty acid composition; fourier transform infra-red (FTIR), elemental analysis. All the fuel properties were ASTM standard and close to those of DF. FTIR results revealed that BD was like diesel like hydrocarbon.

Keywords: spirulina maxima, biodiesel, diesel, tranesterification, properties.

I. Introduction

In the recent years, energy crisis has become acute around the world due to depletion of petroleum crude and increase global demand for fossil fuel. Due to these problem biodiesel from algae are the most promising source total substitution of fossil fuel due to presence of the hydrocarbon chain similar to DF. Fuels derived from green source for use in diesel engines are known as biodiesel. Biodiesel consists of the methyl ester of the fatty acid component of the triglyceride. Biodiesel has some special advantages when compared to diesel fuels [1].

- Biodiesel can be used in existing engines without any modifications.
- Biodiesel is made entirely from vegetable sources; it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues.
- Biodiesel is an oxygenated fuel; emissions of carbon monoxide and soot tend to be reduced compared to conventional diesel fuel.
- Unlike fossil fuels, the use of biodiesel does not contribute to global warming as CO_2 emitted is once again absorbed by the plants grown for vegetable oil/biodiesel production. Thus CO_2 balance is maintained.
- Occupational safety and health administration classify biodiesel as a non-flammable liquid.
- The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel.
- Biodiesel is produced from renewable vegetable oils/animal fats and hence improves fuel or energy security and economy independence.

There is a large number of algae like Chlorella sp. Cylindrotheca sp. Nitzschia sp. Schizochytrium sp. spirulina sp., etc grow all over the world. In this study spirulina maxima is used as a sample to analysis the investigation. Extraction of oil from powder algae several processes are existed. All of them solvent extraction by soxhlet apparatus is well known. In the current investigation soxhlet apparatus, method is used to produce algal oil and transesterification process for synthesizing the crude algal oil. A number of studies has evaluated the potential of using crude algal oil in commercial purpose is insufficient. The aim of this study was to evaluate the potential of using BD as an alternative fuel by determining some physicochemical properties and comparing with base DF.

II. Material and Method

a) *Collection and preparation of algal sample*

Spirullina maxima was collected from Science Lab (BCSIR) Dhaka, Bangladesh. The samples were cleaned in fresh water and dried in an oven at 70^0C [2].

The dried algal biomass was used for biodiesel production.

b) *Materials*

Methanol (99.9%), Diethyl ether, Methylene chloride, Potassium Hydroxide (KOH) (99.2%), n-Hexane (99%) etc. was purchased from the local market at Dhaka, Bangladesh.

c) *Preparation of biodiesel*

i. *Powdering*

The dried spirullina maxima was powdered by a mechanical crusher. The fine grained algal powder was collected after this process.

ii. *Extraction of algal oil (Soxlet Apparatus Method)*

Soxhlet apparatus is a chemical extraction method. *Spirullima maxima* algal powder (0.5 Kg) was fed to a soxhlet extraction fitted with a round bottom flask with condenser. Oil from algae is extracted through

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separated washing or percolation for 48 hours at 45^{0}C with the solvent system as 15 diethyl ether and 10% methylene chloride in n-hexane [3]. From this process 115ml of crude oil was extracted. Then extracted oil was heated to temperature via the rotary evaporator, so that the diethyl ether present in the crude oil was evaporated.

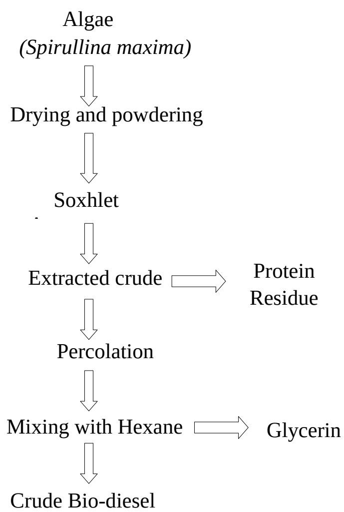

Fig.1: Flow chart of crude biodiesel production from algal powder

iii. *Mixing of Alcohol and Catalyst*

This typical process is mainly done by pouring 5 Liter of crude algal oil into the reactor for preliminary heating to the temperature of about (65-67^{0}C). In a separate container, 19gm of KOH (3.8 gm per liter of oil, got by 3.5 gm stoichiometric equivalent and 0.3 gm. for neutralizing free fatty acid) was dissolved in one liter methanol (200 mL per liter of oil) slowly[4]. This mixture was added continuously to the crude algal oil, and mixing was done properly by using of a stirrer. A typical Biodiesel production setup is shown in fig.4.

iv. *Transesterification Reaction*

Transesterification is the most common method to produce biodiesel. [5] It is the process of reducing viscosity of biodiesel by 75-85% of the original oil value. It is the process of reacting triglyceride with alcohol in presence of a catalyst to produce glyceride and fatty acid ester. Catalyst are usually used to improve the reaction rate, and the yield and alcohol are used to shift the equilibrium to the product side. [6] To complete a transesterification reaction stoichiometric ally a 3:1 molar ratio of alcohol to triglyceride is necessary. However, in actual practice, the ratio needs to be higher to drive the equilibrium to maximum ester yield. [7] Transesterification reaction is given below has been widely used to reduce the high viscosity of triglycerides. [8]

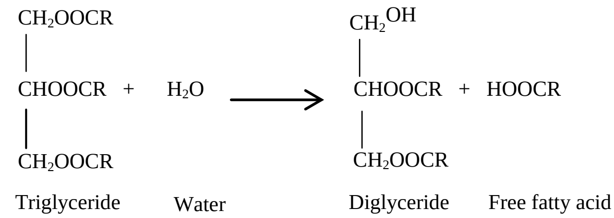

Fig 2 : Transesterification of triglyceride (Overall reaction)

v. *Separation*

After completing the reaction, Glycerin was setting down at the bottom and *spirulina maxima* biodiesel (BD) on the top. Process was continued until separation appears not to be advancing any more. The two product was separated by gravity using settling vessel. The bio diesel is drawn off at the top, and glycerin was drawn off at the bottom of the settling vessel.

vi. *Biodiesel Washing*

Biodiesel was poured off into a separate clean container for washing soap, salt or free fatty acid. Hot water (110^{0}C) was added to the methyl ester. It was stirred lightly and then allowed to settle down. After that the water was drained out from the bottom. The warm water was heated in the main reactor itself. Process was repeated until raising the value of the biodiesel P^H level of 6-7, and no soap bubbles appeared in it.

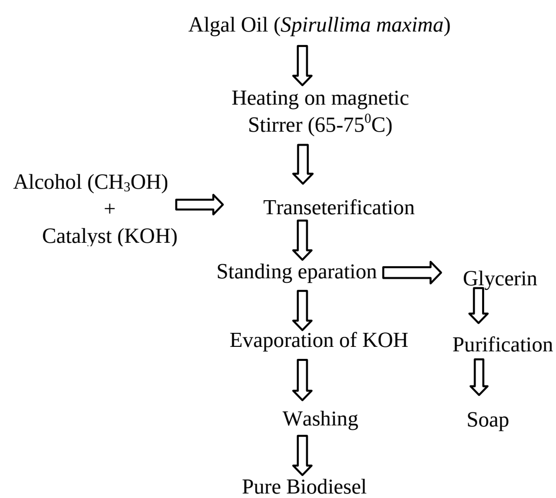

Fig 3 : Flow Chart of Biodiesel Production

The biodiesel was cloudy so it was slowly heated to evaporate out the water. About 3.7 liter of biodiesel were produced for an input quantity of 5 liter of crude oil.

d) *Characterization of biodiesel*

i. *Physicochemical properties*

Physical properties (Density, Viscosity, Flash point, Pour point, Higher calorific value (HCV), Cetane

Number (CN), P^H, Moisture content, Carbon residue, Ash content, Acid value, etc.) and chemical properties (Fatty acid composition, FTIR, elemental analysis) were analyzed.

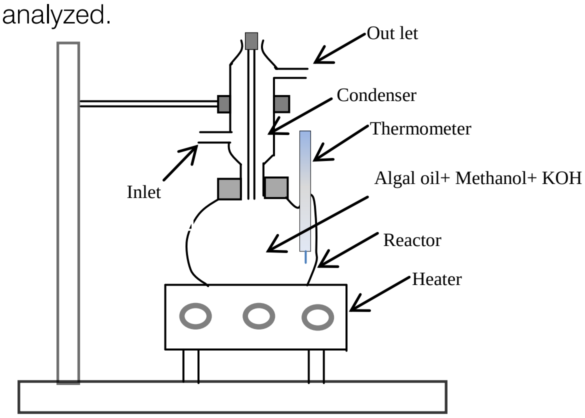

Fig 4 : Biodiesel Production

Fig 5 (a) : Algae

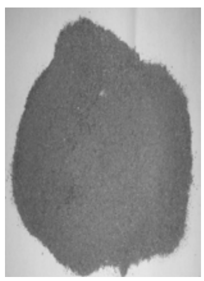

Fig 5 (b) : Grained powder algae

Fig 5 (c) : Extracted crude biodiesel

Fig 5 (d) : Biodiesel

ii. *Fatty Acid Composition*

Fatty Acid Composition was analyzed by Gas Chromatography (GC) (CP-3800 GC varian, USA) equipped with 30 m DB-WAX (J&W, Agilent) capillary column (0.25 mm of internal diameter and 0.25 m of film thickness). Detector (Xame ionization) and Injector (split 1:100) temperatures were kept constant at 250°C. The oven temperature program started at 180°C for 5 min, increased at 4°C min. until 220°C, and kept constant at this temperature for 25 min.

iii. *Fourier Transformed Infra-Red (FTIR) Spectroscopy analysis*

FTIR analysis gives an idea about the suitability of algal oil as Diesel Fuel (DF). It provides the amount of incident spectrum absorbed (percentage) by algal oil which identifies the basic compositional groups along the wave numbers 4000 to 500 per cm.

iv. *Elemental Analysis*

Elemental Analysis of BD in terms of carbon, hydrogen, oxygen, and sulphur (CHNOS) content is important in order to make a necessary material balance of each component. The composition of the algal oil was determined using an elemental analyzer of Model EA1108. Oxygen was calculated by difference. The analysis of the oil was conducted at Analytical Research Division of BCSIR, Dhaka.

III. Result & Discussion

a) *Fuel Properties of algal Biodiesel*

Biodiesel could be used as an alternative fuel for diesel engine only if its physical and chemical properties confirm to the international standards specification. BD was characterized according to ASTM standard. The physiochemical properties of *spirullina maxima* algal biodiesel is presented in table-1. The physiochemical properties of BD are similar to DF.

b) *Fatty Acid Composition*

Spirulina maxima biodiesel (150 gm) was taken to determine the fatty acid composition using the borum trioxide method according to ENISO 5509 standard. Fatty Acid composition was calculated as a percentage of the total fatty acids presents in the sample, determined from peak areas. The fatty acids composition of BD is presented in table 2. The BD consisted of carbon chain length between16 to 20. The higher concentration fatty acids were palmitic, Sterice and Linolenic.

c) *Elemental analysis*

Elemental analysis is shown in table-3. BD has lower carbon content and at the same time having a larger amount of oxygen, which justifies the lower heating value compared to DF.

Table 1 : Property Comparison of BD and DF

Sl No	Properties	ASTM Method	BD	DF
1	Density at 40^{0}C (g/cm^3)	D1298	0.8334	0.86
2	Viscosity (mm^2/s)	D445	4.47	2.83
3	Cetane Number (CN)	D613	55	50
4	HCV (MJ/kg)	D240	38.43	44.5
5	Flash Point (^{0}C)	D93	178	90
6	P^H	-	7	6.54
7	Moisture Content (%)	D6751	0.04	< 0.03
8	Carbon Residue (%)	D524	0.008	0.01
9	Ash Content (%)	D482	Nil	< 0.02
10	Acid value (mgKOH/g)	D975	0.34	0.05

Table 2 : Fatty acid composition of BD

Fattyacid	Structure	% (w/w)
Palmitic	C16:0	38.85
Palmitoleic	C16:1	9.8
Stearic	C18:0	16.41
Oleic	C 18:1	2.3
Linoleic	C 18:2	7.2
Linolenic	C 18:3	15.1
Arachidic	C 20:1	9.7
Others	-	0.64

Table 3 : Elemental analysis of BD and DF

Properties	BD (%wt)	DF (%wt)
C	67.91	86.18
H	10.69	13.8
O	19.86	< 0.01
N	1.54	-
S	< 0.00	0.034

d) FTIR

The target of the current investigation is to examine suitability of BD as an alternative fuel. Considering the above fact, FTIR analysis of BD was performed. FTIR spectrum of BD and DF was shown in fig 6 (a) and 6 (b).

Neat DF			Neat BD		
Frequency range (cm^{-1})	Bond types	Family	Frequency range (cm^{-1})	Bond types	Family
2923.9-2854.5	C-H stretching	Alkanes	2922.1-2852.7	C-H stretching	Alkanes
1745.3	C=0	Aldehyde/ketone	1737.86	C=O	Aldehyde/ketone
1458.3	C-H bending	Alkanes	1456.26	C-H bending	Alkanes
1377.1	C-X	Fluoride	1066.64	C-O	Alcohol
723.3	=C-H bend	Alkanes	719.45	aromatic C-H	benzene

Table 4 : Frequency comparison table of BD and DF

Table 4 represents the functional group compositional analysis for BD and DF. For DF, the strong absorption frequency 2923.9 cm^{-1}, 2854.5 cm^{-1} and 723.3 cm^{-1} represent C-H stretching, which indicate the presence of an alkane and appearance is very strong. The absorbance peaks 1745.3 cm^{-1} and 1377.1 cm^{-1} represented the C=O (Aldehyde/ketone) and C-X (Fluoride) respectively. For BD, strong absorbance peaks 2922.16 cm^{-1}, 2852.72 cm^{-1} and 719.45 cm^{-1} are the C-H stretching, which represent the presence of the alkane group. The absorbance peaks 1737.86 cm^{-1} and 1066.64 cm-1 represent the types of bonds specifically aldehyde/ketones and alcohol respectively. The frequency 719.45 cm^{-1} indicate the presence of benzene. From the FTIR graph, it is seen that major transmittance spectrums peaks both BD and DF are alkanes, and their bond type is very strong.

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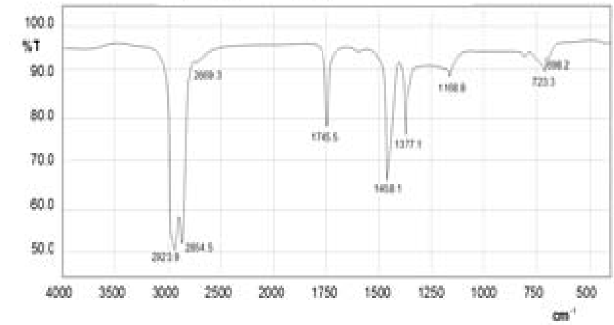
Fig 6(a): FTIR graph for DF



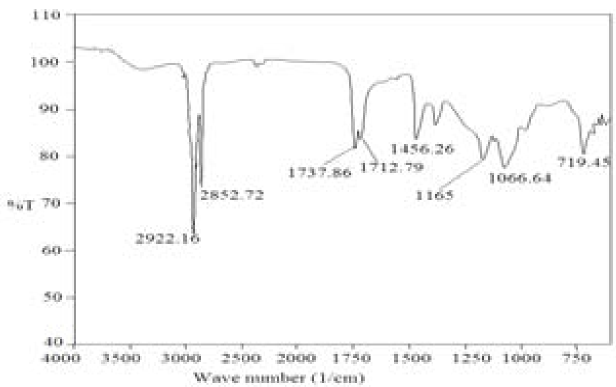


Fig 6(b): FTIR graph for BD

According to the above discussion, clearly both BD and DF are saturated hydrocarbon. The presence of hydrocarbon groups C-H indicates that the liquid has a potential to be used as fuels.[9]

IV. Conclusion

The results of the current investigation are summarized as bellows where pure diesel was used as base fuel for comparing the parameters -

1) The viscosity after the transesterification process was 4.47mm^2/s at 40^{0}C which is 63.3% higher than DF. The viscosity of BD highly decreased after the transesterification process by 70%.
2) The flash point of BD was measured as 178^{0}C. The higher value of flash point decrease of risk of fire and potential safe for storage as compare to DF.
3) CN of BD was found to be 55 whereas DF was 50; higher CN of BD gives higher ignition quality.
4) From FITR graph, the major transmittance spectrums of algal oil peaks was alkanes which indicates that the liquid has a potential to be used as fuels.
5) Palmitic acid percentage by 38.85 is the highest fatty acid composition in BD.
6) Carbon residence of BD is 0.008%, which is suitable for diesel engine from leakage of nozzle, corrosion, cracking of composition.
7) BD has lower carbon content but having a large amount of oxygen compared to DF, which both justify the lower heating value of algal oil.

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Reduce Generators Noise with Better Performance of a Diesel Generator Set using Modified Absorption Silencer

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Keywords: *diesel engine; generator; absorption silencer; noise.*

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Strictly as per the compliance and regulations of:

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Md. Nasir Uddin [α], Md Ahbabur Rahman [σ], M. M. Rashid [ρ], N A Nithe [Ѡ] & JI Rony [¥]

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I. Introduction

Sound pollution means unwanted sounds or noise. It is perceived by most people as annoying. Noise pollution harms most people's lives. Additionally, it is a great cause of environmental pollution. It greatly hampers humans not only physically, but mentally also. For these reasons, noise reduction is in great demand in this society, and noise prevention is a rising concern in all markets. In our society, all of the industries, the residential sector and business plants use generators. Diesel engine generators cause loud sounds.

A silencer is essential and an important part for sound attenuation of engine exhausts. There are many theories and designs of acoustic silencers of generator sets, developed in detail by Stewart theory and design of Acoustic and silencer of Generator set developed in detail by Stewart [1, 2] and he apply it to create many types of silencer and also success that explained in [2].

In 2013 Dr. Chazot, Nenning and Perry performed the method of unity finite element of 2D noise field with sound absorbing materials [3]. Now a days on top is a large company who designing, producing and manufacturing prefab modular flue and also distributing. It disposes of a modern product that certified ISO 9001 and also environment friendly as metaloterm lightweight silencer for flue system. In 2012, Mr. Ghosh, Bose and Chakraborty in india modified muffler and get a good performance of a diesel engine by used it [4]. The review of Generator set and silencer should be not complete without it mixed the effects of different absorption elements [5] .The diesel engine is the main noise sources of sound power also the generator exhaust and radiator fan [6], are measured by the method of sound intensity. At first May and Olson expressed an electronic noise absorber by pressure release on back face of resistive sheet [5]. Its introduce the notion of active absorption. Guicking and Lorenz in the year of 1980 fulfilled this theory and done experiment [7]. Various research have sought to complement multiple hybrid absorbance technique, leading to patent application [8]. In 1997 Mr. nail and Furstoss improved a layer of optical wool backed by air cavity closed through an active surface [9] by an active treatment. In the same year Beyene and Burdisso found active boundary condition [10]. They achieved it by impedance adaption means in layer of porous rear face.

But after the century in 2004 cobo et al. explained structure of thinner hybrid active and passive absorbers feasibility. He used micro perforated panels more than the porous materials[11]. The design mufflers and procedures are also in the literature (Munjal, 1987)[12]. Long time ago Stewart used electro acoustic analogies in deriving acoustic filters theory & design.[1]. After that Davis approach systematic studies result of muffler.[13]. Igarashi and M. Toyama calculated transmission characteristics by using electric circuit. [14, 15]. The last year in 2014 Babu, A.R Rao simulated a new muffler for reduce sound level of SI engine.[16]

In this paper, an absorbance silencer is modified for reduced noise of a generator set. It is constructed using a combination of baffle or perforated duct with sheet metal. The maximum generator has a simple silencer for reduction of the exhaust noise only. In this paper, a silencer is modified to reduce the noise

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level and keep it at a minimum; also generators' noise sources and their characteristics are discussed herein.

a) Method of Noise Measurement

Noise means unwanted sounds that are abnormal or loud- it is a relative term. Singing or hearing a song or musical instruments may be noise for some. Automotive engines create a large portion of the noise in our society. I.C engines are also a great source of sound pollution, as they are a powerful source of noise. The noise sources of both gasoline and diesel engines are the same, but their noise characteristics are different. Noise is highly subjective, and that which is irritating to one can be acceptable for another. To overcome this, noise is measured by a decibel (dB) meter in unit of dBs, withdB(A) representing the human ear's sensitivity of 0 to 180 dB, where 0dB means no sound at all, and 180dB is a loud sound. An alternative explanation for 180 dB is the level of sound an atomic bomb would make upon explosion. The dB scale is a logarithmic meter. If d Bs risein in crements of 10, then the sound level rises 10 decade or 10 fold. If we know the level of noise source and maximum allowed level, then it is easy to calculate the required sound reduction for the silencer. Alternatively, if the level of noise and the necessary noise reduction of silencer are known, then the remaining noise level can be easily calculated. Noise and sound have different frequencies. The unit of frequency is Hertz (Hz). Hertz means period per second, calculated by the equation f=1/t. We can hear from 20Hz to 20 kilohertz (20000Hz), but this depends on age. Machinery like engines, generators, vehicles and ventilators generally produce 50Hz to 3000Hz. The USA standard ASTM E413 describes frequencies of machinery as being in the range of 125 to 4000 Hz [17]. Similarly, The international standard ISO 717 refers to frequencies 100 to 3150 Hz[18]. The SI unit of sound reduction is dB and frequency is Hz[19]. But it is important to know that different frequencies demand different types of silencers

b) Different Types of Generators Noise

Three types of fuels are used in generators: diesel, propane and natural gas. In general, generators are of two types: spark-ignited and diesel. Spark ignites are combined with propane and natural gas engines.

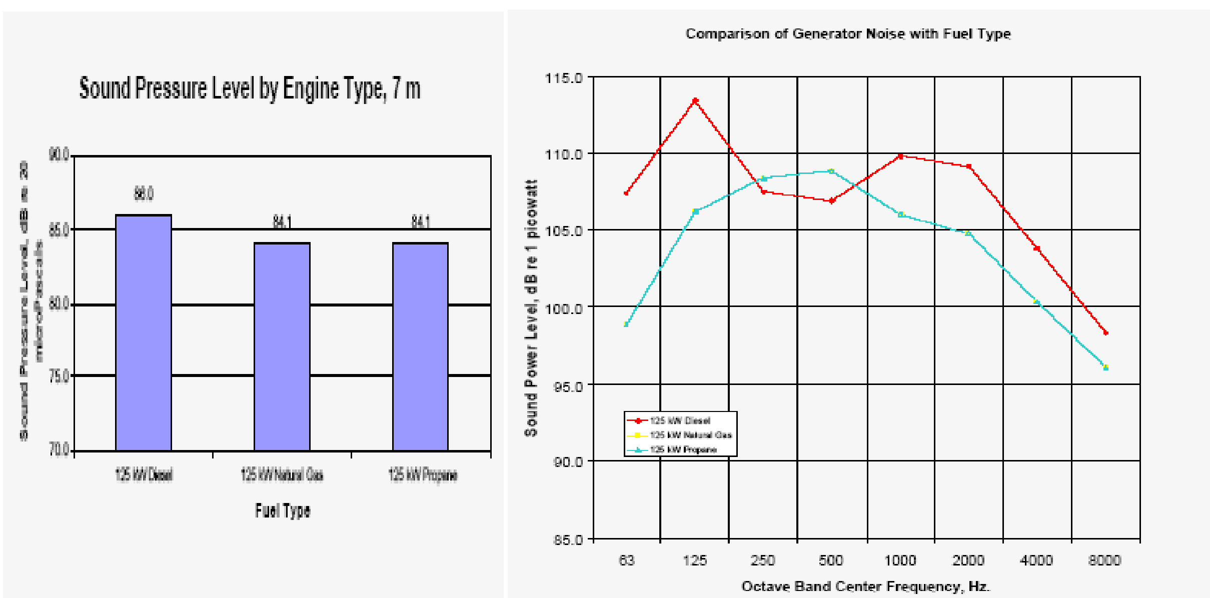


Figure 1 : Noise characteristics of various type of Engine.

The line graph in Figure 1 illustrates the power of noise between two level standards. On this graph, the x-axis shows noise pressure and the y-axis shows the noise power level. The noise power levels of spark-ignited or natural gas and propane generators are the same. The sound power level relates to the generator's total energy and is similar to horsepower. The bar graph in Figure 1 depicts sound variation against fuel type. The diesel engine leads here with 86 dB A, compared to a spark-ignited type generator achieving 84.1dBA for natural gas and propane. It varies with location and distance from the source of noise. The sound pressure level (SPL) of a quiet residential place is 45 dBA during the day, and 35 dB A at night (Ahuja et al., 1997). 70 dBAsis the level of noise of a busy place from 100 foot distance and conversations are around 60 dBAs from 3 feet away. The line graph in Figure 2 shows a comparison of diesel generator noise with size, withvarious lines representing each of the four types of generator: the red line is for a 125 kw diesel generator, the yellow line is for a 500 kw generator, the green line represents a 1 MW generator, and finally the blue line represents a 2 MW diesel generator. The bar graph in Figure 2 illustrates the sound pressure level by engine size: large, 2 MW enginesproduce 99.2dB;1 MW engines achive 94dB; and 91dB and 86dB are generated from 500kw and 125kw engines, respectively [14].

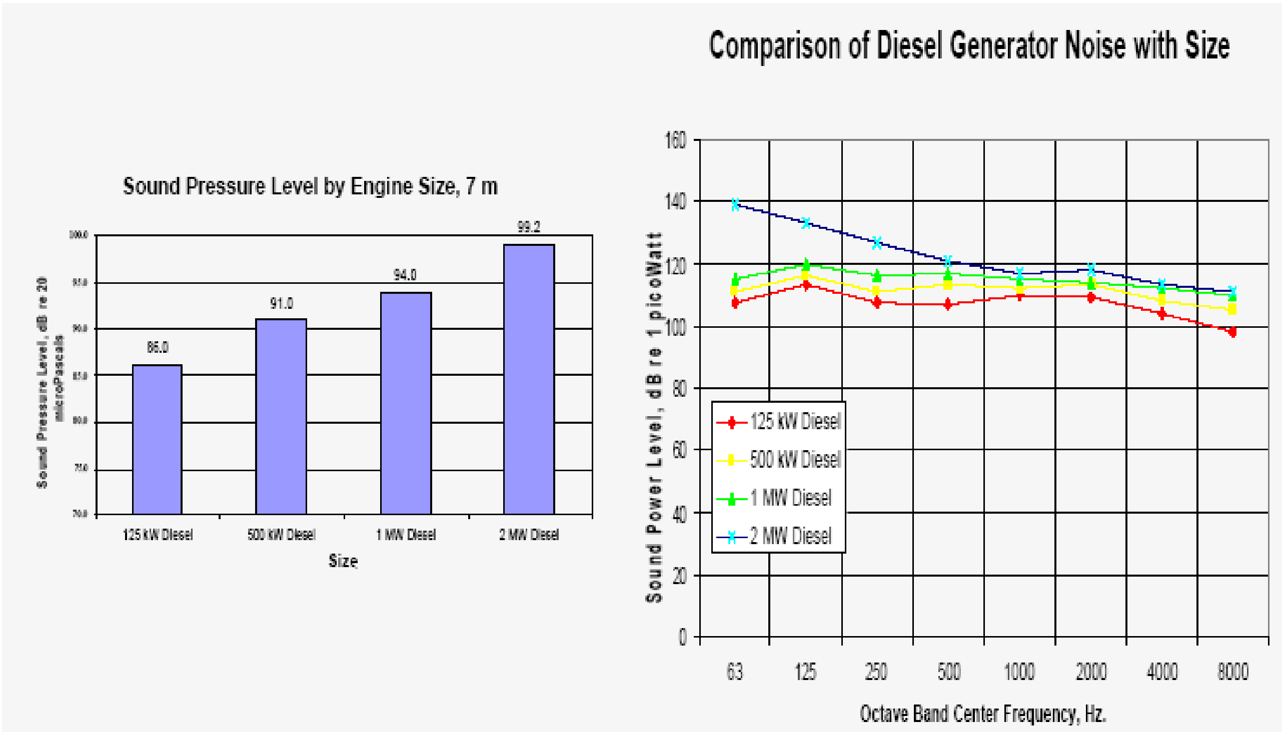


Figure 2 : Noise Characteristics with Engine Size.

c) *Source of Noise Generation in Generator set*

Engines are the cause of much noise pollution today. Engines are of many types, such as I.C. engines, of which there are two types: gasoline and diesel. These two types of I.C. engines have different noise curves, however, the occupational noise source is same for both. For automotive engines, the principle source of noise comes from its intake, radiator and combustion. The dominant source is the engine block of the generator and the air intake. There are also some primary noise sources that are shown below.

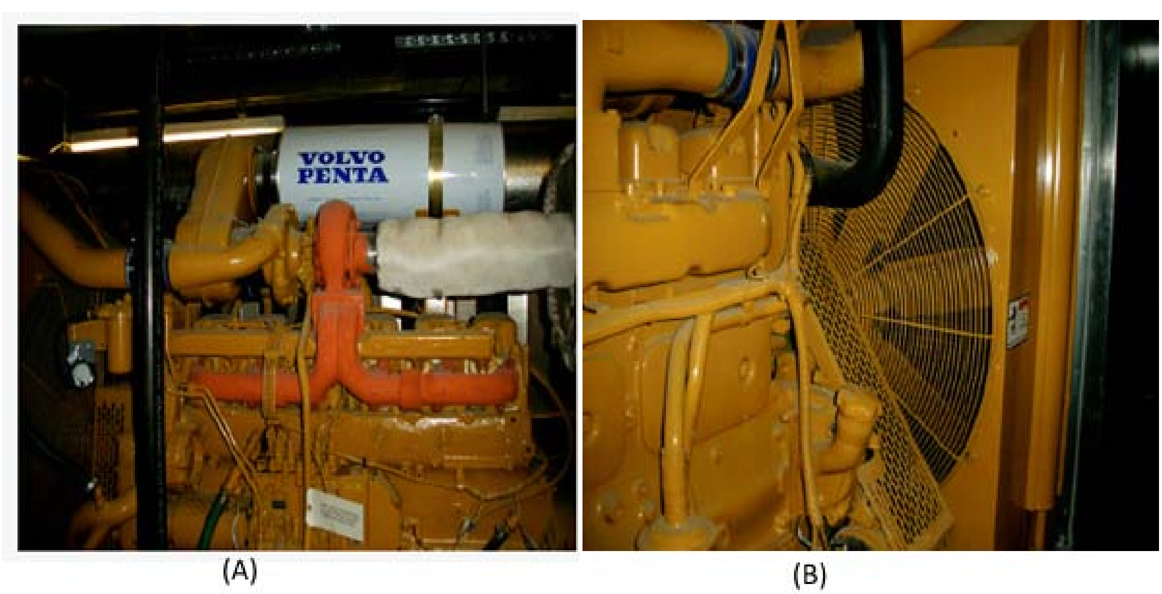


Figure 3 : Source of Noise

Figure 3B shows a radiator fan as the primary noise source. The engine block also combines with the radiator fan to produce noise by discharging radiating air. This noise is produced by the generator, and can dominate part of the frequency spectrum. There are also some parts or units produce noise together, like the exhaust, the turbo charger, the load bank, vibration, the engine, theconnection to ductwork or exhaust pipe, and electrical components. The load bank is very noisy. Often, it is portable and brought in for testing. Maximum noise ordinances will accept noise to the threshold of a code limit. Otherwise, the load bank's place would be a generator room but not outside the room. A significant source of noise is vibration. It is not a normally a source in the case of the generator being placed on the roof or an upper floor. For reduction of the vibration, a spring isolator is used as a supporting structure. Vibration isolation is essential for larger engines of a big generator sets, otherwise supporting structures can become damaged.

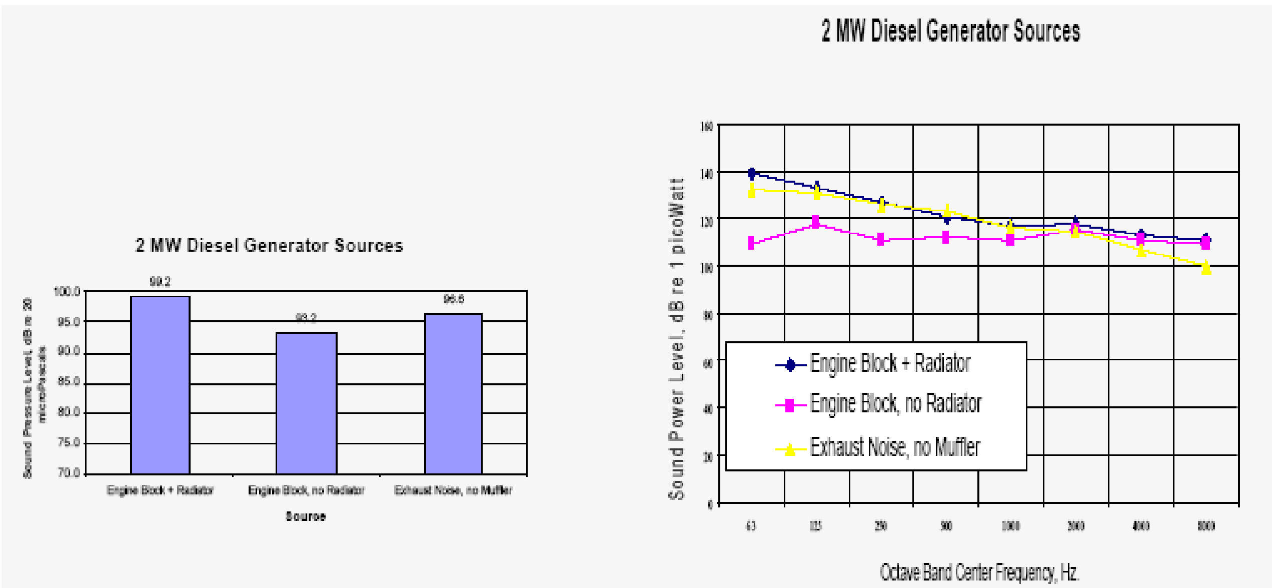


Figure 4 : Noise source of 2MW Diesel Generator.

Figure 4 shows noise characteristics of a 2 MW generator. The line graph in Figure 4 depicts the generator's sound power level. The blue line shows the sound power level of an engine block with a radiator, the pink line shows the sound power level of the engine block without a radiator, while the yellow curve shows sound power levels for the exhaust noise without a muffler. The bar graph in Figure 4 shows the sound pressure levels for each of these same three sources (i.e. engine block with radiator, engine block without radiator, exhaust without muffler). The exhaust system has inherent problems of structure and design, which impose limitations on the procedure for reduction of noise from the engine exhaust. The noise range of the exhaust system is 100-120dBA, which is considered to be very high. Temperatures reaching the range of 950°-1050°F are classed as high temperatures. Similarly, high velocities are those ranging from 5000-15000fpm. Insertion loss is the reduction of noise that happens when an element of silencing is entered into the system. Due to the engines producing a high sound, the muffler insertion loss will vary with variable engines, load and inlet outlet piping configuration. However, a drop of pressure significant. The noise of an engine exhaust varies significantly with its loading. At the full load, the sound level is about 10dB more than the 'no-load' condition. The silenced exhaust noise level is high at low frequencies.

II. Noise Reduction Techniques

The noise reduction techniques are dependent on the generator room, exhaust and its type of structure, borne, noise & vibration. Some techniques are shown in the following sections.

a) *Generator Rooms*

a. Room Enclosure:

i. Roof

ii. Walls

iii. Doors

iv. Internal Lining

b. Intake Air and Discharge Air:

i. Duct Silencers

ii. Acoustic Louvers

iii. Exterior Screens

b) *Exhaust Noise*

a. Resistive Mufflers/ Absorbance Silencer

b. Active Noise Control

c) *Structure Borne Noise & Vibration*

a. Spring isolators on generators larger than 175kW.

b. If a floor joint is present, the weight of concrete beneath the generator should be not less than twice the generator weight.

c. Flexible pipe connectors, duct connectors, electrical connection at the generator.

Active noise cancellation silencers used to be available as amanu factured product, but are not currently available. They were effective in reducing the low frequency tones associated with the cylinder firing. In this research paper, we design and modified resistive mufflers / absorbance silencers for reduction of exhaust noise.

III. Methodology

The methodology involves silencer design and development, and consists of some steps. After this, a modified silencer for use with a generator for a practical experiment is produced. The properly designed muffler for any particular application should satisfy the often – conflicting demands of at least five criteria simultaneously.

a) Criterion and Flowchart of Methodology

The acoustic criterion, which specifies the minimum noise reduction, is required from the muffler as a function of frequency. The operating conditions must be known because large steady-flow velocities or large alternating velocities (high sound pressure levels) may alter its acoustic performance. The aerodynamic criterion specifies the maximum acceptable average pressure drop through the muffler at a given temperature and mass flow. The geometrical criterion specifies the maximum allowable volume and restrictions on shape. The mechanical criterion may specify materials that are durable and require little maintenance. The economical criterion is vital in the marketplace [33]

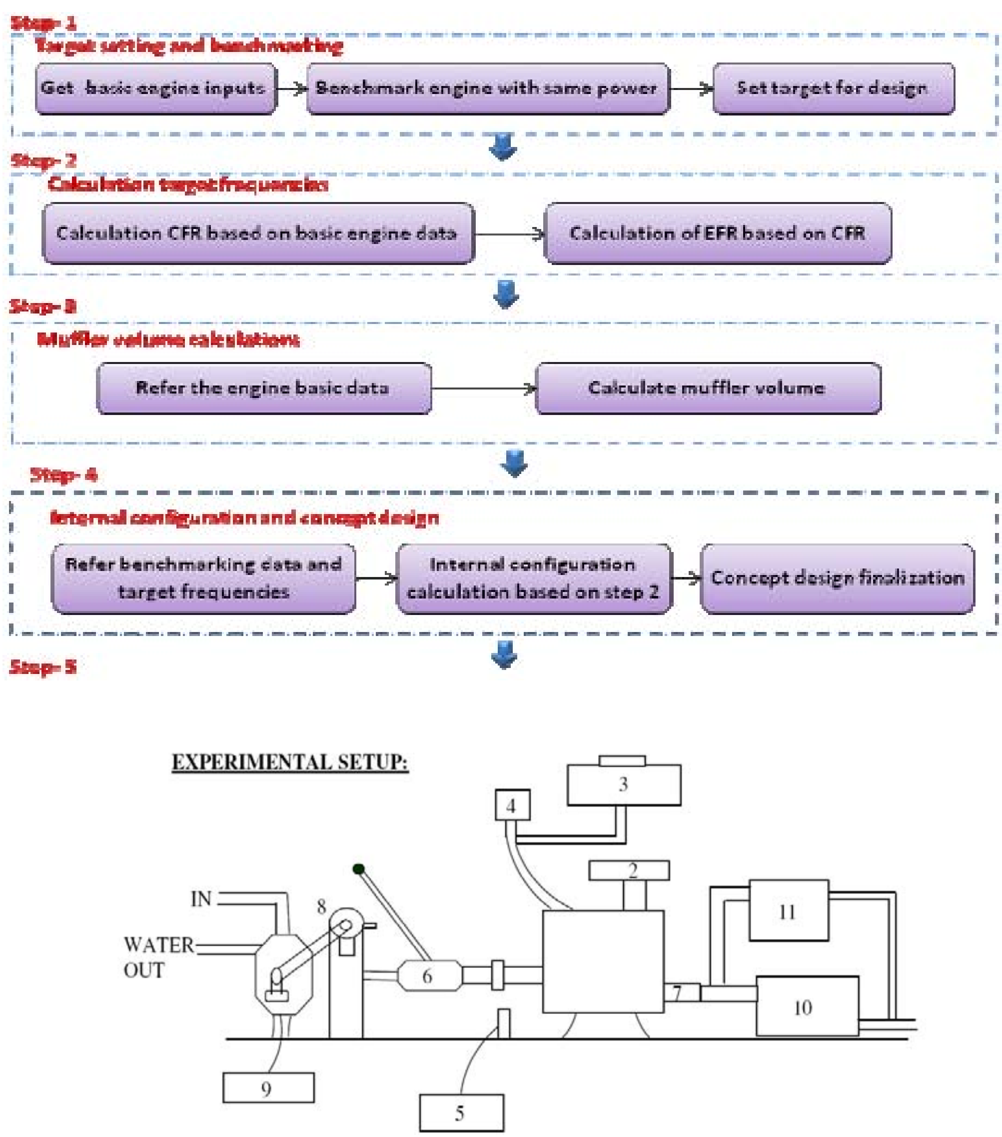


Figure 5 : The steps showing the process of design of the silencer andthe experimental setupof the generator set with a diesel engine.

1. Diesel Engine
2. Filter
3. Tank
4. Burret
5. RPM Indicator
6. Clatch or Shaft
7. Exhaust Outlet
8. Alternator
9. Radiator
10. Silencer
11. Sound Meter

The generator block diagram is replaced by the experimental setup block diagram. The various types of generator sets include 150KW, 350KW, 500KW, 1MW and 2MW diesel engines for use during the experiment and data collection. The experimental silencer was designed for a 500KW diesel engine generator set, and the basic specifications of the generator set are given in Table 1.

Table 1 : Specifications of the generator set

SN	Item	Specification
1	Rating	635KVA
2	Power	508KW
3	Current	850A
4	Rated revolution	1800RPM
5	Pressure	460KPA
6	cylinder	6
7	Cycle/stroke	4
8	Engine Load	75% and Full Load also

Figure 6 : Generator Set

b) *Experimental Evaluation of Unsilenced exhaust Noise in Diesel Generator Set*

The noise of an engine exhaust varies significantly with its loading. At the full load, the sound level is about 10 dB more than the no-load condition. The silenced exhaust noise level is high at low frequencies. Figure 7 shows a 2MW engine with un silenced exhaust noise level load for 16cyl at 1800RPM.

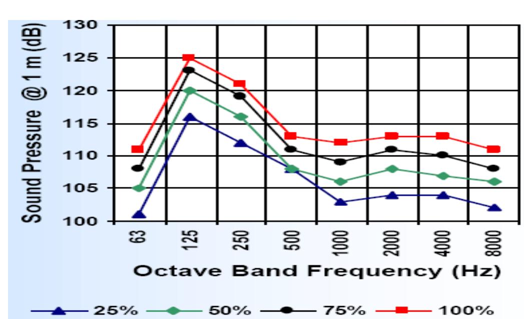


Figure 7 : Sound Pressure at 1m distance for 2MW Engine by load.

The graph shows that the exhaust system starts at 110dBA and varies by 10 dBA, reaching a maximum of 120dBA. It is measured 1m from the outlet exhaust. The exhaust sound is affected by turbochargers of engines and after coolers by cooling fans. Hence, collecting noise data from engines is the optimal method chosen for this experiment. The un silenced engine's exhaust noise level is high at low frequency. Figure 8 shows data comparisons for the various engines including 150KW, 350KW, 500KW and 2 MW diesel engines.

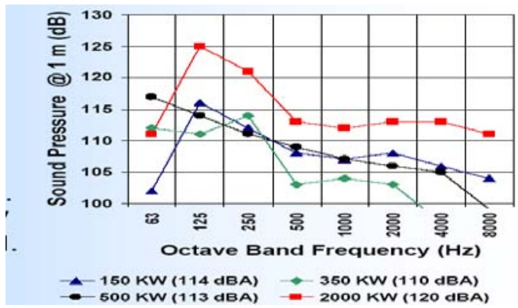


Figure 8 : Sound Pressure of various Engine at 1m distance.

The spectrum of exhaust noise always contains loud sound associated with the cylinder firing rate (CFR). Each cylinder fires once every drive shaft revolution in a 4-cycle engine, and the CFR is calculated with different formulas for 4 cycle engines (Equation (1)), and 2 cycle engines (Equation (2)).

$$CFR = \frac{RPM}{120} \tag{1}$$

$$CFR = \frac{RPM}{60} \tag{2}$$

The engine firing rate is defined as

$$EFR = N * CFR \tag{3}$$

Where, N= number of cylinders.

Figure 9 shows the exhaust noise of a 500 KW diesel engine with 6 cylinders, running at 1800RPM without using any silencers. The narrow band spectrum data was collected at a 3m distance from the outlet of the exhaust without use of a silencer, with the engine running at full load. The engine firing rate (EFR) is 90Hz and the CFR is 15 Hz.[21]

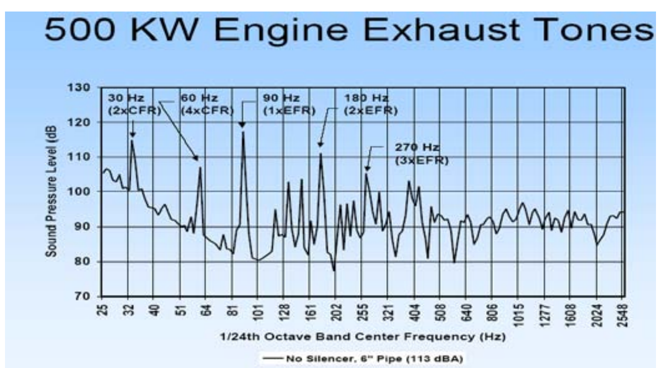


Figure 9 : Sound Pressure Level of CFR & EFR without silencer

IV. Design and Principle of Absorption Silencer

The first step in any design and development activity is to set a target by doing a benchmarking exercise of models, which was carried out in this experiment.

a) Benchmarking

After the benchmarking exercise, one needs to calculate the target frequencies to give more concentration of higher transmission loss. The primary step in silencer design is benchmarking based on engine input data:

$Bore, D = 80mm$
$Stroke, L = 98mm$
$Number\ of\ Cylinder, n = 6$
$Engine\ power, P = 65hp$
$Max. RPM = 1800RPM$
$Allowable\ Back\ Pressure = 10\ in\ H2O$
$Transmission\ Loss\ Noise\ target = 30dB$

b) Calculation of CFR & EFR

The exhaust noise always contains loud sounds associated with the CFR. Each cylinder fires once every drive shaft revolution in a 4-cycle engine, as can be seen in Equation (1) and (2).

$$CFR = \frac{1800}{120} = 15Hz.$$

Engine Firing rate (using Equation (3)): *6*15=90Hz*

c) Volume of the muffler (Vm)

The volume of the muffler isdefined as Vm, with units in litres. The calculation of the volume can be done using Equation (4):

$$Vm = Vf * \frac{\pi}{4}(d^2 * l) * (\frac{n}{2}) \quad (4)$$

Swept volume per cylinder is calculated as follows:

$$Vs = \frac{\pi}{4}(d^2 * l) = \frac{3.14 * 80^2 * 98}{4} = 0.5 \, Lit. \quad (5)$$

Total *n*Vs=6*0.5=3 Lit.*

Volume, $Vm=(n)*\frac{Vs}{2}=1.5$ *Lit.*

The silencer volume is considered to be at least 12 to 25 times larger, with a factor of 16

$$Silencer\ Volume = 16 * 1.5 = 24\ Lit.$$

d) Insertion Loss

Figure 10 shows insertion loss for various mufflers, showing the absorptive muffler performance being optimal in the frequency region of 1000Hz to 2000Hz.

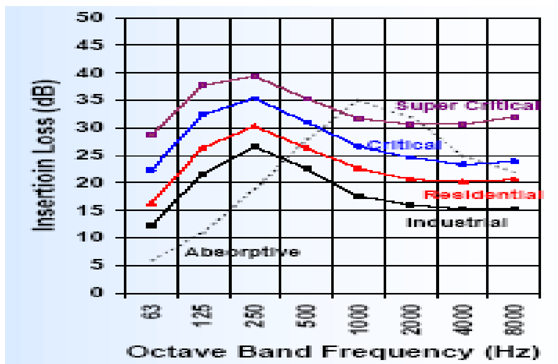


Figure 10 : Insertion Loss of various Muffler

The 500 KW generator engines have an unsilenced exhaust noise level (UNL) of 116 dBA at a 1 m distance. Asafety factor (SF) of 5 dBa is allowed for noise transmission paths. The Exhaust noise criteria (ENC) = Required Noise Criteria (RNC) -5 dBA. This means that if our expected noise level is 60dBA, then we have to design a muffler for 55dBa. The UNL equation from the exact location is shown in Equation (6):

$$Lp(xr) = Lp(x0) - 20\ log\ (xr/x0) \quad (6)$$

For example, $Lp(25\ m) = Lp(1\ m) - 20\ log\ (25/1)$

$$Lp(25\ m) = 116 - 28 = 88\ dBA$$

$$The\ required\ insertion\ loss, IL = UNL - ENC + SF.$$

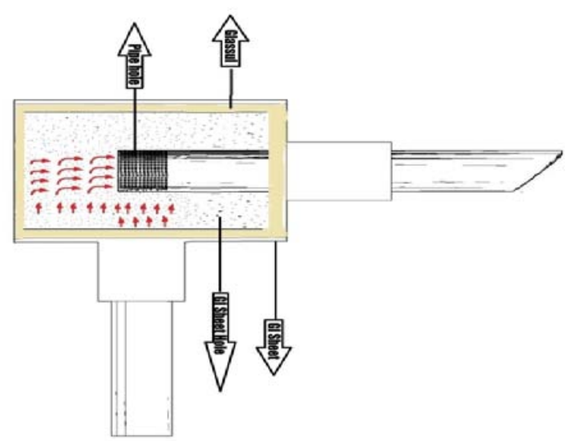
$$IL = 88\ dBA - 55\ dBA + 5 = 38\ dBA.$$

A silencer element'stransfer matrix method (TMM) is a function of state variables [28] , geometry of elements, velocity of mean flow, duct liner properties [29]. The transfer matrix method also influenced by temperature, nonlinear effects, high order mode etc.[30]. The Transmission Loss is shown in Equation (7) below.[24, 31, 32]

$$TL = 20\log \left| \frac{T_{11} + T_{12}/Y_1 + Y_{11}T_{21} + T_{22}}{2} \right| \quad (7)$$

e) Internal Configuration and Design of the Proposed Silencer

The silencer contains glass wool shielded from the exhaust stream by perforated metal. Glass silk, fiber optic or steel wool is commonly used. When the absorbance silencer works effectively, the materials suffer from deterioration in service. The combustion products take the form of absorbing materials. Materials melt due to heat generation until they have low thermal conductivity. The absorbance silencer is designed with low pass filter forms in order for it to be able to deal with the low frequency. Effective measures were used to reduce the sound. The noise power has to be applied in the numerical analysis.



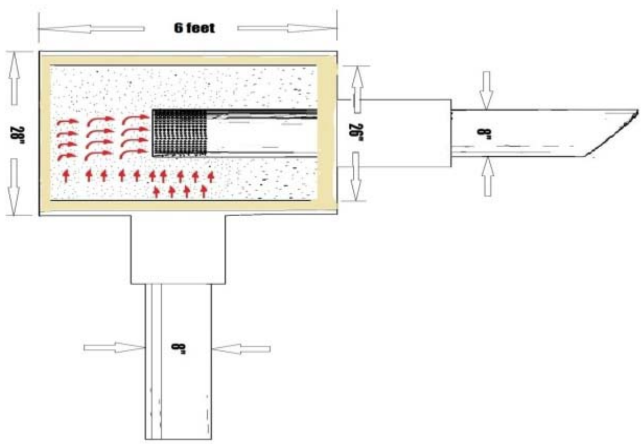


Figure 11 (A,B) : Design of Modified Absorption Silencer

The operation and principle of the new absorption silencer is shown in Figure 11. Exhaust gas enters from the inlet pipe and is directed in multiple directions in the indoor chamber. The indoor space has a U-shape configuration with large spaces. Therefore the gases flowing into the space from the inlet to the outlet are distributed by the inner pipe hole. The inner pipe also has absorption materials like glass fiber, steel wool and sheet hole. The exhaust gases are absorbed automatically by these materials as they move around the inner space. The flow of these gases interfere with the leading gas flow, causing it to have a lower speed [23]. Figure 12 shows the inlet pipe and tail pipes (outlet pipes) with a diameter of 8 inches. The main perforated chamber is 6 feet long with a 28inch diameter. The absorption materials on the coating layer are only 2inches wide. The exhaust outlet pipe has resonance that increases its noise. To remove this, a short tail was used with a length of a quarter wavelengths (λ/4). Equation (8) describes the size of the tail pipe that described by jerry jlilly in AGL acoustic [17].

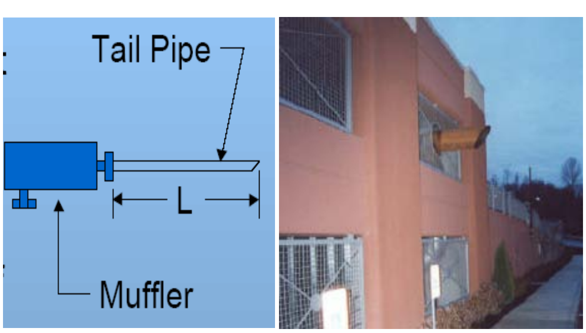


Figure 12 : Tail Pipe.

Here n= positive integer number. when $L = n\lambda/2$, then occurs Resonance and for this reason this size is avoided. Resonance frequency of Tail pipe,

$$fn = nc/(2L) \tag{8}$$

c = sound speed. For a four stroke engine the EFR frequency is 90Hz and its wavelength is 20ft. The best tail pipe is exactly 5 ft. for cancel the EFR frequency of 90 Hz tone at the exhaust of outlet [21]. Here give the calculation for 6 cylinders @ 1800 RPM (950^{0}F)

$$CFR = \frac{1800}{120} = 15Hz$$

$$EFR = 6CFR = 90Hz$$

$$c = 49.03 * \sqrt{(460+950)} = 1841\, ft/\sec$$

$$\lambda_{CFR} = \frac{1841}{15} = 122\, ft.$$

$$\lambda_{EFR} = \frac{1841}{90} = 20\, ft.$$

$$L = \frac{20}{4} = 5\, ft.$$

Where L= tail pipe length. The tail pipe is a metal sheet that lies downstream of the exhaust silencer and has an acoustic resonance that can increase or amplify the final exhaust noise if matched. This resonance can be removed by making the tail half of the wavelength at the tone or sound frequency. However, it is advisable to avoid the tone by creating an accurate size at a quarter of the wavelength. The pipe hole's or perforated holes' number and diameter with measurements are given in Figure13[24].

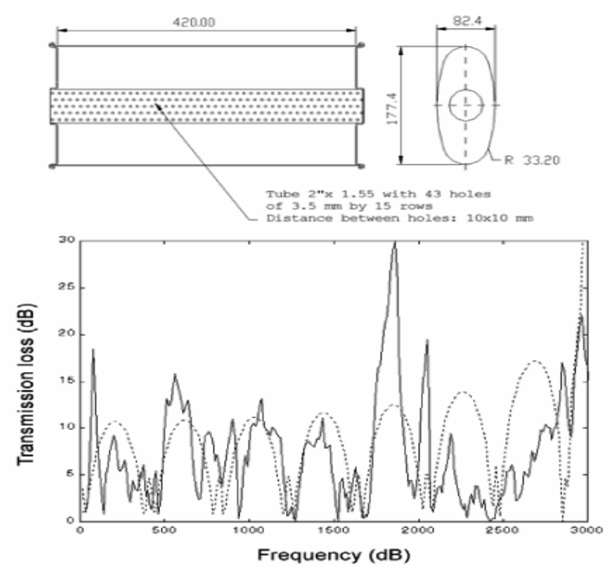


Figure 13 : Transmission Loss of Concentric Perforated Tube.

The pipe hole of expansion chamber of the inner space helps to reduce the sound. The inlet pipe and outlet pipe can be extended to get more attenuation. [25, 26]. The absorption materials also reduce higher frequencies, especially that of mineral wool or glass wool [27].

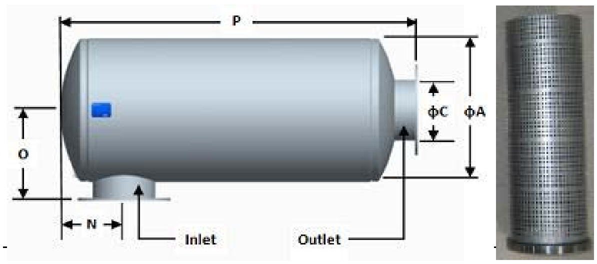


Figure 14 : Side View of Absorption Silencer and Perforated hole

The diameter of inlet and Outlet exhaust pipe is-

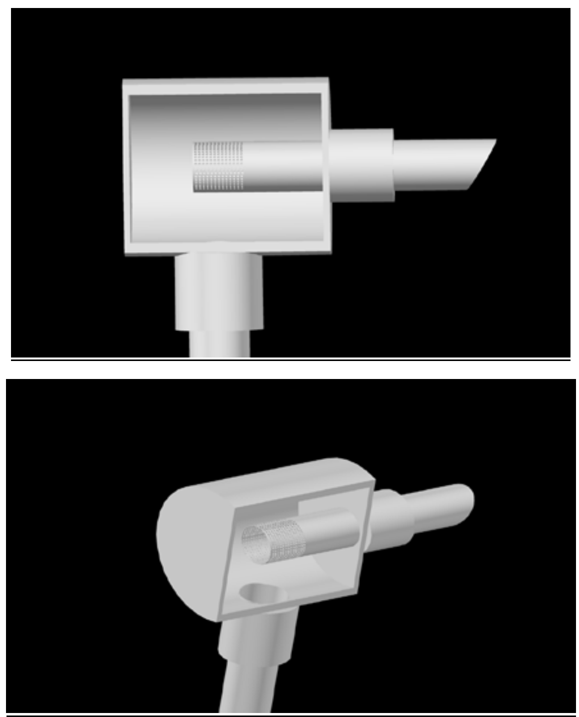
$$Vm = \frac{\pi}{4}(d^2 * l)$$

D2=0.04

D=0.2m=200mm

And the perforated hole diameter is, $d_1=\frac{1.29}{\sqrt{N}}$.[22]

Figure 15 : 3D view of Modified Absorption Silencer



V. Result Analysis with Proposed Silencer

The silencer design is success fulas it reduced the overall noise to the lowest level that can be reached within acceptable limits. It is of good quality and does not have any effect on engine performance. The noise or sound attenuation characteristics of the new absorption silencer was measured and also compared with the old silencer and is presented in Table 2. Shao (2011) measured and tested a new muffler and compared it with traditional muffler. The new muffler was designed with a combination of absorbance materials, a perforated pipe, an expansion chamber, a buffle and inter pole ducting [23]. Figure 16 shows the test result.

Table 2 : Sound attenuation characteristic.

SN	DISTANCE FROM SILENCER	PREVIOUS RECORD dBA	AFTER RECORD dBA	GENERATOR OR LOAD	PREVIOUS TEMP *C	AFTER TEMP *C	PRESURE KPA	RPM
01	1 Meter	120 dBA	85 dBA	75 %	82* C	82* C	460	1800
02	2 Meter	109 dBA	80 dBA	75 %	82* C	82* C	460	1800
03	3 Meter	106 dBA	70 dBA	75 %	82* C	82* C	460	1800

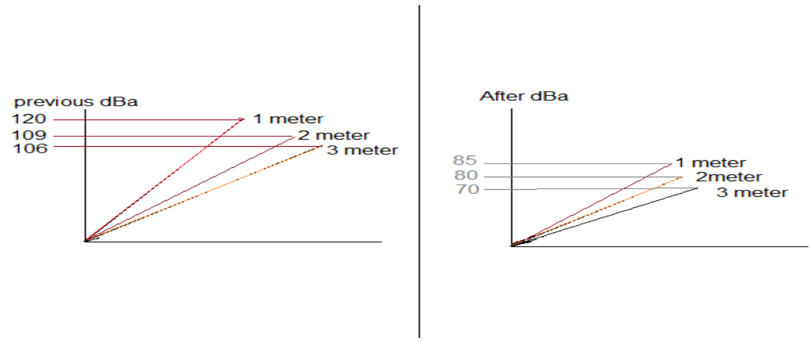


Figure 16 : Sound Test Result.

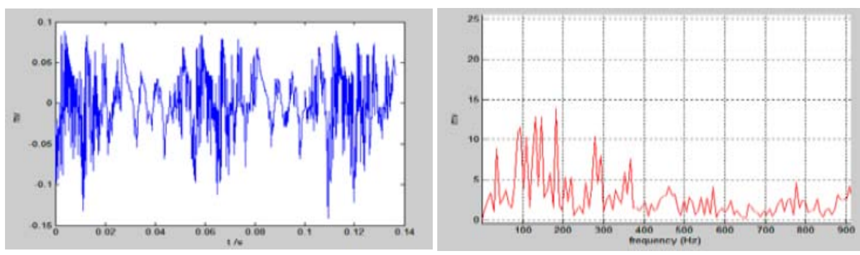


Figure 17 : Time domain chart and spectrum of new absorption silencer

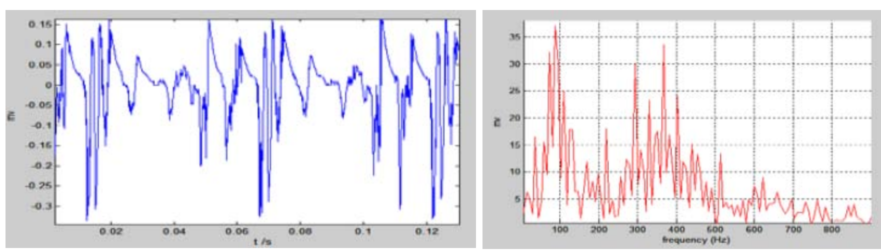


Figure 18 : Time domain chart and spectrum of local or traditional silencer

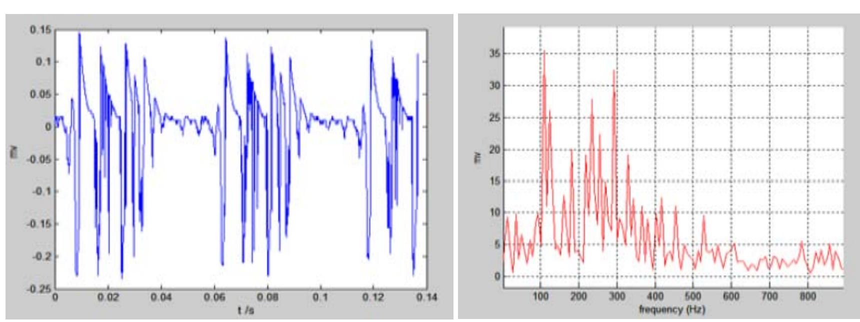


Figure 19 : Time domain chart and spectrum of without silencer

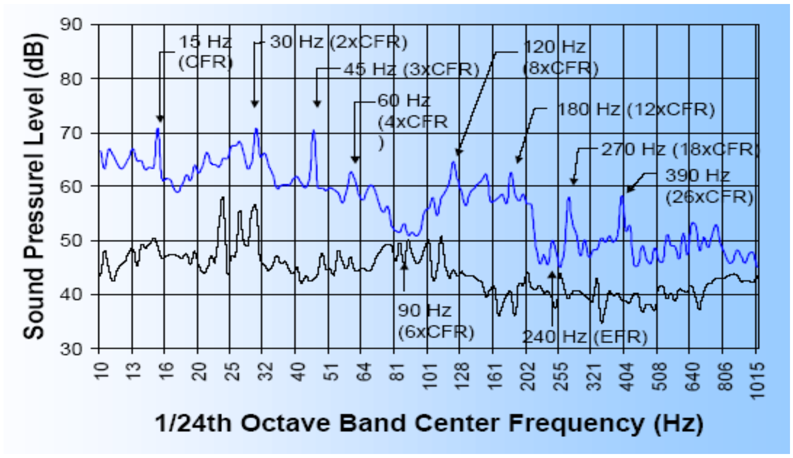


Figure 20 : Sound Pressure Level of CFR & EFR with Proposed silencer

Figure 16 shows that the sound pressure level decreases by approximately 30dB with a modified absorption silencer as compared to a traditional silencer. It also gives a better performance at various distances from the outlet exhaust as compared to other silencers. At 1500 RPM, the modified silencer gives the best result without any change of engine parameters -for example the temperature, pressure and KPA is the same as other traditional silencers. Figures 17 - 19 show the level of sound pressure of an exhaust in three types of silencers.

Table 2 and Figures 17 - 19 illustrate that the modified absorption silencer has better noise reduction properties than other, traditional silencers and mufflers. Figure 20 shows a narrow band spectrum data, collected from a 3m distance from the outlet of an exhaust, used with a proposed silencer. Note the dip in the curve in the vicinity of 80 Hz and 240 Hz. The fact that there is no EFR tone (240 Hz) at all is very impressive.

The main benefit of the modified absorption silencer is the reduction of exhaust noise. However, there are also some other advantages that are highly beneficial, such as: the reduction of noise; possession of a twin wall; the property of being pre-insulated, light and portable; the property of being of a minimal length and weight; possessing an inlet and an outlet that suit modular character; being light weight; having low vibration ability; being easy to build and inexpensive - complex equipment and mounting kits are not needed. In the market, the financial criterion is of crucial importance.[14, 33]. In addition, the modified silencer is easily designed and re-assembled.

Figure 21 : After installation and at running.

VI. Conclusion

The experiment was performed successfully with good conditions. All the spectrums have been observed, in addition to the rules concerning its modification. This paper proposed a practical approach and the importance of a methodology to create a modified exhaust silencer. This design methodology gave a clear basic concept and will help anyone. It saves production time and cost with the easy and simple design. The experiment's conditions and the testing method are correct but the silencer was only tested witha 500KW generator set which ran at 1800RPM. It usually causers duct ion of exhaust gas flow noise.

Further work has to be done to test this absorption silencer with various generator sets such as 1 MW and 2MW engines. Additionally, the inclusion of transmission loss was included by using the TMM. It will developedwith the frequency range in the future in order to give a reliable expected value.

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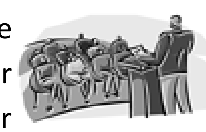

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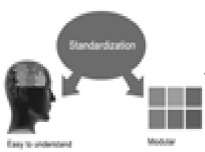

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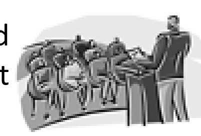

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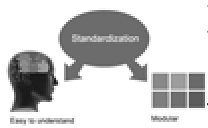

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Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

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.

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

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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.

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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.

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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).

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(Free of charge) from the following website:

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TECHNIQUES FOR WRITING A GOOD QUALITY 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 Computer Science and Information Technology. 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.

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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.

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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
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- 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
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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.

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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.
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- 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.
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- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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