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Simulation Investigation of Effect of Bio- Lubricant Between Tribological Systems of Piston Ring

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Abstract: *In an Engineering situation, a particular machine is selected on the basis of its reliability and life span. The life span and reliability are in turn governed by the frictional wear characteristics of individual component of machine. The life of any machine is determined by the life of its most sensitive part that is susceptible to wear. In Tribological system "piston -ring-liner" observed 40-50% of mechanical frictional losses. To reduce such losses Lubricants perform as anti-friction media. They maintain reliable machine functions, provide smooth operations, and lower the risks of frequent failures. To manufacture lubricant important source is Crude oil. But in today's scenario, crude oil increasing prices as well as depletion of crude oil reserves in the world, and global concerning protecting the environment from pollution have renewed interesting developing and using environment-friendly lubricants derived from alternative sources. A bio lubricant is renewable lubricants that is non-hazardous, biodegradable and emits approximately zero greenhouse gas. The objective is to presents the potential of a bio lubricant based on Jatropha oil as an alternative lubricant. The mechanical properties as well as advantages and disadvantages of the different piston ring material are discussed in the first section. The second part describes the potential of Jatropha oil-based bio lubricants as alternative lubricants. The final part describes the simulation effect of bio-lubricants on piston ring liner system.*

Keywords: Design Methodology, Piston ring analysis, FEA simulation, Results, Conclusion.

I. Introduction

In mechanical systems, the frictional loss is one of many factors in energy consumption. To reduce friction and wear, oil lubricant have been studied to be used as lubricant additives that have promising effects on friction and wear reduction in automotive, mining, and other industrial applications. Oil lubricant of various compositions and sizes have demonstrated certain degrees of friction modifying and anti-wear effects. We recently reported that in the boundary lubrication region, the addition of oil lubricant can reduce the friction coefficient up to 70%, and wear use as high as 75%. Such lubricants consisting of a base oil and dispersed Jatropha oil lubricant emerged as a new class of lubricants, the bottleneck for further development, however, is the aggregation of Jatropha oil lubricant in a base oil. A stable suspension of Jatropha oil lubricant is essential for a usable lubricant. The aggregation of Jatropha oil lubricant limits their ability to lubricate the contact area

The MoS_2 Jatropha oil lubricant can reduce 75% of friction when mixed with lubricant oil. Such reduction was achieved by ultrasonic dispersion immediately before testing, the aggregation of Jatropha oil lubricant could increase friction due to the reduced "shear" effects. Understanding the principles of dispersion is essential to developing novel lubricants. This review is divided into two parts. The first part reviews the methods used to disperse Jatropha oil lubricant in lubricant oil.

Nanotechnology is regarded as the most revolutionary technology of the 21st century. It can be used in many fields and usher's material science into a new era. After investigations on the tribological properties of lubricants with different Jatropha oil lubricant added in it. A large number of papers have reported that the addition of Jatropha oil lubricant to lubricant is effective in reducing wear and friction. Jatropha oil lubricant is found better among all added into the oil. Among those that were added into oils, Jatropha oil lubricant have received much attention and exhibited

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excellent applications for their good friction reduction and wear resistance properties. The reduction of wear depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding speed, surface roughness, lubrication, and vibration. Chemical additives in lubrication fluid controls anti- wear properties, load-carrying capacities, and friction under the specified boundary lubrication conditions. Since stabilization of Jatropha oil lubricant has been resolved by the

Addition of a dispersing agent or the use of a surface modification preparation technique, inorganic Jatropha oil lubricant have received considerable attention in the lubrication field. Jatropha oil lubricant have received considerable attention because of their special physical and chemical properties. The preparation of organic–inorganic complex Jatropha oil lubricant was causing more interest in science and industry. Experimental done on number of Jatropha oil lubricant for lubrication oil additive. However, few of them were used and studied as water base lubrication additives. With the research and development of nanomaterial, many scientific researchers added Jatropha oil lubricant into lubricating oils to improve extreme pressure, anti-wear and friction reducing properties, and the efficiency and service life of machinery were improved and prolonged. The application of advanced nanomaterial has played an active role in improving and reforming traditional lubrication technology. Y.Y. Wu et al. examined the tribological properties of two lubricating oils, API-SF engine oil and Base oil, with mos2 and Nano-Diamond Jatropha oil lubricant used as additives.

The experimental results show that Jatropha oil lubricant, especially base oil added to standard oils exhibit good friction-reduction and anti-wear properties. The addition of base oil Jatropha oil lubricant in the API-SF engine oil and the Base oil decreased the friction coefficient by 16.4 and 4.8%, respectively, and reduced the worn scar depth by 16.7 and 72.8%, respectively, as compared to the standard oils without Jatropha oil lubricant. In addition, investigations were performed using TEM, OM, SEM, and EDX to interpret the possible mechanisms of anti-friction and anti-wear with Jatropha oil lubricant.

The tribological properties are investigated for metal oxides, rare earth compounds, metals, metal borates and metal sulphide used as lubricate additives. The anti-wear mechanism of a metal oxide Nano particulate additive was tribo-sintering of Jatropha oil lubricant on the wear surfaces. That process reduced the metal-to- metal contact and created a load bearing film. The mechanisms change due to colloidal effect, rolling effect, protective film, and third body on the friction-reduction and anti- wear of Jatropha oil lubricant in lubricants as the result of. The results of these investigations show that Jatropha oil lubricant deposit on the rubbing surface and improve the tribological properties of the base oil, displaying good friction and wear reduction characteristics. The synthesis is done on oil is done in our study which gives very good dispensability in organic solvents. In order to estimate the ranges of applications of Jatropha oil lubricant, it was necessary to investigate its tribological behaviour under increasingly severe contact conditions.

II. Necessity of Work

The principal motivation for formulating new additives using Jatropha oil lubricant as a promising solution for improving the Tribological behavior is that Jatropha oil lubricant have the potential to offer significant tribological benefits of both solid and liquid lubrication and extend the life of the mechanical components. The decline of the friction coefficient between the rings/liner assemblies plays a critical role in improving engine performance and fuel efficiency. Bi lubricant additives play a significant role in the formation of a tribofilm layer on the worn surfaces via physical or chemical absorbed mechanism to enhance protection of the worn surfaces and create a rolling effect between sliding surfaces

III. Design Methodology

A. Piston Ring and Its Properties

Piston ring is one of the most important parts of the Diesel/Petrol engines. It is an open-ended ring that fits into a groove on the outer diameter of a piston in a reciprocating engine such as an internal combustion engine or steam engine. The principal function of the piston rings is to form a seal between the combustion chamber and the crankcase of the engine. The goal is to prevent combustion gases from passing into the crankcase and oil from passing into the combustion chamber the three main functions of piston rings in reciprocating engines are:

1. Sealing the combustion/expansion chamber.
2. Supporting heat transfer from the piston to the cylinder wall.
3. Regulating engine oil consumption

B. Ring Material

The materials used to make Piston Rings are one of the most critical factors in its Performance. Thus we have selected Cast Iron bronze and nylon material to make piston Ring.

1) Cast Iron: Cast iron is an iron carbon alloys with a carbon content great then 2%.As the most common ring material, cast iron has a low – friction, wear resistance, characteristics used in a broad range of high temperature and high speed engine application. It produces Consistence presence against the bore. Cast iron retains the integrity of its original shape under heat, Load and other dynamic forces.

2) Polyamide (Nylon6): Polyamide exhibit property of low friction and no lubrication property. Nylon is quiet in operation, resists abrasion, wears at low rate, and easily molded cast, or machined to close tolerance. Nylon is very inexpensive. Nylon is a suitable replacement for a cast iron ring in some hydraulic cylindrical application. This material produces a positive seal and able to absorbed particulates in the hydraulic fluids. The Table 1 summarizes the values that has been used for the simulation analysis in ANSYS for different piston ring

Table No.1: Standard values of Cat Iron and Polymide

Parameters	Cast Iron	Polyamide(Nylon 6)
Density	7200 kg/m3	1150kg/m3
Young's Modulus	120GPa	2.5GPa
Poisson's Ratio	0.211	0.39
Bulk Modulus	69.20GPa	3.788GPa
Shear Modulus	49.55GPa	0.8993GPa
Tensile Yield Strength		0.231GPa

C. Lubricant and its Properties

The main purposes of lubrication are

1. To reduce wear and heat loss that result from the contact of surfaces in motion, that is, to reduce the coefficient of friction between two contacting surfaces;
2. To prevent rust and reduce oxidation;
3. To act as an insulator in transformer applications;
4. To act as a seal against dirt, dust, and water. A lubricant is a substance that reduces friction and wear by providing protective film between two moving surfaces .Lubrication occurs when two surfaces are separated by a lubricant film. Lubricants are available in liquid, solid, and gaseous forms. A good lubricant exhibits the following characteristics: high VI, high boiling point, thermal stability, low freezing point, corrosion prevention capability, and high resistance to oxidation. Here three different kinds of bio-lubricants are being used to reduce the frictional loss of piston ring liner assembly.

Table 2 describes the fuel property in which cylinder liner in being tested.

Properties	Jatropha	Unit
Density@15°C	.918	gm/cc
Density@40°C	35.4	cm^2/s
Flash Point	186	°C
Pour Point	-6	°C
Water Content	-5	%
Ash Content	0.7	%

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Other forces: Solvation, structural and hydration forces

Apart from vdW forces and EDL forces, some other forces, i.e. solvation, structural or hydration forces, come into play when two surfaces or particles approach very close (separation less than a few nanometers) in the liquid. These forces can be monotonically repulsive, monotonically attractive or oscillatory and they can be much stronger than either the vdW forces or EDL forces at small separations. Solvation, structural or hydration forces (in water) arise between two particles or surfaces if the solvent or water molecules become ordered by the surfaces. When the ordering occurs, an exponentially decaying oscillatory force with a periodicity equal to the size of the confined liquid molecules, micelles or nanoparticles appears. Solvation forces depend not only on the properties of the liquid medium but also on the surface physicochemical properties, such as hydrophilicity, roughness, crystalline state, homogeneity, rigidity and surface micro-texture.

D. Experimental (The Cygnus friction and wear test machine configuration)

The Cygnus friction and wear test machine is used to evaluate the friction and wear characteristics of lubrication in this experiment. The Cygnus friction and wear test machine is designed to study friction and wear in dry or lubricated sliding over a wide range of speed, load and temperature. It is a tri-pin-on-disc machine which is conducted by using three pins on a disc as testing specimens. Specifications of the Cygnus friction and test machine is mentioned in table 1.

Table No. 3

Parameter	Value
Test disc diameter	110.0 mm
Test pin diameter	6.0 mm
Test disc speed range	25 to 3000 rpm
Motor	Tuscan; (2000rpm, 1.5 kW)
Load range	0 KG to 30 KG
Electrical input	220 Volt AC 50 Hz

The Cygnus friction and wear test machine is connected with a computer having embedded a block diagram based application construction program Visual Designer. Visual Designer allows developing custom data acquisition, analysis, display in the form of graphical chart or numerical meter .The programs can be controlled simply by drawing a program's data structure in the form of a block diagram. The block diagram can also contain textual comments, allowing the process being monitored or controlled to be documented. The block diagram can also contain textual comments, allowing the process being monitored or controlled to be documented. The block diagram of this experiment is shown in Fig. 2. During this test, the load of disc is 30 N and velocity of disc is 2000 rpm which are fixed for each pin.

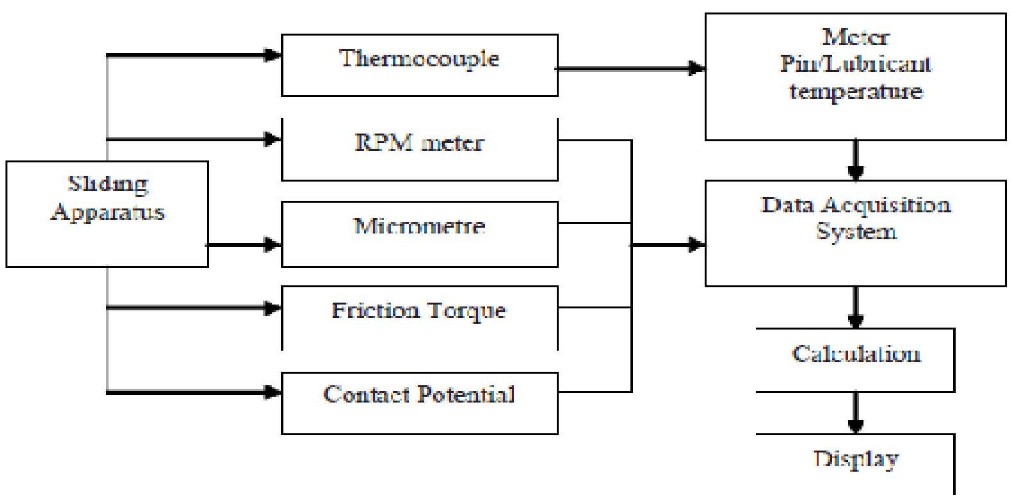

Figure 2: Block Diagrams of Friction and Wear Testing

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E. Preparation of the Specimen

The specimens were made of cast iron material. Nylon 6 is used to build three pin and cast iron is used for disc. The pins are made in workshop by using lathe and cutting machine. The dimensions and geometry of pins and disc are shown on Fig. 3. Prior to conduct the test, the surface of specimens was cleaned properly from dirt and debris. Alcohol was used to clean the surface of specimens. Jatropha is used as lubricant.

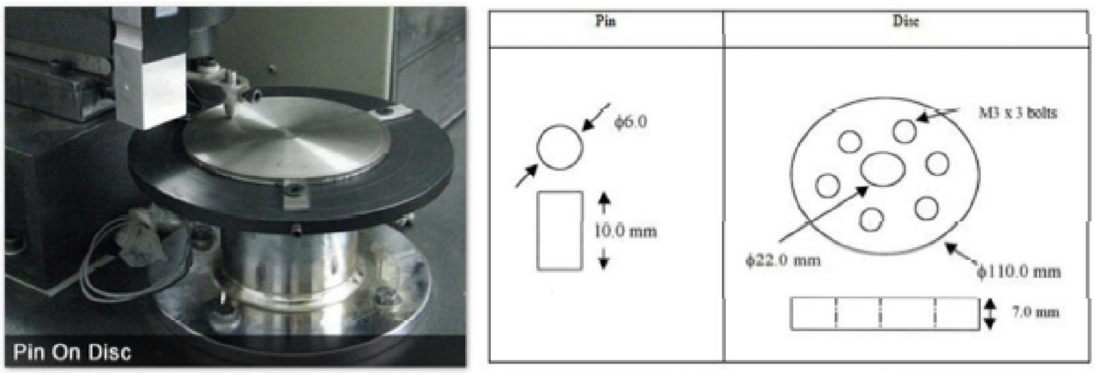


Figure 3: The dimensions and geometry of pins and disc specimens

F. Lubricant Analyser

Multi element analyzer (MOA) was used to analyses metallic wear particles in lubricant atomic emission spectroscopy (AES). AES provides quantitative and qualitative analysis of wear debris in lubricating oil. In the AES technique a rotating disc electrode brings a continuous sample into a gap between the disc and stationary rod electrode causing the individual atoms in the sample to give off light or radiant energy. Whereas, for viscosity Measurement the automatic Anton Par viscosity meter was used with standard ASTM D 445. The viscosity was measured for both 40□C and 100^{o}C controlled bath temperatures.

IV. Finite Element Analysis of Piston And Piston Ring

A, Finite Element Analysis

Finite element analysis (FEA) has become commonplace in recent years, and is now the basis of a multibillion dollar per year industry. Numerical solutions to even very complicated stress problems can now be obtained routinely using FEA, and the method is so important that even introductory treatments of Mechanics of Materials – such as these modules – should outline its principal features. In spite of the great power of FEA, the disadvantages of computer solutions must be kept in mind when using this and similar methods: they do not necessarily reveal how the stresses are influenced by important problem variables such as materials properties and geometrical features, and errors in input data can produce wildly incorrect results that may be overlooked by the analyst. Perhaps the most important function of theoretical modelling is that of sharpening the designer's intuition; users of finite element codes should plan their strategy toward this end, supplementing the computer simulation with as much closed-form and experimental analysis as possible.

Finite element codes are less complicated than many of the word processing and spread sheet packages found on modern microcomputers. Nevertheless, they are complex enough that most users do not find it effective to program their own code. A number of prewritten commercial codes are available, representing a broad price range and compatible with machines from microcomputers to supercomputers.

However, users with specialized needs should not necessarily shy away from code development, and may find the code sources available in such texts as that by Zienkiewicz2 to be a useful starting point. Most finite element software is written in FORTRAN, but some newer codes such as felt are in C or other more modern programming languages.

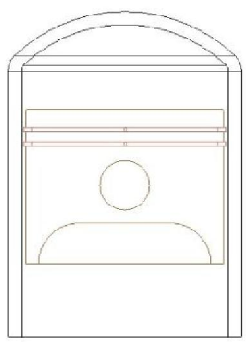
B. The Purpose of FEA

Analytical Solution

- Stress analysis for trusses, beams, and other simple structures are carried out based on dramatic simplification and idealization: – mass concentrated at the centre of gravity – beam simplified as a line segment (same cross-section)
- Design is based on the calculation results of the idealized structure & a large safety factor (1.5-3) given by experience.

a. Modified Piston Ring Assembly Design

A piston need to be designed in such a manner that it can withstand the damage caused by the extreme heat and pressure of combustion process, the gas forces and inertia forces. In addition, the piston should design in such a way that it rigid enough to prevent mechanical and thermal distortion and it should have sufficient bearing area to prevent under wear. The piston is designed based on both strength and thermal considerations. Preliminary dimensions of piston have been determined using the strength and thermal based design approach. Below Fig 4 (a) and (b) shows the design of two piston ring assembly. By using CATIA software piston ring, piston and cylinder is being designed. The boundary condition and specification for further analysis is length in X axis is 89.48mm,Length in Y-axis is 125mm and Length in Z axis is 89.48.volume of the model is 3.7282e+005mm3, Mass is 3.092 kg.



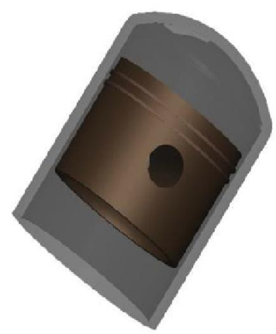


Figure 4: (a) Piston-ring-Liner assembly (b) Model Piston-Ring-Liner Assembly

b. Static Structural Analysis of Piston-Ring-Liner Assembly

Piston and Piston ring plays a very important role in an engine. Let us take an example to explain the Piston phenomenon i.e. working of piston inside an engine. During combustion process, Force gets transmitted to piston through the gudgeon pin. During combustion process piston also experience the shock. The piston is designed in such a manner that it stand and perform during the shock and withstand with the repeated cycles or transient loading, it should not get into fatigue failure. At the time of combustion process, the piston is subjected to distortion and the energy stored inside the piston serves as a determining factor to know the yield and failure conditions of a piston when subjected to static loading. Von misses yield criterion can be formulated in terms of the von misses stress or equivalent tensile stress, σv, a scalar stress value that can be computed from the stress tensor as shown in eq. 1. In this case, a material is said to start yielding when its von Misses stress reaches a critical value known as the yield strength, σy. As shown in eq – (1)

$$\sigma_v^2 = \frac{1}{2}\left[(\sigma_{11} - \sigma_{22})^2 + (\sigma_{22} - \sigma_{33})^2 + (\sigma_{11} - \sigma_{33})^2 + 6(\sigma_{23}^2 + \sigma_{31}^2 + \sigma_{12}^2)\right] \quad \ldots\ldots (1)$$

In this analysis, an attempt has been made to calculate the contact analysis with respect with the different piston ring assembly with specific values, and thereby simulating the working condition. Although this analysis isn't accurate, the obtained results are comparable to the actual stress and deformation values.

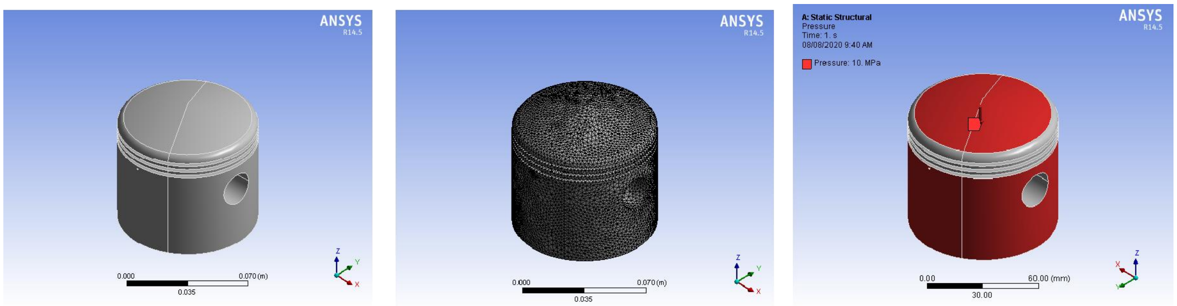


Figure 5: Piston-Ring-Liner Assembly (a) Fixed Support applied over piston (b) Pressure applied over piston. Firstly Piston is being fixed and then a specified pressure is being applied and then the further result is being calculated.

c. Contact Analysis of Piston Ring made by different material

Cast –Iron Piston ring

As we see below are the few result which obtain after the contact analysis between the cylinder liner and the piston ring. In this we are using Piston ring material as Bronze. As we know bronze is one of the best material available in the market for the piston ring. In the above figure von-misses stress and maximum shear stress is distributed on different area and these area indicated by different colours the maximum von-misses stress obtained as 11.89Mpa. The above von-misses stress obtained is coming under the design stress consideration so the above design is safe for the initial condition with pressure applied as 10MPa.As we keep on increasing the pressure we will get different von-misses stress for different Pressure. Also we will get shear stress, frictional stress and the sliding distance result.

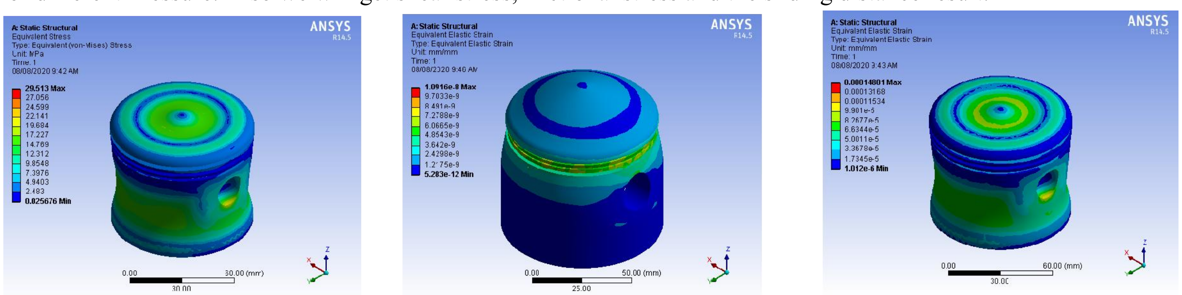


Figure 6: Piston-Ring Assembly (a) Equivalent Stresses (von-misses) (b) Result Maximum shear stress (c) frictional Stress Acting on Bronze Piston Ring (d) Sliding distance occur during the operation.

d. Cast –Iron Piston ring

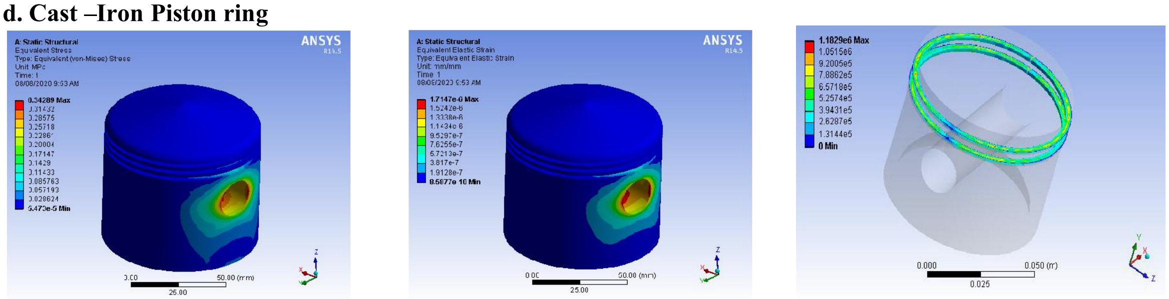


Figure 7: Piston-Ring Assembly (a) Equivalent Stresses (von-misses) (b) Result Maximum shear stress (c) frictional Stress Acting on Grey Cast Iron Piston Ring

As we see below are the few result which obtain after the contact analysis between the cylinder liner and the piston ring. In this we are using Piston ring material as grey cast iron. As we know grey cast iron is one of the oldest material available in the market for the piston ring. In the above figure von-misses stress and maximum shear stress is Distributed on different area and these area indicated by different colours the maximum von-misses stress obtained as

23.74Mpa. The above von-misses stress obtained is coming under the design stress consideration so the above design is safe for the initial condition with pressure applied as 10MPa.As we keep on increasing the pressure we will get different von-misses stress for different Pressure. Also we will get shear stress, frictional stress and the sliding distance result.

e. Polyamide Piston Ring

As we see below are the few result which obtain after the contact analysis between the cylinder liner and the piston ring. In this we are using Piston ring material as Polyamide (Nylon). As Polyamide (Nylone6) is the lightest, cheap piston ring available in the. In the above figure von-misses stress and maximum shear stress is distributed on different area and these area indicated by different colours The maximum von-misses stress obtained as 22.73Mpa. The below von-misses stress obtained is coming under the design stress consideration so the above design is safe for the initial condition with pressure applied as 10MPa.As we keep on increasing the pressure we will get different von-misses stress for different Pressure. Also we will get shear stress, frictional stress and the sliding distance result.

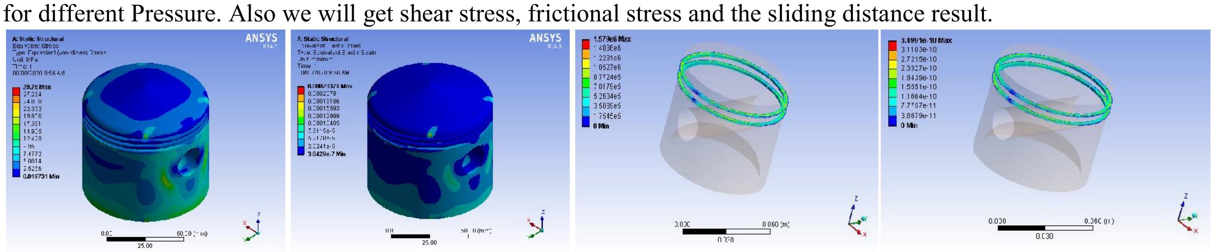


Figure 8: Piston-Ring Assembly (a) Equivalent Stresses (von-misses) (b) Result Maximum shear stress (c) frictional Stress Acting on polyamide Piston Ring (d) Sliding distance occur during the operation.

C. CFD Result for Polyamide (Nylone6) Piston Ring

The above analysis focuses only on the contact analysis between the Piston-ring-liner. But now in this first part an attempt of bio-oil used as lubricant on one of the piston ring instead of any synthetic lubricant because synthetic lubricant are not eco-friendly and economy wise very costly whereas if we go for bio-oil as one of the alternative Lubricant replacement of current lubricant it will help environment as well as it is economically cheap as compared to the other lubricant. The figure below shows three different Bio-Lubricant Sample over Nylon piston Ring.

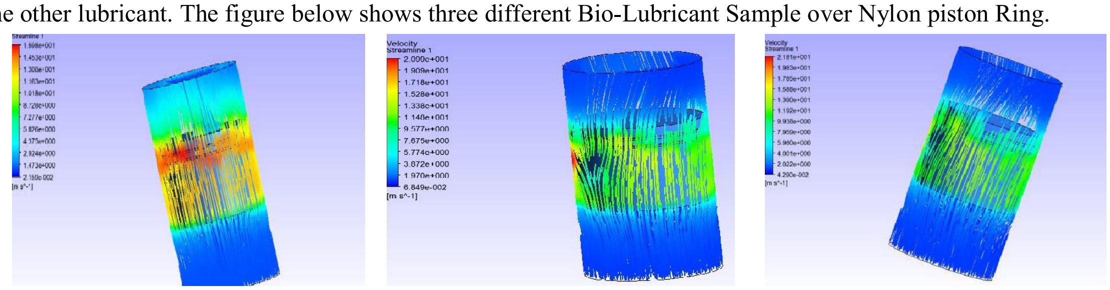


Figure 9: Fluent Analysis (a) Jatropha oil in Polyamide Piston ring Result (b) Jatropha oil in Polyamide Piston ring Result (c) Jatropha oil in Polyamide Piston ring Result

V. Results And Discussion

A. Cygnus friction and wear testing machine result analysis

a. Friction and wear characterization

Figure 10 Show the curves of pins wear as a function of sliding time for various Jatropha oil blended with lubricant SAE 40. The values of linear pin wear under 2000 rpm and 30 N loads for each pin vary from 0.02 to 0.05 mm. It was observed that the higher or maximum wear occurred in the beginning of the experiment for some of the test specimens. It is clear from graph that maximum wear occurred for JBL40 and for JBL10 wear is minimum. We also can observe

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from the graphs that except JBL40, for each JBL, pin wear decreases gradually and constantly. In the beginning of the test, we can see the wear rate was fast in the period of time that is called the running-in period.

During this section, the asperities of the sliding surface are cut off and the contact area of the sliding surface grows to an equilibrium size. The graphs of different JBL curve are difference and decrease almost steady throughout this state. It Means that different JBL give difference rate of wear to the specimens. Generally, the graphs may be divided into two groups which is the first group is higher value of pin wear and the second group is lower value of pins wear. It can be seen that have high value of wear while pure lubricant have low value of pin wear and their value are nearly with each other.

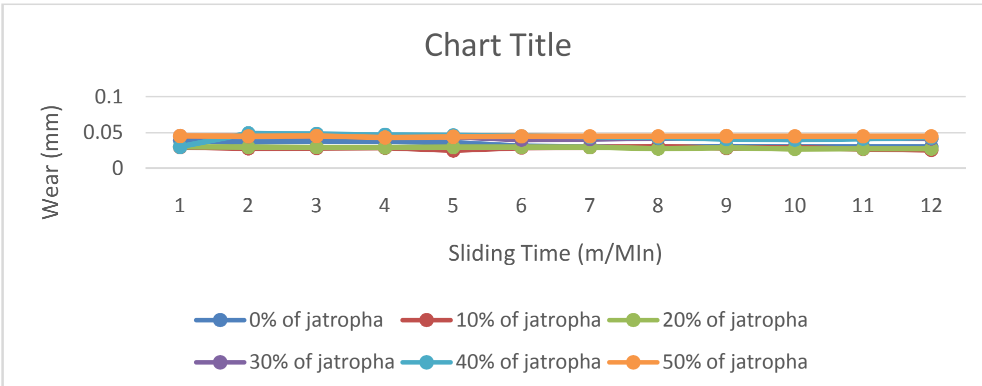

Figure 10: Linear pin wear as a function of sliding time for various bio-lubricants.

b. Coefficient of friction

Figure 11 shows the curves of friction coefficient plotted against the sliding time for various Jatropha oil based bio lubricants. The results in fig. 4 depict that the lubricant regimes that occurred during the experiment were the boundary lubrication where the value of friction coefficient (μ) for boundary lubricant is in the range of 0.001 to 0.2 except for JBL50. For 0% of Jatropha oil based bio-lubricants, it can be seen that the coefficient of friction is highest at the beginning and then it falls down rapidly up to minimum value compared to all samples. This phenomenon can be explained by attributing oxide layer on the aluminium surface.

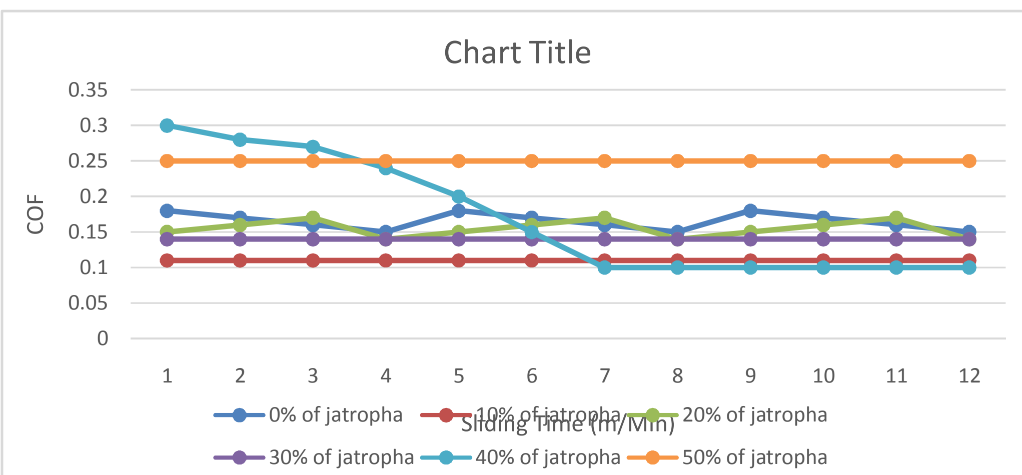

Figure 11: Coefficient of friction as a function of sliding time for various bio-lubricants.

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Lubricant additives reacts with oxide layer which causes to form a thick tribo-film on aluminium surface. At the initial stage, the shear stress of the tribo-film is high, thus, coefficient of friction is high at early time. With continuing the sliding, the aluminium pin is eroded and fresh metal surface is exposed. Since fresh metal surface has lower tendency to react with lubricant additives, the formation rate of tribo-film decreases than beginning. Therefore, shear stress becomes lower than beginning and Lower friction force is experienced. As a result C.O.F decreases with increasing the sliding time. The difference between the values of coefficient of friction is of Jatropha oil based bio-lubricants and pure lubricant (except for JBL50) is very small which ensures the apt of Jatropha oil based bio-lubricants as lubricant. The JBL10 and JBL30 shows the same C.O.F which is almost 0.15 and JBL50 shows almost same C.O.F throughout the whole operation time which is 0.235.

c. Lubricants temperature

Figure 12 shows the relation of the averages oil temperature of varies percentage of Jatropha oil based bio lubricants with the sliding time respectively. The range of temperature is about 20□C to 100□C. From the graphs, we can see that lubricant temperature increases with increasing sliding time for each percentage of Jatropha oil based bio-lubricants. The maximum temperature rise occurred for JBL40 and minimum temperature rise occurred for JBL 10.The progressive increasing in temperature period is known as the running-in period during the asperities of the sliding surface are progressively cut off. From the graphs, it can be noticed that the 30% and 40% of Jatropha oil based bio-lubricant are produce more heat than other while the 10% of Jatropha oil based bio-lubricant is generated lower heat.

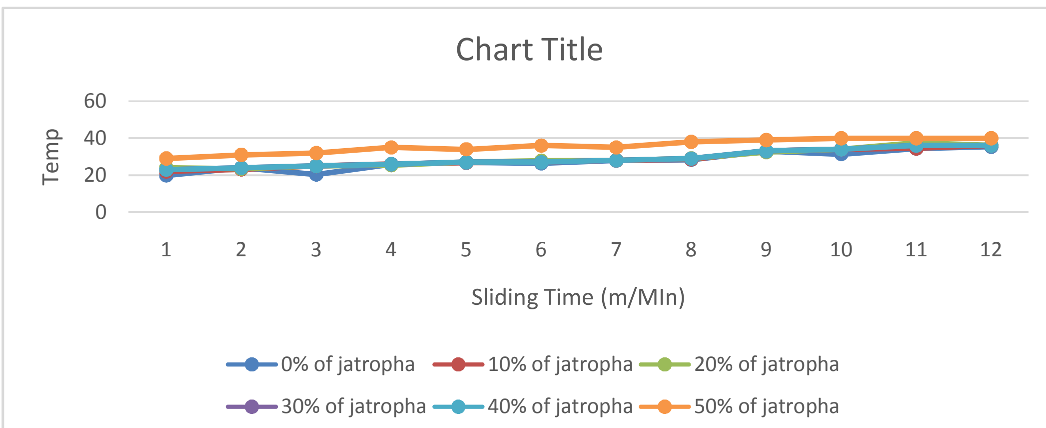

Figure 12: The bio-lubricant temperature as a function of sliding time.

d. Viscosity

Figure 13 show that the viscosity of Jatropha oil based bio-lubricants decreases exponentially for both 40°C and 100°C operation temperatures. Table 2 shows the viscosity grade requirement for the lubricants set by the International standard organization (ISO)while figure 6 shows the behavior of the viscosity of Jatropha oil based bio-lubricants at 40°C and 100°C operation temperatures. Comparing the table 2 and figure 6, it can be stated that at 40°C operation temperature 10%, 20% and 30% of Jatropha oil based bio-lubricants meet ISO VG100 requirement.

But 40% and 50% of Jatropha oil based bio-lubricants do not meet the requirements. However, it can also be noted that all bio-lubricants have higher viscosity than standard value.

Kinematic Viscosity	ISO VG32	ISO VG46	ISO VG68	ISO VG100
@400 C	>28.8	>41.4	>61.4	>90
@1000 C	>4.1	>4.1	>4.1	>4.1

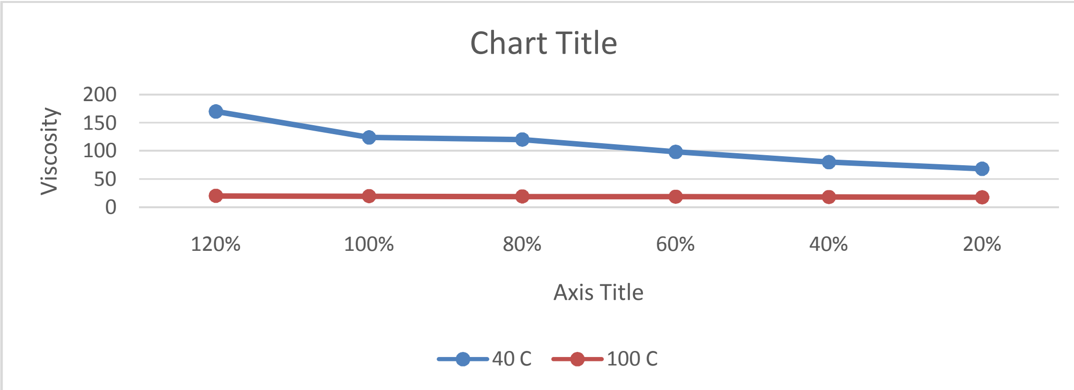

Figure 13: The viscosity of various percentages of Mineral Oil for temperature 40 ºC and 100 ºC operation.

V. CONCLUSION

In the above paper simulation analysis between the piston –ring-liners is being examined with the different type of piston ring. When the pressure is low we got the maximum stress for the all the piston ring under the allowable stress. So the design is safe. If the pressure is keep on the increasing. Von-misses stress will also be increase. In the above analysis we saw that when 10Mpa pressure is applied to the bronze ring von-misses stress obtained as 22.73Mpa. Similarly same pressure is applied to the grey cast iron and Polyamide (Nylone6) we got von-misses stress obtained as 23.74 and 22.758.As we see bronze, grey cast iron and Polyamide is having almost nearby von-misses stress but as we know by economy wise nylon6 is cheap and light in weight which give almost as much as result of grey cast iron and Bronze.

This is first part of contact analysis is done without any lubricant. If further lubrication is provided between the piston-ring-liner the performance of the piston ring will increase. If bio-lubricant is provided in between the piston and cylinder liner they work as a lubricant between two and also these lubricant are bio-friendly. With Polyamide Piston ring (Nylone6) different bio-oil i.e. Jatropha oil is applied and a CFD analysis is performed. The result is satisfactory and they can be used with certain modification as adding additive to change their viscosity and Viscosity index.Based on the above experiment, the following conclusions can be summarized:

1. The rate of wear for various percentage of Jatropha oil based bio-lubricant was different. However, the rate of wear for 10% and 20% of Jatropha oil based bio-lubricant are near to the pure lubricant
2. In this experiment, temperature of lubricating oil increases with sliding increasing time for each percentage of heat compared to the other samples.
3. In this experiment, it has been found that having lower wear resistance bio-lubricant contains higher coefficient of friction.
4. Since Jatropha oil based bio-lubricants have higher coefficient of friction compared to pure lubricant; it can be assumed that the fatty acid molecules available in Jatropha oil do not build a soap film on a surface test.
5. For each experiment, Iron, Aluminium and Chromium content increase because of wear occur in pin and disc.
6. In term of viscosity, except JBL40 and JBL50, all bio-lubricants meet the ISO VG100 requirements

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