CHAPTER VII

INVESTIGATIONS ON THE USE OF NEW LUBRICANTS IN LOW HEAT REJECTION ENGINE

7.1 INTRODUCTION

The conventional lubricants can not withstand high temperatures which are encountered in LIHR engines. Frictional losses in these engines are found to be higher. Hence, the lubrication is one of the major problems associated with these engines [128]. From the base oil supplied by refiners, special lubricants are developed. These newly developed lubricants are blended with different additives and tested in the LIHR engine to see their performance. The analysis of the results are discussed in this chapter.

7.1.1 Frictional Losses

Frictional losses are found to be higher with aluminum piston as it has higher coefficient of thermal expansion. Due to high cylinder temperatures, LIHR engines which are fitted with aluminum pistons have a higher frictional losses than the engines which employ cast iron pistons.

Increasing the piston liner clearance may reduce the frictional losses, at the same time engine power output, thermal efficiency and peak pressure. Hence optimum clearance should be maintained for better performance of the engine. For this reason experimental investigations are carried out with 0.1 mm clearance which is suggested by many researchers.
7.2 DEVELOPMENT OF NEW LUBRICANTS

It is found during the experimentation that the standard lubrication oil SAE:40 breaks down near the top ring reversal point. Due to high temperature environment [61] the viscosity of the standard lubricating oil reduces and hence frictional losses will be higher. Three new oils developed from blending of two base oils are tested in the LHR engine may withstand high temperatures encountered.

The two base oils which are supplied by oil refineries to the lubricating oil companies are i) HVI (high viscosity index) with a viscosity of 9cS (Centi Stokes) at 100°C ii) BS150 (Bright Stack) with a viscosity of 32cS at 100°C. Normally these two oils, refiners supply to companies to be blended in different proportions to get various types of standard grade oils.

Three special lubricating oils developed are named as Special Oil 1 (SPO1), Special Oil 2 (SPO2) and Special Oil 3 (SPO3). Frictional losses are studied with the application of these oils. The SPO1 has a kinematic viscosity of 17cS at 100°C and the next SPO2 has a kinematic viscosity of 23cS at 100°C and SPO3 has a kinematic viscosity of 27cS at 100°C.

Teflon based additive is mixed with new oils and SAE 40 oil and these blended oils are tried in the engine to analyse frictional losses. Then paratone additive is mixed with the new oils and SAE 40 oil and the experimentation is repeated. The main aim is to find the best performed additive. Both of these additives are expected to protect engine surfaces, modify oil properties and protect base stock.
7.3 RESULTS AND DISCUSSION

The newly developed special lubricating oils are employed in the LHR engine to evaluate the performance of the engine and also to study the frictional losses. Processed results are presented in the form of graphs. The comparison is made with the base engine as a reference which uses SAE 40 oil.

7.3.1 Use of Teflon Based Additive

Since this additive has a low sliding friction it can withstand higher operating temperatures of LHR engines. The lubricating oil carries this additive in suspension to all the engine parts which require lubrication. Additive gets coated on the sliding surfaces. Therefore these additives will help in reducing the frictional losses.

7.3.1.1 Effect of Teflon Based Additive in SAE40 Oil

Different amounts of Teflon based additive is added to SAE40 oil and tested for performance in LHR engine. The variation of the brake thermal efficiency with power output for different amounts of Teflon based additive in the SAE40 lubrication oil is shown in fig.7.1. Brake thermal efficiency rise is maximum for 3% additive. The efficiency gain is due to the reduction of frictional losses as is evident from fig.7.2. There is no further improvement in efficiency observed for higher amounts of additive. 6% of the additive gives the lowest frictional losses in LHR test engine. The additive forms a thin coating on the liner surface may be the reason for reduction in the frictional loss [164]. Frictional losses are found to be lowest for 3% additive closely followed by 6% additive at the rated load. Addition of 1.5% Teflon based additive has performed poorly in the LHR engine.
7.3.1.2 Effect of Teflon Based Additive in SPO1

Different amounts of Teflon based additive is added to newly developed SPO1 lubricating oil and tested in the LHR engine. The variation of brake efficiency with power output for four different proportions of Teflon based additive to the base oil SPO1 is shown in fig.7.3. The maximum brake thermal efficiency is seen in the case of 3 and 6% of Teflon based additives and it is higher compared to the SPO1 oil without additive in LHR test engine by about 2% at the engine full load. At low engine loads this additive has not shown any effect. Additives added to SPO1 oil can alter the performance of the engine.

Fig.7.4 shows the variation of frictional mean effective pressure with power output for different amounts of Teflon based additives to SPO1 oil. As the brake power increased frictional losses also have increased. 6% of Teflon based additive to the base oil SPO1 gives the lowest frictional losses when compared with other tested proportions. The imep reduction at the rated load over the LHR test engine with SPO1 oil without any additive is about 50 kN/m².

7.3.1.3 Effect of Teflon Based Additive in SPO2

Fig.7.5 depicts the brake thermal efficiency variation with power output for different amounts of Teflon based additive to the oil SPO2. The addition of 4.5% Teflon based additive to SPO2 oil gives a maximum efficiency and is higher by 1.8% compared to LHR engine without any additive. 6% Teflon based additive added to SPO2 oil has shown marginal reduction in the brake thermal efficiency compared with 4.5% additive.
Figure 7.6 gives the variation of frictional losses for different amounts of Teflon based additives to the oil SPO2. Frictional losses are minimum for 3% of Teflon based additive compared to LHR engine. Fmep is lower by 25 KN/m² when compared to LHR engine.

7.3.1.4 Effect of Teflon Based Additive in SPO3

Fig.7.7 shows the variation of brake thermal efficiency with power output when SPO3 and Teflon based additives are used. SPO3 oil is the thickest of the three tested oils. Additives have not improved the efficiency of the engine. The SPO3 oil without additive is giving higher efficiency. With higher amounts of additive resulted in a reduction in the brake thermal efficiency.

The variation of frictional losses with power output is shown in fig.7.8. Since SPO3 oil is a thick one, the additives which are added to this oil have not shown any variation at full load.

7.4 COMPARISON OF THE NEW OILS WITH OPTIMUM AMOUNT OF TEFロン BASED ADDITIVE

The performance of oils is best when an optimum amount of Teflon is added. After adding the optimum amount of additive the brake thermal efficiencies of SAE:40 oil and the three special oils are indicated in the fig.7.9. The efficiencies of all these oils are almost the same. Without Teflon additive SPO3 gives to give slightly higher brake thermal efficiency. By using SAE: 40 oil with 3% TBA at highest load increase in brake thermal efficiency of 2.0% is observed over LHR test engine.

Figure 7.10 shows the comparison of frictional mean effective pressure with power output for four oils with optimum amounts of T.B.A. SPO1 oil with 6% Teflon
based additive gives lowest frictional losses at full load. SPO3 oil without any additive has the highest frictional losses at lower engine load.

7.5 USE OF PARATONE ADDITIVE

Viscosity index improver raises the viscosity at 100°C where as viscosity at 0°C relatively is unaffected. Poly-isobutylene, polymethacrylate esters, and polyfumerite ester derivatives can improve viscosity index. The paratone is a polymer of butylene having the formula(C₄H₈)ₙ where n may vary from 180 to 270. These polymers have extremely high viscosities. At low temperatures the molecules are coiled up and exist in a colloidal form in the oil but with increase in temperature they unwind, go into solution, and thus increase the viscosity of the oil.

7.5.1 Effect of Paratone with SAE40 Oil

Variation of brake thermal efficiency with power output for different amounts of paratone added to the base oil SAE:40 is shown in fig.7.11. Performance of the engine is best for LHR test engine with 4.5% paratone additive. 6.0% paratone additive in the SAE:40 oil has shown poor performance when tested in the LHR engine.

Fmep variation with power output is depicted in fig.7.12. SAE: 40 oil with 4.5% paratone additive gives lowest frictional losses for the LHR engine. Further addition of paratone additive has increased frictional losses.

7.5.2 Effect of Paratone in SPO1

3% paratone added to base oil gives a maximum efficiency as is evident from fig.7.13. The brake thermal efficiency is increased by 1.3% over the LHR test engine.
Frictional losses decreased by about 45 kN/m$^2$ over that of the LHR test engine as observed from fig.7.14. The performance declines due to the thickening of the oil with the higher amounts of paratone. Therefore, optimum amounts of additives are to be identified for improved performance of the engine.

7.5.3 Effect of Paratone in SPO2

1.5% paratone addition to the SPO2 oil resulted in the best performance as is observed from the figs.7.15 and 7.16. There is a brake thermal efficiency improvement of 1.3%. Whereas frictional losses reduced by 55 kN/m$^2$ for 1.5% paratone over the LHR test engine. Higher frictional losses are observed with the increase in the amounts of paratone. Hence 1.5% paratone additive is sufficient for the reduction of frictional losses.

7.5.4 Effect of Paratone in SPO3

SPO3 oil gives the best performance without any additives when tested in the LHR engine. Pure SPO3 oil gives the highest brake thermal efficiency in LHR test engine as seen from fig.7.17. At high loads this oil has the lowest frictional losses as observed from the fig.7.18.

7.6 COMPARISON OF THE NEW OILS WITH OPTIMUM AMOUNT OF PARATONE

The three special oils with the optimum amount of paratone additive to get the best performance are compared in fig.7.19. Maximum efficiency is obtained for SPO3 oil without the addition of any additive. Brake thermal efficiency is about 0.9% higher than the LHR engine.
Figure 7.20 shows the comparison of frictional mean effective pressure with power output for four oils with optimum concentrations of paratone. Lowest frictional losses are observed in the case of SPO2 oil with 1.5% additive at almost all loads.

### 7.7 EFFECT OF TURBOCHARGING WITH SPO3 OIL IN LHR ENGINE

The overall gain in thermal efficiency of LHR turbocharged engine with SPO3 lubricating oil is shown in fig.7.21. The overall increase in thermal efficiency over base engine is around 42%. Also, thermal efficiency at full load is much higher compared to base engine run with diesel fuel.

### 7.8 CONCLUSIONS

Paratone, Teflon based additives are added in varying proportions to the newly developed lubricating oils SPO1, SPO2, SPO3 and tested for the evaluation of performance of the LHR test engine. From the experimental analysis the following conclusions can be drawn.

1. The SPO3 oil has shown the best performance out of three newly developed special oils that are tried in the LHR test engine.

2. Frictional losses are reduced in the LHR test engine by the addition of Teflon based additive.

3. Frictional losses are lowest for SPO1 oil with 6% Teflon based additive.

4. The brake thermal efficiency increased by 2% when the SPO3 oil is used without any additive in the LHR test engine.

5. Frictional losses are found to be lowest when optimum amounts of paratone additive is used.
6. SPO2 oil with 1.5% paratone additive improves the efficiency by 1.5% compared with pure SPO2 oil used in the LHR engine.

7. The absolute increase in brake thermal efficiency of simulated turbocharged engine with special lubricating oil SPO3 is 42%.
Fig 7.1 Comparison of Brake thermal efficiency with power output for four different amounts of TBA in SEA40.

Fig 7.2 Comparison of Frictional mep with power output for four different amounts of TBA in SEA40.
Fig 7.3 Comparison of Brake thermal efficiency with power output for four different amounts of TBA in SP 01

Fig 7.4 Comparison of Frictional mep with power output for four different amounts of TBA in SP 01
Fig 7.5 Comparison of Brake thermal efficiency with power output for four different amounts of TBA in SP 02

Fig 7.6 Comparison of Frictional m e p with power output for four different amounts of TBA in SP 02
Fig 7.7 Comparison of Brake thermal efficiency with power output for four different amounts of TBA in SP 03.

Fig 7.8 Comparison of Frictional mean effective pressure with power output for four different amounts of TBA in SP 03.
Fig 7.9 Comparison of Brake thermal efficiency with power output for four oils with optimum amounts of TBA.

Fig 7.10 Comparison of Frictional MEP with power output for four oils with optimum amounts of TBA.
Fig 7.11 Comparison of Brake thermal efficiency with power output for four different concentrations of paratone in SAE40.

Fig 7.12 Comparison of Frictional m e p with power output for four different concentrations of paratone in SAE40.
Fig 7.13 Comparison of Brake thermal efficiency with power output for four different concentrations of paratone in SP 01.

Fig 7.14 Comparison of Frictional m e p with power output for four different concentrations of paratone in SP 01.
Fig 7.15 Comparison of Brake thermal efficiency with power output for four different concentrations of paratone in SP 02.

Fig 7.16 Comparison of Frictional m e p with power output for four different concentrations of paratone in SP 02.
Fig 7.17 Comparison of frictional m.e.p with power output for four different concentrations of paratone in SP 03.

Fig 7.18 Comparison of frictional m.e.p with power output for four different concentrations of paratone in SP 03.
Fig 7.19 Comparison of Brake thermal efficiency with power output for four oils with optimum concentrations of paratone.

Fig 7.20 Comparison of Frictional output with power output for four oils with optimum concentrations of paratone.
Fig 7.21 Comparison of Brake thermal efficiency of SPO3 oil lubricated turbocharged LHR engine with base diesel.