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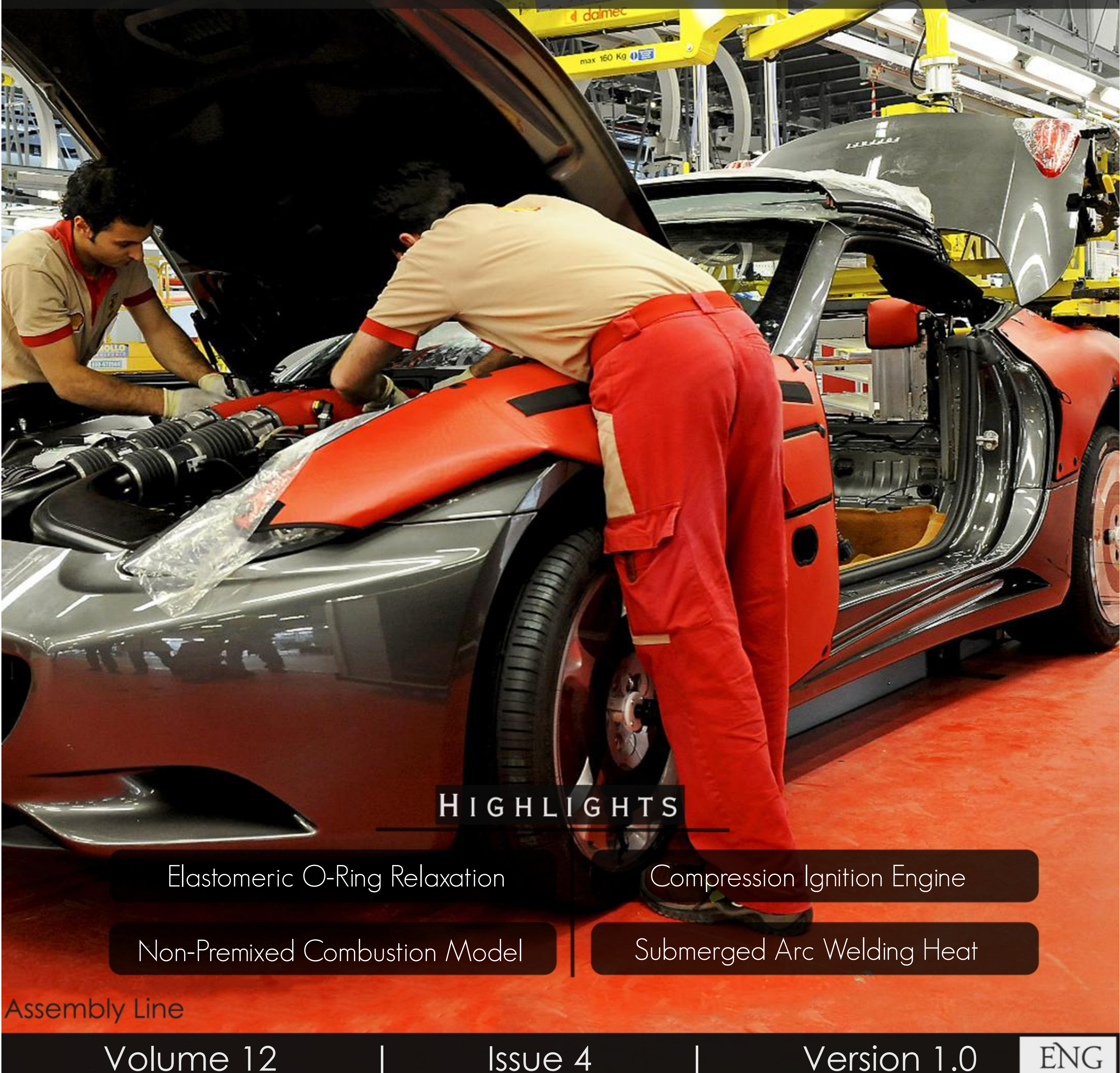

Highlights

Elastomeric O-Ring Relaxation

Compression Ignition Engine

Non-Premixed Combustion Model

Submerged Arc Welding Heat

Assembly Line

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Numerical Simulation of Radial and Axial Compressed Elastomeric O-Ring Relaxation

By Hicham Aissaoui, Mohammed Diany & Jaouad Azouz
Universite Sultan Moulay Slimane Beni Mellal

Abstract - The elastomeric O-ring gaskets are often used in pressurized hydraulic and pneumatic equipments to ensure their sealing. The quality of the O-ring is measured by achieving the desired tightness level. The satisfaction level of practical operation depends on the consistency of long-terms mechanical properties located during the useful life and on the conditions of assembly installation and the O-ring location. Indeed, the gasket is pressed on flat faces or housed in specially arranged grooves for which the dimensions influence greatly the assembly behavior. In this article, an axisymmetric finite element model is proposed to simulate the O-ring relaxation behaviour during the few first days of its installation in both the unrestrained and restrained radial and axial loading cases. The contact stress profiles and the peak contact stresses are determined versus the time relaxation in order to specify the working conditions thresholds.

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NUMERICAL SIMULATION OF RADIAL AND AXIAL COMPRESSED ELASTOMERIC O-RING RELAXATION

Strictly as per the compliance and regulations of:

Numerical Simulation of Radial and Axial Compressed Elastomeric O-Ring Relaxation

Hicham Aissaoui [α], Mohammed Diany [σ] & Jaouad Azouz [ρ]

Abstract - The elastomeric O-ring gaskets are often used in pressurized hydraulic and pneumatic equipments to ensure their sealing. The quality of the O-ring is measured by achieving the desired tightness level. The satisfaction level of practical operation depends on the consistency of long-terms mechanical properties located during the useful life and on the conditions of assembly installation and the O-ring location. Indeed, the gasket is pressed on flat faces or housed in specially arranged grooves for which the dimensions influence greatly the assembly behavior. In this article, an axisymmetric finite element model is proposed to simulate the O-ring relaxation behaviour during the few first days of its installation in both the unrestrained and restrained radial and axial loading cases. The contact stress profiles and the peak contact stresses are determined versus the time relaxation in order to specify the working conditions thresholds.

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Nomenclature

F total compression load (N)

e initial O-ring axial displacement (mm)

d the O-ring cross-section diameter (mm)

D the O-ring mean diameter (mm)

C the ratio e/d

R the axial compression ratio

b the contact width between the gasket and plat (mm)

x radial position compared to the vertical axis of the O-ring cross-section (mm)

p_o maximum contact pressure value or peak contact stress (MPa)

E_{relax} relaxation modulus (MPa)

E_j elastic modulus for gasket (MPa)

α_j coefficient

τ_j relaxation time (s)

η_j viscosity (MPa.s)

Abbreviation

RAL restrained axial loading

RRL restrained radial loading

UAL unrestrained axial loading

URL unrestrained radial loading

Author [α σ ρ] : Faculté des Sciences et Techniques de Béni Mellal, BP 523 Béni Mellal, Morocco. E-mails : h.aissaoui@gmail.com; mdiany@yahoo.com; jaouad.azouz@gmail.com

I. Introduction

The elastomeric O-ring gaskets are widely used in hydraulic and pneumatic equipments to ensure the sealing of the shaft, the pistons and the lids. The correct operation of the O-ring is conditioned, on the one hand, by the maximum value of the contact pressure created during the O-ring compression and on the other hand by the preservation in operating stage of a minimal threshold value below which the sealing of the joint is blamed. Therefore, the evaluation of the maximum value of contact pressure evolution in time has a primary importance to ensure the correct O-ring function during its nominal useful lifetime.

There are two O-ring types, static and dynamic seals. The first seals are classified as either axial or radial squeeze. For the second ones three main classifications are considered, reciprocating, rotary and oscillating seals. The O-ring seals are placed in grooves specially arranged to block their possible displacement and to assure the maximum contact pressure giving the maximum performance. The dimensions of these grooves are provided by the seals manufacturers in tables which are selected according to the cross section O-ring diameter. The origin formulas giving the groove dimensions are not known and the theoretical approach used by the manufacturers is not published.

Several teams were interested in O-ring assembly used in various industrial services. The published works on this subject propose the same analytical approach based in all cases on the Hertzian classical theory [1]. Others studies have more experimental studies using various assemblies to characterize the O-ring itself in traction and compression loads and to model his real behaviour. In the third shutter, finite elements models are developed to numerically simulate assemblies with the O-ring.

George and al. [2] used a finite elements model to study the behaviour of the O-ring compressed between two plates. The gasket characteristics were introduced into the program according to parameter defining the total deformation energy or by using the Neo-Hookean model. The results of this analysis were compared with those of several experimental studies and analytical approaches based on the Hertzian theory. Dragoni et al. [3] propose an approximate model to study the O-ring behaviour placed in rectangular grove. The influence of the grove dimensions variation and the friction coefficient was treated.

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The work of Green and al. [4] reviews the majority of used O-rings configurations. Finite elements models were developed considering hyperelasticity behaviour. The results of these models were confronted with those of empirical studies. New relations expressing the maximum contact pressure and the width of contact were proposed. Rapareilli and al. [5] present a validation of the experimental results by a numerical model which regarded the joint as an almost incompressible elastic material. The effects of the fluid pressure as well as the friction effect between the gasket and the shaft are studied.

In an experimental study [6], the authors tried to determine the influence of the fluid pressure on the contact pressure, which ensures of sealing as well as the ageing deterioration of the joint. Kim and al. [7, 8] tried to find an approximate solution for the mechanical behaviour of the O-ring joints in several configurations. The influence of the friction coefficient is highlighted. An experimental study was carried out to find more realistic elastic modulus values for elastomeric O- ring. They compared their results with those obtained in experiments and by the finite element analysis. They found that the values given by the Lindley [9, 10] to calculate the compressive force are similar to those determined by the finite elements model. The O-ring relaxation was treated by the reference [11] where the degradation is caused by oxidation or nuclear irradiation. The authors describe several improvements to the methods used in there previous studies.

In this study, axisymmetric finite element models are proposed to simulate the O-ring relaxation behaviour during the few first days of its installation in both the unrestrained and restrained radial and axial loading cases. Figure 1 presents the studied cases. The contact stress profiles and the peak contact stresses are determined versus the time relaxation in order to specify the working conditions thresholds. The effect of the temporal variation of the longitudinal elasticity modulus as well as the influence of the axial compression ratio will be analyzed.

II. O-ring Mechanical Characteristics

Most of the previous work dedicated to study the O-ring gasket behaviour use the same analytical model based on the Hertzian pressure contact theory. By adopting this classical theory, Lindley [9, 10] developed a simple approximate formula, relation (2.1), expressing the compressive force, F, according to the ratio of initial compressed displacement by the crosssection O-ring diameter, $C = \frac{e}{d}$.

$$F = \pi D d E (1.25.C^{\frac{3}{2}} + 50.C^6) \qquad (2.1)$$

The same theory allowed finding out the contact width, b, and the maximum value of the contact stress po, according to the formulas (2.2) and (2.3).

$$b = d.\sqrt{\frac{6}{\pi}(1.25.C^{\frac{3}{2}} + 50.C^6)} \qquad (2.2)$$

$$p_o = 4.E.\sqrt{\frac{(1.25.C^{\frac{3}{2}} + 50.C^6)}{6\pi}} \qquad (2.3)$$

The contact pressure distribution according to the radial position on the gasket is given by the equation (2.4).

$$p(x) = p_0\sqrt{1-\left(\frac{2x}{b}\right)^2} \qquad (2.4)$$

These formulas do not utilize the mechanical characteristics of the components in contact with the seal. Only the O-ring elastic modulus, E, are used. Practically, the most used O-ring material has a hyperelastic or viscoelastic behavior. For the relaxation studies, the viscoelastic behavior is the best choice to take into account the effect of hyperelasticity and time variation of mechanical properties.

In previous study [12], it was confirmed that the same equations remain valid for the time evolution study of the O-ring behaviour but using a variable elastic modulus according to time, called relaxation modulus E_{relax}. The viscoelastic behaviour of the gasket is given by the modified Maxwell model [13], presented in figure 2.

The relaxation modulus is defined by:

$$E_{relax}(t) = E_\infty + \sum_j E_j e^{-\frac{t}{\tau_j}} \qquad (2.5)$$

With

$$\tau_j = \frac{\eta_j}{E_j}, \ \alpha_j = \frac{E_j}{E_\infty} \ \text{and} \ E_0 = E_\infty + \sum_j E_j \qquad (2.6)$$

The relaxation modulus in Eq. (2.5) becomes:

$$E_{relax}(t) = E_0\left[1 - \sum_j \alpha_j (1 - e^{-\frac{t}{\tau_j}})\right] \qquad (2.7)$$

The initial elasticity modulus, E_0, and the coefficients α_J, called Prony series coefficients, are deduced from the experimental data of the reference [14]. The time variation of this relaxation modulus is presented in figure 3.

The relaxation study consists to evaluate the variation of the contact stress versus time, when an initial displacement, e, characterized by a compression ratio R, given by the equation (2.8), is imposed to the gasket. For each axial compression ratio, R, the variation of the contact pressure distribution as well as the change of the contact surface width are determined with the relations (2.2), (2.3) and (2.4).

$$R = 100 \times \frac{2.e}{d} = 200.C \qquad (2.8)$$

III. Finite Element Models

The study of the O-ring relaxation, in the four cases presented in Fig. 1, when it is compressed by the application of a constant displacement, consists in following the time evolution of the contact pressure and contact width. To achieve this goal, an axisymmetric finite elements model of each assembly was produced using ANSYS software [15] as showed for RAL case in figure 5.

Since the problem is axisymmetric and the median horizontal or vertical plane, respectively for axial or radial loading, cutting the O-ring in two equivalent parts is a symmetry plane, the joint is modeled by a half-disc with four node's 2D planes elements. The O-ring material is regarded as viscoelastic characterized by the Prony coefficients. The rigid component is modeled by rigid elements for which the displacements are blocked in all directions. The geometric and mechanic characteristics of the O-ring joint are summarized in table 1. In order to check the influence of the O-ring rigidity two initial Young modulus values are considered. The mesh refinement is optimized to have the convergence while using less computer memory capacity.

The value of the imposed displacement on the free seal surface is calculated by the axial compression ratio, R, which varied between 5 and 35 % compared to the O-ring cross-section diameter. Thereafter, the contact pressure distribution is recorded according time.

IV. Results and Discussions

The work presented in this paper is the continuation of an previous work [12] in which it was concluded that the classical theory of Hertzian contact, developed initially for steady operation, remains valid for the relaxation and it is in good agreement with the used finite element model. Consequently, we will just use the finite element analysis to compare the case where the joint is free to move in the direction perpendicular to that of the applied compressive stress and the case where this movement is blocked by placing the seal in a rectangular groove.

After the application of an initial load on unrestrained O-ring upper surface (UAR case), an initial displacement is taking place and will be kept fixe over the relaxation time. Figure 5 presents the variation of the contact pressure between the O-ring and the fixed component when the compression ratio is equal to 5, 15 and 30% for various relaxation times. When the relaxation time increases the contact pressure decreases and the relaxation rate can be calculated for each applied compression ratio. In addition, the contact area is larger when the compression ratio is greater. On the other hand, whatever the relaxation time for the same compression ratio, the contact width remains the same. Thus, when the compression ratio increases from 5% to 15% and to 30%, the contact width, successively, is evaluated to 20%, 38% and 62% of the seal cross section diameter.

For the restrained axial loading case, Fig. 6 shows the contact pressure distribution for R=20% and for two relaxation time, 8 and 24 hours. The same observations, as for UAL case, remain valid but the contact pressure values decreases. The limitation of the radial displacement by the groove creates a pressure contact distribution along the contact surface side of the groove. For each relaxation time, the curve is symmetric about the seal section center. This shows that the influence of the radial position is negligible on the symmetry of contact pressure distribution even in the groove presence.

In order to perceive the importance of the groove on the contact pressure, Fig. 7 compares the two cases of axial loading for different initial elastic modulus. The contact pressure ratio is represented as a function of the relative radial position. For the same compression ratio, the stress value in RAL case is larger than in the URL case. The axial contact area is almost identical in the two cases. So it is clear that the primary advantage of placing the seal in a groove is to increase the contact pressure which ensures more sealing with the same compression ratio. However, the chosen groove dimensions are not optimized to provide better performance. In aerospace applications, the most used standard is SAE AS5857A [16] that provide standardized gland (groove) design criteria and dimensions for elastomeric seal glands for static applications.

To know the extent of the pressure contact, the contact width is shown in Fig. 8 as a function of compression ratio. It is evident that when the O-ring is more compressed the contact area is larger. The analytical values of the contact width given by Eq. (2.2) are closer to those given by the finite element analysis in the URL case. Indeed, the used analytical model does not take into account the presence of seal-groove lateral contact.

For the piston rod and in the static state, the O-ring is solicited radially in the perpendicular axis direction. This configuration is represented by the RRL and URL cases in Fig. 5. To illustrate the effect of compression ratio on the initial contact pressure distribution, Fig. 9 compares these two cases and highlights the creation of the contact pressure at the lateral groove-seal contact surface. At the radial contact, the pressure is greater when the compression ratio increases or when the seal is placed in the groove. For the axial contact, the contact pressure reaches almost 50% of the maximum value recorded at the radial contact.

Figure 10 presents the distribution of the contact pressure at contact interface between the groove and the seal for different time periods. The stress decreases rapidly versus time for all axial position except at the contact area. It is to be noted that for all time periods and for the same compression ratio, the contact width is the same.

Figures 11 and 12 compare the reductions in maximum pressure contact due to the relaxation at different compression ratio for URL and RRL cases. For the same compression ratio, the variation of this stress is more significant at the first hours and it stabilised after. Indeed, for both cases and whatever the compression ratio, the ratio of the maximum contact pressure by the initial elastic modulus decreases with a rate of 56% from its initial value when the relaxation time is 12 hours while it is about 57% after 72 hours.

V. Conclusion

This study shows that the installation of the seal in a groove reduces the compression ratio needed to create a contact pressure threshold provided for sealing the assembly. On the other hand, the first few hours after installing are critical and must be controlled in order to ensure the proper O-ring functioning. The geometric configuration of the groove used in our model is idealized which requires to verify the results obtained when the geometrical defects are introduced to the model. An experimental study is expected to confirm these results and characterize the mechanical behavior of industrial O-rings.

References Références Referencias

1. Timoshenko and Goodier, 1934, « Theory of elasticity », McGraw-Hill.
2. George AF, Strozzi A, Rich JI, Stress fields in a compressed unconstrained elastomeric O-ring seal and a comparison of computer predictions and experimental results, Tribology International, 1987, Vol. 20, No. 5, pp. 237-247.
3. Dragoni E, Strozzi A, Theoretical analysis of an unpressurized elastomeric O-ring seal inserted into a rectangular Groove, Wear 1989; 130:41-51.
4. Green I, English C, Stresses and deformation of compressed elastomeric O-ring seals, 14th International Conference on Fluid Sealing, Firenze, Italy, 6-8 April 1994.
5. Rapareilli T, Bertetto AM and Mazza L, Experimental and numerical study of friction in an elastomeric seal for pneumatic cylinders, Tribology International Vol. 30, No 7, pp. 547-552, 1997.
6. Yokoyama K, Okazaki M and Komito T, Effect of contact pressure and thermal degradation on the sealability of O-ring, JSAE 1998; 19: 123-128.
7. Kim HK, Park SH, Lee HG, Kim DR, Lee YH, Approximation of contact stress for a compressed and laterally one side restrained O-ring, Engineering Failure Analysis 2007; 14: 1680-1692.
8. Kim HK, Nam JH SH, Hawong JS, Lee YH, Evaluation of O-ring stresses subjected to vertical and one side lateral pressure by theoretical approximation comparing with photoelastic experimental results, Engineering Failure Analysis, doi:10.1016/j.engfailanal.2008.09.028.
9. Lindley PB., 1967, Compression characteristics of laterally-unrestrained rubber Oring, J IRI, 1, pp. 220-13.
10. Lindley PB., 1966, Load-compression relationships of rubber units, J Strain Anal, 1(3), pp. 190-5.
11. Gillen K.T., Celina M. and Bernstein R., 2003, Validation of improved methods for predicting long-term elastomeric seal lifetimes from compression stress-relaxation and oxygen consumption techniques, Polymer Degradation and Stability, 82, pp. 25-35.
12. Diany M. and Aissaoui H., 2011 "Finite Element Analysis for Short term O-ring Relaxation", Jordan Journal of Mechanical and Industrial Engineering, Volume 5, Number 6, Dec. 2011 pp. 478 - 482
13. McCrum,N. G., Buckley C. P. and Bucknall C. B., 2004, Principles of Polymer Engineering, Oxford University Press, New York.
14. Christensen, R. M., 1982, Theory of Viscoelasticity - An Introduction, 2nd ed., Academic Press, New York.
15. ANSYS, 2003, ANSYS Standard Manual, Version 11.0.
16. SAE, 2010, AS5857A : Gland Design, O-Ring and Other Elastomeric Seals, Static Applications.

Table 1 : O-ring characteristics

	O-ring	
Subscript	*1*	*2*
d (mm)	6.98	
D (mm)	123.19	
E_0 *(MPa)*	2.82	46.20
ν	0.48	

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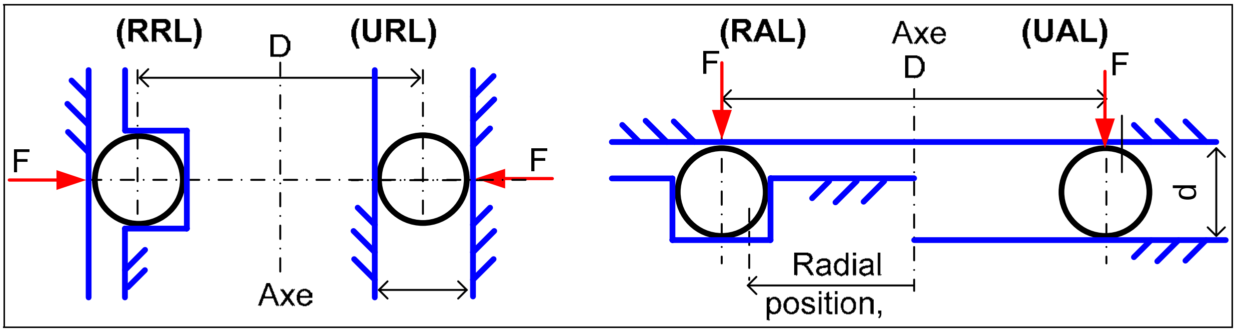

Figure 1 : Unrestrained Axial Loading (UAL); Restrained Axial Loading (RAL) Unrestrained Radial Loading (URL); Restrained Radial Loading (RRL)

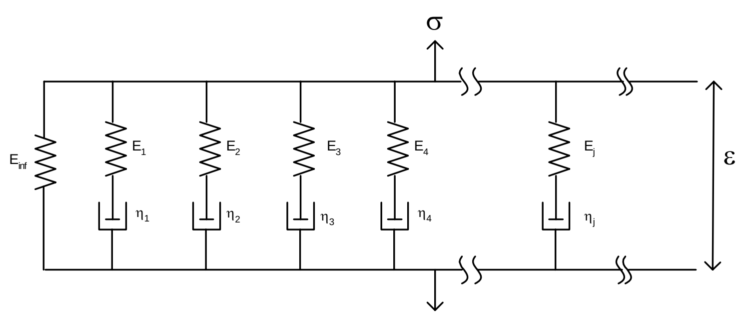

Figure 2 : A generalized Maxwell model

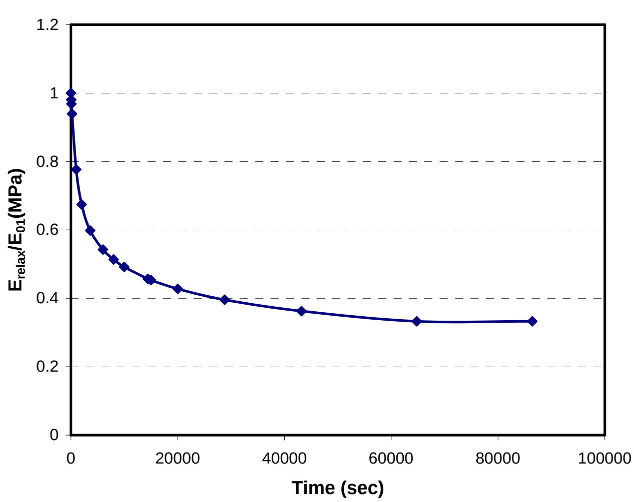

Figure 3 : Relaxation modulus ratio

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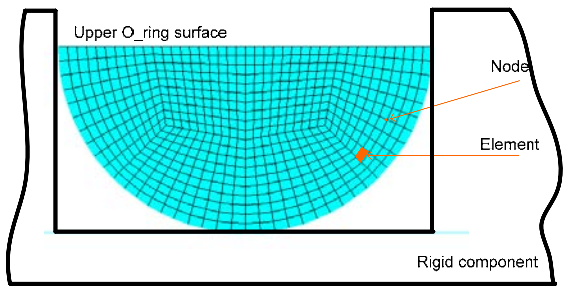

Figure 4 : O-ring axisymmetric finite elements model for RAL case

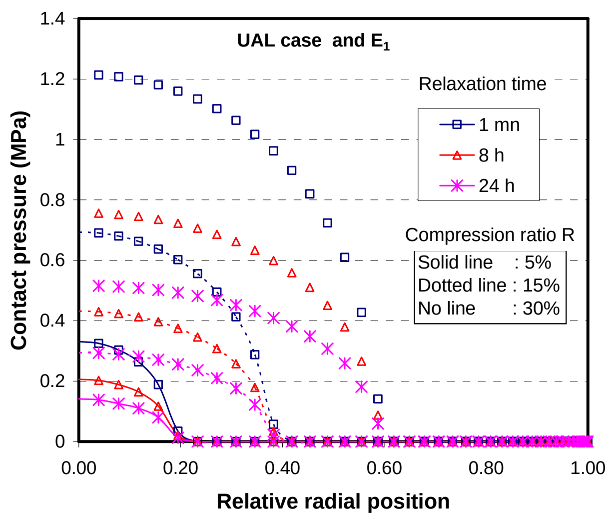

Figure 5 : Contact pressure variation for UAL case

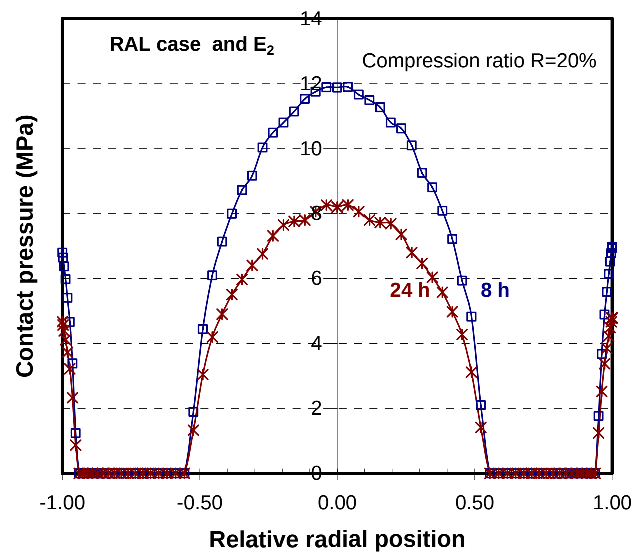

Figure 6 : Contact pressure variation for RAL case

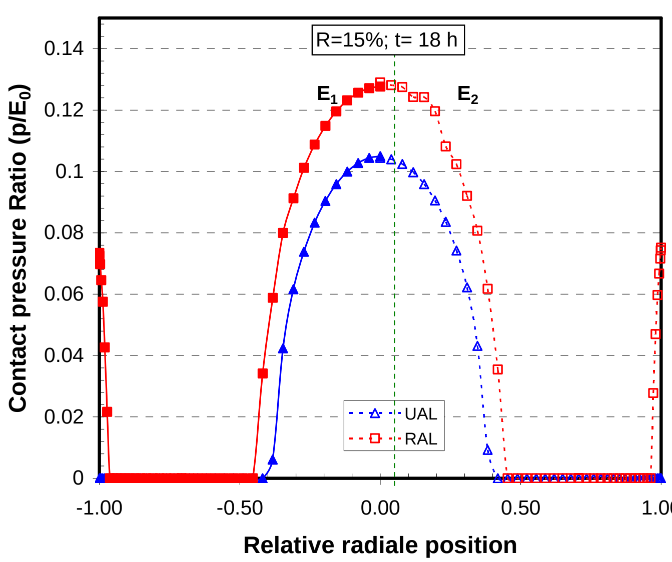

Figure 7 : Comparison of pressure contact for UAL and RAL

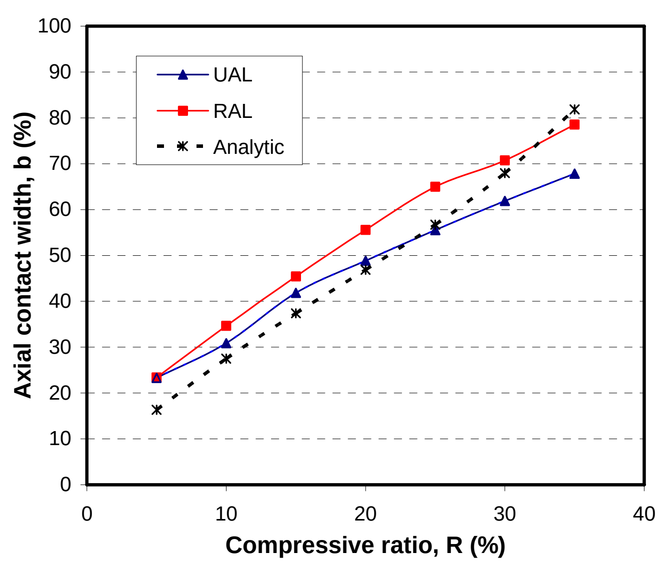

Figure 8 : Axial contact width variation

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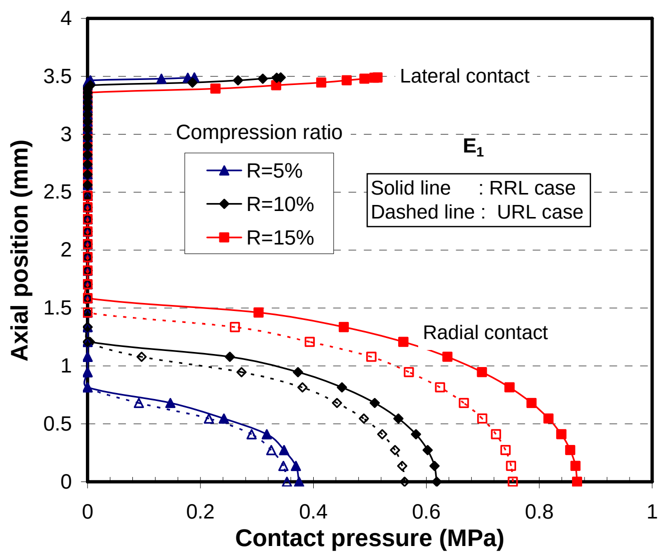

Figure 9 : Initial contact pressure vs compression ratio

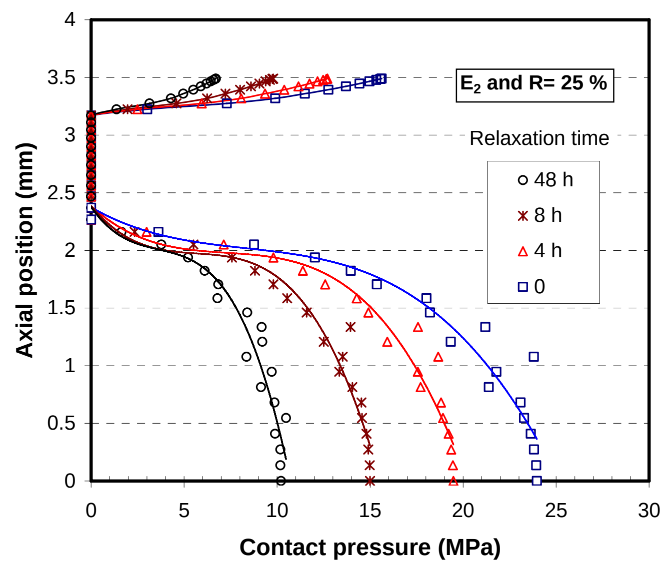

Figure 10 : Relaxation stress in RRL case

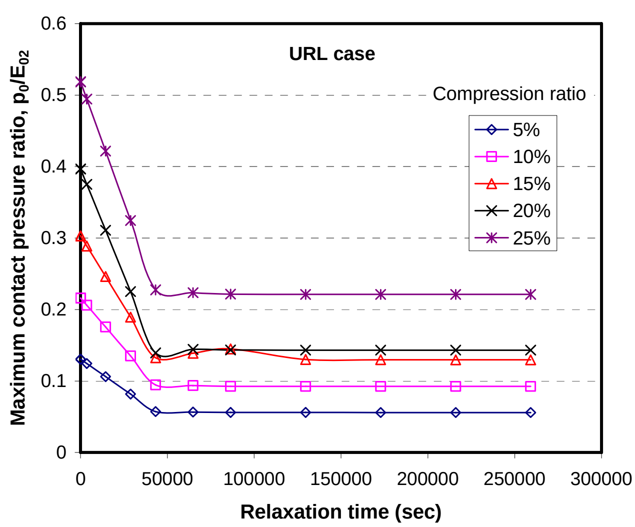

Figure 11 : Relaxation of pressure contact for URL

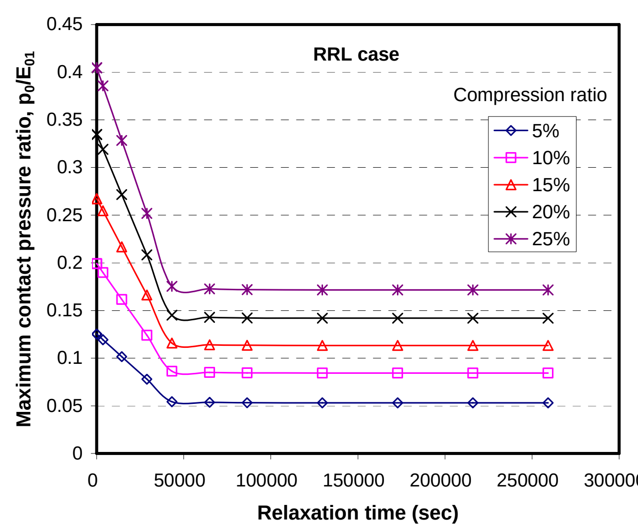

Figure 12 : Relaxation of pressure contact for RRL case

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Study of Different Methods of Using Vegetable Oil as a Fuel for Compression Ignition Engine

By Nandkishore D.Rao, Dr.B. Sudheer Premkumar & Dr. M.Yohan
Jawaharlal Nehru Technological University, India

Abstract - This paper present a comparative study of performance and emission characteristics of compression ignition engine with different method of using straight vegetable oil. Single cylinder water cooled, constant speed diesel engine which is generally used for water pump or generator sets is used for investigations. During tests, engine is operated with petrodiesel, vegetable oil (at normal room temperature and at 90°C) and vegetable oil-ethanol emulsions at room temperature. The engine performance parameters and emissions are measured with different test fuels from no load to full load conditions.

Keywords : Compression Ignition engine, Vegetable oils, Micro-emulsions, Performance, Emissions, Blending, Esterification, pre-heating.

GJRE-A Classification : FOR Code: 090201

STUDY OF USE OF DIFFERENT METHODS OF USING VEGETABLE OIL AS FUEL FOR COMPRESSION IGNITION ENGINE

Strictly as per the compliance and regulations of:

Study of Different Methods of Using Vegetable Oil as a Fuel for Compression Ignition Engine

Nandkishore D.Rao [α], Dr.B. Sudheer Premkumar [σ] & Dr. M.Yohan [ρ]

Abstract - This paper present a comparative study of performance and emission characteristics of compression ignition engine with different method of using straight vegetable oil. Single cylinder water cooled, constant speed diesel engine which is generally used for water pump or generator sets is used for investigations. During tests, engine is operated with petrodiesel, vegetable oil (at normal room temperature and at 90°C) and vegetable oil - ethanol emulsion at room temperature. The engine performance parameters and emissions measured with different test fuels from no load full load conditions.

At normal temperature, the Straight vegetable oil (SVO) shows lower thermal efficiency, higher specific energy consumption with higher exhaust gas temperature as compared to diesel at all loading conditions. Preheating and emulsion of vegetable oil show improvement in engine performance. The smoke opacity is higher with neat vegetable oil and it reduces with preheating and emulsification. However, NO_x emissions are lower with unheated vegetable oil as compared to preheated oil due to lower in-cylinder temperature due poor combustion. With micro-emulsion, NO_x emissions are lowered as compared to pre-heated oil due to high latent heat of ethanol and water traces present in ethanol. Overall it is observed that oxides of nitrogen emissions with vegetable oil(at room temperature/preheated/emulsified) are lower as compared to mineral diesel. Higher unburned hydrocarbon and carbon monoxide emissions are observed with unheated SVO as compared to diesel. However, these emissions are considerably reduced with pre-heated and emulsified vegetable oil.

It could be concluded that with micro- emulsion of vegetable oil, the engine performance and emissions improved significantly.

Keywords : Compression Ignition engine, Vegetable oils, Micro-emulsions, Performance, Emissions, Blending, Esterification, pre-heating.

Author α : Department of Automobile Engineering, Guru Nanak Dev Engineering College, Bidar Karnataka- India.
E-mail : ndrao1234@yahoo.com
Author σ : Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Hyderabad Andhrapradesh - India.
E-mail : bsudheerpk@yahoo.co.in
Author ρ : Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Anantpur Andhrapradesh – India.
E-mail : yohan.jntua.me@jntua.com

I. Introduction

In country like India, majority of population lives in rural areas and they depend on agriculture. The diesel engines are popular in rural areas where it is not possible to have uninterrupted electric supply to run electric motor for water pump sets. If fuel for these diesel engines is prepared locally, it makes the farmers self-sufficient in regard to their energy needs.

There are many vegetable oils which can be used as fuel for diesel engines. The edible oils like sunflower oil, pea nut oil, soya oil etc are costly and are for human consumption. The non edible oils obtained from plant species such as *Jatropha curcas* (Ratanjyot), *Pongamiapinnata*(Karanj), *Calophylluminophyllum* (Nagchampa), *Hevca brasiliensis, honge, honne and rubber etc.* can be used as fuel for diesel engine. The land which is not suitable for agricultural purpose may be used for growing these trees to produce oil seeds, upon extraction, oil can be used as fuel for diesel engine with minor modifications. The vegetable oils offer many benefits including sustainability, regional development, reduction in green house gases, reduction on dependency on mineral diesel which is imported from foreign countries. Straight vegetable oils have very high viscosity which results into inferior engine performance

The viscosity of the vegetable oil can be reduced by converting it to biodiesel, mixing it with mineral diesel, preheating and diluting the vegetable oil with solvent. The trans-estrification(conversion of vegetable oil to its esters) with a lower alcohol yields a fuel with lower viscosity but reduces the feasibility of Direct use of vegetable oil. Also the esters have a solidification temperature about 4 degree C., requiring the use of fuel preheaters in cold winters.

Blending of vegetable oil with diesel fuel fall short of meeting the farmer's goal of energy self – sufficiency. Cracking and refining are effective in upgrading vegetable oils, but it increases the cost of fuel and negate direct on farm utilization of the harvested vegetable oil. The concept of diluting vegetable oil with ethanol, another agricultural based energy source may be possible for on the farm preparation of fuel. This mixing of vegetable oil and ethanol is confronted with the difficulty of phase separation. Hence, a 1-butanol is used as a non-ionic surfactant to dispersethe water and alcohol in vegetable oil to form a micro-emulsion. Pre-heating of vegetable oil reduces its viscosity thereby improving the engine performance. The Past investigation show that the preheated vegetable oil in diesel engine resulted in improved engine performance and combustion characteristics with lower hydrocarbon, particulate and higher NO_x emissions as compared toun-heated vegetable oil. **M. Pugazhvadivu and K. Jeyachandran [1]** conducted experimental investigation on diesel engine to study effect of pre-heated waste fried oil (WFO) on engine performance and emission characteristics. The engine performance improved significantly with maximum reduction in CO and smoke emissions with WFO at 135°C as compared to unheated WFO. They concluded that pre-heated WFO at 135°C can be a substitute for diesel. **M. Pugazhvadivu and G. Sankaranarayanan [2]** used preheated mahua oil s fuel for dieselengine and concluded that pre-heating the mahua oil to 130°C gave higher thermal efficiency with lower HC,CO, smoke and higher NO_x as compared to unheated mahua oil. **Sagarpramodraokadu and Rajandra H. Sarda [3]**conducted experiments on single cylinder COMET engine at different speeds with karanja oil heated from 30° C – 100°C .It was reported that at all speeds, pre-heated fuel showed marginal increasein brake thermal efficiency and significant increase in NO_x as compared to unheated oil. **Avinash Kumar agrawal and K. rajamohan [4]** used karanja oil and its blends with diesel with and without preheating. They reported that, with pre-heated fuel engine efficiency slightly improved with lower brake specific energy consumption. It is also reported that pre-heated oil showed lower carbonmonoxide, Hydrocarbon emissions with increased NOx emissions. **Dhinagar et.al. [5]** conducted experiments with neem oil, rice bran oil and karnji oil with and without pre-heating. With pre-heated oils engine efficiency is improved. **T. K. Bhattacharya et al [6]** used diesel alcohol micro emulsions for diesel engine. They reported that with increase in percentage of alcohol and ethyle acetate in emulsion, the specific fuel consumption of engine increased due to their lower gross heat of combustion. The carbon monoxide emissions were reduced up to 44.4percent with different emulsions as compared to diesel. The hydrocarbon emission was marginally higher for all loads. Nitrogen Dioxide emissions were lower. **Kerihuel. M et. al. [7]** investigated performance of diesel engine with micro-emulsions of Animal fat with water and methanol. Lower exhaust gas temperature, higher volumetric efficiency with micro-emulsions were observed as compared to diesel. Lower unburnt hydrocarbon, carbon monoxide, Nitrogen oxide emissions were also observed with micro emulsions.

In this work, engine performance, emissions with unheated vegetable oil, preheated vegetable oil and emulsion of vegetable oil with ethanol are investigated.

II. Material and Experimental Setup

a) Materials

The non edible oil (Honge oil) is filtered through 2 micron oil filter supplied by AOF filters, Hyderabad. The vegetable oil is preheated to a temperature of 90°C(PSVO) to reduce its viscosity. The micro-emulsion, ESVO (emulsion of vegetable oil, ethanol and butanol) is prepared for investigation While preparing emulsion butanol is added to vegetable oil and then ethanol is added. The emulsion is stirred for three hours using magnetic stirrer. Various physical and chemical properties of diesel, vegetable oil and emulsion are determined using standard testing procedures and results are tabulated in table No. 1.Viscosity is measured by using redwood viscometer, calorific value was estimated using bomb calorimeter (supplied by Datacone industries Pvt. Ltd),flash and fire points are determined by using Marten-penesky closed cup apparatus. It can be seen that with increase in percentage of ethanol in emulsion its viscosity reduces.

Table No 1 : Properties of diesel, Honge oil and Micro-emulsions

Properties	Diesel	Neat Honge oil	ESVO
Viscosity in Cst	4.25	40.25	25.78
Flash point (°C)	79	190	42
Fire point (°C)	85	210	50
Calorific value(kJ/kg)	42700	37258	34633
Specific gravity (at25°C)	0.833	0.925	0.90

b) Experimental setup

A TV-1, Single cylinder, constant speed, direct injection, diesel engine manufactured by kirloskar oil engine limited is used for experimental investigations. This engine is generally used for running water pumps for irrigation and generator sets. It is coupled to a water cooled eddy current dynamometer for loading. Engine is equipped with thermocouples to measure temperature of coolant, exhaust gas and water at inlet and outlet of calorimeter. A rotameter is used to measure amount of water flow, a manometer with air box is used to measure air flow rate and burette is used to measure fuel flow. Detailed engine specifications are given in table no 2.

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Table No 2 : Specifications of Engine

Sl.No	Parameter	Specification
1	Type	Four stroke direct injection single cylinder diesel engine
2	Software used	Engine soft
3	Nozzle opening pressure	200 bar
4	Rated power	3.5KW @1500 rpm
5	Cylinder diameter	87.5 mm
6	Stroke	110 mm
7	Compression ratio	17.5

The fuel flow rate is measured on volumetric basis using burette. Fig 1 shows the schematic diagram of experimental setup. Two fuel tanks (one for diesel and other for test fuels) are connected to burette. The engine is first started with mineral diesel and switched on to test fuels. A four gas analyzer was used to measure concentration of NO_x, CO and Unburnt hydrocarbon in the exhaust. The smoke concentration is measured using smoke meter. Details of emission measuring instruments is tabled in Table No 3

Table No 3 : Specification of Gas analyser and smoke meter

Machine	Measurement Parameter	Range	Resolution
Gas Analyser	CO(Carbon Monoxide)	0-15%	0.01%
	CO_2 (Carbon Dioxide)	0-19.9%	0.1%
	NO_x (Oxides of Nitrogen)	0-5000ppm	1ppm
	HC(Hydrocarbon)	0-20000ppm	1ppm
DIESEL SMOKE METER	Opacity	0-99.9%	0.1%

Initially experiment is carried out with injection pressure and injection timing set by manufacturer (200 bar and 23deg btdc) and diesel fuel at different loads. With same settings, experiment is repeated with unheated vegetable oil (SVO), pre-heated vegetable oil (PSVO) and micro-emulsion (ESVO) of filtered vegetable oil and ethanol with butanol as emulsifier. Variation in humidity and ambient temperature is neglected because all tests are performed for short duration. During all experiments, engine loading is done using an eddy current dynamometer. Fuel consumption is measured using burette .Thermocouples are used to measure exhaust gas temperature before it enters to the exhaust gas calorimeter.

After completing tests on every test fuel, fuel lines, fuel filters are drained and sufficient new test fuel is allowed to flow so that no trace of previous test fuel remains in injection system. After this again engine is allowed to run for 10 min on new fuel so it can be ensured that engine is operating with required emulsion.

III. Results and Discussion

a) *Performance Parameters*

The significant performance parameters like Brake thermal efficiency, Specific energy consumption and Exhaust gas temperature are calculated and are discussed.

i. *Brake thermal efficiency*

The Variation of brake thermal efficiency (BTE) with load with different fuels is presented in Fig.2. In all cases the brake thermal efficiency increases with increase in brake power. This may be due to lower heat losses. It is noticed that the brake thermal efficiency is about 21.12%, 22.56% 23.33% and 31.85%, with SVO, PSVO, ESVO and diesel respectively. The reason for lower thermal efficiency with SVO is lower heat content, higher viscosity and poor volatility. With pre-heating and emulsions thermal efficiency increases due to reduction in viscosity, better atomization of fuel and better combustion. The increase in thermal efficiency is more with ethanol emulsion due to presence of inherent oxygen in ethanol improves the combustion process by supplying additional oxygen .

ii. *Brake Specific Energy Consumption*

The Brake Specific energy consumption (BSEC) is an ideal variable to compare fuels with different densities. Because it gives an idea of amount of heat energy supplied to develop the power. Better the combustion lower will be the BSEC. The BSEC decreased with increase in load due to better combustion. Variation in BSEC with load is presented in fig 3. The brake specific energy consumption (BSEC) with raw vegetable oil is highest among all test fuels this may be due to lower calorific value and poor atomization because of higher viscosity. The BSEC with preheated vegetable oil and micro emulsions is lower as compared to SVO due to improved combustion because of better atomization. The BSEC is lower with emulsion as compared to PSVO due to better atomization and micro-explosions of ethanol leading to a secondary atomization, enhancing the fuel atomization (Refer Fig.3.)

iii. *Exhaust Gas Temperature*

Fig 4 indicates the exhaust gas temperature for various fuels. The exhaust gas temperature increases with increase in load for all tested fuels. This increase in EGT is due the fact that at higher load, extra amount of fuel is injected to develop more power. The neat vegetable oil shows highest exhaust temperature (402˚C) as compared to diesel due to slow combustion. This may be attributed to poor atomization due to high viscosity. Also poor volatility of SVO results in poor distribution of air fuel mixture in combustion chamber and poor or slow combustion. By preheating the vegetable oil viscosity of the fuel decreases and volatility of the fuel increase which results in better atomization and quick evaporation and mixing of fuel vapours with air. This results in faster combustion and low exhaust gas temperature. and emulsions. Lower exhaust gas temperature with emulsions is due to better atomization and reduction in charge temperature as a result of vapourization of ethanol and better combustion.

b) Emission Parameters

The main emissions from compression ignition engine are hydrocarbon, carbon monoxides, oxide of nitrogen, smoke and particulates.

i. *Carbon monoxide and hydrocarbon emissions*

Fig. 5 and Fig. 6 shows the CO and HC emissions with various fuels. The maximum CO emissions are found at rated power. The carbon monoxide emissions with vegetable oils are higher as compared to diesel fuel. This trend may be due higher viscosity and poor atomization. Micro emulsion and preheated vegetable oil show lower CO emissions as Compared to un-heated SVO. With preheated oil the CO emissions are reduced due to better spray characteristics which leads to more complete combustion. The ESVO show drastic reduction in carbon monoxide emissions as compared to straight vegetable oil due to lower viscosity and water admitted with ethanol replaces a portion of fuel containing carbon. In addition, the presence of ethanol increases the availability of oxygen during combustion resulting in more complete combustion. Some of the CO produced during combustion of emulsions may be converted into CO_2 by using extra oxygen molecule present in the emulsion.

Unburnt hydrocarbon emission from unheated vegetable oil fuelled engine higher as compared to diesel fuel. This may be due poor vaporization and improper atomization of the vegetable oil which results in incomplete combustion. The UBHC emissions are low with pre-heated oil because of impoved vapourization and better mixing of fuel vapours with air, more complete combustion. with micro-emulsion, the hydrocarbon emissions are lower than SVO and pre-heated oil at full load. But at part load HC emissions with ESVO are slightly higher than pre-heated oil this may be attributed presence of ethanol leads to lower combustion temperature which leads to partial combustion.

ii. *Nitrogen Oxide emissions (NO_x)*

The nitrogen oxide emissions increase with increase in load as the load increases, the overall fuel-air ratio increases resulting in increased average gas temperature in the combustion chamber.

Fig.7 shows variation of NO_x emissions with load. The NO_x emissions are lower with vegetable oils as poor volatility and lower heating value of vegetable oil gives lower premixed combustion resulting to lower combustion temperatures as compared to diesel fuel. Pre-heating of oil reduces the viscosity which results in improvement in combustion leads to higher NO_x emissions as compared to un-heated oil. Further NO_x emission with ESVO is drastically reduced due high latent heat of evaporation of ethanol and butanol and lower combustion temperatures along with shortened combustion duration.

iii. *Smoke emissions*

The smoke density is high at higher loads due to more fuel being injected into the combustion chamber resulting to incomplete combustion. Smoke emissions with vegetable oil are higher due to poor atomization, injection of larger droplets causing more over rich zones in combustion chamber. With Pre – heated oil and emulsion smoke emission is lower as Compared to SVO. The lower smoke emissions with micro-emulsions may be due to more complete combustion and presence of additional oxygen. (Fig. 8)

IV. Conclusions

Following conclusions are drawn from above investigation:

1. The brake thermal efficiency improved with pre-heated and emulsified vegetable oil as compared to unheated vegetable oil. The BTE with emulsions are very close to diesel.
2. Exhaust gas temperature is lower with micro emulsions and pre-heated oils due to better combusiton.
3. Carbon monoxide emission is lower with ESVO emulsion as compared to diesel, unheated and preheated vegetable oil.
4. Unburnt hydrocarbon emissions are higher with unheated vegetable oil and lower with pre-heated oil

and ESVO at full load as compared to diesel due to lower combustion temperature. However lowest UBHC emissions are observed with ESVO.

5. Nitrogen oxide emission is lower with vegetable oil and micro-emulsions on account of lower combustion temperature. Whereas NO_x emissions are higher with pre-heated oil.
6. Smoke opacity is lower with pre-heated oil and ESVO.

References Références Referencias

1. M. Pugazhvanivu, K. Jeyachandran. (2005) Investigations on the performance and exhaust emissions of a disel engine using preheated waster frying oil as fuel. Renewable Energy 30 2189–2302
2. M. Pugazhvanivu, G. Sankaranarayanan. Experimental studies on a diesel engine using mahua oil as fuel. Indian Journal of Science and Technology. Vol.3, No.7 787-791.
3. Sagar Pramodrao Kadu, Rajendra H.Sarda. (2010). Experimental Investigations on the Use of Preheated Neat Karanja oil as Fuel in a compression ignition engine. World Academy of Science, Engineering and Technology 72,540-544.
4. Avinash Kumar Agarwal, K. Rajananoharan. (2009). Experimental investigations oof performance and emissions of karanja oil and its blends in a single cylinder agricultural diesel engine. Applied Energy 86106-112.
5. S. Dhinagar, and B. Nagalingam. (1993. “Experimental Investigation on Non-Edible Vegetable Oil Operation in LHR Diesel Engine for Improved Performance”, SAE 932846.
6. T. K. Bhattacharya, Ram Chandra and T. N. Mishra. (2006) Performance Characteristics of a Stationary Constant Speed Compression Ignition Engine on Alcohol-Diesel Microemulsions. Agricultural Engineering international: the CIGR E journal. Manuscript EE04002.Vol VIII.
7. Kerihuel, M.Senthil Kumar, J.Bellettre an M. Tazerout.(2005). Investigation on a CI Engine Using Animal Fat and its Emulsions with Water and Methanol as fuel. SAE 2005-01-1729.

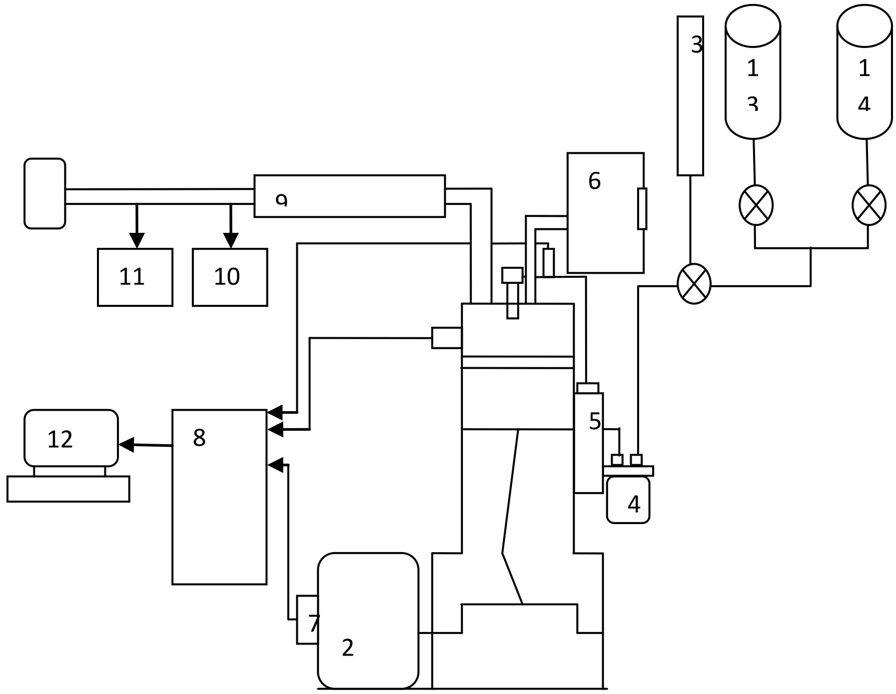

Figure 1: Schematic diagram of experimental setup.

1-Test engine, 2-Eddy current dynamometer, 3-fuel burette, 4-Fuel filter, 5-Fuel injection pump, 6- air box with U tube water Manometer, 7-TDC marker and speed sensor, 8- Data acquisition system and loading device , 9-Exhaust gas calorimeter, 10-Smoke meter,11-four gas analyser, 12-computer ,13 and 14- Fuel tanks.

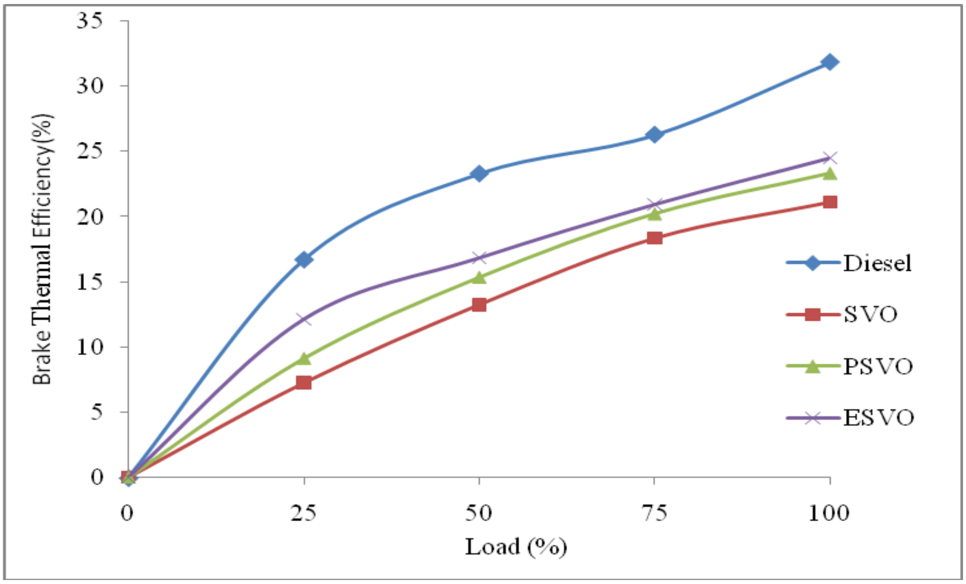

Figure 2 : Variation of Brake Thermal Efficiency with Un-heated & pre-heated Neat Vegetable oil and Emulsion

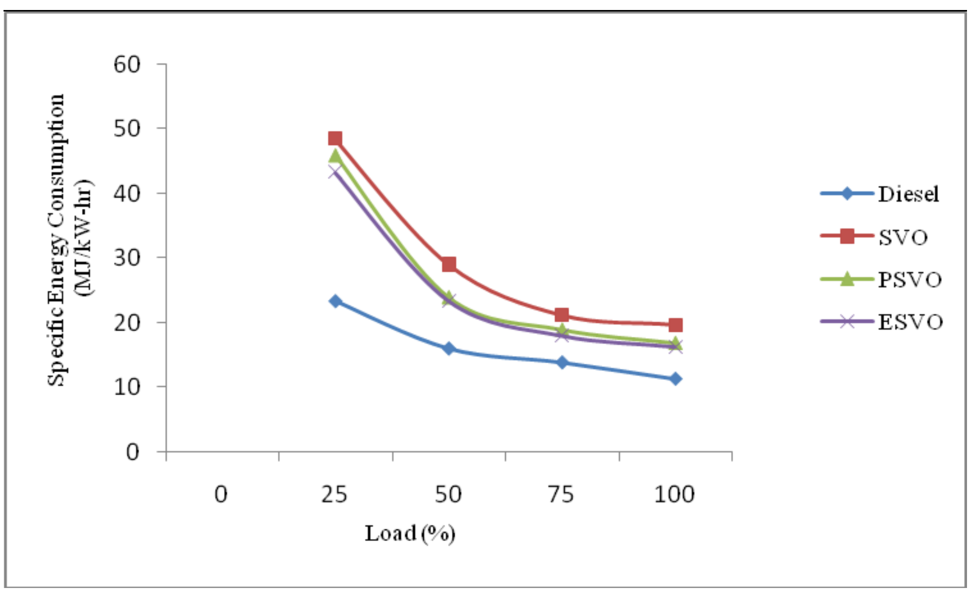

Figure 3 : Variation of Brake Specific Energy Consumption with Un-heated & preheated Neat Vegetable oil and Emulsion

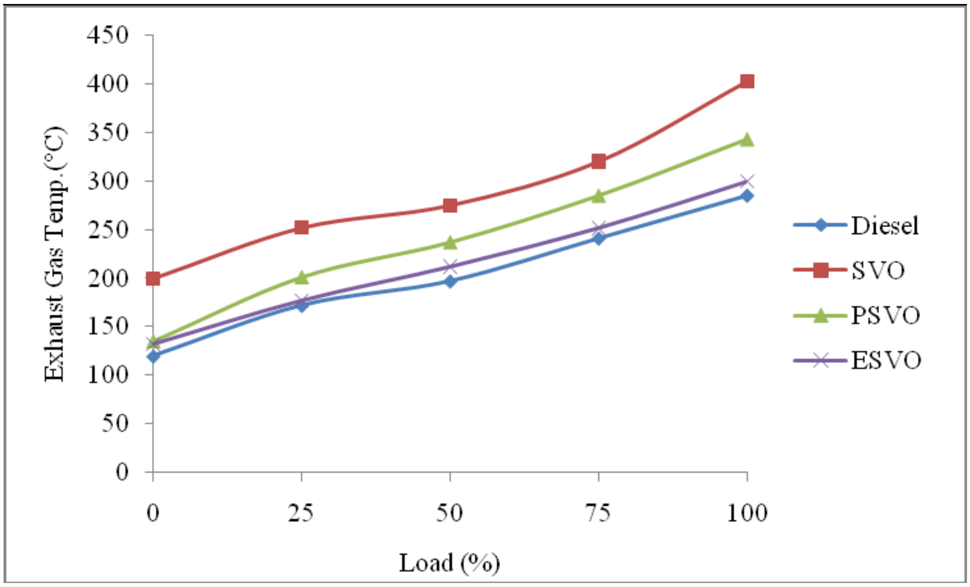

Figure 4 : Variation of Exhaust Gas Temperature with Un-heated & pre-heated Neat Vegetable oil and Emulsion

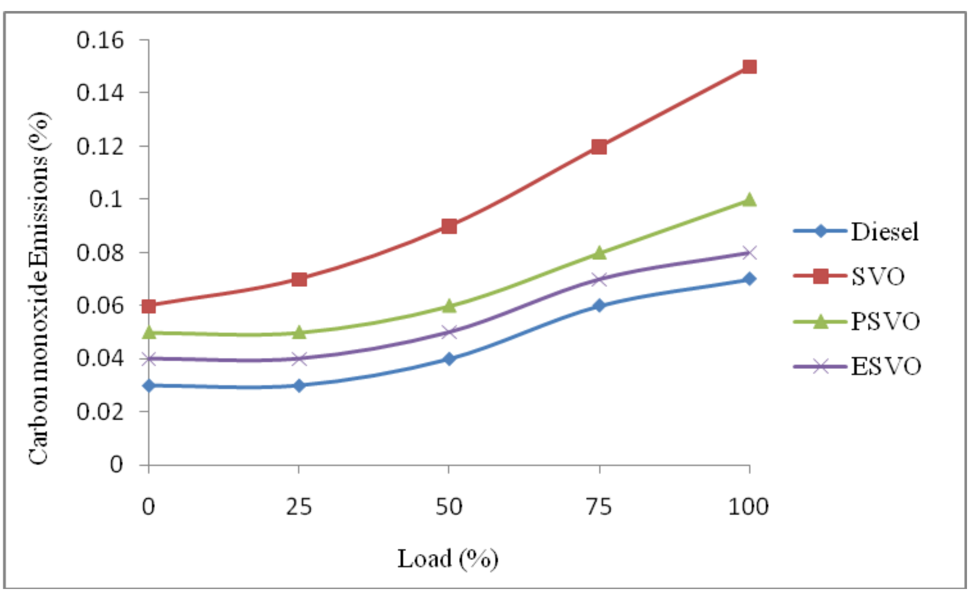

Figure 5 : Variation of Carbon Monoxide with Un-heated &pre-heated Neat Vegetable oil and Emulsion

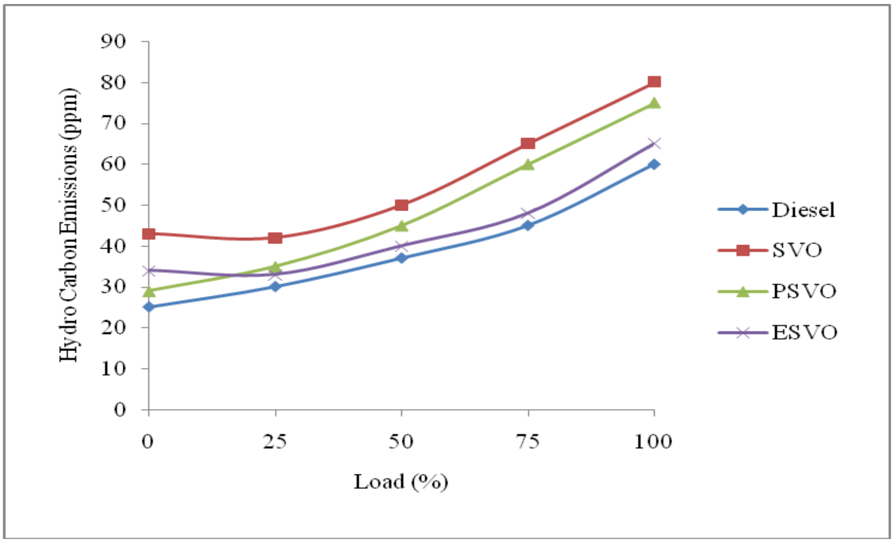

Figure 6 : Variation of Unburnt Hydrocarbons Un-heated &pre-heated Neat Vegetable oil and Emulsion

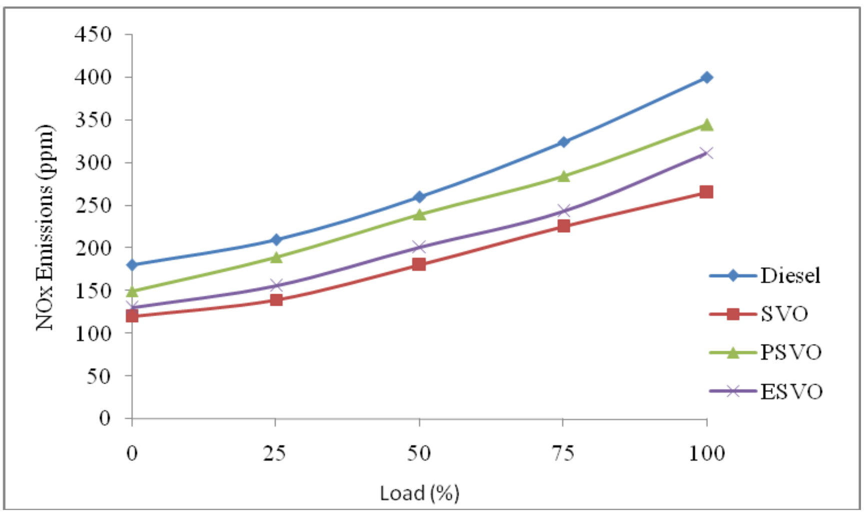

Figure 7 : Variation of Oxides of Nitrogen with Un-heated &pre-heated Neat Vegetable oil and Emulsion

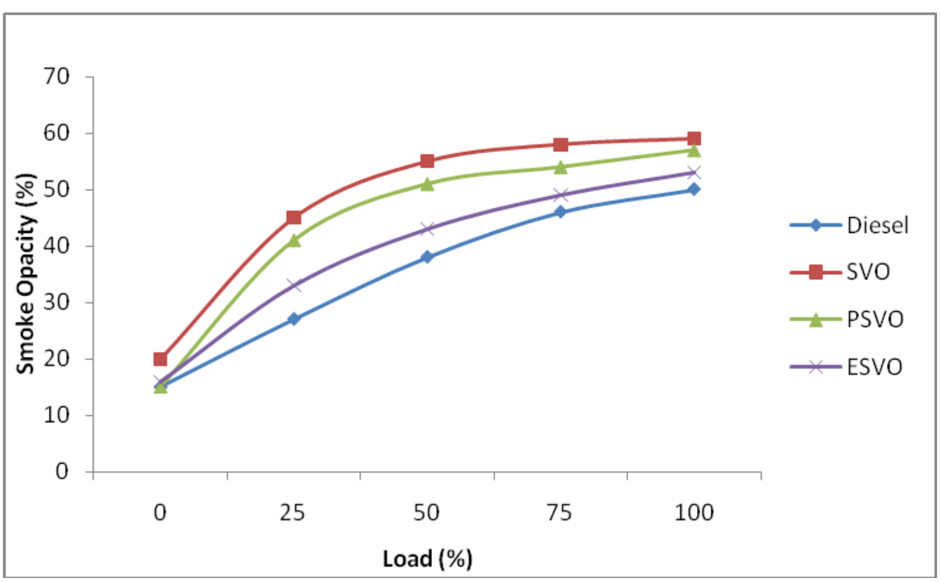

Figure 8 : Variation of Smoke Opacity with Un-heated &pre-heated Neat Vegetable oil and Emulsion

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CFD Analysis of Scramjet Engines with Ramp fuel Injector using Non-Premixed Combustion Model

By K. Deb, K.M.Pandey & A.P.Singh
National Institute of Technology, India

Abstract - This paper presents the supersonic combustion of hydrogen using ramp based injector with two-dimensional turbulent non-premixed combustion model. The present model is based on the standard k-epsilon (two equations) with standard wall functions which is P1 radiation model. In this process, a PDF (Probability Density Function) approach is created and this method needs solution to a high dimensional PDF transport equation. As the combustion of hydrogen fuel is injected from the ramp based injector, it is successfully used to model the turbulent reacting flow field. It is observed from the present work that, the maximum temperature occurred in the recirculation areas which is produced due to shock wave-expansion and the fuel jet losses concentration and after passing successively through such areas, temperature decreased slightly along the axis. From the maximum mass fraction of OH, it is observed that there is very little amount of OH around 0.013 were found out after combustion. By providing ramp, expansion wave is created which cause the proper mixing between the fuels and air which results in complete combustion.

Keywords : Mach number, CFD, combustion, hydrogen fuel, non-premixed combustion, scramjet, standard k-epsilon turbulence model, standard wall functions, steady state, mass fraction.

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Strictly as per the compliance and regulations of:

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K. Deb [α], K.M.Pandey [σ] & A.P.Singh [ρ]

Abstract - This paper presents the supersonic combustion of hydrogen using ramp based injector with two-dimensional turbulent non-premixed combustion model. The present model is based on the standard k-epsilon (two equations) with standard wall functions which is P1 radiation model. In this process, a PDF (Probability Density Function) approach is created and this method needs solution to a high dimensional PDF transport equation. As the combustion of hydrogen fuel is injected from the ramp based injector, it is successfully used to model the turbulent reacting flow field. It is observed from the present work that, the maximum temperature occurred in the recirculation areas which is produced due to shock wave-expansion and the fuel jet losses concentration and after passing successively through such areas, temperature decreased slightly along the axis. From the maximum mass fraction of OH, it is observed that there is very little amount of OH around 0.013 were found out after combustion. By providing ramp, expansion wave is created which cause the proper mixing between the fuels and air which results in complete combustion.

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I. Introduction

Ramped fuel injectors employed as a means of fuel-air mixing enhancement has been the subject of a considerable amount of previous research. Interest in these fuel injectors was largely initiated by the National Aero-Space Plane (NASP) program in an effort to improve fuel/air mixing in scramjets. Northam [1] investigated a variety of wall-mounted injector ramps. Both swept and un-swept ramp injectors were studied in various duct configurations. Emphasis was placed on near parallel injection for thirst recovery at high vehicle flight Mach numbers. Consequently,fuel was injected from ramps at an angle of 10.3"to the combustor wall. Fuel at *Mf*= 1.7 was injected into a *Ma*= 2 airflow. The injector design incorporated reflected shock waves intersecting the injected fuel to enhance mixing. Analysis of results comprised largely of shadowgraph flow visualization and combustion efficiency calculations. Results found the swept ramp injector to have generally superior performance over the un-swept ramp. A combination of ramp and subsequent downstream perpendicular injection was found to improve combustion efficiency only in the case of un-swept injectors. An experimental effort was conducted by Hartfield [2] considering very similar ramp injector. Their work revealed highly three-dimensional flow fields which "dramatically illustrate the domination of the mixing process by stream wise vorticity generated by the ramp". Experiments consisted of non-reacting flow with seeded air injected into free stream air for free stream conditions of Mach 2 and Mach 2.9. A primary objective of the study was the determination of the influence of free stream Mach number on injector performance for a given injector geometry. A laser-induced iodine fluorescence technique was employed to collect temperature and injectant concentration data. Analysis of global mixing performance was limited to a parameter reflecting the percentage of duct area mixed to within static flammability limits. It was found that the injectant mixed faster at lower free stream Mach numbers. Comprehensive flow field visualization was presented clearly delimiting the Vortical flow structures. A reacting Navier-Stokes code was utilized by Rigging [3] to solve both swept and unswept ramp configurations with fuel injected at Mach 1.7 through circular orifices from ramp injectors. The code employed a two step finite-chemistry model together with the Baldwin-Lomaxturbulence model. Both reacting and non-reacting cases were considered with laminar flowcalculated for non-reacting cases. The numerical solutions afforded a more thorough performanceanalysis including measures of circulation, fuel concentrations, mixing efficiency, and totalpressure recovery and, in the case of reacting flow, combustion efficiency. Basic gridding techniques and boundary condition treatments were used and grid convergence issues were not addressed. Results showed substantially higher mixing performance as well as flow losses for the swept configuration over the unswept ramp. The study concluded that vorticity increased fuel mixing and that near-field mixing was controlled by large-scale vortices while far-field mixing was controlled by smaller scale turbulent diffusive processes.

A significantly improved injector design was proposed by Marble[4] et al. who introduced the"contoured wall fuel injector"." The ramp injector

Author α σ ρ : Department of Mechanical Engineering, N.I.T Silchar, Assam, India. E-mail : pandeykrishna566@gmail.com

design was integrated with the combustor wall which allowed for shock structures promoting baroclinic torque generated vorticity. A combined computational and experimental effort focused on the demonstration of enhanced mixing through the generation of stream wise vorticity and its use for hypersonic propulsion. It was determined that the characteristic mixing times were fast enough for scramjet applications. While limited quantitative analysis and no comparison with other designs was presented, a ground breaking proof of concept was shown. The investigation concluded that the ramp injector under consideration "can lead to rapid enhancement of the mixing process". A further conclusion was that a mechanism to destabilize the large vortices must be sought to ensure complete mixing. A modified design to Marble's injector was studied by Davis[5]. The fuel injector embodied the elements of the contoured wall fuel injector but was more modular since it could be mounted on a flush combustor wall. The study focused on jet penetration and mixing behaviour under a variety of different operating conditions. A swept and unswept injector configurationwas experimentally tested. Unfortunately, quantification of mixing performance was minimal and comparison with other injectors was absent. The superior vortex generating ability of the swept configuration over the unswept was established. A thorough investigation of the injector design advanced by Marble was undertaken by Waitz . A concurrent experimental and numerical effort was undertaken to study Mach 1.7 helium (used to simulate hydrogen) injected into a Mach 6 airstream. Several parametric dependencies were investigated including: injector spacing, ramp geometry, boundary layer effects and injectant/free stream velocity and pressure ratios. A detailed description of flow fields and flow phenomena were presented. The work demonstrated that the induced vorticity coalesced into a counter-rotating pair of vortices promoting helium migration up into the main stream. The two main sources of vorticity, baroclinic torque and cross-streams hear, were identified and characterized. It concluded that shock-impingement produced effective mixing by deposition of baroclinic torque at the fuel air interface while cross-stream shear induced vorticity can be less effective due to vortices generated remote from the fuel air interface. Flow visualization was employed to identify salient flow features. Excellent comparisons of experimental and computational results were presented along with comprehensive mixing performance and loss analysis. The suitability of injector design to scramjet applications was addressed and it was concluded that the injector design in question was a feasible candidate for mixing enhancement. An interesting approach to improve fuel/air mixing enhancement is through the use of various nozzle geornetries used to inject fuel from ramp injector. Haimovitch experimentally investigated six different injector-nozzle inserts to precondition the fuel flow. The mainobjective was to determine the influence of the resultant fuel jet on the vortical flow field inducedby the ramp injectors. Seeded air at Mach 1.63 was used to simulate fuel injected into a Mach 2 main stream. Mie scattering visualization revealed a minor difference in the mixingperformance between the candidate injectors. More comprehensive computational results were provided by Eklund[6] who studied Mixing in the context of a reacting flow field the Navier-Stokes equations were solved with a finite-rate chemical kinetics model for H2-air reaction together with an algebraic eddy viscosity turbulence model .Two configurations: swept compression and swept expansion ramp injectors, were used to inject Mach 1.7 fuel at 100with respect to the main flow. A major conclusion of the investigation was that mixing was significantly reduced by combustion. A reduction of up to 25% in mixing efficiency was observed for the reacting case. Riggins and Via [7]furthered investigation of generic swept and unswept ramp injectors with a more refined numerical model. Larger computational grids were employed simulating laminar and turbulent mixing. Insightful analysis of results underscored the dominant role of turbulence in the far-field, although turbulence modelling issues were not fully addressed. Comparison with high-enthalpy experimental results determined that CFD is a valuable engineering tool for injector design. More sophisticated numerical modelling was applied to ramp injectors by Lee[8]. The contoured wall injector design of Marble was investigated to determine the mixing characteristics in the presence of combustion. A numerical algorithm employing the three-dimensional Navier-Stokes equations coupled with a chemical reaction model and a K-epsilon turbulence model was used for the study. Freestream air conditions were held constant while changing initial fuel pressure and density. The study concluded that changes in fuel density had a significant impact on mixing and combustion performance while pressure changes had little effect. It further asserted that the mixing process has a strong influence on combustion, whereas the combustion process does not have any significant effect on the mixing process. The results suggest that the mixing process may be decoupled from the combustion process with only minor differences in performance trends. A more intricate ramp injector configuration was studied by Baurle[9] in a combinedexperimental and computational investigation. Ramp injectors were mounted on oppositesides of the combustor in an indigested fashion with four fuel injection ports located atthe base of each ramp. The nozzles in the base of the ramps were angled with respect to thecombustor wall and a yaw angle was also introduced. The injector nozzle flow was included as part of the computational domain which consisted of a remarkable 13.5 million grid nodes. A more intricate ramp injector configuration was studied by Baurle in a combinedexperimental and computational investigation. Ramp injectors were mounted on oppositesides of the combustor in an indigested fashion with four fuel injection ports located atthe base of each ramp. 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II. Materials and Methods

a) Physical Model

A mathematical model consists of equations concerning the dependent and the independent variables and the relevant parameters that describe some physical phenomenon. In general, a mathematical prototype consists of differential equations that govern the performance of the physical system, and the related boundary conditions.

b) Governing Equations

The advantage of employing the complete Navier-Stokes equations extends not only the investigations that can be carried out on a wide range of flight conditions and geometries, but also in the process the location of shock wave, as well as the physical characteristics of the shock layer, can be exactly determined. We begin by describing the three-dimensional forms of the Navier-Stokes equations below. Note that the two-dimensional forms are just simplification of the governing equations in the three dimensions by the omission of the component variables in one of the co-ordinate directions. Neglecting the presence ofbody forces and volumetric heating, the three-dimensional Navier-Stokes equations are derived as [16]:

Continuity Equation:

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0 \tag{1}$$

X-momentum equation:

$$\frac{\partial(\rho u)}{\partial t}+\frac{\partial(\rho uu)}{\partial x}+\frac{\partial(\rho vu)}{\partial y}+\frac{\partial(\rho\omega u)}{\partial z}=\frac{\partial\delta_{xx}}{\partial x}+\frac{\partial\tau_{yz}}{\partial y}+\frac{\partial\tau_{zx}}{\partial z} \tag{2}$$

Y-momentum equation:

$$\frac{\partial(\rho v)}{\partial t}+\frac{\partial(\rho uv)}{\partial x}+\frac{\partial(\rho vv)}{\partial y}+\frac{\partial(\rho\omega v)}{\partial z}=\frac{\partial\tau_{xy}}{\partial x}+\frac{\partial\sigma_{yy}}{\partial y}+\frac{\partial\tau_{zy}}{\partial z} \tag{3}$$

Z-momentum equation:

$$\frac{\partial(\rho\omega)}{\partial t}+\frac{\partial(\rho u\omega)}{\partial x}+\frac{\partial(\rho v\omega)}{\partial y}+\frac{\partial(\rho\omega\omega)}{\partial z}=\frac{\partial\tau_{xz}}{\partial x}+\frac{\partial\tau_{yz}}{\partial y}+\frac{\partial\sigma_{zz}}{\partial z} \tag{4}$$

Energy Equation:

$$\frac{\partial(\rho E)}{\partial t}+\frac{\partial(\rho uE)}{\partial x}+\frac{\partial(\rho vE)}{\partial y}+\frac{\partial(\rho wE)}{\partial z}$$

$$=\frac{\partial(u\sigma_{xx}+v\tau_{xy}+w\tau_{xz})}{\partial x}+\frac{\partial(u\tau_{yx}+v\sigma_{yy}+w\tau_{yz})}{\partial y}+\frac{\partial(u\tau_{zx}+v\tau_{zy}+w\sigma_{zz})}{\partial z}+\frac{\partial(k\frac{\partial T}{\partial x})}{\partial x}+\frac{\partial(k\frac{\partial T}{\partial y})}{\partial y}+\frac{\partial(k\frac{\partial T}{\partial z})}{\partial z} \tag{5}$$

Assuming a Newtonian fluid, the normal stress σ_{xx}, σ_{yy} and σ_{zz} can be taken as combination of the pressure p and the normal viscous stress components τ_{xx}, τ_{yy}, and τ_{zz} while the remaining components are the tangential viscous stress components whereby $\tau_{xy}= \tau_{yx}$, $\tau_{xz}= \tau_{zx}$, and $\tau_{yz}= \tau_{zy}$. For the energy conservation for supersonic flows, the specific energy, E is solved instead of the usual thermal energy H applied in sub-sonic flow problems. In three dimensions, the specific energy E is repeated below for convenience:

$$E = e + \frac{1}{2}(u^2 + v^2 + \omega^2) \quad (6)$$

It is evident from above that the kinetic energy term contributes greatly to the conservation of energy because of the high velocities that can be attained for flows, where Ma>1.Equations (1)-(6) represent the form of governing equations that are adopted for compressible flows. The solution to the above governing equations nonetheless requires additional equations to close the system. First, the equation of state on the assumption of a perfect gas unemployed, that is,

P= ρ R T, where R is Gas constant

Second, assuming that the air is calorically perfect, the following relation holds for the internal energy:

e= C_v T, where C_v is specific heat at constant volume. Third, if the Prandtl number is assumed constant (approximately 0.71) for calorically perfect air), the thermal conductivity can be evaluated by the following:

$$k=\frac{\mu C_p}{pr}$$

The Sutherland's law is typically used to evaluate viscosity μ, which is provided by:

$$\mu = \mu_0 \left(\frac{T}{T_0}\right)^{1.5} \frac{T_0 + 120}{T + 120} \quad (7)$$

Where μ_0 and T_0 are the reference values at standard sea level conditions Generalized form of Turbulence Equations is as follows:

$$k\frac{\partial k}{\partial t} + \frac{\partial(uk)}{\partial x} + \frac{\partial(vk)}{\partial y} + \frac{\partial(wk)}{\partial z} = \frac{[\frac{V_T}{\sigma_k}\frac{\partial k}{\partial x}]}{\partial x} + \frac{\partial[\frac{V_T}{\sigma_k}\frac{\partial k}{\partial y}]}{\partial y} + \frac{\partial[\frac{V_T}{\sigma_k}\frac{\partial k}{\partial z}]}{\partial z} + (S_k = P - D)$$

$$(\varepsilon)\frac{\partial \varepsilon}{\partial t} + \frac{\partial(u\varepsilon)}{\partial x} + \frac{\partial(v\varepsilon)}{\partial y} + \frac{\partial(w\varepsilon)}{\partial z} = \frac{\partial[\frac{V_T}{\sigma_k}.\frac{\partial \varepsilon}{\partial x}]}{\partial x} + \frac{\partial[\frac{V_T}{\sigma_k}.\frac{\partial \varepsilon}{\partial y}]}{\partial y} + \frac{\partial[\frac{V_T}{\sigma_k}.\frac{\partial \varepsilon}{\partial z}]}{\partial z} + (S_\varepsilon = \frac{\varepsilon}{k}(C_{\varepsilon 1}P - C_{\epsilon 2}D)$$

Where

$$P = 2V_T[(\frac{\partial u}{\partial x})^2 + (\frac{\partial v}{\partial y})^2 + (\frac{\partial w}{\partial z})^2] + V_T[(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x})^2 + (\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y})^2 + (\frac{\partial w}{\partial x} + \frac{\partial u}{\partial z})^2]$$

And D=Ɛ

IV. Computattional and Model Parameters

a) *Geometry and mesh generation*

Mesh generation was performed in a Fluent pre processing program called Gambit. The current model is ramp-based fuel injector with non-premixed combustion as shown in figure 3. The boundary conditions are such that, the air inlet and fuel inlet surfaces are both defined as pressure inlets and the outlet is defined as pressure outlet. Recent research has revealed that perhaps the numerical model will improve if the air inlet is defined as pressure inlet and the fuel inlet is defined as a mass flow inlet. In this particular model the walls of the combustor duct do not have thicknesses. The domain is completely contained by the combustor itself; therefore there is actually no heat transfer through the walls of the combustor.

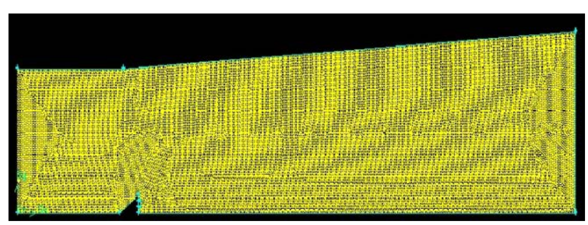

Fig 1 : Gambit profile of ramp-based fuel injector

b) *Boundary Conditions*

During analysis we have taken same pressure for both fuel and air for all the models. Pressure inlet and pressure outlet conditions were taken on the left and right boundaries respectively. Pressure inlet condition was taken for fuel injector. The top and bottom boundaries, which signify the sidewalls of the isolator, had symmetry conditions on them. The walls, obstacles and other materials were set to standard wall conditions.

The computations were initially carried out with various levels of refinement of mesh. There exists a definite level of refinement beyond which there is no significant quantitative change in the result. The limit of that refinement is called the Grid Independent Limit (GIL). The input parameters that were for the model is shown in tabulated form.

Table 1 : Input Data

Input Parameters	Air	Fuel
Mach No	2.13	1.5
Temperature	1000K	300K
Inlet Pressure	835931.25 Pa	197583.75 Pa
Operating Pressure	101325 Pa	101325 Pa
Mass fraction of H_2	0	1
Mass fraction of N_2	0.740	0
Mass fraction of O_2	0.25	0
Mass fraction of H_2O	0.01	0
Turbulent Kinetic Energy(k)	10	2400
Turbulent Dissipation rate(ε)	650	10^9

c) Modeling Details

In the CFD model, the Standard k-**ε**turbulent model is selected which is one of the most common turbulence models. It is a two equation model that means it includes two extra transport equations to represent the turbulent properties of the flow. This two equation model accounts for history effects like convection and diffusion of turbulent energy. Further, because of the intense turbulent combustion, the eddy-dissipation reaction model is adopted. The eddy-dissipation is based on the hypothesis of infinitely fast reactions and the reaction rate is controlled by turbulent mixing. Both the Arrhenius rate and the mixing rate are calculated and the smaller of the two rates is used for the turbulent combustion. While no-slip conditions are applied along the wall, but due to the flow being supersonic, at the outflow all the physical variables are extrapolated from the internal cells. Energy equations were considered and the solution was initialized from the air inlet for simplicity. For hydrogen-air mixing, ideal gas mixing law was followed for determination of thermal conductivity and viscosity, while density was assumed to be for ideal gas. Mass diffusivity was assumed to be following kinetic theory.

V. Results and Discussions

The various plots of properties such as static temperature, densities etc. along the length of the combustor for the different models are given below. The red colored regions are the regions where the properties attain their maximum values. The blue colored regions indicate the regions where the properties are at their minimum. The properties that were analyzed were:

1. Static Temperature
2. Density
3. Mass Fraction of H_2
4. Mass Fraction of H_2O
5. Mass Fraction of O_2
6. Mass Fraction of OH

The static temperature was taken as an indication of combustion efficiency of the fuel (hydrogen). Higher combustion efficiency means a greater percentage of the injected fuel undergoes combustion resulting in a higher static temperature at the combustor exit. Study of the mass fraction contours of H2, O2 and H2O showed evidence of fuel injection, air fuel mixing and combustion respectively. The presence of H2O indicated the occurrence of combustion. Turbulent kinetic energy was an indication of vortex formation in the cavity which enhances air-fuel mixing. The X-velocity was the velocity at which the combustion products exit the combustor. It represented the thrust available for propulsion of the scramjet. The static pressure and density contours and static pressure and density graphs help in visualizing the shock waves produced by the velocity of hydrogen injection. Moreover, interaction of the reflected shock waves with the air-fuel mixing boundary (visible in the density and static pressure contours) further enhanced the mixing and promoted.

a) Static Temperature

From Fig 2 it is evident that static temperature increases from inlet to the outlet. This is due to combustion of the air and injected H2 fuel. The heat released due to combustion heats up the combustion products (water) and hence, an increase in the static temperature from 300K to 2620 K is observed.

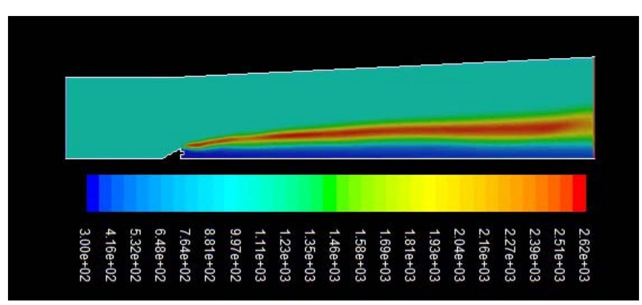

Fig 2 : Contour of Static Temperature

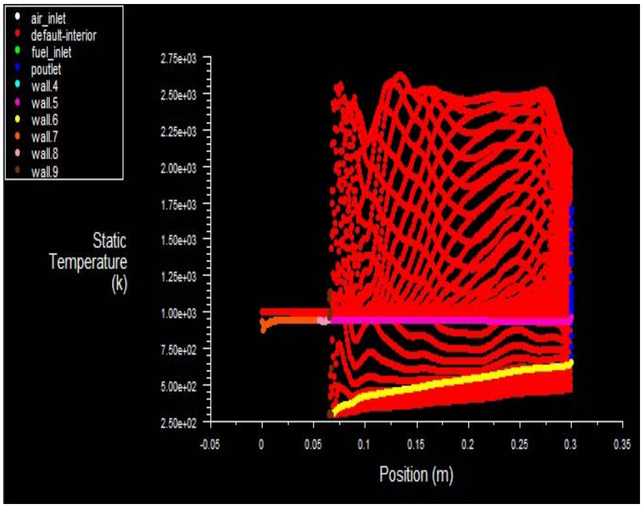

Fig 3 : XY Plot of Static Temperature

b) Density

Plot of density distribution at interior shows that density increases with H2 injection and then, it decreases gradually with mixing and combustion of air and hydrogen fuel mixture and the subsequent expansion of the combustion products. From the contour a maximum density of 0.3614743kg/m^3 is observed at the inlet and injection zones and it decreases to a minimum value of 0.07206715 kg/m^3.

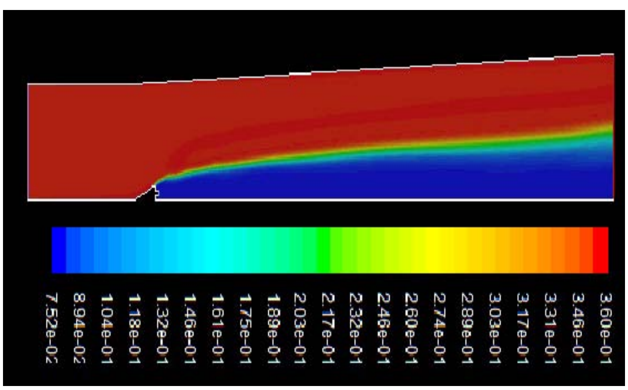

Fig 4 : Contour of Density

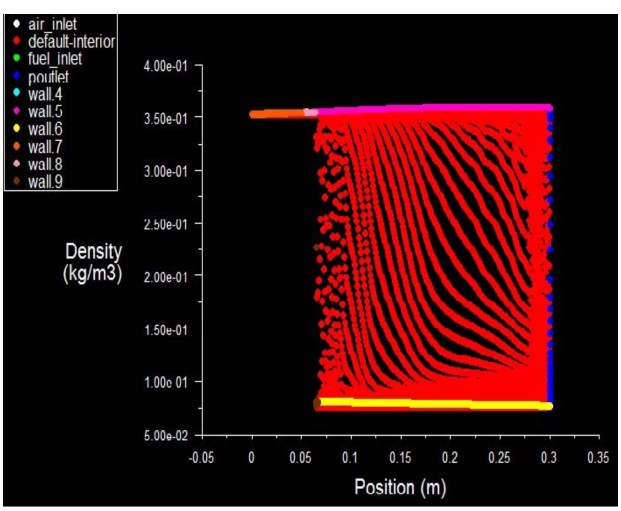

Fig 5 : XY Plot of Density

c) Mass Fraction of H_2

The below graph shows the distribution of H_2 in the interior of the combustor. As can be seen, the mass fraction of hydrogen is maximum at the fuel injection port and continues to decrease along the length of the combustor due to combustion. Thus, the graph provides evidence of combustion.

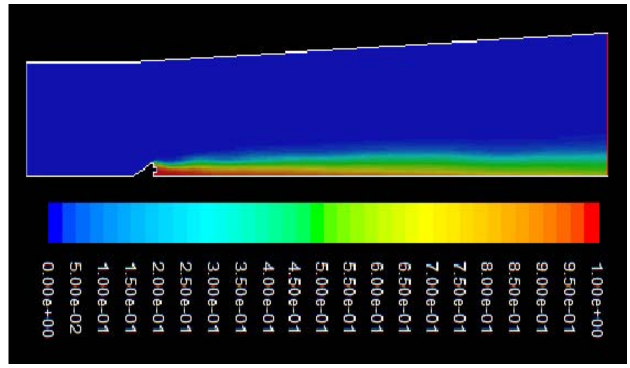

Fig 6 : Contour of Mass Fraction of H_2

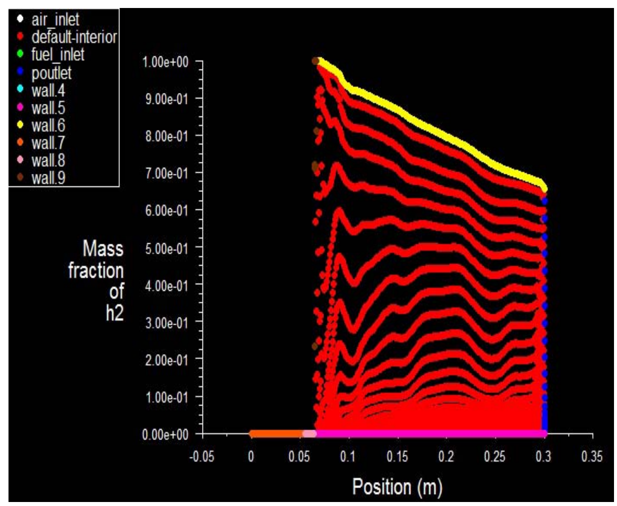

Fig 7 : XY Plot of Mass Fraction of H_2 at interior

d) Mass Fraction of H_2O

The contour and XY Plot of water Mass fraction for the flow field downstream of the injector is shown in the fig 8 and fig 9. From the figure 8 and 9 it is observed that, water concentration is found to be maximum value of 0.2958731 in the shear layer formed between the two streams of flow and the low-velocity recirculation regions within the core of the upcoming jet. Typically, when dealing the chemical reaction, it's important to remember that mass is conserved, so the mass of product is same as the mass of reactance. Even though the element exists in different the total mass of each chemical element must be same on the both side of equation.

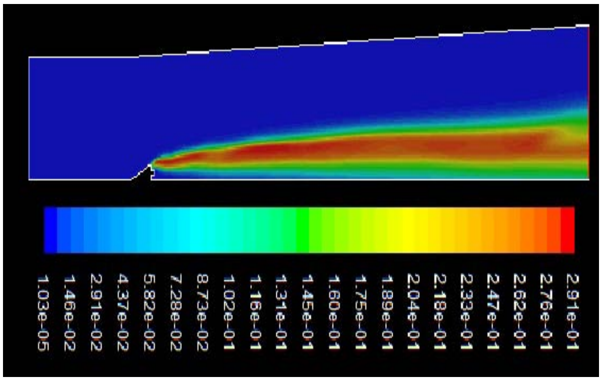

Fig 8 : Mass fraction of H_2O

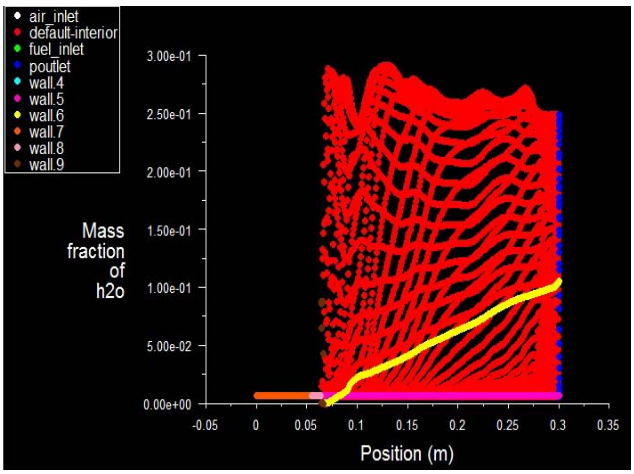

Fig 9 : XY Plot of Mass Fraction of H_2O

e) Mass Fraction of O_2

The contour and XY Plot of O_2 Mass fraction for the flow field downstream of the injector is shown in the figure 10 and figure 11. Oxygen is increased in every combustion reaction in combustion applications and air provides the required oxygen. All components other than air collected together with nitrogen. In air 21% of oxygen and 79% of nitrogen are present on a molar basis. From the figure 10 it is observed that, the maximum mass fraction of O_2 is 0.277 which is seen at the beginning of combustion. Figure 11 shows that the profile between the mass fraction of O_2 and the position of the combustion on all conditions such as air inlet, fuel inlet, pressure outlet, default interior and all walls.

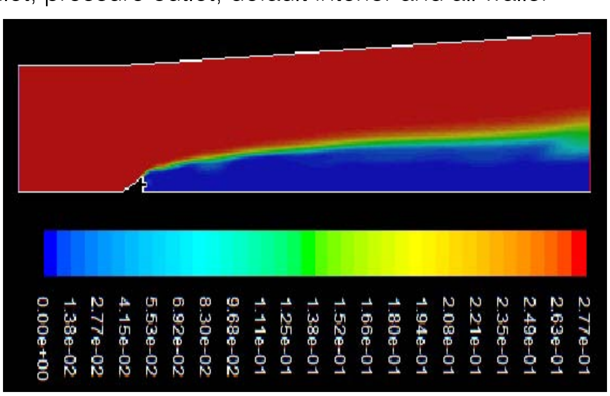

Fig 10 : Contour of Mass Fraction of O_2

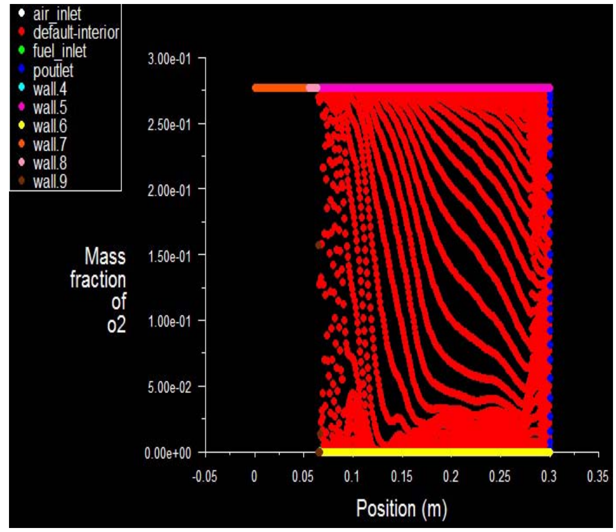

Fig 11 : XY Plot of Mass Fraction of O_2

f) Mass Fraction of OH

The contour of mass fraction of OH is shown in figure 12. From the figure 12 it is observed that, the maximum mass fraction of OH is 0.01353 which is found out after combustion, where the minimum value is 0. Figure 13 shows that the profile between the mass fraction of OH and the position of the combustion on all conditions such as air inlet, fuel inlet, pressure outlet, default interior and all walls.

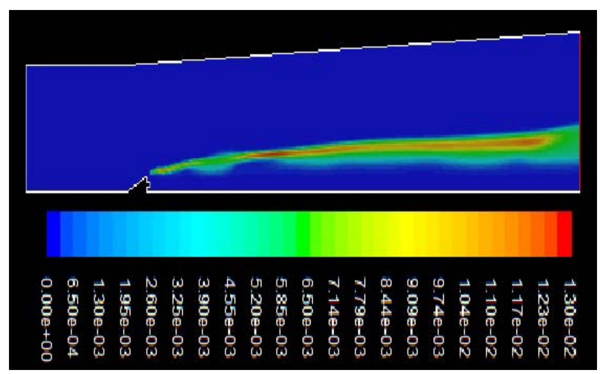

Fig 12 : Contour of Mass Fraction of OH

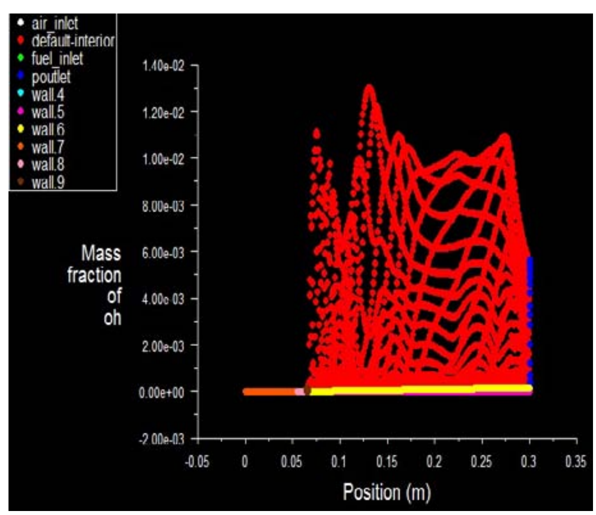

Fig 13 : XY Plot of Mass Fraction of OH

VI. Conclusion

The computational analysis of 2D ramp-based fuel injector was carried out with k-ε turbulence model for exposing the flow structure of progress of hydrogen jet through the areas disturbed by the reflections of oblique shock. For that single step reaction kinetics has been used to model the chemistry. The k-ε turbulence model also predicted the fluctuations in those regions where the turbulence is reasonably isotropic. From the maximum mass fraction of OH a very small amount of OH (1.3e-02) was observed after combustion. From the above analysis, it is observed that for a scramjet engine having a wall injector with a ramp of 10.13mm, if hydrogen is injected at a speed of Mach 1.5 to an incoming air stream at Mach 2.13 speed, a rich air-fuel mixture can be achieved and efficient combustion of this mixture gives a maximum temperature of 2620K at the outlet of the combustor. Also, there is a weak shock formation. Due to ever increasing human need for greater speed and reduced travel time, hypersonic combustion systems will become more and more important in the future. As the mixing time for fuel in the combustor system is very less (~1ms), newer and better injection systems have to be developed that enhance fuel-air mixing and reduce ignition delay period, thus increasing both combustion efficiency and thrust.

References Références Referencias

1. Northam, G., Greenburg. I., and Byington, C., "Evaluation of Parallel Injector Configuratians for Supersonic Combustion", Proceedings of the 25th *AIAA* Joint Propulsion Conference. No. AIAA-89-2525. 1989.
2. Hartfield, R.J., Hollo. S. D., and McDaniel, J. C., "Experimental Investigation of a Supersonic Swept RampInjector Using Laser-Induced Iodine Fluorescence," Proceedings of the *21st AIAA* Fluid Dynamics. PlasmaDynamics and Lasers Conference, No. AIAA-90- 1518. Seattle, WA. 1990.
3. Riggins, D.W. and McClinton, C. R., "Analysis of Losses in Supersonic Mixing and Reacting Flows," Proceedings of the 27th *AIAA* Joint Propulsion Conference, No. AIAA-9 1-2266. Sacramento. CA. 1991.
4. Marble, F., Zukoski, E., Jacobs, J., Hendricks, G., and Waitz. I., "Shock Enhancement and Control of Hypersonic Mixing and Combustion", Proceedings of the 26th AIAA Joint Propulsion Conference, No. AM-90- 1981,1990.
5. Davis. D. and Hingst, W., "Progress Toward Synergistic Hypermixing Nodes", *Proceedings of the 27th AIAA Joint Propulsion Conference and Exhibit,* No. AIAA- 91-2264, 199 1.
6. Eklund, D. R., Stouffer, S. D. and Northam, G. B., "Study of a Supersonic Combustor Employing Swept Ramp Fuel Injectors, "Journal of Propulsion and Power, Vol. 13, No. 6, 1997, pp. 697-704
7. Riggins, D. W. and P. H., "Vortex Generation and Mixing in Three-Dimensional Supersonic Combustors," Journal of Propulsion and Power, Vol. 1 1. No. 3. 1995, pp. 419426.
8. Lee, J., "Numerical Study of Mixing in Supersonic Combustors with Hyper-mixing injectors." Journal of Propulsion and Power, Vol. 10, No. 3, 1994, pp. 297-304.
9. Baurle, R. A., Fuller, R. P. White, J. A., Chen, T.H., Gruber, M. R., and Nejad, A. S., "An Investigation of Advanced Fuel Injection Schemes for Scramjet Combustion," Proceedings of the 36th *AIAA* Aerospace Sciences Meeting and Exhibit, No. AIAA-98-0937, Reno, NV, 1998
10. J. Schumacher. "Numerical Simulation of Cantilevered Ramp Injector Flow Fields for Hypervclocity Fuel-Air Mixing Enhancement". 2000. Ph.D. Thesis, University of Toronto
11. K. M. Pandey and A. P. Singh, "Recent Advances in Experimental and Numerical Analysis of Combustor Flow Fields in Supersonic Regime", *IJCEA, Vol. 1, No. 2, August 2010.*
12. C. J. Montgomery, Wei Zhao, B.R. Adams, D.R. Eklund and J.Y. Chen, "Supersonic Sonic Combustions Simulations using reduced Chemical Kinetic Mechanisms and ISAT", *AIAA Conference on CFD, Orlando, Florida, June, 2003.*
13. Eklund, D. R., Baurle, R. A., and Gruber, M. R., "Numerical Study ofa Scramjet Combustor Fuelled by an Aerodynamic Ramp Injector in Dual-Mode Combustion," AIAA Paper 2001-0379, Jan. 2001.
14. Ben Yakar A., Hanson R., "Cavity Flameholders for Ignition andFlame Stabilization in Scramjets: An Overview", Journal of Propulsion and Power, Vol. 17, No. 4, July-August 2001, pp 869-876.
15. Allen, W.H., King, P.I., Gruber, "Fuel-Air Injection Effects on Combustion in Cavity-Based Flameholders in aSupersonic Flow,"AIAA-2005-4105, 41st AIAA/ASME/SAE/ASEE Joint Prop. Conf., Tucson, AZ, 10-13 Jul 2005.
16. Jiyun tu, guan Heng yeoh and chaoqun liu. "*Computational Fluid Dynamics*", Elsevier Inc. 2008.
17. Wei Huang, Shi-bin Luo, Mohamed Pourkashanian, Lin Ma, Derek B.Ingham, Jun Liu and Zhen-guo Wang; "Numerical Simulations of a Typical Hydrogen Fuelled Scramjet Combustor with a Cavity Flameholder"; WCE 2010, London, UK, July 2010.
18. Weipeng Li, Taku Nonomura, Akira Oyama and Kozo Fujii; "LES Study of Feedback-loop Mechanism of Supersonic Open Cavity Flows"; 40th Fluid Dynamics Conference and Exhibit, AIAA 2010-5112, 28 June - 1 July 2010.
19. J. Philip Drummond, Glenn S. Diskin, and Andrew D. Cutler, "Fuel-Air Mixing And Combustion In Scramjets", American Institute of Astronautics and Aeronautics (AIAA-.2002-3878).

20. M. Akbarzadeh and M. J. Kermani, “Numerical Computation of Supersonic-Subsonic Ramjet Inlets; a Design Procedure”, 15th. Annual (International) Conference on Mechanical Engineering-ISME2007 May 15-17, 2007, Amirkabir University of Technology, Tehran, Iran ISME2007-3056.

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Experimental Investigation on Compression Ignition Engine Fuelled by Biodiesel Blended With Diesel

By S.K. Mahla & S. Gomasta
IIT Delhi, India

Abstract - Increased environmental concerns and depletion of fossil fuel resources necessitates the search for a viable alternative fuel for diesel engine. Bio-fuels are renewable, can supplement fossil fuel, reduce green house gas emissions and mitigate their adverse effects on the climate changes resulting from global warming. However, further reduction in engine emission becomes one of major tasks in engine development. One promising approach to solve this problem is to add the oxygenated fuels in biodiesel. Biodiesel commands crucial advantages such as technical feasibility of blending in any ratio with petroleum diesel fuel. Superiority from the environment and emission front, its capacity to provide energy security to remote and rural areas and employment generation. In this paper, the investigation is made with addition of biodiesel in different proportion and effect on engine performance and emissions were computed. The emission is found to be reduced considerably while the engine performance is also improved marginally.

Keywords : Biodiesel, Rice Bran Oil, Diesel engine, Emission, Performance, Environment, Blending.

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EXPERIMENTAL INVESTIGATION ON COMPRESSION IGNITION ENGINE FUELLED BY BIODIESEL BLENDED WITH DIESEL

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S.K. Mahla [α] & S. Gomasta [σ]

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I. Introduction

The concept of using bio-fuels in diesel engine was originated from the demonstration of the first diesel engine by the inventor of diesel engine "Rudolf Diesel" at the world exhibition in Paris in 1900 by using peanut oil as a fuel. However, due to abundant supply of petro-diesel, R&D activities in vegetable oil were not seriously persuaded. It receive attention only recently when it was realized that petroleum fuels were dwindling fast, and environment friendly renewable substitute must be identified. In India, diesel engines being more efficient and sturdier than spark ignition engines are frequently used on Farms, in heavy trucks, city buses, locomotives, electricity generators farm equipments, underground mine equipments etc. Diesel used in diesel engine contains higher amounts of aromatics and sulphur, which causes environmental pollution. In recent years, serious efforts have been made by several researchers to use different sources of energy as fuel in existing diesel engines. Biodiesel is receiving increased attention as an alternative non-toxic, biodegradable and renewable diesel fuel. Properties of biodiesel are similar to mineral diesel and can be used in conventional diesel engines without significant modifications. It can be blended in any proportion with fossil based diesel to create a stable biodiesel blend. Therefore, the biodiesel has become one of the most common bio-fuels in the world.

The source of biodiesel usually depends on the crops amenable to the regional climate. Soybean oil in the United States and rapeseed oil in European countries are the most commonly used biodiesel. In tropical countries, palm oil and coconut oil are common sources of biodiesel. Rice bran is a by-product obtained from the outer layers of the brown rice kernel during milling to produce polished rice. In the present study rice bran Oil (RBO) is used for production of biodiesel. RBO is extracted from the rice barn, which is a by-product obtained during the grinding of paddy. Biodiesel from RBO offers significant potential as an alternative low cost feedstock for biodiesel production. Since rice is the staple diet in a large part of India, there is a huge potential to produce and utilize RBO. Though Indian is the second largest producer of paddy, hardly 50% of the barn is utilized for producing RBO and only 19% of edible grade RBO is consumed as a cooking media. Hence RBO is commercially feasible for biodiesel production.

Whole rice grain comprises Endosperm: 70- 72; Hull: 20; Barn: 7- 8.5; and Embryo: 2-3% (dry weight basis). Out of this 7- 8.5% of Barn contains: oil: 15- 20%; wax: 0.4- 1.5%; proteins: 5-8%; soluble carbohydrates: 40- 50%; fiber: 5- 8%; Typical composition of RBO is triglycerides: 81.3- 84.3%; diglycerides: 2- 3%; monoglycerides: 5- 6%; free fatty acids: 2 -3%; wax: 0.3%; glycolipids: 0.8%; and phospholipids: and unsaponifiables: 1.6%. The rice bran biodiesel is prepared in the laboratory through transesterification.

Biodiesel, which can also be known as fatty acid methyl ester (FAME) is produced by the transesterification (alcoholysis) of vegetable oil or animal fat and alcohol to yield fatty acid methyl ester (FAME) and glycerol, the key reaction is shown in Fig. 1.

Author α : Department of Mechanical Engineering, GGS College of Modern Technology, Kharar-140301, Mohali Punjab, India.
Author σ : Department of Mechanical Engineering, Kanpur Institute of Technology, Kanpur, U.P., India.

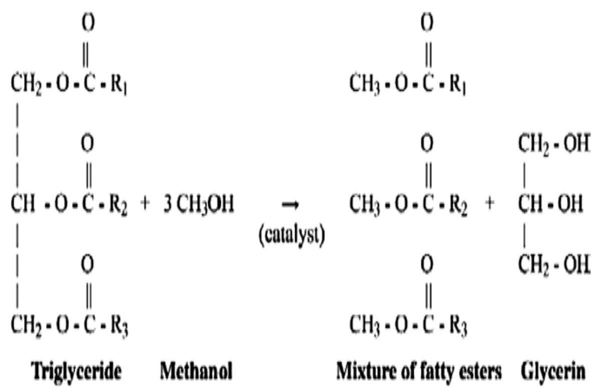

Figure 1 : Transesterification of triglycerides with methanol to FAME

The reaction is catalysed by alkali, acid or enzyme. When Triglycerides (TG) reacts with an alcohol, the three FA chains are released from glycerol skeleton and combine with the alcohol to yield FAME. Alkali (sodium hydroxide, potassium hydroxide), acids (sulphuric acid Hydro chloric acid) catalyze reaction. Alkali catalyzed transesterification is faster than acid catalyzed transesterification and is most used commercially. However, immediately following the milling process, rapid deterioration of the crude fat in the barn by lipase and to a lesser extent, oxidase makes the barn unfit for human consumption. Rice bran contains several types of lipase that are site specific and cleave the 1,3 site of triglycerols (TG). Depending on the nature of barn and the storage conditions, spoilage due to lipase continues after the milling [1]. Rapid increase in the free fatty acid (FFA) content in the rice bran occurs within hours, followed by about 5% per day increase in FFA content. The producing of an off flavour and soapy taste, and the change of functional properties of the barn were also reported [2]. Heating of barn immediately after milling inactivate the lipase and prohibit the formation of FFA. Various methods for the stabilization of rice barn have been described in the past [3]. However, due to the dispersed nature of rice milling, it is difficult to collect the barn continuously from the mills in large quantities, thus making central treatment impractical. Moreover, stabilization of barn results in additional cost. As a result, the utilization of rice bran is limited and is mainly used as animal feed and boiler fuel [4].

Haxane is commonly used as the solvent in the commercially extraction of oil from rice barn. RBO is one of the most nutritious oils due to its favourable fatty acid composition and a unique combination of naturally occurring biologically active and antioxidant compounds, such as ϒ- oryzanol, vitamin-E, Phytosterols, and tocotrienols [5]. In addition, rice bran also contains high molecular weight wax esters, which is a source of policosanols [6]. Although RBO is highly nutritional, it is not popular worldwide and its production is limited by several factors. Crude RBO has been difficult to refine because of its high content of FFA, unsaponifiable matter and dark colour [7]. The refining loss for RBO is particularly acute because of 2-3 times the percentage of FFA content in the oil. Due to the rapid splitting of lipid by active lipase present in the barn, RBO available in most Asian countries contain 40—50% FFA [8]. Crude RBO with less than 5% FFA is desirable for economic refining purpose. This leads to lack of widespread commercial use of RBO due to economic factors. As a result, only a small portion (<10%) of RBO is processed into edible oil. Hence RBO with high FFA content is potentially cheap feedstock for biodiesel production.

Alkaline – Catalysed Transesterification Alkali catalysed transesterifcation is used in the commercial production of biodiesel. Even at ambient temperature, the alkali catalysed reaction usually reaches 95% conversion in 1- 2 hour. On the other hand the acid catalysed reaction commonly requires temperatures above 100°C [9] and reaction times of 3- 48 hours have been reported, except when reaction were conducted in high temperature and pressure [10]. However for alkali-catalysed transesterification, the starting materials (oil or fat) must be dry and free of FFA. It is suggested that the FFA content of the refined oil should be as low as possible (below 0.5%) and Fuege and Grose also stressed the importance of oils being dry (<0.06%) and free of FFA [11].

II. Experimental Setup & Procedure

The present study was conducted on a single cylinder four stroke direct injection diesel engine of Kirloskar make, which is primarily used for agricultural purpose and house hold electricity generation as shown on figure 2.

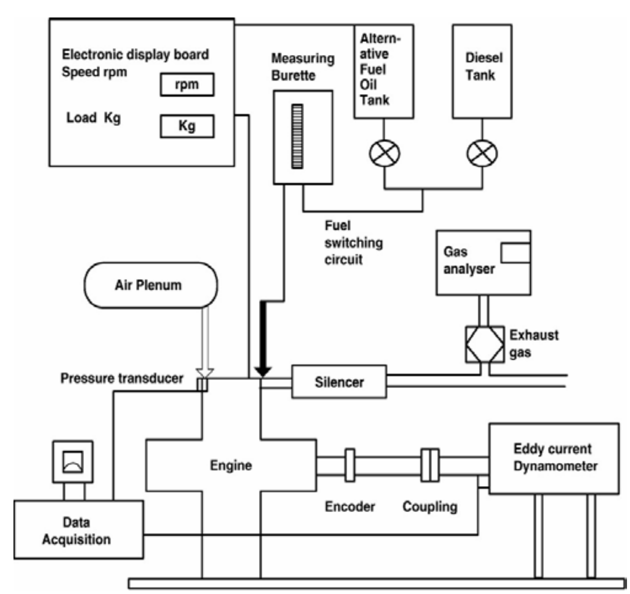

Fig. 2 : Experimental Setup

Engine was chosen as single cylinder because it was light and easy to maintain. Being air cooled means absence of radiator and water body and pump, made the system more suitable for the hot and arid conditions. The objective is to replace diesel fuel to the maximum without much loss of performance and significant reduction in emission. The compression ratio of 17: 1 and was normally aspirated and air cooled. The shaft of the diesel engine was coupled to generator set of 3KW capacity. A load bank was made using three numbers of 1KW electric heaters. The emission data were recorded with the help of automotive emission analyser AIRREX HG 540 & Gas Composition was measured from NAMTECH SM054. A calibrated burette and a stop watch were used to measure the volumetric flow rate of fuel. The schematic diagram of the experimental setup along with all instrumentation is shown in figure -2

Manufacturer	Kirloskar
Engine Type	Single cylinder, four stroke, air cooled, diesel engine
Bore/ Stroke	87.5/110
Rated Speed	1500 rpm
Rated Power	5 BHP/3.5 kW
Inlet valve opens/ Inlet valve closes	4°BTDC/35.5° ABDC
Exhaust V/v opens/ Exhuast V/v closes	35.5° BBDC/4.5° ATDC

Table 1 : Engine Specifications

The emission analyser was calibrated for standard diesel engine and set to zero before each experiment. The general specification of engine is given in table 1.

The fuels used in this study are standard diesel and biodiesel is prepared in the laboratory using transesterification process, which consists of a water bath, reaction flask with condenser and a mechanical stirrer. Flask has three openings, one for temperature measurement (reaction temperature), second for stirrer and third for condenser. The blending was done on volume basis. With three blend ratio of 0%, 5%, 10% and 20% of ethanol with 100%, 95% 90% and 80% of diesel respectively. The commercial diesel fuel and anhydrous ethanol were used for the preparation of different blends. Pure diesel fuel was used as base fuel for ethanol diesel blends in this study. Different diesel – biodiesel fuel blends were kept for 24 hours and they showed no phase separation in the blends. These were designated as B0, B5, B10 & B20. The experiments were conducted under steady state for four different load (No Load, 1KW, 2KW and 3KW load) conditions and three different proportions of blends. All data were collected after the engine was stabilized. All the gaseous emissions were measured after 20 minutes of running of engine so that the stable conditions were achieved and average result could be evaluated. The steady state tests were repeated to ensure that the results are repeatable.

III. Result & Discussion

Various parameters for engine performance and emissions were recorded using various proportions of blends of biodiesel and neat diesel at four different loading condtions of engine viz. no load, 33% load, 66% load and full load. The parameters under consideration were brake thermal efficiency, brake specific fuel consumption; brake specific energy consumption and exhaust gas temperature, whereas for emissions unburned hydrocarbon, carbon monoxide, carbon dioxides and smoke capacity were identified as key parameters.

Fig 1 represents the variation of brake thermal efficiency with engine load. As the load increases the brake thermal efficiency of the engine also increases from 2.5% at no load and 5% blend to 19% for full load at 20% blend ratio. The increase in efficiency is attributed to the increase the specific gravity of the blend along with the decrease in lower heating value, as a result lesser mass of the fuel is consumed and so the relative increase in the efficiency. The early initiation of combustion leads to a significant pressure rise before TDC complete combustion and hence increase in break thermal efficiency.

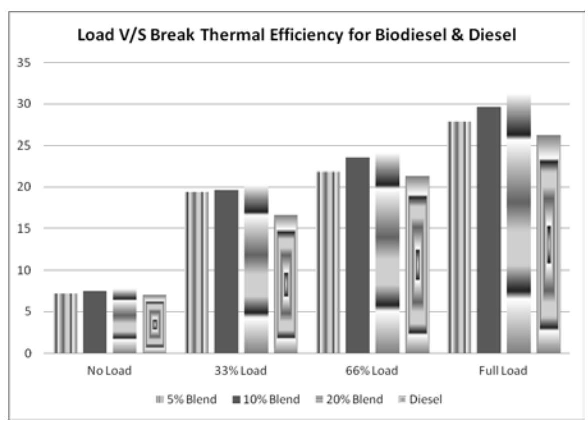

Fig.3 : BTE Vs Engine Laod

Fig 4 represents the variation of brake specific fuel consumption with engine load. The brake specific fuel consumption decreses with increse in engine load. this is evident from the Fig 3. Again the brake specific fuel consumption is reduced across the range of fuel and blend ratios. The reason for this is the increase in specific gravity of the blended fuel. The reduction is in the range of 2% to 16% from 5% blend at no load to 20% blend and full load conditions.

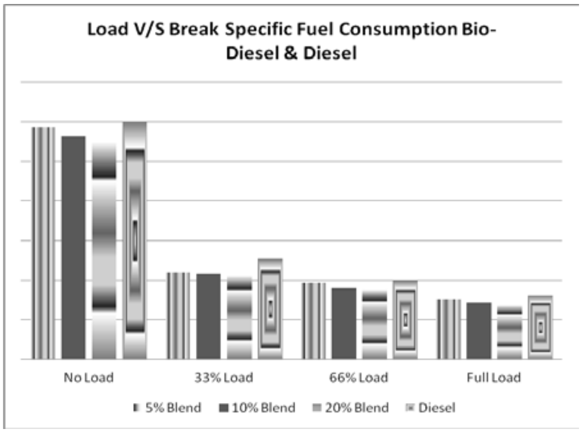

Fig. 4 : BSFC Vs Engine Load

The brake specific energy consumption of the blended fuel is reduced along the same line as the break specific fuel consumption as shown in Fig 5. This mau be due to better utilization of fuel at higher loads as compared to lower loads.

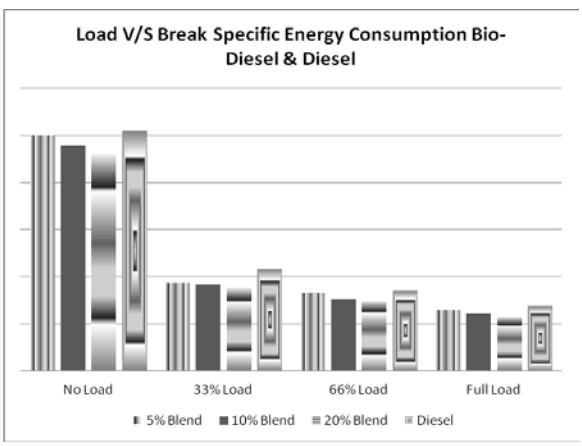

Fig 5 : BSEC Vs Engine Load

Fig 6 represnts the variation of exhaust gas temperature with engine load. The engine runs cooler as the heating value of the fuel is less than pure diesel. This is evident from the fact that the density is lower and hence mass of fuel consumed is less. The lower heating value of blend isalos found to be less so the resultant of these will have a positive effect on the engine i.e it runs at much lower tempertrure throughout the blend mixtures and load condition.

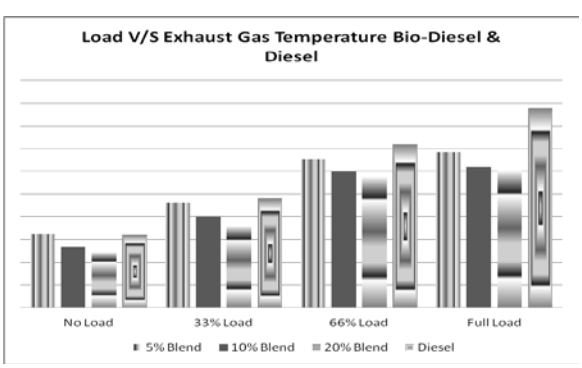

Fig 6 : EGT Vs Engine Load

Biodiesel causes significantly lower emissions compared with neat diesel and is attributed to higher oxygen content almost 10% than pure diesel and lower C/H ratio. The exhaust emission of CO and hydrocarbons (HC) is much lower than regular diesel fuel. This is because of presence of oxygen content in the RBO. As a result, burning efficiency and combustion reaction were much improved. Near absence of sulphur and aromatic content in biodiesel is another reason behind lower emissions. Emission of CO increases with increase in load as shown in fig 7. This is perhaps due to presence of fuel rich mixture at higher loads. It is also observed that CO emission is function of percentage of rice barn methyl ester in the blend.

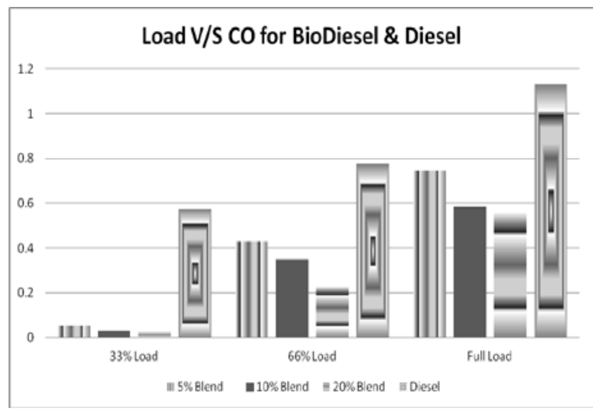

Fig. 7 : CO Emission Vs Engine Load

The variation of HC emission with engine load is shown in Fig. 8.The emission of unburned hydrocarbons in the lower heat release engine is because of the decrease in quenching distance and increase in lean flamability limits. The higher temperatures of combustion chamber walls and in cylinder gas in low heat release engine operation enables oxidation reaction to proceed closer to their completion of combustion.

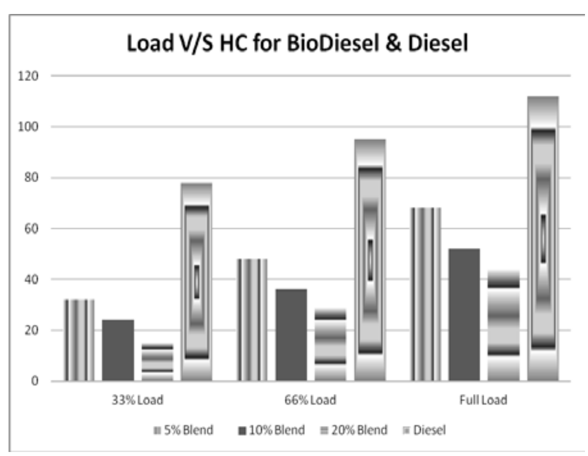

Fig. 8 : HC emission Vs Engine Load

The variation of carbon dioxide emission with load for diesel are shown in figure Fig 9. The CO_2 emission increased with load for all the blend ratios. Biodiesel is known for green house gas reduction.

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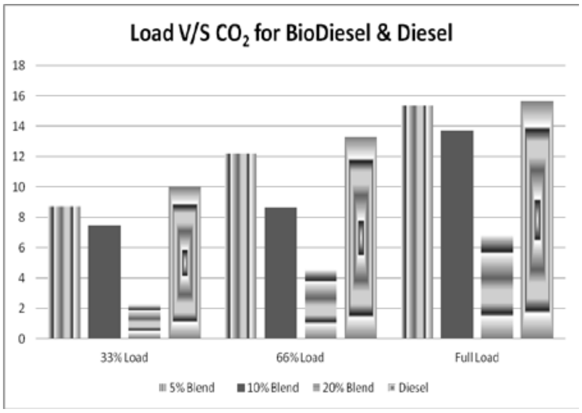

Fig. 9 : CO_2 emission Vs Engine Load

Smoke capacity increases with the increase of load as shown in Fig. 10. This is because of the amount of fuel per unit time increases as the engine load increases consequently, smoke increases. The smoke emission is reduced at all load conditions and blend ratios. Once again the reason being presence of oxygen in the lended fuel. Oxygen content of the biodiesel molecules enables more complete combustion even in regions of the combustion chamber with fuel rich diffusion flame and promotes the oxidation of already formed soot. The reduction is in the range of 10% at 33% load to 35% for full load condition.

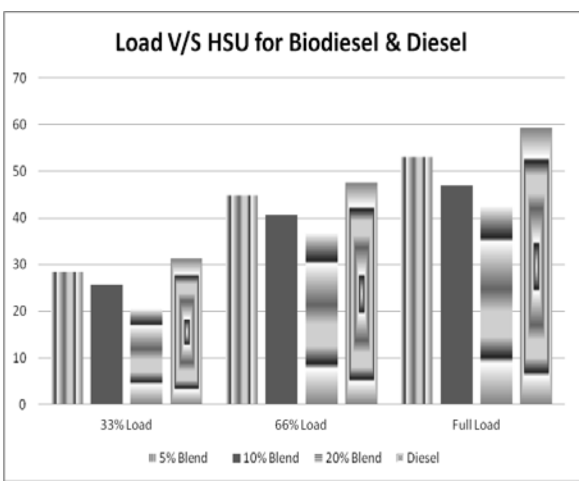

Fig. 10 : Smoke Opacity Vs Engine Load

IV. Conclusion

Based on the experimental result of this work following conclusion are drawn.

1. The high FFA level of crude rice barn can be reduced to less than 0.5% in a two step pretreatment process of transesterification using acid catalysed reaction with methanol.
2. No problem was faced at the time of starting the engine and ran smoothly over the range of rice bran oil blend ratio in the fuel. There were no sign of phase separation.
3. BSFC, and BSEC were lower than pure diesel because of lower heating value whereas the Break thermal efficiency is slightly higher. The engine is found to be running cooler across the range of fuel blend.
4. Emission of gases from the engine were less than that of pure diesel. So is the reduction of hydrocarbon, as the blend ratio increased the amount of emission also reduced.

References Références Referencias

1. Barnwal BK, Sharma MP. Prospects of biodiesel production from vegetable oil in India, Renewable and Sustainable Energy Review, 2005; 9; 363-378.
2. Canakci M, Gerpen JV, Biodiesel Production from oils and fats with higher free acids. Transaction ASAE 2001; 44; 1429 – 1436.
3. Cheng Y. L., Shiou A.L., Effect of emulsification variables on fuel properties of two and three phase biodiesel emulsion. Fuel 2007; 86; 210- 217.
4. Goffman F.D., Pinson S., Bergman C., Genetic diversity for lipid content and fatty acid profile in rice barn; Journal of American oil & chemical Society; 2004; 485 – 490.
5. Ramadhas A.S., Jayaraj S., Murlaleedharan C., Biodiesel production from high free fatty acid rubber seed oil. Fuel; 2005; 84; 335 -340.
6. Mittelbach M., Poklukar N., Ozonolysis of olifins. 2. Linsead oil as a renewable resource for alkyl 3,3-dlalkoxypropanoates. Synthesis- Stuttgart; 1990; 4; 331-332.
7. Bhattacharya D.K., Chakrabarty M.M., Vaidyanathan R.S., & Bhattacharya A.C., A critical study of the refining of rice barn oil; Journal of American Oil & Chemical Society; 1983; 60; 467 – 471.
8. Rao R.M, Tuli R., Prevention of hydrolytic rancidity in rice bran during storage; Journal of Agriculture Food Chemistry; 1999; 47; 3050 – 3052.
9. Houston D.F.; Rice barn and polish, in Rice Chemisrty and Technology, edited by D.F. Houston (American Association of Central Chemists. St. Paul MN) 1972, 1- 56 Cicero A.F.G., & Gaddi A., Rice barn oil and ϒ- oryzanol in the treatment of hyperlipoproteinaemias and other conditions; Phytother Res, 2001; 15; 277 - 289
11. Rogers E.J., Rice S.M., Nicolosi R.J., Carpenter D.R., McClelland C.A., Romanczyk L.J., Identification and quantitation of ϒ- oryzanol component and simulataneous assessment of tocols in rice barn, Journal of American Oil & Chemical Society; 1993; 70; 301 – 307.
12. Ramjan Vali S., Processing of the rice bar n oil and isolation of bio-active minor constituents from rice barn and its oil; Ph.D. thesis; Indian Institute of Chemical Technology; Hyderabad;2001.

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Effect of Hot Forging on Chemical Composition and Metallographic Structure of Steel Alloys

By Shishay Amare Gebremeskel & Prof. Ratnam Uppala (Ph.D)
Bahir-Dar University, Ethiopia

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GJRE-A Classification : FOR Code: 091207

EFFECT OF HOT FORGING ON CHEMICAL COMPOSITION AND METALLOGRAPHIC STRUCTURE OF STEEL ALLOYS

Strictly as per the compliance and regulations of:

Effect of Hot Forging on Chemical Composition and Metallographic Structure of Steel Alloys

[Case Study on Din-100CrMn6 Steel]

Shishay Amare Gebremeskel[α] & Prof. Ratnam Uppala (Ph.D)[σ]

Abstract - Massive defective products as a result of faulty heat- treatment process of a specific steel alloy, DIN 100CrMn6, are observed as a series issue. This is due to the remarkable market loss faced on the target industry of this research, Akaki Basic Metals Industry. The defective product of the stated steel alloy, mill grinding steel ball of cement industry, was observed and made reproduced its actual prototype using the same material and following the same production flow of the target industry. Three stages of the production flow were selected and the necessary tests, metallographic structure and the chemical composition, of the material were conducted at each selected process stages. The test stages adopted are; testing the raw material, the just as forged, and the heat treated final product. From the chemical composition and metallographic structure result of the first test stage, the mostly pearlite.

With small amounts of cementite at grain boundaries are observed at raw material stage. On the second test stage, the amount of C, Si, Mn, and Cr slightly decreased. This is due to decarburization and oxidation, upon heating to the forging temperature. Still the composition of the alloy steel is in accepted limits. At third stage while heat treatment of forged balls serious deviation occurred in the process, severe decarburisation and oxidation occurred and the chemical composition of alloy heat-treated balls changed to unacceptable levels reslting total rejection of total product. Based on these observed test results, the material used, and the process environment, solutions for the existing problem were addressed. Customization of the existing forging process and fixing of the temperature controllers for the furnaces in addition to careful selection of heat treatment mediums are important. Following the standard temperature sets for each type of heat treatment and applying appropriate soaking time to the corresponding material is highly recommended.

Keywords : Hot forging, chemical composition, metallographic structure, defects, DIN-100CrMn6, oxidation and decarburization.

I. Introduction

Forging is the working of metal in to a useful shape by hammering or pressing. It is the oldest of the metal working arts, having its origin with the primitive black smith of Biblical time. The development of machinery to replace the arm of the smith occurred early during the industrial revolution. Today there is a wide variety of forging machinery which is capable of making parts ranging in size from a bolt to a turbine rotor or an entire airplane wing. Most forging operations are carried out hot, although certain metals may be cold- forged. Two major classes of equipment are used for forging operations. The forging hammer, or drop hammer, delivers rapid impact blows to the surface of the metal, while the forging press subjects the metal to a slow- speed compressive force [1]. Since heating the preformed billet up to the forging temperature is a must in hot forging, the temperature in combination with the further process of forging alters the metallographic structure and the material composition of the parent material.

Author α σ : Department of Mechanical Engineering, Institute of Technology, Bahir-Dar University, Bahir-Dar, Ethiopia.
E-mails : sismar123@gmail.com, ratnamuppala@yahoo.co.in

II. Classifications of Forging Process

a) Open die forging (ODF)

In its simplest form, open die forging generally involves placing a solid cylindrical work piece between two flat dies (platens) and reducing its height by compressing it. This operation is also known as upsetting. The die surface may be shaped, as conical or curved cavity, there by forming the ends of the cylindrical work piece during upsetting [2]. Since more surface of the billet is exposed to atmosphere it attains high convection heat loss and it oxidizes contents of the material and creates scales on the surface and intermolecular boundaries.

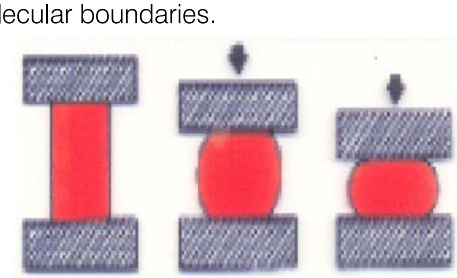

Fig. 1 : Upsetting of a cylinder, in open die forging.

b) Closed die forging (CDF)

In true closed die forging no flash is formed and the work is completely surrounded by the die. In impression die forging any excess metal in the die cavity is formed in to a flash, but this is not the case in closed die forging. Thus proper control of the volume of the

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material is essential to obtain a forging of desired dimensions. Under sized blanks in closed die forging prevent the complete filling of the die; over sized blanks may cause premature die failure or jamming of the dies [2]. In this type of forging the billet has very short time to be exposed to atmosphere and hence less oxidation. The main effect here is from the conduction heat transfer through the dies and intermolecular reaction of the material contents that results scales between intermolecular boundaries.

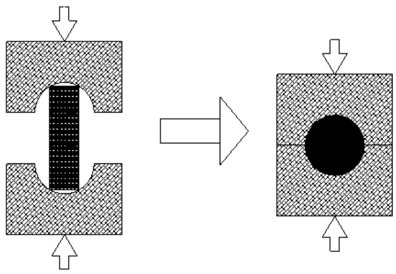

Fig. 2 : Illustration of perfect closed die forging (with no flash)

c) Impression die forging (IDF)

In impression die forging, the work piece acquires the shape of the die cavities (impressions) while it is being upset between the closing dies. Some of the material flows radially out ward and forms a flash. Because of its high length- to- thickness ratio, the flash is subjected to high pressure. These pressures in turn mean high frictional resistance to material flow in the radial direction with in the flash gap. Because high friction encourages the filling of the die cavities, the flash has a significant role in the flow of material in impression die forging.

Furthermore, if the operation is made at elevated temperatures, the flash, because of its high surface to thickness ratio, cools faster than the bulk does and helps fill the die cavities [2].

In this process material is affected by convection heat loss and surface oxidation through and on the flash. Conduction heat transfer through on work piece-dies interface and intermolecular reaction of the material contents have similar effects as in closed die forging.

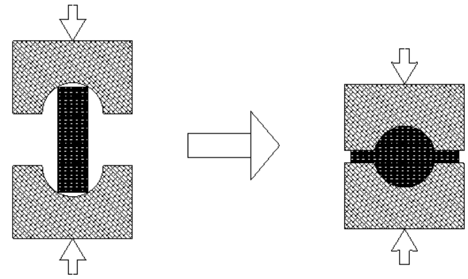

Fig. 3 : Illustration of impression die forging (with flash)

From the above classification of forging process forging of mill grinding steel balls, an interest of this research, lie on impression die forging.

The hot forged mill grinding steel balls produced has got defects like surface and internal scales, cracks, and loss of expected hardness and strength. So it is mandatory to study the effect of heating the bulk, forging environment, and the further progress of the forging process from the start up to the end.

III. Motivation

Development in forging process industries show the range of advancement from a simple upsetting of open die forging to the high precision closed die forging. Hot closed die forgings or hot impression die forgings are the most widely applicable forging processes for products having intricate shape and demanding high precision. Dies with different shapes of cavities corresponding to the product required are mounted on a forging machine and necessary type of loading on a heated billet via the dies is applied to deform the work piece in to required shape, hence hot closed/impression die forging. While doing this, the result of the deformation will depend on the type and inclusions of material, the cavity geometry, the amount of load, the type of loading, the material temperature, the die-work piece interface condition, and other variables.

A b c

Fig. 4 : a) steel balls b) steel ball forging dies c) trimming dies; photo from Akaki Basic Metals Industry

The specific product, forged mill grinding steel ball of cement delivered from **Akaki Basic Metals Industry,** my target industry, is produced using hot impression die forging process. Steel material, with DIN standard of 100CrMn6, is used and cement balls were produced and supplied to their customer, **Mugher Cement Industry**. **Mugher Cement Industry** has got these balls as 100% defective after a 15 days service life. Due to this reason the industry has already stopped producing steel balls for cement industries and exposed to huge losses.

This is the main motivation to carry on this research, focusing on the material evaluation of the product with respect to its material content and metallographic structure. Thus, these tests are done and compared with the parent material condition. This will help the factory to think over the solutions adjust the forging process parameters and behaviour of the forging environment.

IV. Materials and Methods

Here literatures starting from about three decades ago are reviewed with a main focus on studying the effect of forging process on the material properties. For this purpose laboratory tests are conducted as a method for the research. At the same time, background of the research is also included.

a) Basics of Forging Process

In forging an initially simple part (a billet), for example, is plastically deformed between two tools (or dies) to obtain the desired final configuration. Thus, simple part geometry is transformed into a complex one, whereby the tools "store" the desired geometry and impart pressure on the deforming material through the tool/material interface. Forging processes usually produce little or no scrap and generate the final part geometry in a very short time, usually in one or a few strokes of a press or hammer. As a result, forging offers potential savings in energy and material, especially in medium and large production quantities, where tool costs can be easily amortized. In addition, for a given weight, parts produced by forging exhibit better mechanical and metallurgical properties and reliability than do those manufactured by casting or machining.

Forging is an experience-oriented technology. Throughout the years, a great deal of know-how and experience has been accumulated in this field, largely by trial-and-error methods. Nevertheless, the forging industry has been capable of supplying products that are sophisticated and manufactured to very rigid standards from newly developed, difficult-to-form alloys. The physical phenomena describing a forging operation are difficult to express with quantitative relationships. The metal flow, the friction at the tool/material interface, the heat generation and transfer during plastic flow, and the relationships between microstructure/properties and process conditions are difficult to predict and analyze. Often in producing discrete parts, several forging operations (pre-forming) are required to transform the initial "simple" geometry into a "complex" geometry, without causing material failure or degrading material properties.

Consequently, the most significant objective of any method of analysis is to assist the forging engineer in the design of forging and/or performing sequences. For a given operation (pre-forming or finish forging), such design essentially consists of (a) establishing the kinematic relationships (shape, velocities, strain rates, strains) between the deformed and un-deformed part, i.e., predicting metal flow, (b) establishing the limits of formability, i.e., determining whether it is possible to form the part without surface or internal failure, and (c) predicting the forces and stresses necessary to execute the forging operation so that tooling and equipment can be designed or selected, Shirgaokar [27].

Relating to the compressive nature of forging process, Ettouney and Hardt (1983) [4] aimed to predict failure of specimens undergoing compression so as to permit maximum deformation before unloading and stress relieving. In this paper a method for determining flow stress characteristics of a cylindrical compression specimen is introduced, so that the state of stress at the surface can be found. They determined flow stress using measurements that can be made in- process, i.e., compression force, height reduction, and bulge radius.

Grobaski (2004) [13] noted about hot forging that it is a forging process done where the work piece is heated up to about 75% of its melting temperature. As the temperature of the work piece, prior to forging approaches the melting temperature, the flow stress and energy required to form the material is decreased. Therefore, the strain rate or rate of production can be increased.

Tremaine (2005) [18] characterized the defects of four different sample materials using a light microscope and summarized that hydrogen flake and voids are the main internal defects.

Durakan [11] stated the industrial applications and advantages of the induction heating in hot forging and the induction heating furnace units and the operating parameters affect the resultant temperature of the heated billet. The operating parameters are like power supplied, conveyor speed, and the induction coil box, hole, diameter. Michael L.He (2007) [17] put the metallographic photos for different defects and interpreted them by grouping as raw material, forge, heat treat, and unusual defect types.

b) Hot Impression Die Forging

The forging and its variety hot closed-die-forging (CDF), (or hot impression forging), beyond any doubt, is the oldest metal processing technology. It started when the prehistoric people learned to smith virgin gold peaces and later to heat sponge iron and to beat it with a stone in order to form useful implements.

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For a long time forging has strongly depended upon, first and foremost, skills of the blacksmith and from that point of view it related to the arts. In opposite to its practice, the theoretical grounds, which roots are deep in to two fundamental sciences – the continuum mechanics and metal physics – are relatively young and have been developing very intensively [21].

Hot impression die forging is the plastic deformation of metal between die halves which carry the impressions of the desired final shape, at a temperature and strain rate such that re-crystallization occurs simultaneously with deformation, thus avoiding strain hardening. For this to occur, high work piece temperature (matching the metal's re-crystallization temperature) must be attained throughout the process, so energy needed for this preheating. By hot forging, it can be produced a great variety of shapes with virtually any steel. The extensive scale formation occurs on the surface of the work piece. Larger tolerances and allowances are needed for further machining. A form of hot forging is isothermal forging, where materials and dies are heated to the same temperature. In nearly all cases, isothermal forging is conducted on super alloys in a vacuum or highly controlled atmosphere to prevent oxidation [10].

c) Hot Impression Die Forging as a System

Hot impression die forging system, as in other forging systems, comprises all the input variables such as the billet or blank (geometry and material), the tooling (geometry and material), the conditions at the tool/material interface, the mechanics of plastic deformation, the equipment used, the characteristics of the final product, and finally the plant environment where the process is being conducted.

The "systems approach" in forging allows study of the input/output relationships and the effect of the process variables on product quality and process economics. Fig.5 below shows the different components of the forging system. The key to a successful forging operation, i.e., to obtaining the desired shape and properties, is the understanding and control of the metal flow. The direction of metal flow, the magnitude of deformation, and the temperatures involved greatly influence the properties of the formed components. Metal flow determines both the mechanical properties related to local deformation and the formation of defects such as cracks and folds at or below the surface [27].

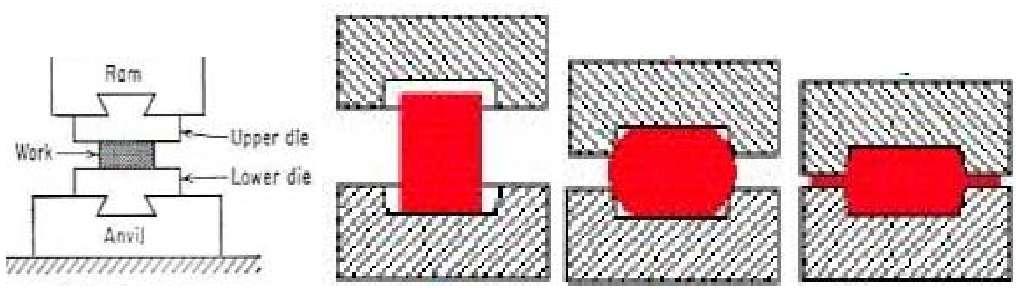

Fig. 5 : Components and progress of a particular hot impression die forging system[27]

i. *Material Characterization*

For a given material composition and deformation/ heat treatment history (microstructure), the flow stress and the workability (or forge-ability) in various directions (anisotropy) are the most important material variables in the analysis of a metal forging process. For a given microstructure, the flow stress, $\bar{\sigma}$, is expressed as a function of strain, $\bar{\varepsilon}$, strain rate, $\dot{\bar{\varepsilon}}$, and temperature, T:

$$\bar{\sigma} = f(\bar{\varepsilon}, \dot{\bar{\varepsilon}}, \mathrm{T}) \qquad (2.1)$$

To formulate the constitutive equation (Eq.2.1), it is necessary to conduct torsion, plane-strain compression, and uniform axi-symmetric compression tests. During any of these tests, plastic work creates a certain increase in temperature, which must be considered in evaluating and using the test results. Workability, forge-ability, or formability is the capability of the material to deform without failure; it depends on (a) conditions existing during deformation processing (such as temperature, rate of deformation, stresses, and strain history) and (b) material variables (such as composition, voids, inclusions, and initial microstructure). In hot forging processes temperature gradients in the deforming material, due to local die chilling for example, also influence metal flow and failure phenomena [27].

ii. *Tooling and Equipments*

The selection of a machine for a given process is influenced by the time, accuracy, and load/ energy characteristics of that machine. Optimal equipment selection requires consideration of the entire forging system, including lot size, conditions at the plant, environmental effects, and maintenance requirements, as well as the requirements of the specific part and process under consideration. The tooling variables include (a) design and geometry, (b) surface finish, (c) stiffness, and (d) mechanical and thermal properties under conditions of use.

iii. *Friction and Lubrication at the Die-Work Piece Interface*

The mechanics of interface friction are very complex. One way of expressing friction quantitatively is through a friction coefficient, μ, or a friction shear factor, m. Thus, the frictional shear stress, τ, is:

$$\boldsymbol{\tau} = \mu\sigma_n \tag{2.2}$$

Or

$$\boldsymbol{\tau} = f\,\overline{\sigma} = \frac{m}{\sqrt{3}}\overline{\sigma} \tag{2.3}$$

Where σ_n is the normal stress at the interface, $\overline{\sigma}$ is the flow stress of the deforming material and f is the friction factor ($f = \frac{m}{\sqrt{3}}$). There are various methods of evaluating friction, i.e., estimating the value of μ or m. In forging, the most commonly used tests are the ring compression test, spike test, and cold extrusion test [27].

iv. *Deformation Zone and Mechanics of Deformation*

In forging, material is deformed plastically to generate the shape of the desired product. Metal flow is influence mainly by (a) tool geometry, (b) friction conditions, (c) characteristics of the stock material, and (d) thermal conditions existing in the deformation zone. The details of metal flow influence the quality and properties of the formed product as well as the force and energy requirements of the process. The mechanics of deformation, i.e., the metal flow, strains, strain rates, and stresses, can be investigated by using one of the approximate methods of analysis (e.g., finite-element analysis, finite difference, slab, upper bound, etc.).

v. *Properties and Geometry of the Product*

The macro- and micro-geometry of the product, i.e., its dimensions and surface finish, are influenced by the process variables. The processing conditions (temperature, strain, strain rate) determine the micro-structural variations taking place during deformation and often influence the final product properties. Consequently, a realistic systems approach must include consideration of (a) the relationships between properties and microstructure of the formed material and (b) the quantitative influences of process conditions and heat treatment schedules on micro-structural variations.

d) Possible Defects of Hot Impression Die Forging Products of Alloy Steels

Dieter (1988) [1] discussed that the common defects in forging are, surface cracking, cracking at the flash, cold shut (fold), and internal cracking. Surface cracking can occur as a result of excessive working of the surface at too low a temperature or as a result of hot shortness (high sulphur content). Cracking at the flash of closed die (impression die) forgings is another surface defect since the crack generally penetrates in to the body of the forging when the flash is trimmed off. This can be avoided by increasing the flash thickness, relocating the flash to a less critical region, hot trimming, or stress relieving the forging prior to cold trimming of the flash. Another common surface defect of impression die forging is the cold shut or fold. It is produced when two surfaces of metal fold against each other without welding completely. This can happen when metal flows past part of the die cavity that has already been filled or that is only partly filled because the metal failed to fill in due to a sharp corner, excessive chilling, or high friction. A common cause of cold shuts is too small die radius.

Loose scale or lubricant residue that accumulates in deep recesses of the die forms scale pockets and causes under fill. Incomplete de-scaling of the work piece results in forged-in scale on the finished part.

Secondary tensile stresses can develop internal cracks, especially during upsetting of a cylinder or a round, as a result of the circumferential tensile stresses. It can be minimized by proper die design, using concave dies. Internal cracking is less prevalent in impression die forging because compressive stresses are developed by the reaction of the work with the die wall. Small crack, or flakes at the centre of the cross section can be occurred after cooling due to the development of residual stresses, especially in large forgings, associated with high hydrogen content.

As far as the reviewed studies of former research journals and books above, there is no as such clear study, particularly, focusing on the forged mill grinding steel ball of cement. This paper mainly emphasized on testing the material, studying the test results to help to interpret them, and to suggest the root causes for the defective balls, and suggesting the possible solutions.

e) Material Evaluation by Laboratory Tests

Metallographic and Spectrometry Tests

An experiment of metallographic structure and spectrometry (material composition) is done at three stages of the particular forging process of 100CrMn6 steel ball. Stage-1: Testing the raw material; Stage-2: testing just as forged; and Stage-3: testing the heat treated final product; is conducted following the standard procedures.

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Fig. 6 : Photos while the author conducting the experiment.

Stage-1: Testing the raw material

The chemical composition and the metallographic structure of the *raw material (billet)* for the particular product, mill grinding steel ball of DIN 100CrMn6, are tested and observed. The test results are as follows:

Table 1 : Observed chemical composition of the tested raw material

Steel designation	Percentage composition of elements in the 100CrMn6 steel alloy (%)									
	C	Si	Mn	Cr	P	S	Total	Fe-balance	C+Si+Mn+Cr (important elements)	P+S (detriments)
100CrMn6 observed (raw material)	0.93	0.57	1.18	1.69	0.03	0.022	4.422	95.578	4.37	0.052

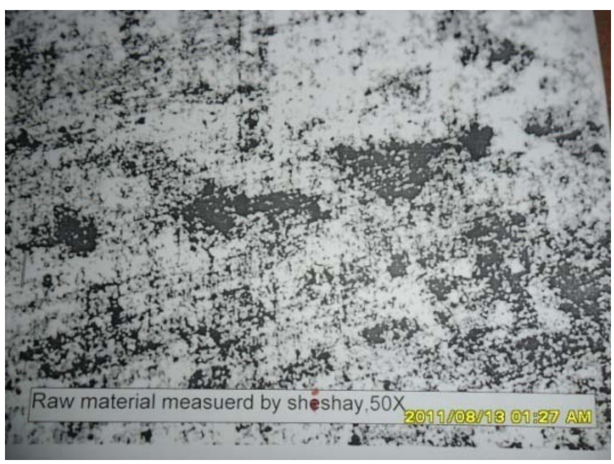

Fig.7 : Observed metallographic structure of the tested raw material (50X)

Stage-2: Testing just as forged

The chemical composition and the metallographic structure of the *as forged product*, mill grinding steel ball of DIN 100CrMn6, are tested and observed. The test results are as follows:

Table 2 : Observed chemical composition of the as forged product

Steel designation	Percentage composition of elements in the 100CrMn6 steel alloy (%)									
	C	Si	Mn	Cr	P	S	Total	Fe-balance	C+Si+Mn+Cr (important elements)	P+S (detriments)
100CrMn6 observed (as forged)	0.92	0.56	1.16	1.63	0.028	0.028	4.326	95.674	4.27	0.056

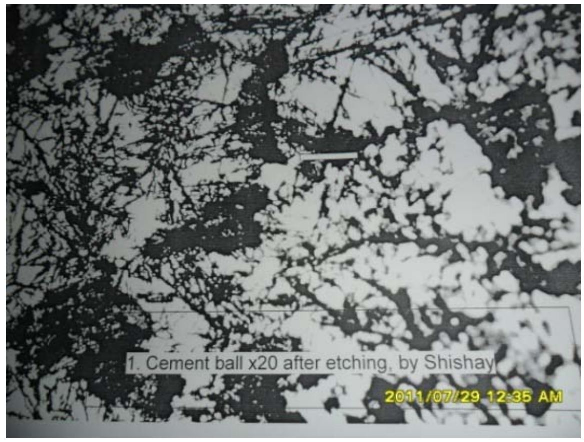

Fig. 8 : Observed metallographic structure of the as forged product (20X)

Stage-3: Testing the heat treated final product

The chemical composition and the metallographic structure of the *heat treated final product*, mill grinding steel ball of DIN 100CrMn6, are tested and observed. The test results are as follows:

Table 3 : Observed chemical composition of the heat treated final product.

Steel designation	Percentage composition of elements in the 100CrMn6 steel alloy (%)									
	C	Si	Mn	Cr	P	S	Total	Fe-balance	C+Si+Mn+Cr (important elements)	P+S (detriments)
100CrMn6 observed (heat treated final product)	0.67	0.339	0.89	0.87	0.039	0.034	2.842	97.158	2.769	0.073

Fig. 9 : Observed metallographic structure of the heat treated final product (20X)

V. Results and Discussions

a) Comparison of Test Results with Existing DIN Standard

Collecting the test results of the above three stages and bringing to one pool will help for ease of comparison and evaluation.

Table 4 : Comparison of observed chemical composition of, the raw material, the as forged, and the heat treated final product, steel ball material with the standard one.

Steel designation	Percentage composition of elements in the 100CrMn6 steel alloy (%)									
	C	Si	Mn	Cr	P	S	Total	Fe-balance	C+Si+Mn+Cr (important elements)	P+S (detriments)
1.3520 steel (100CrMn6) DIN standard	0.95-1.05	0.40-0.65	0.90-1.20	1.30-1.60	0.027	0.02	-------	---------	--------------	-------------
1.3520 steel (100CrMn6) DIN standard (*average*)	1.00	0.525	1.05	1.45	0.027	0.02	4.072	95.928	4.025	0.047
100CrMn6 observed (raw material)	0.93	0.57	1.18	1.69	0.03	0.022	4.422	95.578	4.37	0.052
100CrMn6 observed (as forged)	0.92	0.56	1.16	1.63	0.028	0.028	4.326	95.674	4.27	0.056
100CrMn6 observed (heat treated final product)	0.67	0.339	0.89	0.87	0.039	0.034	2.842	97.158	2.769	0.073

(a) (b) (c)

Fig. 10 : Observation of metallographic structure of, (a) the raw material (50X); (b) the as forged (20X); (c) heat treated final product (20X), 100CrMn6 mill grinding steel ball of cement industries, done in Akaki Basic Metals Industry.

From the chemical composition (Table 4) and metallographic structure (Fig. 10) shown above, the ferrite-pearlite matrix of the raw material (Fig. 10a) with graphite flakes and impurities are concentrated in between the grain boundaries. This ferrite-pearlite matrix has got austenatized and the amount of C, Si, Mn, and Cr decreased due to decarburization and oxidation, upon heating to the forging temperature. The carbides, oxides, and flakes are concentrated more in the boundaries (Fig. 10b) of the austenite grains.

These concentrations cause the propagation of continuous crack during the hardening treatment while the austenite grains are dominantly transformed to bainite (ferrite + cementite) (Fig. 10c).

Expressing the fall of the chemical composition of the important alloying elements and rise of the detrimental ones with respect to the Fe-balance, graphically, is very important and is shown bellow. The trend of fall and rise of the elements is done along test stages starting from the DIN standard value up to the third test stage. Percentages of Fe content are indicated on Y-axis for all graphs. Important alloying elements are C, Si, Mn, and Cr while the detrimental elements are P and S.

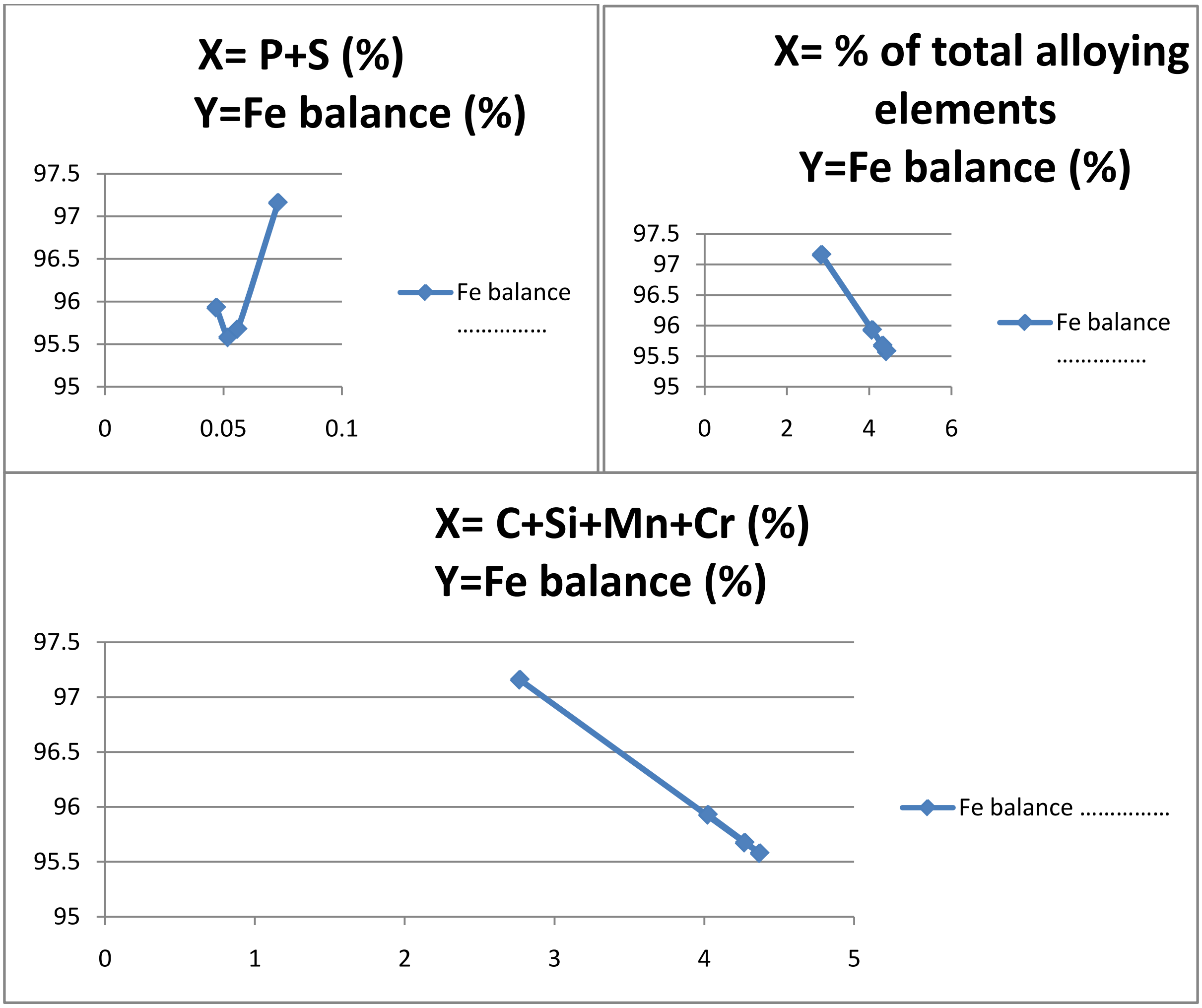

Fig. 11 : Graphical expression showing the fall of composition of the main alloying elements and rise of the detrimental elements along the test stages

The experimental observation for chemical composition of the raw material, the as forged, and heat treated final product of steel ball, is compared with the standard one as in the above table (Table 4) and above figure (Fig.11). The decarburization and oxidation of the main alloying elements resulted in decreasing their content and the necessary hardness and strength of the final ball. The percentage of undesirable elements, S and P, has also increased little bit at the final product which causes the hot and cold shortness respectively.

The main reasons for the problems observed from the metallographic structure and chemical composition of the forging done in the target industry, Akaki Basic Metals, are:

- Heatd billet is highly exposed to open air,
- Uncontrolled temperature of heating furnace and heat treatment furnace atmosphere and,
- Uncontrolled soaking temperature during quenching.

VI. Conclusion

As solving the problem addressed by this research is very crucial for the target industry as well as for the nation, one progress of identifying the root causes for the defective balls are well done. The current product of, mill grinding steel ball for cement industry, the target industry is rejected as defective since it has surface cracks, oxide scales, internal cracks, surface folds, and others. Up to the forging stage the chemical composition of the balls is with within acceptable levels. While heat treatment due to the faulty heat treatment process, without temperature and furnace atmosphere controls, serious deviations occurred in chemical composition particularly carbon content and chromium content resulting in total rejection of the product and its properties. Even the microstructure of the product after heat treatment is with lot of ferrite which is soft phase. After this conclusion about the existing conditions of the defective product the following solutions are recommended. (1) The industry has to fix temperature as well as atmosphere controls for the furnaces while following the standard rules for the furnace temperature, soaking time, and selection of the right quenching media corresponding to the forging material. (2) If some modifications are possible in the industry, after forging of the balls and removing flashes, immediate quenching of forged balls in oil and tempering should be done in forging section.

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References Références Referencias

1. George E. Dieter, Mechanical Metallurgy, SI Metric Edition, 1988, MC Graw- Hill, PP 564-585. 1
2. Serope Kalpakjian, Manufacturing Processes for Engineering Materials, 2nd Edition, 1991,USA, PP 315-343. 2
3. www.asminternational.org 3
4. O. Ettouney and D.E. Hardt, A Method of In-Process Failure Prediction in Cold Upset Forging, Massachusetts Institute of Technology, Journal of Engineering for industry Vol. 105/161, August 1983. 4.
5. S.B. Mehta and D.B. Gohil, Computer Simulation of Forging Using Slab Method Analysis, International journal of scientific and engineering research volume 2, issue 6, June 2011. 5.
6. F.R.Biglari and M Zamani, Die Wear Profile Investigation in Hot Forging, Proceedings of the world congress engineering, July 2008, London, UK. 6.
7. M. Skunca.et.al, Relations Between Numerical Simulation and Experiment in Closed Die Forging of a Gear, Journal of Materials Processing Technology, 2006. 7
8. Forging Solutions, Open Die Case Studies, 2007, www.forging.org. 8.
9. Forging Solutions, Open Die- articles, 2007, www.forging.org. 9.
10. Gulgun Aktakka, Analysis of Warm Forging Process, A Thesis Submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical University, January 2006, pp 1-11. 10.
11. Ilker Durukan, Effects of Induction Heating Parameters on Forging Billet Temperature, A Thesis Submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical University, September 2007, pp 1-24. 11.
12. Yilmaz Can, M Tahir Altinbalik, and Herol Akata, An Investigation on Forging Loads and Metal Flow in Conventional Closed Die Forging of Pre-forms Obtained by Open- Die Indentation, Indian Journal of Engineering and Materials Science Vol.11, December 2004, pp 487-492. 12.
13. Thomas C. Grobaski, Preliminary Research for the Development of Hot Forging Die Life Prediction Model, A thesis presented to the faculty of the Fritz J. and Dolores H.Russ College of Engineering and Technology of Ohio University, August 2004, pp 12-26. 13.
14. Dr. Lionel Fourment, Forging Process Optimisation, 06904 Sophia Antipolis Cedex-France. 14.
15. Harshil Parikh, Bhavin Mehta, Jay Gunasekera, Forging Process Analysis Preform Design, Ohio University, Athens, Ohio 45701. 15.
16. M. Jolgaf.et.al, Billet Shape Optimization for Minimum Forging Load, European Journal of Scientific Research Vol.24, 2008, pp 420-427. 16.
17. Michael L. He, Metallographic Interpretation of Steel Forging Defects, Microscopy Society of America, 2007. 17.
18. Alisha Tremaine, Characterization of Internal Defects in Open Die Forgings, FIERF Grant Project for Undergraduate Research, November 2005. 18.
19. Aditya Ashok Battin, Finite Element Analysis of Forging, The University of Texas at Arlington, August 2009, pp 12- 35. 19.
20. Dr. Taylan Altan, Hot Forging Trends and Applications, 4th Precision Forging Work Shop Plymouth, June 2008. 20.
21. B. Tomov, Hot Closed Die Forging- state- of Art and Future Development, Journal of Achievements in Materials and Manufacturing Engineering Volume 24, September 2007. 21.
22. Manas Shirgaokar, Gracious Ngaile, and Gangshu Shen, Process Modeling in Impression Die Forging Using Finite- Element Analysis, ASM International, 2005. 22.
23. M. Sedighi, M. Hadi, and S. Kolahdou, Optimization of Preform in Close Die Forging by Combination of Neural Network and Genetic Algorithm, World Applied Science Journal, 2009. 23.
24. Chunhui Luo, Modelling the Behaviour of Inclusions in Plastic Deformation of Steels, Royal Institute of Technology, Stockholm, May 2001. 24.
25. Seam Mc Kelvey and Ali Fatemi, Influence of Surface Finish on Fatigue Behaviour of Forged Steel Including Heating Method, Hardness, and Shot Cleaning Effect, The University of Toledo, May 2011. 25.
26. A. Gigovic- Gekic.et.al, Analyse and Research of Non-metallic Inclusions for Steel 100Cr6, METABK 48(1) 29-32 (2009). 26.
27. Manas Shirgaokar, Forging Processes Variables and Descriptions. 27.

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Detrmination of Wear Resistance of Neem, Mango and Cork Wood Polyacrylonitrile Composites

By Md Abid Ali, Dr.K.N.S Suman & Dr.V.V.S.Kesava Rao
Andhra University, Visakhapatnam, India

Abstract - Wood has long been used by the plastics industry as in expensive filler to increase strength and stiffness of the thermo plastic or to reduce raw materials cost. Wood Polymer composites consist primarily of wood and thermoplastic polymers. The commercial successes of these materials have been primarily by the promise of improved moisture performance, recycled and waste material utilization and efficiency in product and process design. Wood polyacrylonitrile composite (WPC) from neem, mango and cork wood was synthesized. The process was carried out through benzoyl peroxide(0.05mol/l)catalyzed impregnation polymerization of acrylonitrile,4mol/l,6mol/l into neem wood cork wood and mango wood in benzene medium at 75+-10c. The properties of WPCs over untreated woods were evaluated in terms of wear resistance test of wood was improved with impregnation of polyacrylonitrile .Impregnation of polyacyrlonitrile (PAN) into neem, mango and cork woods were was confirmed through scanning electron microscope.

Keywords : benzoyl peroxide, Polyacronitrile, impregnation, wear resistance, composite materials.

GJRE-A Classification : FOR Code: 091202,091210

DETRMINATION OF WEAR RESISTANCE OF NEEM, MANGO AND CORK WOOD POLYACRYLONITRILE COMPOSITES

Strictly as per the compliance and regulations of:

Detrmination of Wear Resistance of Neem, Mango and Cork Wood Polyacrylonitrile Composites

Md Abid Ali [α], Dr.K.N.S Suman [σ] & Dr.V.V.S.Kesava Rao [ρ]

Abstract - Wood has long been used by the plastics industry as in expensive filler to increase strength and stiffness of the thermo plastic or to reduce raw materials cost. Wood Polymer composites consist primarily of wood and thermoplastic polymers. The commercial successes of these materials have been primarily by the promise of improved moisture performance, recycled and waste material utilization and efficiency in product and process design. Wood polyacrylonitrile composite (WPC) from neem, mango and cork wood was synthesized.

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Keywords : benzoyl peroxide, Polyacronitrile, impregnation, wear resistance, composite materials,

I. Introduction

Wood polymer composites (WPCs) results from the polymerization of liquid monomers already impregnated in wood. In principle WPCs should display super mechanical properties; dimensional stability to chemical degradation and less moisture absorb temperature than non-impregnated wood. A number of wood preservatives developed during those wood treatment processes and are under continuous demands which can develop the modified wood materials with improved mechanical strength, thermo-oxidative stability and resistance biodegradation for the better outdoor applications. Polymerization of polyacrylonitrile into poplar wood has also been reported and the composites indicated excellent moisture resistance and thermo oxidative stability [1,2]. Temperature affects physical, structural properties of wood. Several affects have been made to establish the relationship between temperature and thermal stability of wood [3,4,5,6].The physical and mechanical properties of wood may be improved by preparing composites of wood with vinyl monomers [7]. Reinforcement of several monomers like styrene, methyl methacrylate has provided substantial thermal stabilities to different types of woods[8,9].However, since most vinyl monomers are non-polar; there is little interaction between these monomers and hydroxyl groups of the cellulose fibers. Wood, a renewable resource and naturally occurring material abundantly available has a wide range of applications as construction material ,pulp,paper,fire board products as well as source of energy and as raw materials for various industrially important chemicals. Considerable work has been done on the modification of wood [10].Meyer(1981)[11] reported that wood treated with vinyl type monomer followed by curing(radiation or catalyst)significantly improves the moisture resistance, hardness etc. The advantage of impregnation at normal conditions is the large quantities of samples of various sizes and shapes can be conveniently impregnated compared to vacuum impregnation [8]. Thermo gravimetric analysis (TGA) is one of the major thermal analysis techniques used to study the thermal behavior of carbonaceous materials. The rate of weight loss of the sample as a function of temperature and time is measured to predict thermal behavior of the materials. Thermal analysis as TG has become the polymer characterization method the most frequently used.The TGA is particularly more adopted for mass variation study.In this work,we studied the process of degradation of wood poly acrylonitrle composites.compressive streangth of imprenated eucalyptus wood specimens is greater than that of non impregnated ones indicating that monocomponent polyurethane resin can be considered for impregnated impregnating wood[12].In thermo gravimetric list thermal decompositions of rice husk floor from room temperature to 3500 was similar to that of wood floor.Thus rice husk floor was thought to be a substitute for wood floor in agricultural lignocellulosic fiber-thermoplastic polymer composites in the aspect of thermal decomposition[13].Physical and mechanical grown A auriculiformis of three different ages(8,12,13 years)from sirsi,Karnataka indicate that the wood can be used for tool handles in work shops and factories and agricultural sectors ,light packing cases[14].The mechanical stability of cedar wood samples were

Author α : Assistant Professor, Department of Mechanical Engineering, Andhra University, Visakhapatnam, India.
E-mail : mdabid_786@yahoo.co.in
Author σ : Professor, Department of Mechanical Engineering, Andhra University, Visakhapatnam, India.
Author ρ : Associate Professor & HOD, Department of Mechanical Engineering, Anurag Engineering College, Kodad, India.

increased by using P(AGE/AN),P(AGE/MMA) copolymers.[15].Polymerization of polymethyl methacrylate and acrylonitite into Block Berry Wood has also been reported and composites indicated excellent wear stability and thermo oxidation stability[16].Polymerization of acrlonitrile into Indian Cork wood has also been reported and composites indicated excellent compressive resistence and thermal stability[17]. The effect of moisture content on mechanical properties of wood polystyrene composites in relation to their mechanical properties was studied[18].. A number of composites have shown improved dimensional stability and mechanical properties and proposed that they could replace the quality woods in high grade products[19]. Better tensile properties were observed in poly methyl vinyl methacrylate impregnated kadom and mango woods in presence of N-vinyl pyrrolidone tripropylene glycol diacrylale, trimethyloyl propane triacrylale, copper sulphate and urea [20]. Poly methymethacrylate was impregnated into low-grade woods in ligand paraffin, the composites so formed have shown increased hardness, impact strength dimensional stability and were proposed to be useful for tools and roofing [21].

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II. Experimental Methods

a) *Materials*

All the chemicals and solvents (AR) were purchased from M/S SDFCL Chemicals Ltd; Mumbai.

The monomer acrylonitrile was purified by extracting it with aqueous NAOH (10%) to remove inhibitor contents fallowed by repeated washings with distilled water. The fraction at 78^{0}C was used for the impregnation polymerization reaction. Other chemicals and solvents were used without further purification.

b) *Sample Preparation*

Wood specimens were prepared as per IS:1708-1986.The moisture content of wood was deduced according to ASTMD1037-72a and was found to be 12.75%.

c) *Impregnation Procedure*

The Benzene solution of acrylonitrile at concentration of 4M, 6 Moles and Benzene solution of benzoylperoxide at 0.05M have also been prepared. Samples were then placed into an impregnation chamber. Some loads were applied on the samples before impregnation so that no flotation occurs. The appropriate monomer system was then introduced through a dropping funnel and the specimens were left immersed while atmospheric pressure was reached and allowed to stand for up to 24H(ASTMD-1413-61).Treated wood specimens were then wrapped in commercially available Al foil and cured in oven at 95^0 C for 2H to induce the impregnation polymerization reaction. Impregnation of polyacrylonitrile into neem,mango and cork woods were confirmed through scanning electron microscopy.

Fig.1 : Polymerization Process

III. Measurement

a) *Wear Resistence*

ASTMD10044 Model is used.The Vacuum control should be set high enough to remove abrading and abrasive particulars but not high enough to lift flexible specimens.

Fig. 2 : Experimental setup for Wear Resistence test.

The specimen of Neem,Cork and Mango woods and their PAN composites of 2M, 4M and 6M of 4 inches Round with ¼ inch center hole and holded it in holder of testing machine E100-125, tighten with S-21 extension nut. The abrasive wheels H – 18 calibrade used. the evaluation of wear is based on Weight loss method. The Taber wear index (rate of wear) is the loss in weight in milligrams per thousand cycles of abrasion for a test performed under resistance quality of the material

$$\frac{100mg.\times 1000\,cycles}{500\,cycles\,test} = 200\ TABLE\ WAER\ INDEX\ (Weight\ Loss\ Method)$$

IV. Results and Discussions

a) Wear Strength

ASTMD1044 model wear tester is used. In the wear test for specific materials it is assumed that, when possible, test should be conducted in an atmosphere in controlled humidity and 70-74 degrees Fahrenheit temperature. The samples have been conditioned in the test atmosphere for at least 24 hours before testing. The Vacuum control should be set high enough to remove abrading and abrasive particulars but not high enough to lift flexible specimens. The specimen of Neem,Mango and Cork woods and their PAN composites of 2.0 M, 4.0M and 6.0M of 4 inches circle with ¼ inch center hole and hooded it in holder of testing machine E100-125, tighten with S-21 extension nut. The abrasive wheels H – 18 calibrate used. The evaluation of wear is based on Weight loss method.

i. *Conditioning*

Specimens of untreated wood are dried to a moisture content of 7% or 8%t. Specimens should be seasoned for 24 hours or longer in the conditioned atmosphere of the laboratory at 50 percent relative humidity and 70 – 74 F temperature. Wear resistance tests of natural and PAN Wood has been made on the Abraser. Panels has selected for flatness, uniform thickness, and freedom from warp. Prepared the surface by sanding it smooth and free of indentations or other surface defects that might occur in the path of the abrading wheels. A special extension nut, S-21 is available for holding material ¼ to ½ inch in thickness. This nut requires a 3/8 inch center hole in the specimen in place of the usual ¼ inch hole. The section is the outline all the elements of a typical test procedure from analysis of the testing problem to final evaluation of results and mechanics of testing, the preparation and mounting of specimens, and the setup and operation of the Abraser is presumed.The value of the Abraser in research and control programs depends to a considerable extent of the test problem, the service requirements and the desired wear characteristics of the material examined. Time and material may be saved by analyzing this problem and planning procedure before embarking the use of Polycrylonitrile wood.

An air-conditioned test room is strongly recommended where reproducible precision results are required. Both heat and moisture affect the abrasion resistance of most materials, and particularly organic materials. Abrasion research projects are usually carried out in an atmosphere maintained at 70-75^{0}F temperature and 50 percent relative humidity. Without exception, samples which were to be tested should be seasoned in the test atmosphere for at least 24 hours. When tests were to be conducted. Temperature and humidity conditions has specified kept constant in all tests.It was essential that record of every phase of test procedure be kept for purpose of comparison and in order that the test may be exactly duplicated at any future time.

ii. *Selecting the method of evaluating test results*

Test Results are expressed as a wear factor / numerical abrasion index of the test specimen.The wear factor arrived at by one of the method of calculating results is not directly comparable. The method of calculating results should be expressed with the wear factor. The tests have been performed by Weight loss method.

When the results are to be compared with those of similar materials having nearly the same specific gravity. The Taber wear index (rate of wear) is the loss in weight in milligrams per thousand cycles of abrasion for a test performed under resistance quality of the material.

$$\frac{100mg.\times 1000\,cycles}{500\,cycles\,test} = 200\ TABLE\ WAER\ INDEX\ (Weight\ Loss\ Method)$$

iii. *Weighing the specimen*

Before Testing, Immediately before these tested on the Abraser, the specimen has been weighed to the nearest tenth of a milligram in a sensitive laboratory balance and the weight entered in the record.Accuracy of results depends on correct weighing of the specimen. A high precision analytical balance should be used and its accuracy periodically checked. Sufficient time should be taken to assure maximum accuracy in the weight determination.

After Testing,at the end of the abrading operation, clean the specimen thoroughly by brushing it free of any loose particles Weight the specimen in the same balance and with the same care as before testing and entered the reading to the nearest tenth of a milligram in the test record for calculating the wear factor (table 1 to table.3).

Table 1 : Wear index Tests of Neem Wood and its PAN Composites

S.No	Concentration	Taber Wear resistence mg/1000 cycles
1	0M	70.5
2	2M	48.4
3	4M	34.9
4	6M	30.0

Table 2 : Wear index Tests of Mango Wood and its PAN Composites

S.No	Concentration	Taber Wear resistence mg/1000 cycles
1	0M	70.5
2	2M	338.5
3	4M	187.7
4	6M	111.8

Table 3 : Wear index Test of CorkWood and its PAN Composites

S.No	Concentration	Taber Wear resistence mg/1000 cycles
1	0M	347.3
2	2M	438.2
3	4M	94
4	6M	220.9

V. Conclusions

Results of these tests demonstrated that the Mechanical properties of impregnated wood specimens are greater than that non impregnated ones. .The wear resistance of the Polyacrylonitrile(PAN) reinforced wood composites is increased.Due to increase of Polyacrylontrile Concentration Weight loss decreases.

VI. Acknowledgement

The authors are thankful to V. Kiran Kumar, CIPET, Hyderabad, India for providing Equipment for Testing these Samples.

References Références Referencias

1. T.K ZAID M.G.H,SA.P.L AND ALAM "Mechanical and Thermal Properties of Popular wood polyacrylonitrile Composites", J Polym Int.54;198-201
2. R DEVI, T.K.MAJ"STUDIESSTUDIES OF PROPETIES OF RUBBER WOOD WITH IMPREGNATION OF POLYMER"BULL. Mater.Science.Vol25,no6November 2002pp527-531.
3. Beall,F.C.and Eichkner,H.W,1970." Thermal degradation of wood components. A Review of literature".USDA, Forest Service Res.paper.FPL130.
4. Clemons.C2002.Forest product journal,52:10.
5. Wolcott, M.P and Karl Englund A Technology Review of Wood-Plastic Composites.
6. Wechsler, Salim Hiziroglu." Some of the properties of Wood Plastic Composites". Building & Environment 42(2001) 2637-2644.
7. Hyung Chick Pyun, Jae Rok Kim and Hee Lee." A Study on the preparation of Wood Plastic combinations. Monomer Integrations and Gamma-ray induced Polymerizations. Journal of the Korean Nuclear Society Volume IV No.1, March 1972.
8. B elvy, Gary R. Dennis and Loo-Teck Ng (1995), Journal of Material Processing Technology 48 (1995) 365-372.
9. K.M.I., Khan M.A. And Hussain (1996) Radiate Physc. Chem. Vol.48, 781-786.
10. Rowell, R.M. 1983. Controlled release delivery systems. In: bioactive polymer wood composites, Marcel dekkkerInc., N
11. Mayer, J.A. 1981. Wood Polymer Impregnated In: Encyclopedia of polymer science and eng.. Marks, Bikales, Menzes, Ovaberger (eds.) 17, 887-900.
12. Waldemir Rorigues,Mariano Martinez Espinosa,Wagner LuisPolito"Comparison of the Compressive Strength of Impregnated and Nonimpregnated Eucalyptus Subjected to Two Different Pressures and Impregnation Times"Materials Research,Vol.7,No.2,241-245,2004.
13. Hyun-joong Kim,Young Guen Eom,"Thermogravimetric analysis of Rice Husk Flour for a New Raw Material of Lignocellulosic Fiber-Thermplastic Polymer Composites,Mokchae Konghak29(3):59-67.2001.
14. S.R.Shukla,R.V.Rao,S.K.Sharma"Physical and mechanical properties of plantation grown Acciaauriculiforms of three different ages"Australian Forestry2007.,vol.70.No2.pp86-92.
15. Dilik solpan,"Modification of some Mechanical propertiers of cedar wood Radiation Induced in situ copolymerization of Allyl Glyciddyl Ether with Acrlonityrile and Methyl Methacrlate"Iranian Polymer Journal/vol.8 No.2(1999).
16. Y.K Tyagi and P.L.Sha"Charecterization of Thermo-oxidative and wear Stability of Black Berry Wood and its polymethylmetacrylate and Polyacrylonitrile Impregnated Wood Composites" 16 December 2009.
17. Md.AbidAli,Dr.K.N.S.Suman,Dr,V.V.S.KesavaRao,"mechanical and thermal properties of Indian Cork Wood PolyAcrlonitrile Composites",Journal of Automotive Mechanical &Aerospace Engineering ResearchISSN:2229-9270,March2011.
18. Widlak, H. and Dudzinski, J 1992. Mechanical properties of wood polysterene composites produced from wood of variouys moisture contents, Prac Komisji Technology Drewna, 13, 127-137.
19. Lingfei, Ma. And Yang, Y. Yu. 1996. Study on wood plastic composites, Zhejiang Linxueyuan Huebao, 13 (1), 104-108.
20. [20].Ali, K.M.I; Khan, A.M and Hussain, M. M. 1994. Wood Plastic Composites with methylmethacrylate Polym. Plast. Technol. Eng.33 (4), 477-482.
21. Mohan, H. and Iyer, R.M. 1991. Study of wood polymer composites. Rad. Technol, Asia Conf. Proc. North Am. North Brook Ill. 93-97 (1991), CA 121 (6), 1994.

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Optimization of Submerged Arc Welding Heat Affected Zone Toughness in X-120M line Pipe Steel

By Jai Dev Chandel & Nand Lal Singh
M S University of Baroda, Vadodara, India

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Keywords : X-120M, LDSAW, HAZ, CTOD, toughness, heat input, macro hardness.

GJRE-A Classification : FOR Code: 091505,091399

Strictly as per the compliance and regulations of:

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Jai Dev Chandel[α] & Nand Lal Singh[σ]

Abstract - In view of the ever-increasing demand for energy and ever increasing operating pressure of line pipe, it is very essential to develop high strength steel and production technology for manufacturing the line pipes of high strength of level to X-120M. Recent experiments show that the grade (X-80M) with respect to grade (X-70M) could give investment cost saving of pipe line construction project. if we use X-120M steel line pipes, the cost saving is much higher. Therefore, economic transport of gas from remote sources is an important consideration in today's global economic environment. To solve these challenges, a high strength grades, large diameter line pipe of X-120M strength level through J-C-O-E technique has to be developed. The J-C-O-E longitudinal double submerged arc welding (LDSAW) of X-120M line pipe has major challenge to establish the toughness for heat affected zone (HAZ) at theX-120M strength level, as the SAW welding is high heat input welding process. So the maintaining the strength and toughness at the strength level of X-120M of heat affected zone (HAZ) is very critical as the cooling rate is very high. In this paper the heat input for LDSAW process has been optimized with respect to the toughness down to -20 ^{0}C in HAZ of X-120M strength level. The effect of varying level of heat input in increasing order form minimum heat input of LDSAW process has been studied with three wire tandem system of submerged arc welding system. The experimental procedure at varying level of heat input has been established similar to line pipe welding except line pipe formation. The testing performed on test coupons are charpy V-notch testing, crack tip opening displacement (CTOD), Vicker's macro hardness testing. The said tests for all level of heat input established the optimum level of heat input for toughness of X-120M in the HAZ of LDSAW weld down to -20 ^{0}C.

Keywords : X-120M, LDSAW, HAZ, CTOD, toughness, heat input, macro hardness.

I. Introduction

Heat affected zone (HAZ) is the portion of the base metal (Plate Material) lying next to the fusion line of longitudinal double submerged arc weld (LDSAW), which has not been melted but whose mechanical properties or microstructures have been altered by the heat of the welding. The HAZ is subjected to a complex thermal cycle (sudden heating followed by rapid cooling), in which all temperatures from melting range of the steel down to mere warming involved, and therefore HAZ consists of series of graded structures . Microalloying technique [1] and dynamic accelerated cooling process after controlled rolling were applicable to develop low composition parameter (Pcm) high grade line pipe steel which is required for prevention of cold cracking in girth welding. The HAZ toughness was improved by adding small amount of titanium ('Ti'). The hardenability of boron ('B') treated new type of steel was considered by using the effective 'B' contents calculated equilibrium as free 'B'. The effect and its mechanism of 'B' [2] addition to steel containing fine 'Ti_2O_3' particles on toughness improvement of HAZ in large heat input welding process has been studied. The formation of intergranular ferrite (IGF) in HAZ is promoted and HAZ toughness is improves markedly after large heat input welding by adding 'B' in steel containing 'Ti_2O_3'. While 'B' segregates of gamma (γ) grain boundaries suppresses nucleation of grain boundaries alpha(α) ferrite, 'B' at gamma (γ)/Ti_2O_3 interface doesn't suppress nucleation of IGF from 'Ti_2O_3' because of 'B' absorption into 'Ti_2O_3'. Consequently fine IGF nucleation is accelerate by the effect of both 'Ti_2O_3' and 'B' so that refining of HAZ microstructure and improvement of HAZ toughness are achieved even after large heat input welding process. The CGHAZ has been studied [3, 4] for different steel composition like carbon with Al-Si and Al, Si-face, Al-free, 'Si' and 'Nb' alloyed. The above combination did not make much difference but the difference made by the reduction in the carbon percentage to improve low temperature toughness of HAZ is appreciable. The matrix microstructures [5] are also reported to have a strong influence on HAZ toughness. In bainitic and mertensitic steel the austenite grain transform to lath structure, the lath structure occurs in bundles or packets with low range boundaries between the laths and large misorientation occurs across packet boundaries. In such structures the packet width is the main microstructural features controlling cleavage crack propagation. It was reported that the ductile-brittle transition temperature is a logarithm function of the inverse square root of the product of the pocket diameter. The presence of M-A phase is the dominate factor for determining the toughness of intercritically cooled coarse grain (ICCG) HAZ. The evaluation of the mechanical properties [6, 7] for the base metal and the weld together with field weldability were carried out for X-80M TMCP steel plates. The steel has a bainite microstructure and has excellent

Author α σ : M S University of Baroda, Vadodara, India.
E-mails : jaidev.chandel@jindalsaw.com, singhnl_msu@yahoo.com

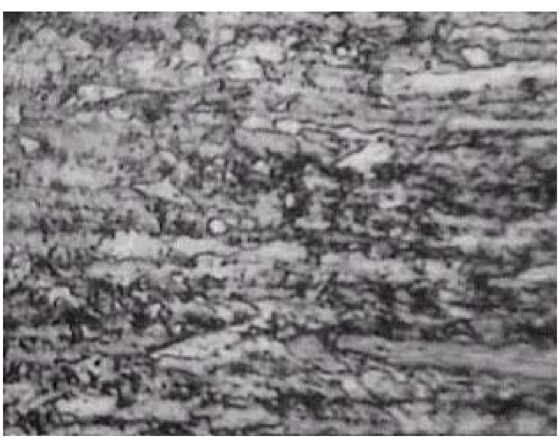
arrestability to unstable ductile fracture. With lowered 'Si' content the HAZ fusion line show excellent toughness. Fracture mechanics [8] test results reveals that the weld joints are affected the mechanical and metallurgical heterogeneity in welds. It was exhibited that the CGHAZ corresponds to potential local brittle zone in welds which controls the initiation brittle fracture. It was claimed that strength overmatching of weld metal was not always beneficial, because the HAZ toughness was decreased with increasing the degree of strength overmatching of weld metal. This is due to the constraint effect of the overmatching weld metal. The overmatching weld metal elevates the local stress in the HAZ which facilities fracture initiation in the HAZ. Recent investigation on structural significance of low toughness HAZ showed no implication on the integrity [9, 10]. It is therefore recommended that the existing procedures for defining and testing HAZ toughness are reconsidered under consideration of the actual loads, the defect probability and incorporating the size of the local brittle zone (LBZ), also their significance on the structural integrity.

II. Materials and Experimental Methods

Experimental TMCP and ACC steel plate is of API-5L, X-120M and Chemistry of experimental plate shown in table # 01. The parameters Pcm and C_{EQ} are calculated as per formulae given as Pcm = C + Ni / 60 + Si / 30 + (Mn + Cu + Cr) / 20 + Mo/15 + V / 10 + 5B and C_{EQ} = C + Mn/6 + (Cr+Mo+V)/5 + (Ni + Cu)/15. The light micrograph of the experimental TMCP and ACC steel plate shown in figure # 01.

Table 1 : Weight Percentage of Elements of X-120M Steel Plates

Element	C	Si	Mn	P	S	Cr	Ni	Mo	Al	Cu
Wt. (%)	0.065	0.290	1.950	0.012	0.005	0.170	0.040	0.130	0.042	0.021
Element	Ti	V	Nb	Ca	N	B	Al/N	Nb+V+Ti	Pcm	CE
Wt. (%)	0.012	0.001	0.042	0.001	0.002	0.004	21	0.055	0.211	0.454



Base Plate 1200 X

Figure 1 : Bainitic Microstructure of X-120M Steel Plate

To establish the toughness of heat affected zone (HAZ), number of test coupon has been made from V-Nb-Ti-B microalloyed steel with low Pcm plate of API-5L, X-120M. The steel plate used in this study has been produced through TMCP and accelerated cooled process to achieve the strength, toughness and weldability the level of X-120M with bainitic microstructure. The welding of the test coupons has been carried out by the combination of gas metal arc welding (GMAW) and double submerged arc welding (DSAW) processes. The root pass weld (Continuous tack weld) by GMAW and the final welding were completed with three wire tandem submerged arc welding (SAW) technique by one pass from first side opposite to the root run and second pass on the root weld side of the test coupons. The welding procedure has been made to maintain the minimum HAZ, optimum cross penetration, defect free elliptical weld pool shape, competitive epitaxial dendrite growth in the weld. The test coupon assembly is shown in figure # 02 (a) having (2800 mm X 300 mm X 14.3 mm) with double-Y joint geometry as shown in figure # 02 (b). The heat input of GMAW kept constant as shown in the table # 02. The different heat put levels of test coupons is shown in the figure # 03. After first pass of SAW welding, the test coupons were allowed to cool down room temperature to achieve the fast cooling rate.

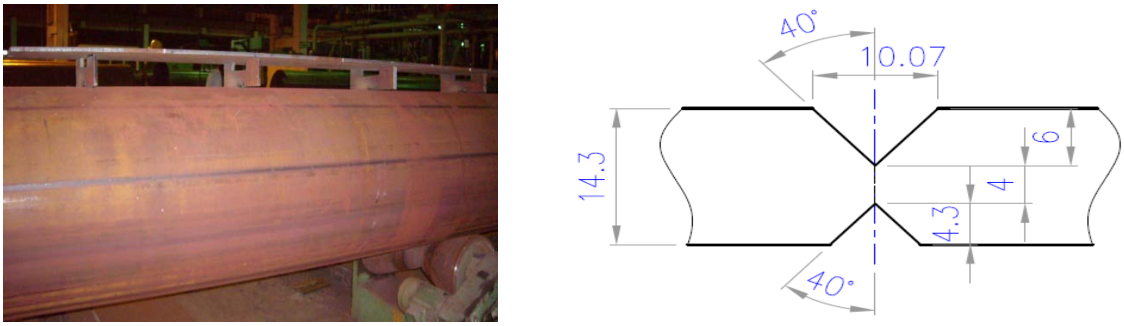


Figure 2 (a) : Weld Test Coupon Assembly, (b) Double-V joint geometry for Test Coupon

Table 2 : GMAW heat put level

Current (A)	Voltage (V)	Speed (m/min.)	Heat Input (kJ/mm)	Shielding Gases	Flow Rate (lpm)	Wire Diameter (mm)
190	21	0.6	0.48	CO_2	15	1.2

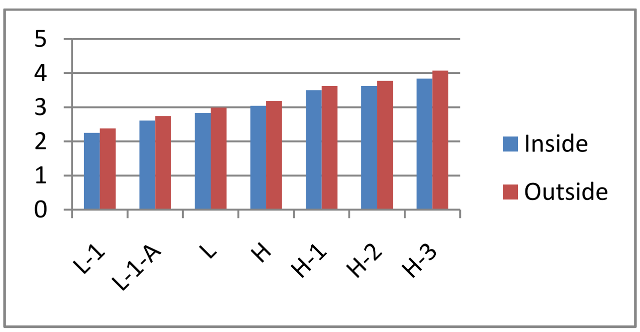


Figure 3 : SAW process at different heat put level (kJ/mm)

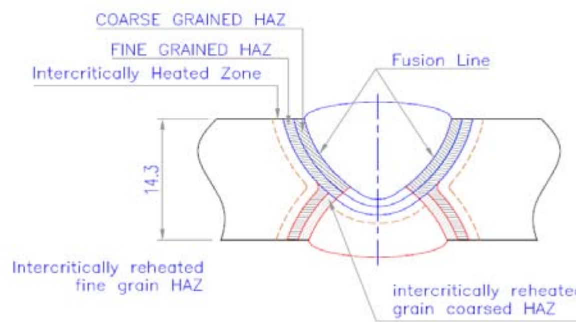


Figure 4 : HAZ of Double Submerged Arc Weld

III. Results and Discussion

a) Evaluation of Heat Affected Zone (HAZ)

The test coupon welded with different heat input level as shown in the table # 03, the HAZ of each test coupon is shown in figure # 04 was evaluated for non destructive examination (Visual Examination, X-ray examination and manual ultrasonic examination) and destructive examination (charpy V-notch test. Fracture toughness 'δ' (CTOD), Vickers macro hardness (HV_{10}) testing and light microscopy.

b) Visual Examination

All the samples welded at different heat input have been visually inspected for any visual defects as per AWS specification AWS – B1.11 (Guide for visual examination of welds) and API-5L. All the welded samples has no defect such as undercut and under fill is observed except the test coupon # L-1, H-2 and H-3, having very high convexity weld bead, which is beyond the acceptance level of the line pipe standards/ specifications.

c) Manual Ultrasonic Examination

The test coupons welded at different heat input have been scanned by manual ultrasonic as per ASME Section-V and API-5L. The test coupon # L-1 was having indication along the entire length and test coupons # H-2 and H-3 were having two indications each. Rest of coupons was having no significant indications.

d) X-rays Examination

The test coupons welded at different heat input have been exposed to the X-rays as per ASME Section-V and API-5L. The test coupon # L-1 was having lack of penetration (LOP) along the entire length and test coupons # H-2 and H-3 were having slag inclusions. Rest of coupons was having no significant defect as per API-5L. Hence the test coupon L-1 was discarded from further investigation in the present study.

e) Charpy V-Notch Toughness (CVN)

The sample for CVN drawn for each test coupon from the HAZ and prepared with notch at the CGHAZ is shown in the figure # 05. The results of the each Heat Input Transition temperature CVN values are shown in the figure # 06.

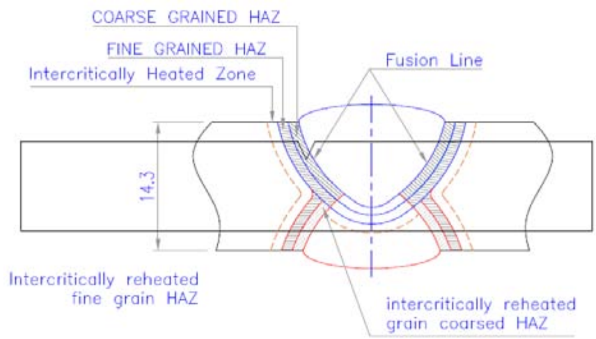


Figure 5 : Charpy V-Notch Located in CGHAZ

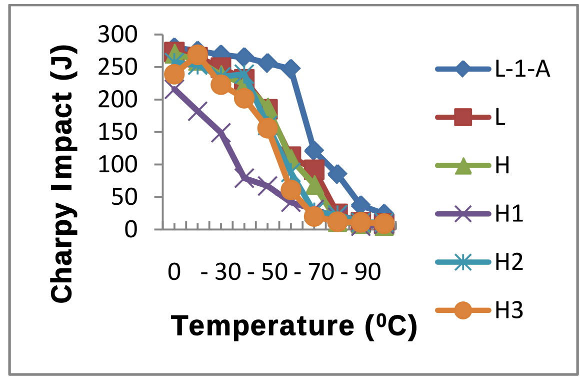


Figure 6 : Charpy V-Notch Toughness Values in Joules for HAZ

f) Fracture Toughness 'δ' (CTOD)

The sample drawn for Fracture Toughness test δ (CTOD) of HAZ for all the weld test coupon for HAZ has been prepared with notch at CGHAZ as shown in figure # 07. The samples prepared have the CT type configuration. The results of the 'δ' (CTOD) for HAZ are shown in the figure # 08.

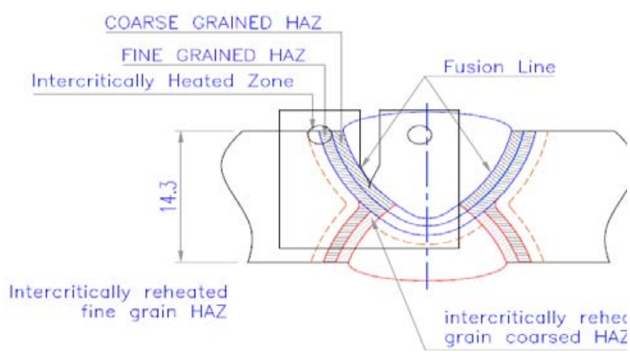


Figure 7 : CTOD Tip Located in CGHAZ

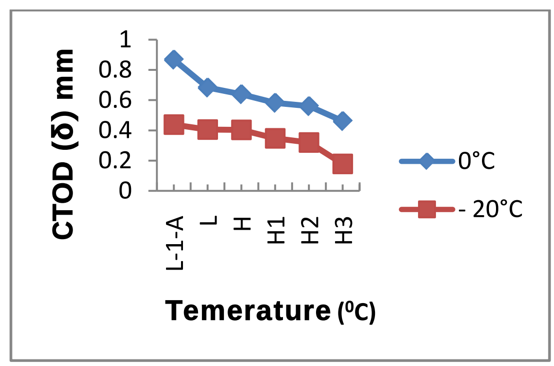


Figure 8 : CTOD (δ) Values-HAZ of the test coupons

g) Macro Hardness of HAZ Test Coupons

The Vickers's hardness testing in the HAZ for all test coupons has been performed on the samples drawn from the welded test coupons along the cross section perpendicular to the weld. The hardness of the HAZ has been taken on the location shown in figure # 09 and results are shown in the figure # 10.

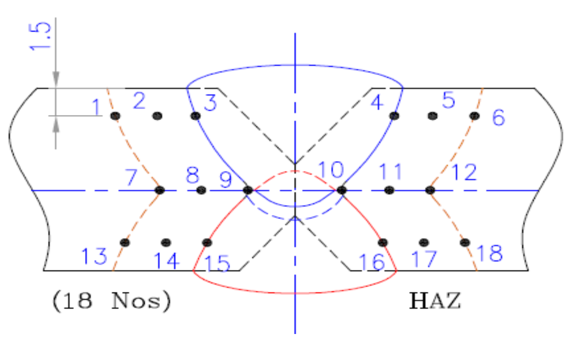


Figure 09 : Spots of Indentation in the HAZ

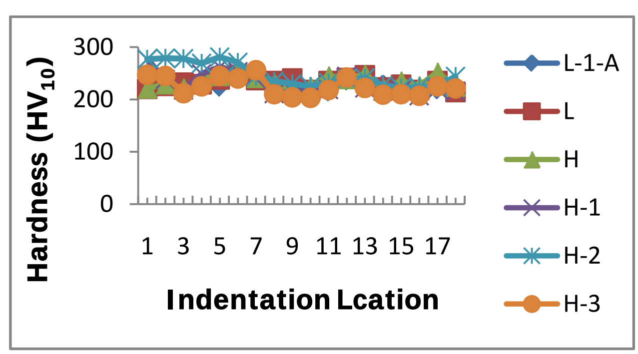
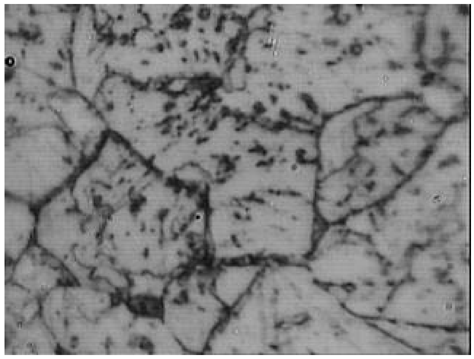
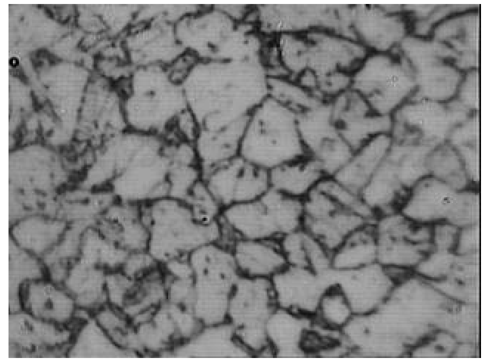


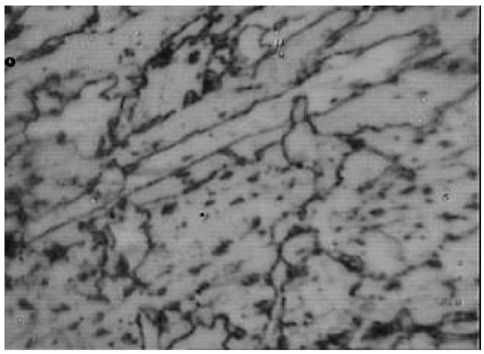
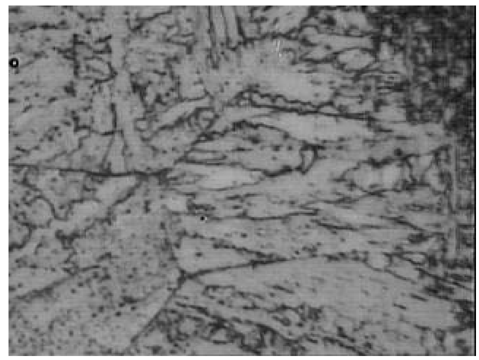
Figure 10 : HAZ Hardness (HV_{10}) of the Test Coupon

h) Microstructural Evaluation

The light microscopy on the welded plates for HAZ evaluation has been performed with a 2% nital solution as an enchant for grain. HAZ micrographs (i.e. L-1-A, L, H, H1, H2, H3) are shown in Figures # 11-16 respectively.

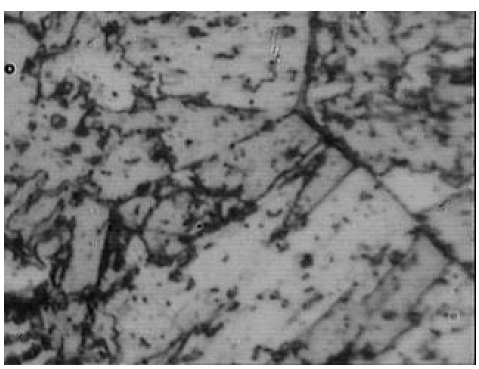
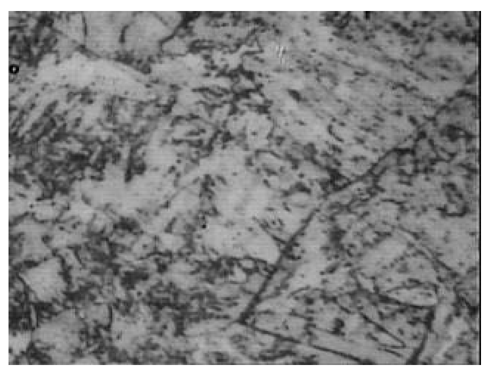



CGHAZ (Fussion Line) (1200X) CGHAZ (1200X)

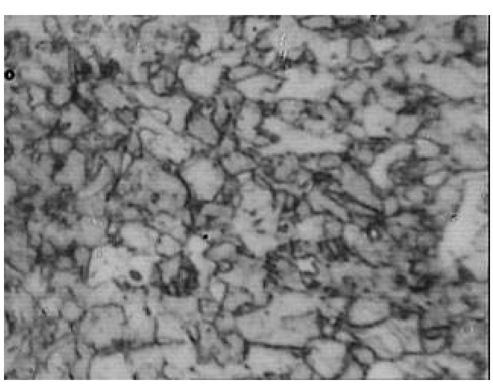
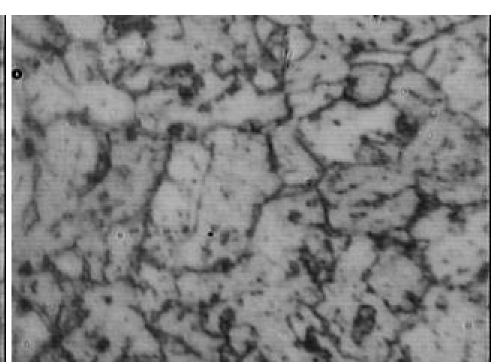



FGHAZ (1200X) FGHAZ (1200X)

Figure 11 : Micrographs shows bainitic type ferrite and lath type ferrite along with coarsed precipitates in the ferrite matrix of HAZ Test Coupon of 'L-1-A' HAZ

CGHAZ (Fussion Line) (1200X) CGHAZ 1200X)

FGHAZ (1200X) FGHAZ (1200X)

Figure 12 : Micrographs shows non polygonal type ferrite with coarsed precipitates in the ferritic matrix of HAZ Test Coupon of 'L' HAZ along with Panoramic View

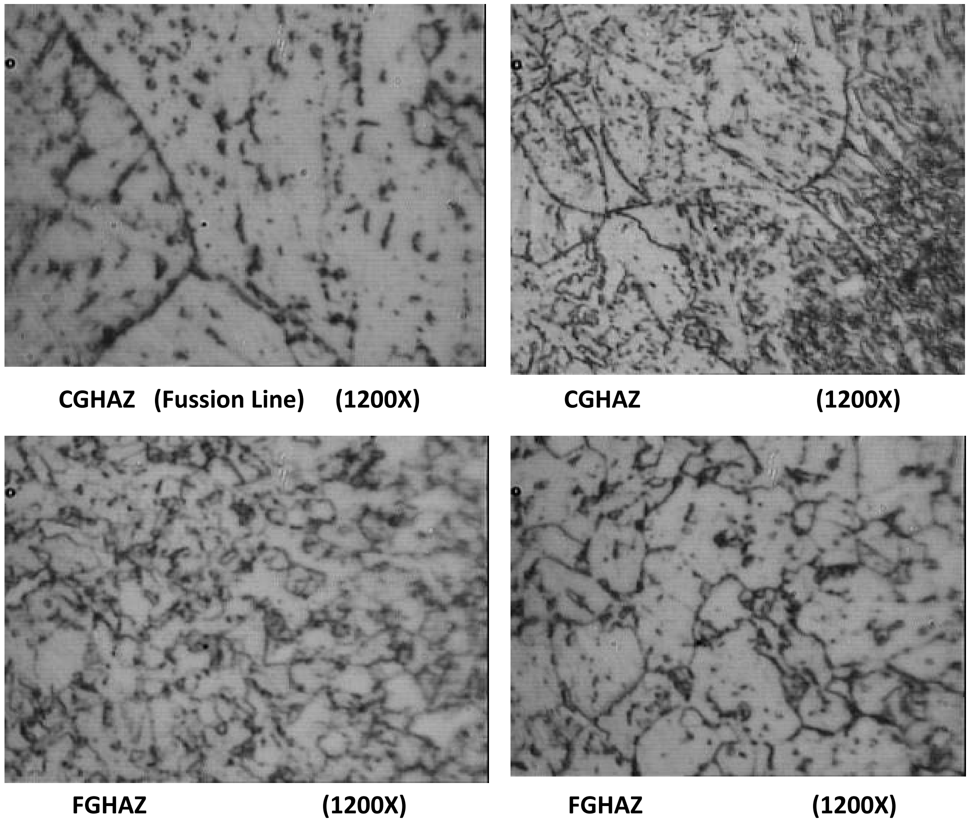


Figure 13 : Micrographs shows non polygonal type ferrite with coarsed precipitates in the ferritic matrix of HAZ Test Coupon of 'H' HAZ

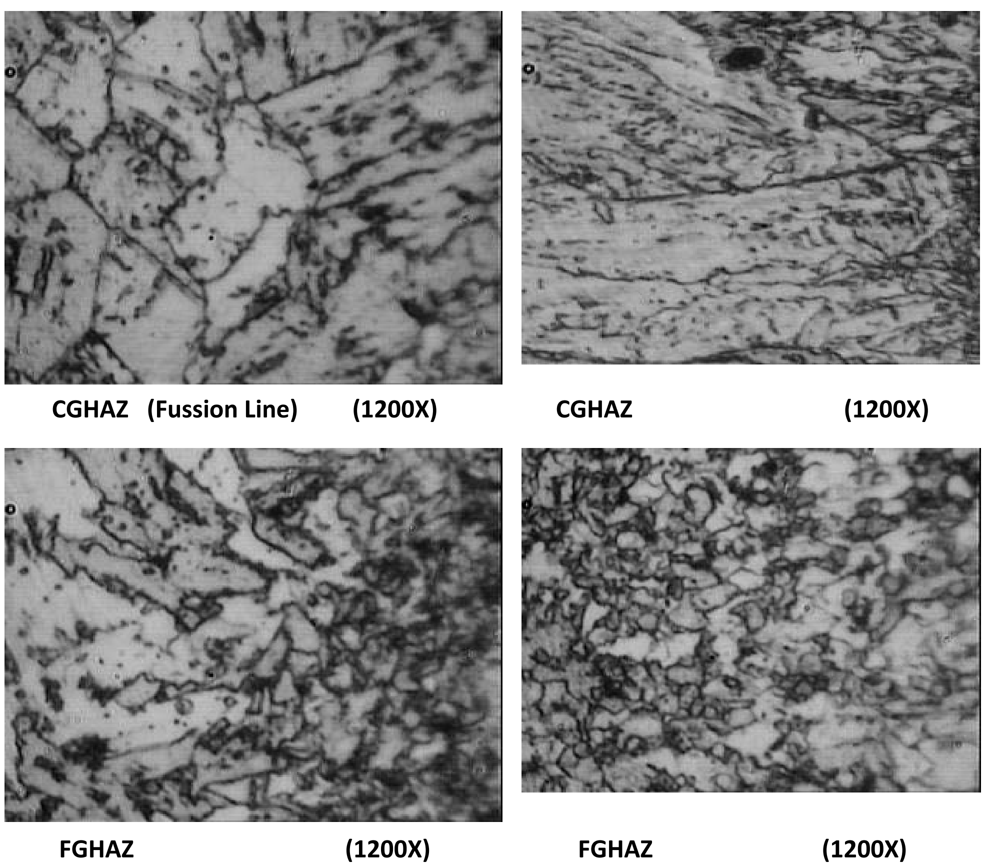
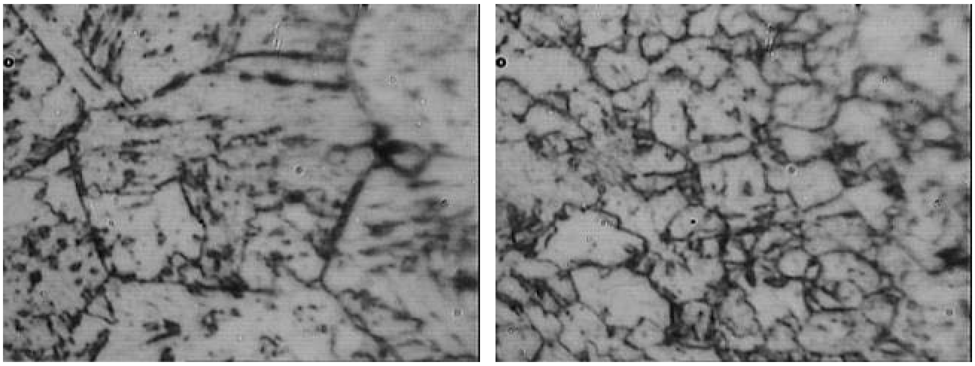
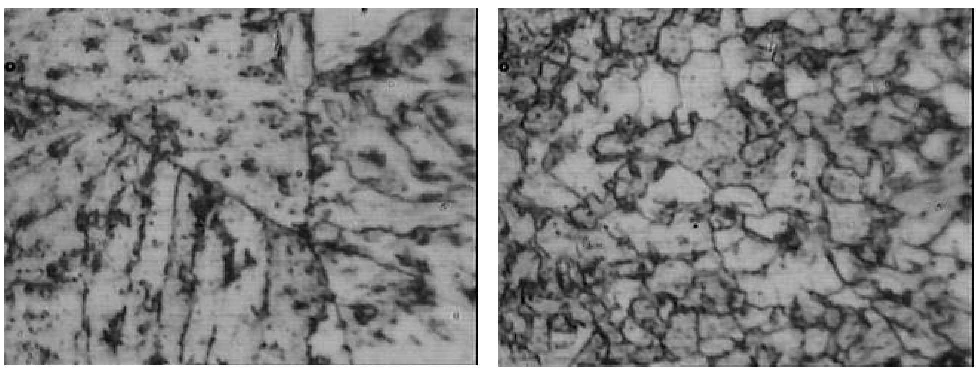


Figure 14 : Micrographs shows lath type ferrite with coarsed precipitates in the ferritic matrix of HAZ Test Coupon of 'H-1' HAZ



CGHAZ (Fussion Line) (1200X) FGHAZ (1200X)

Figure 15 : Micrographs shows granular type ferrite with carbides and coarsed precipitates in the ferritic matrix of HAZ Test Coupon of 'H-2' HAZ



CGHAZ (Fussion Line) (1200X) FGHAZ (1200X)

Figure 16 : Micrographs shows non polygonal type ferrite with coarsed precipitates in the ferritic matrix of HAZ Test Coupon of 'H3' HAZ

For optimization of HAZ in API-5L, X-120M TMCP and accelerated cooled steel plate, seven heat input level in increasing order have been studied for best candidate heat input level to have required level of toughness or the required resistance of ductile fracture propagation in TMCP and ACC steel plate material. The experiment is designed to verify the toughness for all level of heat input as shown in the figure # 03. All the level of heat input test coupons are examined visually and no significant defect such as undercut and under fill was observed. Test coupons # L-1, H-2 and H-3, convexity is found very high in the weld bead, which is beyond the acceptance level of the line pipe specifications API-5L. In X-rays examination and ultrasonic examination there was lack of penetration along the entire length of the test coupon in L-1 and has been discarded from further investigation in the present study. In rest of the test coupons, no significant non-conformity was observed. It is found that dendrites are epitaxially grown from the base metal (fusion boundary between base and weld) and terminates in the center of the weld competitively without any center line segregation. None of the sample has the defect like lack of fusion, lack of penetration and crack like defects in the HAZ and weld except L-1. As the heat input increases the cross penetration also increases. In charpy V-notch toughness the CVN values are excellent down to the -40 ^{0}C and starts decreasing suddenly after -40 ^{0}C (i.e. at -60 ^{0}C) except the one heat input level 'L-1-A' which show the excellent CVN values at -60 ^{0}C as shown in figure # 06. The CVN values (toughness) decreases suddenly to -80 ^{0}C i.e. behavior is transiting from ductile to brittle in 'L-1-A'. The fracture toughness test has been performed for all level of heat input test coupons. The heat input level 'L-1-A' found to have the highest crack tip opening displacement (CTOD) values at -20 ^{0}C among all the test coupons of heat input levels. The results of Vicker's macro hardness test showing the general trend of increase in hardness but confusing. The Vicker's hardness measurement is on macro scale and might not able to pin point hard and soft structures. In light microscopy the microstructure at HAZ shows good fusion between parent metal and weld without any micro-defects. Immediate after fusion line, coarse grain HAZ was seen, microstructure at coarse-grained HAZ shows mixture of lower transformation products with carbides. At fine-grained HAZ microstructure comprises of uniform grains of lower transformation products with carbides. The only difference is the size of phases (grains) and percentage of carbide, martensite and ferrite contents. As the level of heat input increases the grain grows proportionally and the percentage of the carbide and martensite is increasing. The test coupon # L-1-A Micrographs shows Bainitic type ferrite and lath type ferrite along with coarsed precipitates in the ferrite matrix of HAZ. As the heat input increases the Bainitic type ferrite and lath type ferrite starts decreasing i.e. more coarsed type structure. The above observation is also supported by data of mechanical testing namely CVN and CTOD.

The result of various tests shows the trend of different properties the heat input level corresponding to the test coupon number 'L-1-A' showing the best results for toughness as the target values of heat affected zone (HAZ). From the above study, it was found that the heat input level named "L-1-A" produce the minimum HAZ and highest toughness level and appropriate hardness.

References Références Referencias

1. Nakanishi M, Hashimoto T, Komizo Y, Akasaka M, 1986. Weldability of Low C-Nb-Ti-B Steel for Line Pipe – Transactions of the Iron and Steel Institute of Japan Vol. 26 No. 5.
2. Yamamoto Kohichi, Hasegawa Toshiei, Takamura Jin-Ichi, 1996. Effect of Boron on Intra-Granular Ferrite Formation in Ti-Oxide Bearing Steels. - ISIJ International, Vol. 36, No. 1.
3. Graf M K, Niederhoff K, 1990. Toughness Behaviour of the Heat-Affected Zone (HAZ) in Double Submerged-Arc Welded Large Diameter pipe- Pipeline Technology Conference Proceedings, Belgium.
4. Graf M, Niederhoff K, 2000. Properties of HAZ (Heat Affected Zone) in Two Pass Submerged - arc Welded Large - Diameter Pipe. (Means of Influencing, Specified & Necessary Tests Accompanying Pipe Production) - Pipeline Technology Proceedings, 3rd International Conference Belgium.
5. Li Y, Crowther N, Green M J W, Mitchell P S, Baker T N, 2001. The Effect of Vanadium and Niobium on the Properties and Microstructure of the Intercritically Reheated Coarse Grained Heat Affected Zone in Low Carbon Microalloyed Steels. - ISIJ International, Vol. 41 No. 1.
6. Bersch B, Dortmund, 1976. Influence of Heat Input on the HAZ (Heat Affected Zone) Properties of Line Pipe Steels – Proceedings of International Conference, Welding of HSLA (Microalloyed) Structural Steels, Rome Italy.
7. Itakura N, Kawabata F, Amano K, Yamaura T, Aoki M, Ihara K, 1999. X-80 UOE Line Pipe with Excellent Heat Affected Zone Toughness of Longitudinal Welds – ASME International.
8. Minami F, 1996. The Local Approach to Fracture Strength Evaluation OF Welded Joints- Transactions of JWRI, Vol. 25, No. 2.
9. Andreas Liessem, Marion Erdelen-Peppler, 2004. A Critical View on the Significance of HAZ Toughness Testing. – International conference IPC, Calgary, Alberta, Canada.
10. Woo-Sik Kim, Jong-Hyun Baek, Dongil Kwon, 2004. Failure Assessment Diagram for Assessing Cracks in the Weldment Heat- Affected- Zone of a Natural Gas Pipeline. - Pipeline Technology Proceedings, Conference, Ostend, Belgium.

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

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

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

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

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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

Procedures (Methods and Materials):

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

Results:

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

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

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

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

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

Figures and tables

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

Discussion:

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

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

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

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

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