VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DESIGN AND DEVELOPMENT OF AN OIL PREHEATING SYSTEM TO STUDY THE PERFORMANCE OF A DIESEL ENGINE

Rajesh Nayak[1], Indrajith[1] and Chandrakant R. Kini[2]
[1]Department of Mechanical and Manufacturing Engineering, Manipal Institute of Technology, Manipal University, Manipal, India
[2]Department of Aeronautical and Automobile Engineering, Manipal Institute of Technology, Manipal University, Manipal, India
E-Mail: chandrakini@gmail.com

ABSTRACT

When a diesel engine is cranked while the engine is cold, there is surface to surface contact between the moving parts of the engine such as the crank shaft and its journal bearings, the crank pin and the big end journal bearing of the connecting rod etc. The lubricating oil in the sump requires some time to absorb heat from the combustion process of the engine and reach its optimum operating temperature and viscosity and form a complete lubrication film between all the moving and contact surfaces of the engine. There is high friction and wear between the moving components of the engine until the lubrication film has been formed .It is estimated that approximately 40% of the total wear in an engine during its operating lifespan occurs when the engine is idling to reach its optimum operating temperature. Therefore if oil can be pre heated to its optimum operating temperature before cranking the engine, the oil will form a complete lubrication film in a shorter period of time and it would be possible to reduce idling time, wear and tear between components, fuel consumption, emissions and save time and money in terms of running costs of the engine during the long term operation of the engine. The objectives of this project are to fabricate an oil pre heating system to suit the operating requirements of a 2 cylinder 4stroke Kirloskar diesel engine and to conduct performance tests on the Kirloskar engine equipped with the oil pre heating system to study and analyze the effect of pre heating oil its efficiency parameters.

Keywords: diesel engine, oil preheating system, performance test.

1. INTRODUCTION

All internal combustion engines are equipped with lubrication systems to supply lubricating oil which forms a protective lubricating film between the moving parts and contact surfaces in order to reduce friction, wear and to prevent seizure. The engine components which are to be lubricated are main crankshaft bearings, big end bearings of the connecting rod, small end bearings, camshaft bearings, piston and cylinder walls, timing gears and valve mechanism. These components are subjected to different types of lubrication.When a diesel engine is cranked while the engine is cold, a certain period of time is required for the formation of the lubricating film due to the following reasons.

a. The oil pump has to supply oil to the moving parts and contact surfaces by circulating the oil between parts which have very small clearances.

b. Oil has to circulate under pressure through the limited space of the oil gallery. When the viscosity of the oil is relatively high at room temperature. This greatly limits the ability of the oil to form a complete lubricating film upon every surface of the engine within a relatively short period of time during which the engine is idled.

c. Some time is required for the lubricating oil in the sump to absorb heat from the combustion process of the engine and reach its optimum operating temperature and viscosity and form a complete lubrication film between all the moving parts and contact surfaces of the engine. Thus, between the event of cranking the engine when it is cold and the event of formation of a complete lubricating film, there is an interval of time during which there is no lubrication film between moving parts and contact surfaces. Therefore there is direct surface to surface contact between the moving parts of the engine such as the crank shaft journals and its journal bearings, the crank pin and the big end journal bearing of the connecting rod etc. As a result of this there is high friction and a high rate of wear between the moving components of the engine until the lubrication film has been formed. It is estimated that approximately 40% of the total wear in an engine during its operating lifespan occurs when the engine is being idled to reach its optimum operating temperature.

The largest values for friction and rate of wear can be observed at the region between the beginning of boundary lubrication and commencement of elastohydrodynamic lubrication, when the viscosity of the engine oil is relatively high at room temperature. Any increase in friction adversely affects fuel consumption. When a diesel engine is cranked while the engine is cold, there is surface to surface contact between the moving parts of the engine such as the crank shaft and its journal bearings, the crank pin and the big end journal bearing of the connecting rod etc. The lubricating oil in the sump requires some time to absorb heat from the combustion process of the engine and reach its optimum operating temperature and viscosity and form a complete lubrication film between all the moving and contact surfaces of the engine. There is high friction and wear between the moving components of the engine until the lubrication film has been formed. It is estimated that approximately 40% of the total wear in an engine during its operating lifespan occurs when the engine is idling to reach its optimum operating temperature. Therefore if oil can be pre heated to its optimum operating temperature before cranking the engine, the oil will form a complete lubrication film in a shorter period of time and it would be possible to reduce idling time, wear and tear between

ARPN Journal of Engineering and Applied Sciences

components, fuel consumption, emissions and save time and money in terms of running costs of the engine during the long term operation of the engine [1-4].

2. OBJECTIVES OF THE STUDY

a) To design and develop an oil preheating system to suit the operating requirements of the Kirloskar two cylinder 4stroke diesel engine.
b) To conduct performance tests on a Kirloskar two cylinder 4 stroke diesel engine and determine the efficiency of the engine in terms of fuel consumption before pre heating the engine oil and after pre heating the engine oil.

3. PROCEDURE FOR PREHEATING OF LUBRICATING OIL

8 litres of Mack 20 W 40 multigrade oil is poured into the storage tank which has been mounted on the stand by placing a funnel on the filler. When the oil has been filled the funnel is removed from the filler port and the filler cap is closed. The 1st thermocouple stem is inserted into the tank through the smaller port on the right hand side of the filler cap to measure the temperature of the oil at room temperature before heating. The 2nd thermocouple stem is inserted into the oil sump through the oil level port. The thermocouple stems are connected to their respective digital temperature indicators to obtain readings simultaneously at both points. The thermocouples are connected to their respective power outlets & the digital temperature indicators are switched on. The heater coil has been fixed inside the tank in such a way that it will heat the oil uniformly above and below the length of the. The heating coil is connected to the power outlet and it is switched on. The change in temperature is monitored by observing the readings from the digital temperature indicators. As soon as the oil has been heated to the required temperature the heating coil is switched off. The ½" flow regulating ball valve is opened and the heated oil flows through the braided hose pipe. The braided hose pipe is connected at one end to the ball valve through a ½ "brass barb fitting and the other end to the valve cover plate of the engine head through another ½" brass barb fitting. The ends of the braided hose are secured to the brass fittings by ½" steel worm gear hose clamps at each end of the hose. The valve cover plate has been modified for this purpose. Heated oil flows from the braided hose and enters the head of the engine through the ½ inch brass barb fitting welded to the valve cover plate. The oil circulates through the oil gallery of the engine and eventually reaches the crankcase where it accumulates in the sump. When the entire volume of heated oil in the storage tank has been transferred to the sump, the ball valve is closed and the engine is cranked and idled to allow the heated oil to circulate and form a complete lubricating film between all contact surfaces. The engine is now ready to be tested. A scaled down representation in the form of a diagram of the entire experimental apparatus has been shown below in Figure-1.

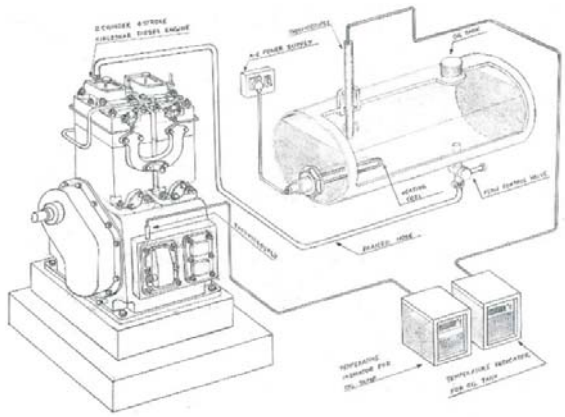

Figure-1. Scaled down representation of the entire experimental apparatus.

Table-1. Engine specifications.

Rated brake power	**BP = 7.35 kW**
Rated Speed	N = 1500 RPM
Bore Diameter	D = 80 mm
Stroke Length	L = 110 mm
Orifice Diameter	d_o = 20 mm
Coefficient of Discharge	C_d = 0.62
Calorific Value of Fuel	CV = 42000 kJ/kg
Mass Density of Fuel	ρ = 0.82 grams/cc

The engine specifications are tabulated in Table 1 as shown above.

4. EXPERIMENTAL PROCEDURE FOR PERFORMANCE TEST

Apparatus required:

Engine oil of the recommended grade, 2 stem type thermocouples, digital temperature indicators, a heating coil, an oil tank and performance testing equipment (hydraulic dynamometer).

Procedure:

1. 8litres of MAK 20 w 40 engine oil is supplied to the oil storage tank mounted on the stand.
2. The heating coil fitted to the oil tank is switched on and the engine oil stored in the oiltank is preheated to the experimental temperature 'ET'.
3. The thermocouple is inserted into the oil tank and the increase in temperature is monitored until the oil is heated to the experimental temperature 'ET'.
4. When the oil attains the temperature 'ET', the heating coil is switched off and the preheated oil is transferred to the oil sump through an oil supply pipe by opening the flow control ball valve.

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

5. The engine is cranked and performance tests are conducted for 0, ¼, ½ and ¾ loads.
6. After the performance test has been completed the engine is stopped and allowed to cool to room temperature.
7. The oil stored in the sump is drained by loosening the drain plug bolt with a 14 number ring spanner.
8. The drained oil is transferred to the oil storage tank mounted on the stand.
9. The entire procedure is repeated six times in the same order for six different temperatures which are increased in increments of ten degrees.
10. The performance test is conducted for temperatures 30, 40,50,60,70 and 80^{0}C.
11. The values are noted in the observation table and the performance parameters are calculated.

5. RESULTS AND DISCUSSIONS

Temperature versus efficiency parameter graphs were plotted to analyse the data that was obtained by calculating the values of the efficiency parameters. The temperature of the engine oil was selected as the parameter against which the efficiency parameters would be compared because the viscosity of the oil is inversely proportional to its temperature. Any change in viscosity of the engine oil will also affect the efficiency parameters of the engine. The path traced by the curves of the graph will represent a corresponding increase or decrease in a particular efficiency parameter with respect to the temperature of the engine oil. The temperature of the engine oil has been represented along the x axis of the graph and the corresponding efficiency parameter has been represented along the y axis of the graph. The scale of the graph has been written on the top right hand corner of the graph. It is to be noted before beginning the analysis that the oil pre heating system was used to heat the engine oil before cranking the engine.

The power supply to the heating coil of the oil pre heating system was switched off before transferring heated oil to the sump of the engine.

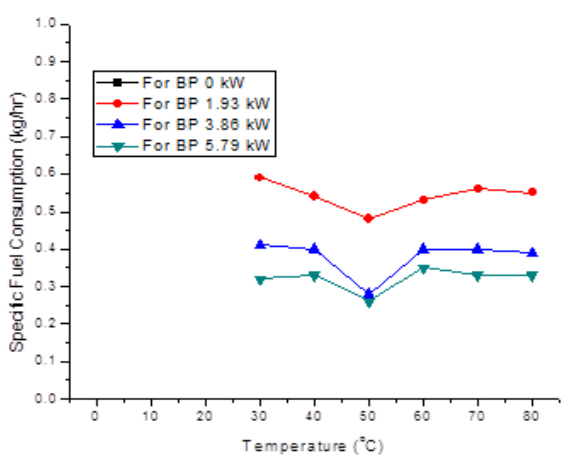

Figure-2. Plot of temperature vs specific fuel consumption.

The oil pre heating system operates at maximum efficiency in the zero load region because the oil pre heating system is used to circulate heated oil to the sump before cranking the engine.

However a specific fuel consumption vs temperature curve cannot be plotted for zero load since at zero load condition the value of break power is zero. As the load increases specific fuel consumption increases as seen in Figure-2.

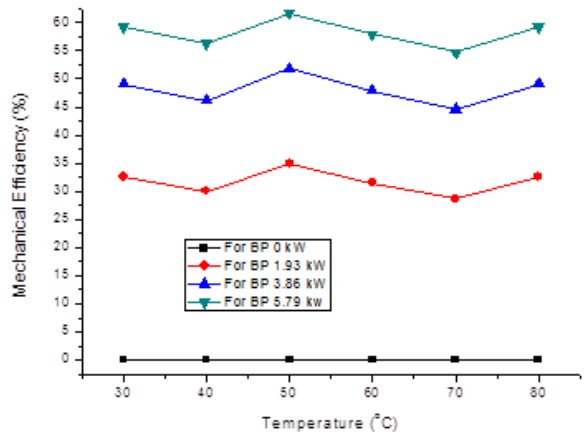

Figure-3. Plot of temperature vs mechanical efficiency.

The oil pre heating system operates at maximum efficiency in the zero load region because the oil pre heating system is used to circulate heated oil to the sump before cranking the engine as shown in Figure-3. Hence the effect of oil temperature on mechanical efficiency cannot be studied for zero load condition.

Indicated thermal efficiency is the efficiency with which heat energy from combustion of fuel is converted into a useful work output. It gives the efficiency with which the chemical energy of fuel is converted into mechanical work. The fuel that was used in the performance test was supplied to the engine at room temperature. The temperature inside the combustion chamber of the Kirloskar diesel engine would be in the range of 300 to 600^{0}C after the combustion of fuel. The oil that was used for this test was pre heated to a maximum temperature of 80^{0}C. Heat always moves from a region of high temperature to a region of low temperature. The difference in temperature of the combustion chamber and the temperature of the oil in the sump will cause the heat that is generated by the combustion of fuel to move towards the region of lower temperature i.e. oil stored in the sump.

Hence the heat will be transferred from the top of the cylinder head to the bottom of the crank case (sump).

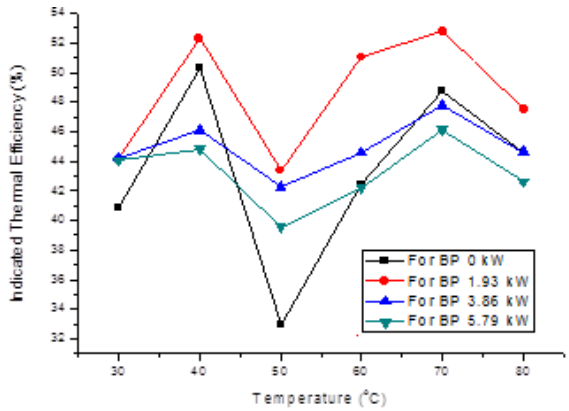

Figure-4. Plot of temperature vs indicated thermal efficiency.

The piston rings of the piston will prevent the entry of oil into the combustion chamber. Hence the pre heated oil cannot transfer any heat to the air fuel mixture. Therefore the temperature of the pre heated engine oil will not affect the indicated thermal efficiency of the engine as seen in Figure-4.

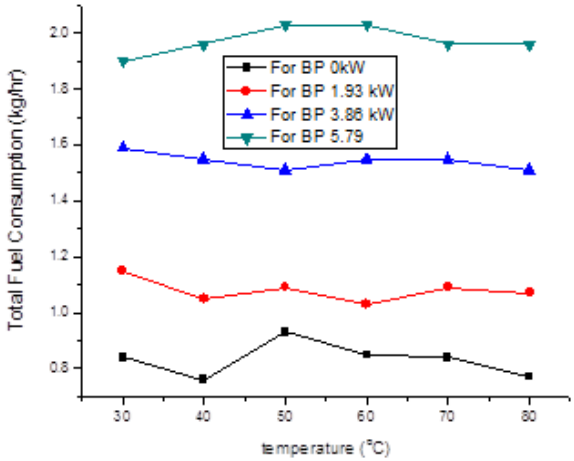

Figure-5. Temperature vs total fuel consumption graph.

Since the oil pre heating system is used before cranking the engine, the system operates at maximum efficiency in the zero load region. Hence a temperature vs total fuel consumption graph at zero load for each temperature value was plotted. It can be observed from the graph that the value of total fuel consumption decreases from 0.84 kg/hr at 300^{0}C to 0.77 kg/hr at 800^{0}C.

In the temperature vs. total fuel consumption graph graph it can be observed that the engine consumed the smallest quantity of fuel (0.76 kg/hr) when the engine oil was pre heated to a temperature of 40 ^{0}C. Hence this value of temperature can be considered as the optimum pre heating temperature of this oil for this engine. It can also be observed that the system operates at maximum efficiency in the zero load region because the oil pre heating system is used to circulate heated oil to the sump before cranking the engine. The viscosity of a lubricant changes with temperature. In almost all cases, as the temperature increases, the viscosity decreases; and conversely as the temperature decreases, the viscosity increases.

When oil was pre heated to its optimum operating temperature before cranking the engine, the high temperatures caused the oil molecules to move away from each other and form smaller molecules. Hence the space between oil molecules increased. The resistance offered by each oil molecule to the flow of oil molecules in adjacent layers was reduced. Thus the intermolecular friction between the oil molecules was reduced. Hence the viscosity of oil was reduced. Oil flow with low intermolecular friction and it circulated through the narrowest clearances with minimum resistance to flow thus forming a complete lubricating film in a short period of time.

When oil is heated, the increase in temperature of oil causes a corresponding reduction in its viscosity hence it can be inferred from the graph that the fuel consumption of the engine decreases with the increase in temperature of engine oil.Hence it can be inferred from the graph that the fuel consumption of the engine decreases with the increase in temperature of engine oil within the heating temperature range as shown in Figure-5.

6. CONCLUSIONS

The design parameters of the oil pre heating system were decided upon and the design received approval for fabrication. It was proved that the fuel consumption of a 4 stroke diesel engine could be reduced by reducing the viscosity of the engine oil by regulating the temperature of the engine oil.

7. SCOPE FOR FUTURE WORK

While conducting the performance test it was observed that a large percentage of the heat from the pre heated oil was lost in the form of convective heat loss.

The engine block and crank case are made of cast iron which has a very large value of thermal conductivity (80 Watt /meter Kelvin). Cast iron is a very good conductor of heat. Consequently, it absorbs a large percentage of heat from the pre heated oil when oil comes into surface contact with the cast iron components of the engine. The cast iron components of the engine can be modified to reduce the cross sectional thickness of each surface of the components to limit the quantity of heat that can be absorbed by each cast iron surface. Alternatively, the cast iron components can be replaced by components made of steel or aluminium. Both of these materials have significantly lower values of thermal conductivity than that of cast iron. Thus the percentage of heat loss can be reduced considerably by these methods by implementing these solutions individually or together.

REFERENCES

[1] High Shear Oil Viscosity Measurement and Relationship to engine operation. James. A. Spearot ASTM special Technical publication 1608.

[2] The Relationship between Engine Oil and Engine Performance T.W. Selby and R.M. Stewart.

[3] The effect of Crankcase Oil Viscosity on Engine Friction at Low Temperatures Cockbill, B. and Bennett, J. SAE Technical Paper 2000-01-2052, 2000, doi:10.4271/2000-01-2052.2006.

[4] Effect of Engine Oil Viscosity on Low-Temperature Cranking, Starting, and Fuel Economy, F. Caracciolo and M.L. Mcmillan SAE Technical Paper 790728, 1979, doi: 10.4271/790728.

[5] 2007. The Effect on Friction of Engine Oil Seal Using Low Viscosity Engine Oil for Fuel Economy Improvement. Sae-Il-Jeon, Han-Goo-KimSe-Jong-YooAnd Myoung-Hun Oh SAE Technical Paper 2007-01-3539, doi: 10.4271/2007-01-3539.