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Design & Fabrication of Reciprocating Liner Test Machine & Wear Testing of Piston Rings using JatrophaOil

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ABSTRACT

Engines maintenance is the most important aspect for increasing engine life which in turn increases the life of vehicle. Engine performance directly depends upon the condition of its components like piston, cylinder liner,piston ring & also depends upon lubricating oil. In this project, main aim is the health monitoring of the cylinder liner and piston ring through the study of Bio lubricant Jatropha Oil used during testing on our own fabricated test rig.

In this project, firstly a test rig is fabricated which works on the four bar mechanism and then wear of piston ring will be tested by Bio lubricant Jatropha Oil with the help of microscopic analysis of the wear Debris & using Electronic weighing Scale (precision balances of 0.001g accuracy).

General Terms

Kinematic Viscosity: It is an Oil's resistance to flow & shear.

Viscosity Index: It is arbitrary measure for the change of viscosity with change in temperature.

Total Base Number: It is a measure of reserve alkalinity of a lubricant.It reflects the ability to neutralize the contaminants of combustion by-products & acidic materials.

Keyword

Wear Test, Piston rings, Bio Lubricant, Jatropha Oil, Mineral Oil, CATIA V5, Fabrication of Test rig.

1. INTRODUCTION

The current automobile sector is one of the most polluting factors in the greenhouse gas scenario with our research we are trying to find out suitable lubricant replacement which can decrease the harmful emissions from an automobile. Not only this, it will also help in increasing the age of an engine as it produces less acidic substances. 20 to 40 percent of engine frictional losses are attributable to the piston ring assembly.

By considering the benefits of Bio-Lubricant over the Mineral Oil,we are using Jatropha as bio lubricant and these are triglyceride esters derived from plants and animals.

Also, we are introducing 4-bar slider crank mechanism on which the engine works, so that we can get more accurate results.

2. CHARACTERISTICS

2.1 Lubricant Characteristics

Table 1: Lubricant Characteristics

Properties	Jatropha Oil	Mineral oil 20w/50
Density (kg/m^3)	154	90
Kinematic viscosity (cp) at 40 deg. C.	230	175
Total Base No.	3.9	10.5
Flash point deg. C	0.2	-30
Refractive Index	1.4689	1.4815
Viscosity Index	539	127
Ash content %	0.005	.134
Sulphated ash	0.038	1.000

2.2 Material Characteristics

Table 2: Material Characteristics

Sample	Material	Surface Treatment	Hardness (BHN)	Roughness
Ring	Cast Iron	Chrome coated	920	0.121
Liner	Grey Cast Iron	Honing	20.3	1.052

2.3 Assumptions

i) Consider only primary motion of Piston.

ii) Neglects the effects of combustion gas temperature.

3. DESIGN METHODOLOGY

3.1 Theoretical Framework

Research on advanced heat engine concepts, such as the low heat rejection engine, has shown the potential for increased thermal efficiency, reduced emissions, lighter weight, simpler design, and longer life compared to current diesel engine designs. These improvements are achieved through the reduction or removal of the cooling system, insulation of the combustion chamber components with ceramics, and converting increased exhaust energy to shaft output power with a recovery turbine. A major obstacle in the development of a functional advanced heat engine is overcoming the tribological problems resulting from high temperatures at the piston ring-cylinder liner interface, especially at top ring reversal (TRR).

As Jatropha oil has better lubricating characteristics as compared to mineral oil [mentioned in Table 1]. In addition, less cost,availability, Renewable & Biodegradable in nature & contains Less Sulphur which reacts with atmosphere at high temperature to form harmful substances.

3.2 Procedural Structure

Present, aim is to Design and Fabricate a Piston Liner Testing Machine which can be used as a replacement of engine for performing wear tests. The machine will be first designed on 3D modeling software (Catia V5).

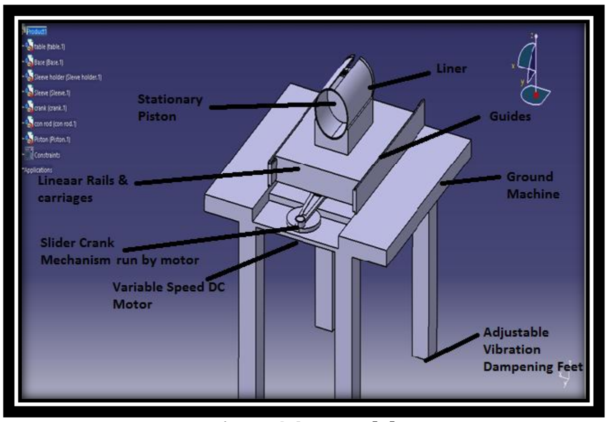

Fig 1: CAD Model

4. FABRICATED TEST RIG

This test rig is a simple representation of the motion between a piston ring & a cylinder liner. In this case, the piston ring is held stationary while the cylinder liner is reciprocated. This apparatus is used to determine the wear at the contact between a piston ring segment & cylinder liner segment.Such a simplified test neglects secondary motion as well as combustion gas temperature but allows for the investigation of several variables affecting piston & cylinder liner friction. Contact pressure, Lubricant viscosity, piston speed & surface finish can all be varied .Extensive testing with this apparatus has provided a better understanding of the fundamentals & aided in the development of our analytical models.

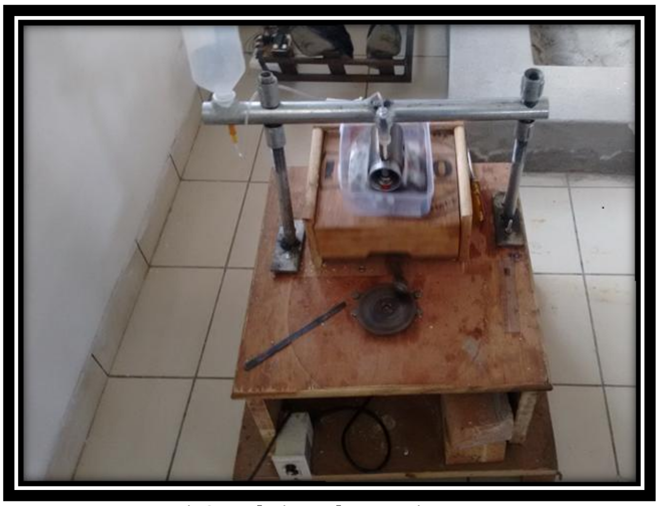

Fig2: Fabricated Test Rig

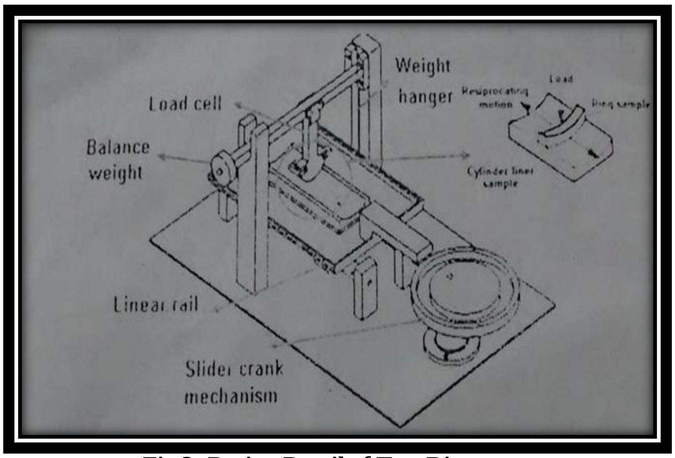

Fig 3: Design Detail of Test Rig

5. CALCULATIONS

We have run the apparatus for 2000 meters

Stroke Length of piston is 40 mm.

At 300 rpm,

Sliding velocity = 2*0.080*300/60 = 0.80m/se

Time required for piston to travel 2000 meter = 2000/0.80 = 41min 40sec

At 200 rpm,

Sliding velocity = 2*0.080*200/60 = .53m/sec

Time required = 2000/.53 =1hr 2min 53sec

At 100 rpm,

Sliding velocity = 2*0.080*100/60 = .26m/sec

Time required = 2000/.26 = 2hr 8min 12sec.

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Table 3: Calculations

S. No.	Load (N)	RPM	Sliding velocity (m/s)	Duration of Run	Lubricant in use
1.	10	300	0.80	41 min 40 sec	100% Jatropha oil
2.	10	200	0.53	1 hr 2 min 53 sec	100% Jatropha oil
3.	10	100	0.26	2 hr 8 min 12 sec	100% Jatropha oil
4.	10	300	0.80	41 min 40 sec	100% Mineral oil
5.	10	200	0.53	1 hr 2 min 53 sec	100% Mineral oil
6.	10	100	0.26	2 hr 8 min 12 sec	100% Mineral oil

6. OBSERVATIONS

6.1 Wear Measurements for Mineral Oil

Table 4: Readings before the experiment

Tested RPM	Oil Ring	Compression Ring 1	Compression Ring 2	Top Ring
300	1.9798	1.1106	1.1128	4.0612
200	1.9737	1.1061	1.0992	4.0566
100	1.9681	1.1003	1.0940	4.0518

*all the above readings of Wear in grams

Table 5: Readings after the experiment

Tested RPM	Oil Ring	Compression Ring 1	Compression Ring 2	Top Ring
300	1.9727	1.1061	1.0992	4.0566
200	1.9681	1.1003	1.0940	4.0418
100	1.9642	1.0951	1.0901	4.0453

*all the above readings of Wear in grams

6.2 Wear Measurements for Jatropha Oil

Table 6: Readings before the experiment

Tested RPM	Oil Ring	Compression Ring 1	Compression Ring 2	Top Ring
300	1.9752	1.1095	1.1050	4.0676
200	1.9681	1.0995	1.0973	4.0436
100	1.9646	1.0981	1.0961	4.0294

*all the above readings of Wear in grams

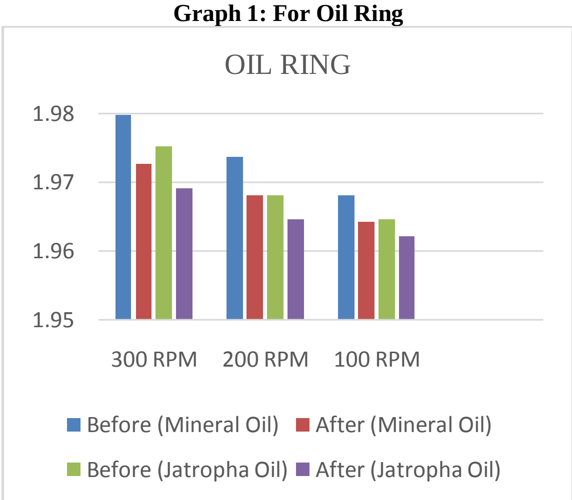
Table 7: Readings after the experiment

Tested RPM	Oil Ring	Compression Ring 1	Compression Ring 2	Top Ring
300	1.9691	1.1055	1.0973	4.0636
200	1.9646	1.0946	1.0961	4.0334
100	1.9621	1.0935	1.0929	4.0236

*all the above readings of Wear in grams

6.3 Graph Analysis

Graph 1: For Oil Ring



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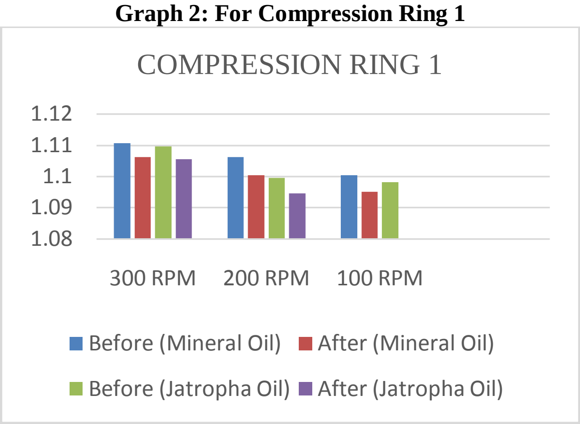
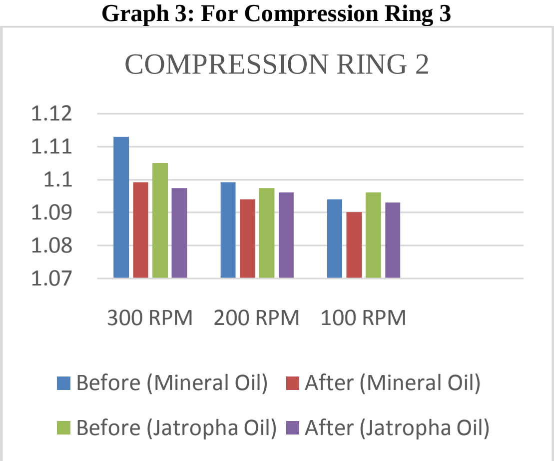
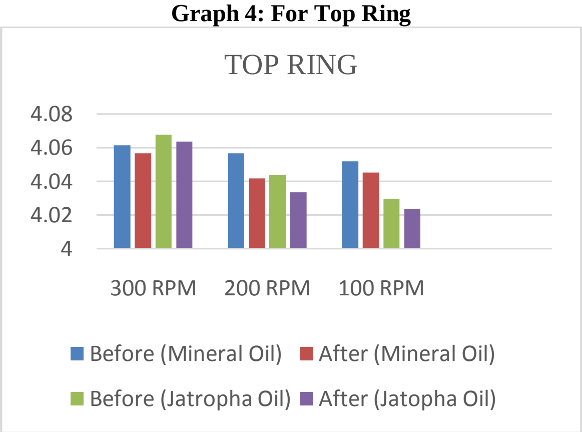
Graph 2: For Compression Ring 1



Graph 3: For Compression Ring 3



Graph 4: For Top Ring



From the above observations, we have seen that by using Jatropha oil, the wear for the piston rings is reduced to a significant value.

Take, Oil ring (running at 300 rpm), about 10% wear is reduced by using Jatropha oil as compared to mineral oil.

Take, Compression Ring 1 (running at 200rpm), about 15-20% wear is reduced by using Jatropha Oil as compared to mineral oil.

6.4 Microscopic Wear Analysis

It is important believe that the surface irregularities in conjunction with the type of lubricant play an important role tothe engine performance & life.

A Morphological feature of wear particles is an important quantitative aspect of wear particle image analysis. It is the best way to recognise the main cause of particle generation. Microscopic observation in fig. 5 shows rubbing wear particles those are platelets from the shear mixed layer which exhibit super ductility generated by the test Rig. The ridges on the wear surface get flattened and form cornices along the ridge peak.

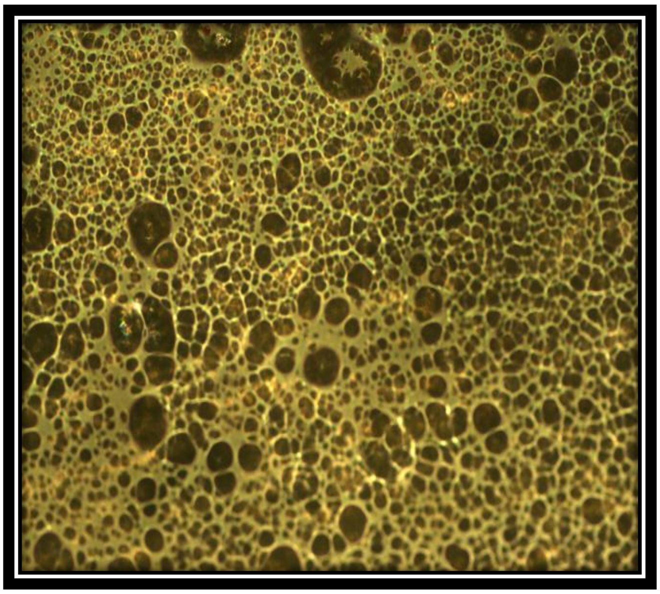


Fig 4: Without Wear, Fresh Rig

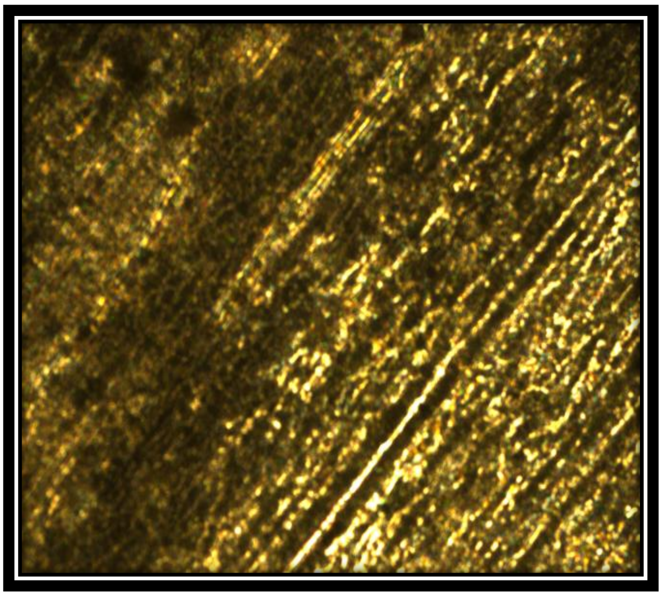


Fig 5: With Wear, using Jatropha as a Lubricant

7. CONCLUSION

In our Project, we have designed a Piston liner Tester Machine, and then fabricated the final design.

Then we have tested the wear characteristics of Piston rings, in the presence of Bio-Lubricating, Jatropha oil.

Finally, we have test their properties on the Reciprocating Liner test machine. The various results obtained will be used for comparing these oils with mineral oil and commenting on a suitable replacement. This way we will also use the finally selected oil on an in-use automobile

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