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Improving Fuel Economy with MoDTC without Increasing TEOST33C Deposit

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Abstract: *Efforts to reduce CO2 emissions have made Fuel Economy Improvement (FEI) a major issue for automotive manufactures. Low friction engine oils are known to improve this matter. The combination of lower viscosity and effective friction reduction technologies is key to assist FEI. MoDTC (Molybdenum dialkyldithiocarbamate) is one of the most effective FM components in boundary lubrication. The effect of MoDTC for FEI was evaluated and the maximum friction reducing performance was improved by more than 10% on the motored engine test and 1% FEI was obtained on the Chassis Dynamo Test. Though negative results of MoDTC on bench tests for boosted gasoline engine oils (TEOST33C) have been seen, further research shows that the properties of base oil has a large impact in deposit generation. As a result, has become known that adding high doses of MoDTC to engine oil is possible without increasing deposits.*

Category: Engine & Drivetrain

Keywords*: friction modifiers, gasoline engine oils, thermal stability.*

1. INTRODUCTION

Fuel economy improvement is one of the greatest challenges for automotive manufacturers today due to stricter fuel economy standards put in place around the world. Employing low friction lubricants is known as a cost effective approach for improving fuel efficiency of vehicles and more than 1 % of fuel economy improvement has been achieved in earlier studies by making use of engine oils specifically designed to reduce friction energy loss [1],[2]. These engine oils consist of low-viscosity and high-viscosity-index base stocks as well as Mo-based friction modifiers (FM). MoDTC is one representative of these types of FMs.

The turbocharging with downsizing is one of the most important technologies for improving the fuel efficiency of gasoline engines, however this strategy is now forcing new challenges for lubricant development. An abnormal combustion which occurs at high engine torque and low engine speed in highly boosted DI engines, known as low-speed pre-ignition (LSPI) may lead to engine damage in serious cases and is now one barrier for pursuing further fuel economy improvement. Many studies have been carried out regarding LSPI and several factors which can affect this phenomena has been reported and has indicated that lubricant components such as MoDTC give some positive effect for reducing LSPI frequency. [3],[4].

It has been a challenge in the newly developing engine oil standard ILSAC GF-6 that maintains the performance regarding the LSPI phenomena. There are other tests regarding turbocharger compatibility in the GF-6 draft, one of which is the thermo-oxidation engine oil simulation test (TEOST). It has been reported that MoDTC gives a negative effect on the TEOST33C deposit formation. Even though it is effective for improving high temperature oxidation stability [5]. Developing the technology for improving turbocharger compatibility in engine oil containing high doses of MoDTC means reducing TEOST33C deposits. This will contribute to an increase in options for OEMs and oil manufacturers to develop engine oils for next generation.

In this study, Friction performance of MoDTC containing and non-containing oils which comply with GF-5 specification is evaluated in several bench tests. The effect of MoDTC for improving fuel efficiency is also studied with the chassis dynamo test using a specific driving schedule. The influence of lubricant components on the TEOST33C is investigated, and the effect of base oil which contribute to reducing deposits most, is studied in detail with fully formulated engine oil in TEOST33C and on the motored engine test.

2. FRICTION AND FUEL ECONOMY TEST

MOLYBDENUM DITHIOCARBAMATE
THE FRICTION MODIFIER IN THIS STUDY

The chemical structure of Molybdenum dialkyl-dithiocarbamate (MoDTC) which is used in this study is shown in figure 1. This MoDTC consists of binuclear molybdenum and dialkyl-dithiocarbamate with C8 and C13 alkyl radicals.

Figure 1 Chemical Structure of MoDTC

FRICTION TEST WITH GF-5 ENGINE OILS

Tribological characteristics of engine oils were put under an SRV reciprocating friction test and Bowden-Leben type friction test. The test apparatus was made up of a plate, oscillating cylinder or ball, and a block heater. Prior to a test, a small amount of oil was applied to a plate.

The friction test result is shown in figure 2. Significant friction reducing performance of MoDTC containing oil is observed in wide range of contact pressure. It can be expected that MoDTC can reduce friction in several friction parts in engine.

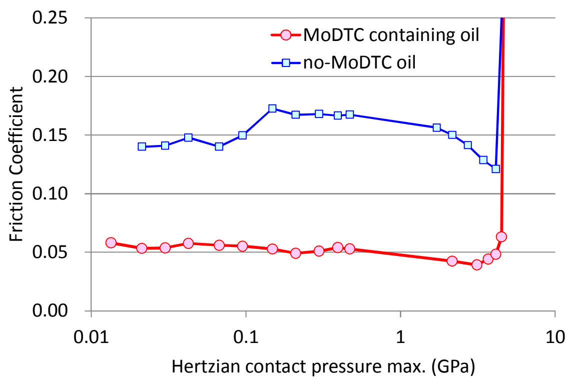

Figure 2 Friction test result of engine oils containing MoDTC

Motored engine test is carried out with 3.0L V6 gasoline engine. 0W-20 GF-5 engine oil which does not contain MoDTC is used in this study. The friction torque without MoDTC was studied then the test was repeated with MoDTC being added, and friction torque reduction ratio was calculated. As a result more than 10% of friction reduction was observed especially at low engine rotation speed where more contribution of boundary lubrication can be expected.

The fuel economy improvement performance of MoDTC was studied with chassis dynamo test on JC08 driving schedule shown in figure 3 with the same set of oils as on the motored engine test. As a result, 1% of fuel economy improvement by MoDTC was observed in this study as shown in figure 4.

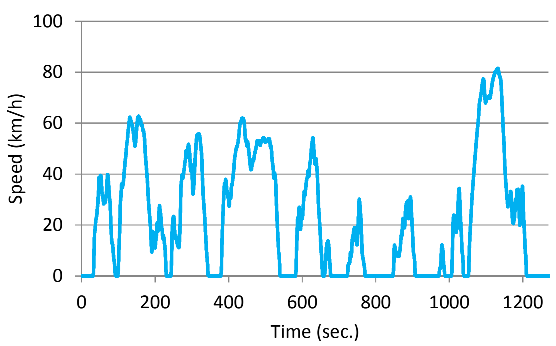

Figure 3 JC08 Driving Schedule

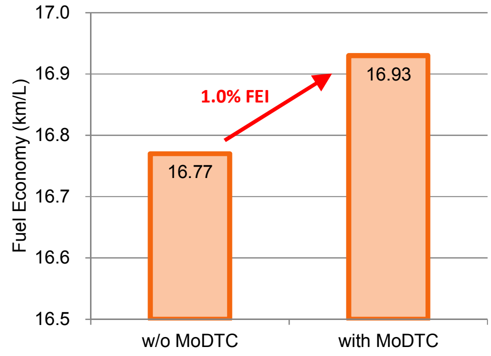

Figure 4 FEI Performance of MoDTC on Chassis Dynamo Test, schedule JC08

3. STUDY REGARDING TO THE TEOST33C

The friction reducing and fuel economy improvement performance of MoDTC would be as large as described in the previous section. The impact of MoDTC and other components, such as ZnDTP, detergents, dispersants, ashless AOs and base oils, for TEOST33C studied in this study is summarized in Table 4.

Table 2 Summary of Component Impact on TEOST33C

Components	Effect
Base oil	Large impact
ZnDTP	Amount: Large impact Type: Small impact
Ashless AO	No large effect neither phenol type or amine type
Detergent	No large effect neither Ca sulfonate or Ca salicylate
Dispersant	No large effect
MoDTC	Large impact

There is a report that the addition of MoDTC and ZnDTP led to an increase of TEOST33C deposits as shown in figure 5[5].

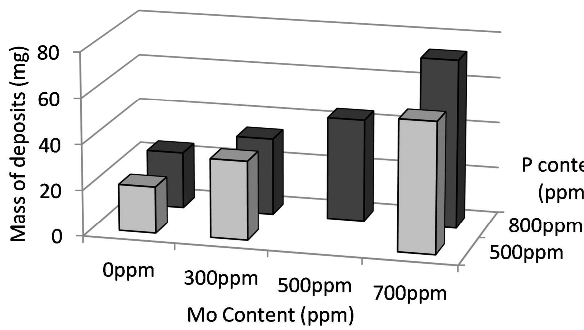

Figure 5 TEOST33C Deposit Amount [5]

It has become clear that the base oil has large impact on the deposit amount on TEOST33C. The test result is shown in figure 6. The concentration of MoDTC is maintained at 500ppm of Molybdenum. It is obvious that degree of refining will not give any effect on this test since any advantage of highly refined mineral oil and synthetic oil is observed. The molecular weight which influences to viscosity and evaporation property of base oil will contribute to deposit formation as shown in figure 7. Evaporation property especially 90% evaporating temperature has strong correlation with deposit amount therefore a lubricant’s persistency at high temperature is considered to be the key property.

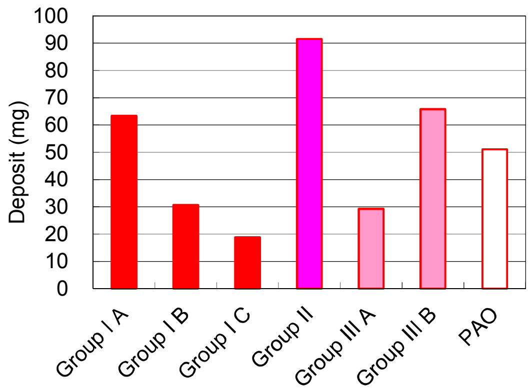

Figure 6 The influence of Base oil for TEOST33C Deposit

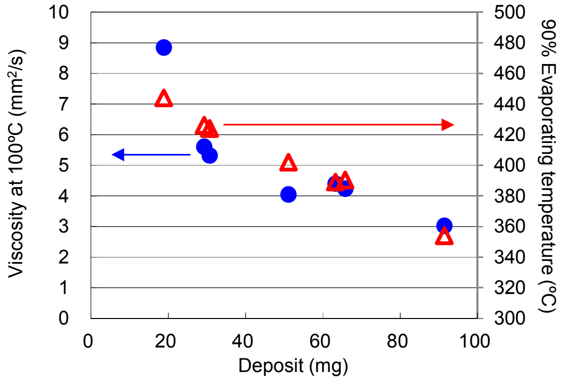

Figure 7 The Correlation Between Property of Base Oil and TEOST33C Deposit

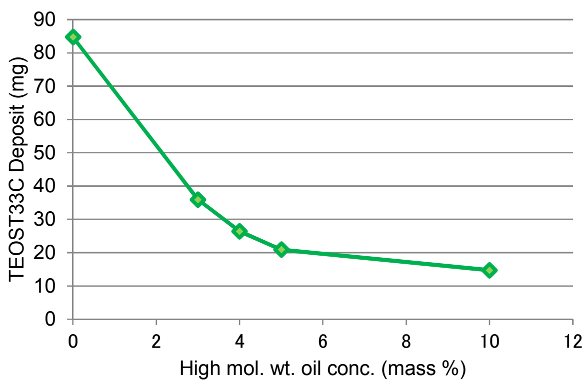

Figure 8 The Effect of High Mol. Wt. Base Oil on Reducing TEOST33C Deposit

Formulating with a small amount of high molecular weight base oil is one possible way to elevate the high temperature persistency of engine oil. PAO40 is used as the high molecular weight base oil in this study. The viscosity is adjusted to 5W-30 and HTHS viscosity at 150°C is maintained at 2.9mPa·s in all oils by changing concentration of VII. MoDTC dosages are 500ppm of Molybdenum. The substantial effect of this approach is observed and the deposit amount can be less than 30mg when high molecular weight base oil was more than 4% as indicated in figure 8.

Motored engine test was carried out with same oil in TEOST33C study which containing 5% of high molecular weight base oil. More than 10% of friction torque reduction was observed compared with GF-5 5W-30 oil in the market.

4. CONCLUSION

MoDTC has a significant potential for improving fuel economy.

The persistency of lubricant at high temperature will give a large impact on TEOST33C. It will be possible adding high dose of MoDTC for fuel economy improvement without serious deposit increase.

5. ACKNOWLEDGEMENTS

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