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Research Paper

EXPERIMENTAL INVESTIGATIONS IN AN INSULATED DI DIESEL ENGINE WITH NEWLY DEVELOPED LUBRICANTS

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Ever since the rise of fuel cost and rapidly depleting conventional energy sources the diesel engine manufacturers have been allocating a great deal of research for the improvement of the engine thermal efficiency and developing of alternative fuels. The alternative fuels developed should be renewable with low emissions. This recognizes alcohol as a preferable replacement because these are derived from indigenous sources and are renewable. But the alcohols by their nature do not make a good C.I Engine fuels and this can be ignited in the high temperature combustion chambers. So in the present work a thermally insulated (PSZ coated cylinder head, valves and air gap liner and air gap piston) engine is developed for improving fuel efficiency and to reduce the emissions. The low viscosity of alcohols leads to the problem of injection and equipment wear and tear. In order to compensate this, the fuel injection pressure has been reduced to 165 bar for the experimentation. Tests are conducted on a single cylinder 4-stroke, water-cooled 3.68 KW Kirloskar C.I. engine. Performance of lubricating oil plays an important role in determining the amount of power output and the improvement in the efficiency of the engine. At present first we tried the commercial lubricant for the experimentation. But the performance of this lubricant is inadequate at escalated thermal environment and the frictional losses are found to be higher. So in the present work new lubricants are developed and are further blended with different additives and analyzed the frictional losses to find the best oil.

Keywords: Insulated engine, Alcohol and new lubricating oils

INTRODUCTION

Developing of insulated combustion chamber with high temperature materials is one of the promising and innovative methods of igniting alcohols in diesel engine, which allows hot operation near adiabatic conditions. The insulated engine consists of PSZ coated cylinder head, valves and air gap liner and air

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gap piston (Pradeepram *et al.*, 1983). This not only reduces the heat transfer to the cooling water but also improve the thermal efficiency by improving the heat transfer to the exhaust gases. This energy can be converted into useful brake power output with turbocharger and further the thermal efficiency of the engine can also be increase.

Due to the higher temperatures in the combustion chamber, the commercial lubricating oils will not withstand for longer time. So the need for high temperature lubricant is the major problem in the development of insulated engine (Wallance *et al.*, 2000). The most important lubricant requirements are oxidative stability, deposit sludge control and the lubricating oil viscosity must be consistent with temperatures. The lubricating oil should have high viscosity index in order to meet severe operating conditions (Flynn and MacBeth, 1986). So in our work, new liquid lubricants have been developed for the high temperature applications.

PREPARATION OF THE INSULATED COMPONENTS FOR THE ENGINE

The first and most difficult part of this work is the design and fabrication of insulated components which included the piston, cylinder liner, cylinder head and valves.

Piston Insulation

The thermal conductivity of air is low, so this is used as an insulating medium. An air-gap of 2 mm (which is optimized based on the literature) is provided between a metallic crown and the standard piston made of Aluminum alloy (Wallance *et al.*, 2000). The two pieces were separated by gaskets of suitable materials and fastened. Figure 1 shows the constructional details of the air-gap piston.

Figure 1: Aluminum Crown with an Air-Gap Insulation

Cylinder Liner Insulation

In this case air with its low thermal conductivity is used as the insulating medium. A thin mild steel sleeve is circumscribed over the cast iron liner maintaining a 2 mm layer of air in the annular space between the liner and the sleeve (Varaprasad *et al.*, 2000). The joints of the sleeve are sealed to prevent seepage of cooling water into the air-gap region.

Cylinder Head and Valves Insulation

The bottom surfaces of the cylinder head and valves are machined to a depth of 0.5 mm and coated with PSZ material of equal thickness (Wade *et al.*, 1984). With the valves assembled on the cylinder head the area of the combustion chamber insulated is about 90-92% of the total area. Figure 2 shows the constructional details of the PSZ coated cylinder head.

Figure 2: PSZ Coated Cylinder Head

DEVELOPMENT OF NEW LUBRICANTS

In India the oil refineries supply two base oils to lubricating oil companies, to blend in different proportions in order to get various types of standard grade lubricating oils (Sutor and Bryzik, 1989; and Wang, 1993). The two base oils are HVI (High viscosity index) with viscosity of 9 cS (centi strokes) at 100 °C and BS (bright Stack) with a viscosity of 32 cS at 100 °C.

These two oils are mixed in different proportions to get three new oils. They are named as new oil 1 (NO. 1), new oil 2 (NO. 2) and new oil 3 (NO. 3). All the three oils are used in pure blended form without any additives. The kinematic viscosities of the new oils at 100 °C are 18 cS with NO. 1, 21 cS with NO. 2 and 23 cS with NO. 3. These three oils are tested in the insulated engine and the friction losses are studied. In the next phase of experimentation, a commercially available Teflon based friction reducing addictive is mixed with the three new oils and the SAE 40 oil. The effect of T.B.A with new oils on the brake thermal efficiency and the frictional losses of insulated engine are studied.

EXPERIMENTAL DETAILS

Experiments are conducted on a single cylinder, 4-stroke, water-cooled 3.68 KW Kirloskar DI Diesel engine at the recommended injection timing of 270 bTDC at various loads with the above configuration of the engine (BP9). All the tests are conducted at the rated speed of 1500 rpm. Experiments are conducted with alcohol as fuel and the same is compared with diesel fuel in Normal Engine (NE). The experimental set up is as shown in the Figure 3.

Figure 3: Experimental Set Up for an Insulated Diesel Engine

RESULTS AND DISCUSSION

The investigations are made on the Insulated engine with newly developed lubricating oils to evaluate the performance of the engine and the frictional losses and the same is compared with the normal engine, which uses the conventional SAE 40 oil.

Use of Teflon Based Additive

The commercially available Teflon based friction reducing additive which can withstand for high temperature is added to the newly developed lubricating oil in different proportions. It is in suspension in the lubricating oil to which it is mixed and flows along with the normal oil to various engine components. It gets coated on the sliding surfaces and stays in place and in turn reduced the friction. Therefore these additives will help in reducing the frictional losses.

Effect of Teflon Based Additives in SAE 40 Oil

Different amounts of Teflon based additive is added to SAE 40 oil and tested for the performance in Insulated engine. The variation of the brake thermal efficiency with power output for different amounts of Teflon based additive in the SAE 40 lubricating oil is shown in Figure 4. For 1% of the additive, the improvement in the brake thermal efficiency is found to be maximum due to the reduction of frictional losses and is evident from Figure 5. For higher amounts of additive, the T.B.A itself increases the frictional losses, so thermal efficiency decreases further. 1% of the additive gives the lowest frictional losses in insulated engine and for 2% it is highest because Teflon material forms a thin coating on liner and piston which reduces friction between them. The remaining results are in between these two.

Figure 4: Comparison of Brake Thermal Efficiency with Power Output for Four Different Amounts of T.B.A in SAE 40

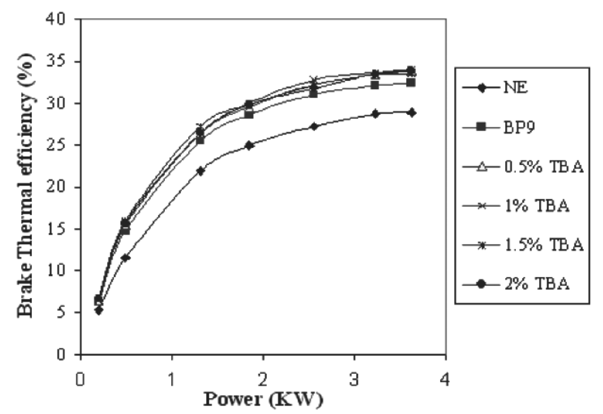
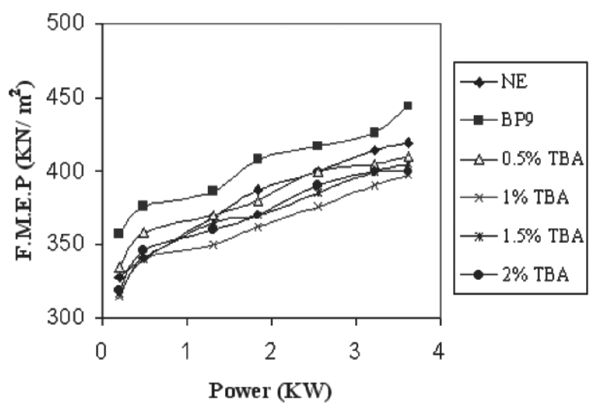


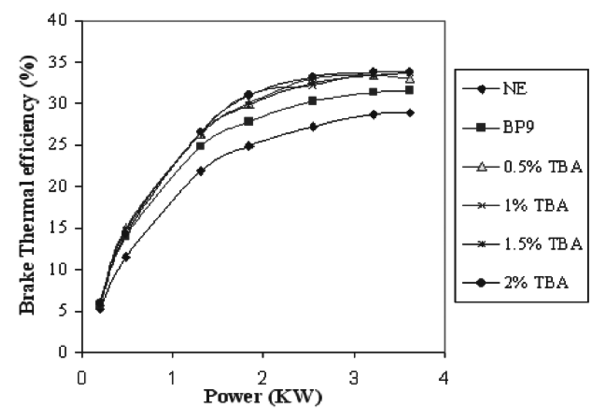
Figure 5: Comparison of F.M.E.P. with Power Output for Four Different Amounts of T.B.A in SAE 40



Effect of Teflon Based Additive in NO. 1

Different percentage of Teflon based additive is added to newly developed NO. 1 lubricating oil and tested in the insulated engine. The variation of brake thermal efficiency with power output for four different proportions of Teflon based additive to the NO. 1 is observed and analyzed in the Figure 6. It is seen that, the maximum brake thermal efficiency is obtained for 2% of Teflon based additive and it is higher compared to the NO. 1 oil without additive in BP9 by about 7% at the engine rated load. At

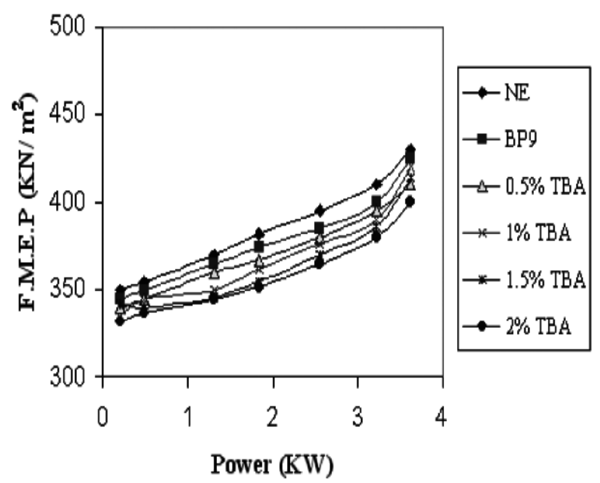
Figure 6: Comparison of Brake Thermal Efficiency with Power Output for Four Different Amounts of T.B.A in NO. 1



low engine loads this additive has not shown much effect.

Figure 7 shows the variation of frictional mean effective pressure with power output for different amounts of Teflon based additives to NO. 1. As the brake power increased frictional losses also increased. 2% of Teflon based additive to the NO. 1 gives the lowest frictional losses when compared with other tested proportions. The F.M.E.P reduction at the rated load with NO. 1 with 2% TBA is 19 kN/m^2 over BP9.

Figure 7: Comparison of F.M.E.P with Power Output for Four Different Amounts of T.B.A in NO. 1



Effect of Teflon Based Additive in NO. 2

Figure 8 depicts the brake thermal efficiency variation with power output for different amounts of Teflon based additive to the oil NO. 2. The addition of 1.5% Teflon based additive to NO. 2 oil gives a maximum efficiency and is higher by 8.3% compared to BP9 without any additive. 2% Teflon based additive added to NO. 2 oil has shown marginal reduction in the brake thermal efficiency compared with 1.5% additive.

Figure 8: Comparison of Brake Thermal Efficiency with Power Output for Four Different Amounts of T.B.A in NO. 2

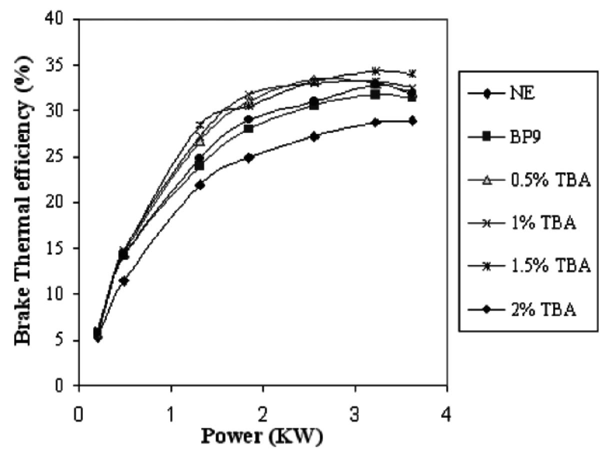
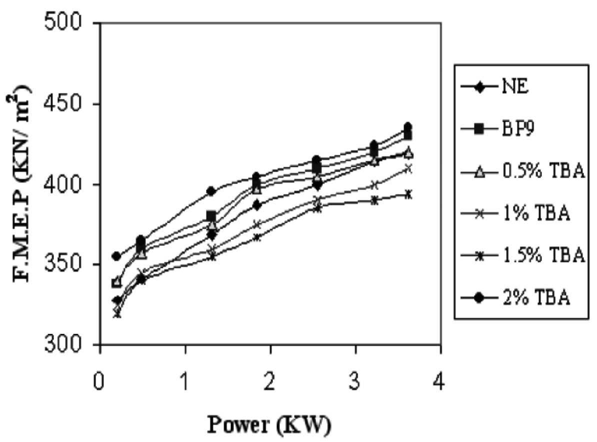


Figure 9 gives the variation of frictional losses for different amounts of Teflon based additives to the NO. 2. Frictional losses are minimum for 1.5% of Teflon based additive and maximum for 2% of T.B.A compared to BP9. F.M.E.P is lower for 1.5% T.B.A by 14 KN/m^2 when compared to BP9.

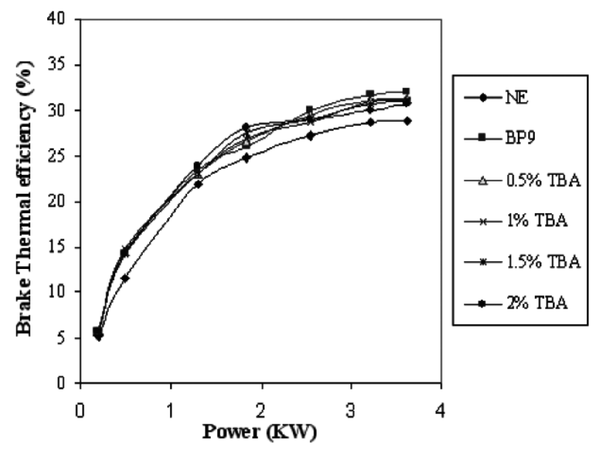
Figure 9: Comparison of F.M.E.P with Power Output for Four Different Amounts of T.B.A in NO. 2



Effect of Teflon Based Additive in NO. 3

Figure 10 shows the variation of brake thermal efficiency with power output for different

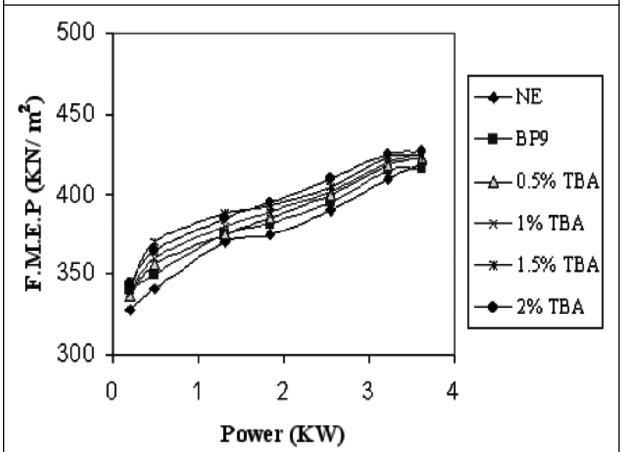
Figure 10: Comparison of Brake Thermal Efficiency with Power Output for Four Different Amounts of T.B.A in NO. 3



proportions of Teflon based additive in NO. 3. The NO. 3 without additive is giving higher efficiency. The efficiency is not much affected for 1% and 2% addition of Teflon additive. The oil performance declines with the addition of higher amounts of Teflon based additive. The base oil itself is very thick and hence the addition of friction reduction additives does not have any effect on this NO. 3.

The variation of frictional losses with power output is shown in Figure 11. Since NO. 3 oil is a thick one, the additives which are added to this oil have not shown any variation at rated load. Hence the NO. 3 oil gives lowest frictional losses compared to all other oils tested.

Figure 11: Comparison of F.M.E.P with Power Output for Four Different Amounts of T.B.A in NO. 3



CONCLUSION

Based on the experiments with the Teflon based additives in three new oils in insulated engine; the following conclusions can be drawn:

- Among the three new oils tested, the NO. 2 oil has shown the best performance.
- Frictional losses are lowest for NO. 2 oil with 1.5% Teflon based additive and is about 14 KN/m^2 compared to the insulated engine.
- The brake thermal efficiency is increased by 8.3% for NO. 2 oil with 1.5% TBA the insulated engine compared to BP9.

All the above investigations are fruitful and these results are expected to lead to a substantial contribution to the development of insulated engine.

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