SAE Number 2008-28-0126

INFLUENCE OF FUEL ASPHALT ON DETERGENCY OF TRUNK PISTON ENGINE OILS - NOVEL LABORATORY ASSESSMENT PROTOCOL

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ABSTRACT

This paper presents a novel laboratory assessment model, which involves a sequential testing protocol to assess the fuel asphalt tackling efficiency of trunk piston engine oils. Test protocol involves a combination of laboratory tests like thermo engine oil oxidation simulation test-which was originally designed to assess the detergency characteristics of engine oils of high speed engines, thermal aging in presence of fuel and assessing the relative distribution of fuel asphalt in the bulk of the liquid and a micro oxidation test. Extensive experimentation was conducted on a wide variety of formulations based on several classes of detergent chemistries and the relative merits of these formulations towards asphalt tackling efficiency were ascertained with substantial degree of discretion.

INTRODUCTION

Fuel ingress by way of fuel dilution of un-burnt fuel or blow by into crankcase oil is very common in trunk piston engines (DG sets) (1). In such an eventuality, the highly polar, aromatic fuel asphalt, when comes in contact with the non polar lubricating oil, plates out as black deposit on various engine parts (2). This can be reasoned out as lube-fuel incompatibility arising out of polarity gradient between the two phases. This phenomenon is known as “Blackening”. This blackening merely disturbs the aesthetics of engine in terms of general cleanliness level when occurs in colder engine parts like rocker arm, cam area crankcase walls. However, the same may prove detrimental when blackening/deposits accumulate in hotter engine parts like piston under crown, piston rings/groves etc (3), leading to hampering of heat exchange and piston seizures. Further, blackening may severely impair the lubricating oil in terms of excessive oil thickening thereby not enabling the user to realize its complete drain potential. In view of the above, optimization of trunk piston engine oil formulations towards their asphalt tackling efficiency assumes greater significance. No standard test methods are available to assess this particular attribute especially in presence of fuel asphalt. Since, performance of trunk piston engine oils is not governed by any universal specification, this aspect remains un assessed during developmental stage in spite of its severe implication in the real time service.

Several researchers in the past, including the authors' group (1,4-6) attempted to develop a viable fuel asphalt tackling laboratory methods in case of trunk piston engine oils. Asphalt dispersion technique (4) filterability test after aging with fuel (5,6) were investigated in the past by our group with some amount of success.

Thermo oxidation Engine Oil Simulation Test (TEOST) (7-8) is essentially designed to predict the deposit forming tendencies of engine oil in the piston ring belt and upper piston crown area. This test is basically developed for screening passenger car motor oils (PCMO) and included in respective higher end API PCMO specifications.

This paper outlines the attempts of the authors' laboratory to adopt the above mentioned test procedure for the first time in conjunction with authors' in-house filterability test to develop a meaningful laboratory test protocol for assessing the impact of fuel asphalt on the detergency of trunk piston engine oils (TPEOs). Several blends were screened on these twin methods and also in the common detergent laboratory screening test method-panel coker to arrive at a good candidate formulation. This new protocol will thus, in its fully developed state, may emerge, as a useful screening tool of TPEO's to assess their detergency characteristics in presence of fuel asphalt.

EXPERIMENTAL

Table-1 gives the list of experimental blends of this study. Out of these blends, base blend (A) and benchmark blend (BM) are OEM approved TPEOs conforming to a threshold performance level of API CF.

Table:1: Experimental blends

SNO	EXPERIMENTAL BLEND	CODE
1.	Base Blend+10 % RFO	A+10% RFO
2.	Base Blend+20 % RFO	A+20% RFO
3.	Base blend+ AO-1+10 % RFO	A-AO 1+ 10 % RFO
4.	Base blend+ AO-1+20 % RFO	A-AO 1+ 20 % RFO
5.	Base blend with 50% PD+10 % RFO	AS + 10 % RFO
6.	Base blend with 50% PD+20 % RFO	AS + 20 % RFO
7.	Base blend with high PD+AO-1+20 % RFO	AS-AO 1 + 20 % RFO
8.	Base blend with high PD+AO-2+20 % RFO	AS-AO 2 + 20 % RFO
9.	Base blend with low PD+ 10 % RFO	AAC+ 10 % RFO
10.	Base blend with low PD +20 % RFO	AAC+ 20 % RFO
11.	Base blend with low PD+ AO-1+ 10 % RFO	AAC-AO 1 + 10 % RFO
12.	Base blend with low PD+ AO-1+ 20 % RFO	AAC-AO 1 + 20 % RFO
13.	Base blend with PBO +20 % RFO	A-H +20%RFO
14.	Base blend with PBO+ AO-1+20 % RFO	A-H -AO1+20% RFO
15.	Base blend with PBO+ AO-2+20 % RFO	A-H -AO2+20% RFO
16.	Base blend with low level Extract+AO-1+ 10 % RFO	A Aex-1-AO 1 + 10 % RFO
17.	Base blend with medium level Extract+AO-1+ 10 % RFO	A Aex-2-AO 1 + 10 % RFO
18.	Base blend with high level Extract+AO-1+10 % RFO	A Aex-3-AO 1 + 10 % RFO
19.	Base Blend with low PD+ heavy base oil+AO-1+ 10 % RFO	AAC-HB-AO-1+ 10 % RFO
20.	Bench Mark Oil+10% RFO	BM + 10% RFO
21.	Bench Mark Oil+20% RFO	BM + 20% RFO

AS and AAC are blends formulated with new generation detergents. A-H, Aex blends are formulated with different base oils comprising of more polar components. AO-1 and AO-2 are commonly available commercial antioxidants.

TEOST experiments on neat and fuel-contaminated versions of various experimental blends were conducted in accordance with ASTM D 7907-06 method.

Panel coker, micro-oxidation and filterability experiments were conducted as per the previously published procedures (5-6)

RESULTS AND DISCUSSION

1. TEOST & PANEL COKER RESULTS

I) BASE LINE PERFORMANCE:

FIG.1: Base Line Performance of Base Blends

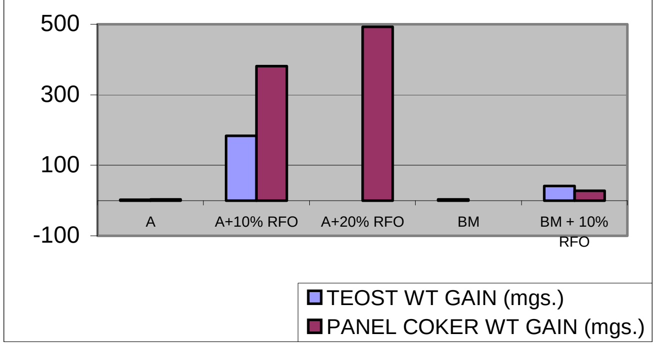


Fig.1 shows the comparison of base blends in their neat and fuel contaminated versions in TEOST and Panel coker weight gain values. Both A and BM blends in their neat versions yielded very minimal (3-5 mg) deposits. However in presence of fuel (both at 10% and 20% concentration levels- higher the fuel content/contamination, higher the deposits), blend A yielded much higher deposits compared to BM. This underlines the basic difference in the nature of detergent chemistry between both A and BM blends.

II).EFFECT OF DETERTENTS:

FIG.2: Effect of Detergents

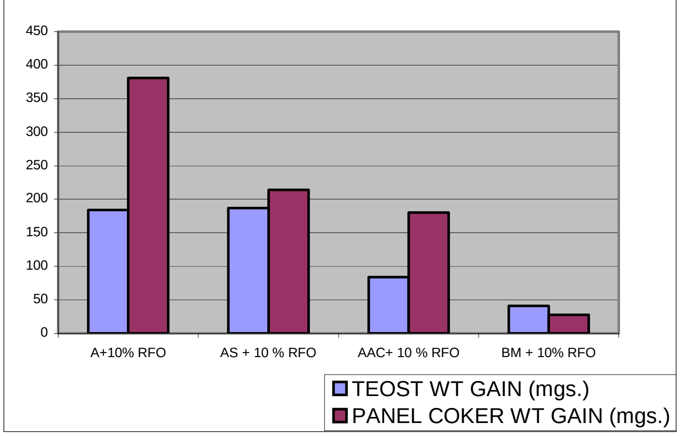


Fig.2 depicts the effect of various detergents on TEOST and Panel coker deposits. Since fuel contaminated versions offer the real time situation, results of those versions are only depicted. From the graph, it is evident that both panel coker and TEOST are discriminating the change in detergent composition from A to AS and AAC by way of reduction of deposits. If we closely observe the cross correlation of TEOST and Panel Coker in the above set of data, it is inferred that though there is no one to one agreement but directional correlation can be ascertained. Above graph, clearly indicates that change of detergent composition is improving the fuel asphalt related detergency but still a perceptible gap among these blends and BM exists.

III)EFFECT OF ANTIOXIDANTS:

FIG.3: EFFECT OF ANTIOXIDANTS

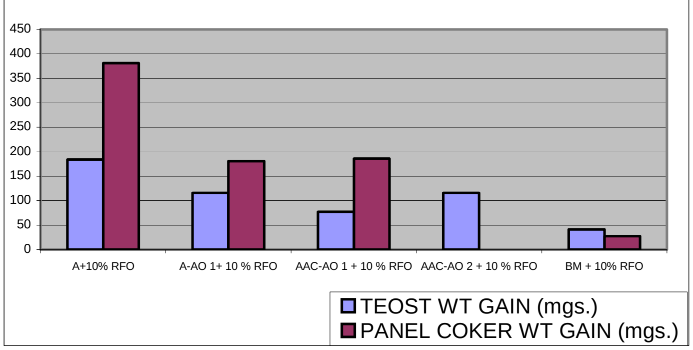


Fig.3 indicates that though their response is varied with different detergents, addition of antioxidants brings about a positive impact in deposit reduction in presence of fuel. In fact AAC-AO-1 almost matched with BM so fare in the investigated experimental blends in yielding lesser deposits in TEOST experiment at 10% fuel concentration.

FIG. 4: MICRO OXIDATION TEST DATA

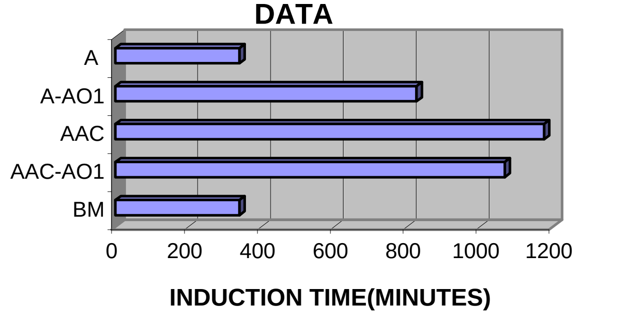


Fig.4 brings about the fact that nature of detergent will decisively impact the oxidation stability of whole blend composition. AAC and AAC-AO-1 blends yield higher induction times in micro oxidation experiments underlining good inherent oxidation stability of AAC compared to A and also good antioxidant response in the former case. It may be noted that all the above data are of neat blends as fuel at elevated test temperatures may pose safety problems and also would not have led to any meaningful results .

IV). EFFECT OF BASE OIL COMPOSITION:

FIG.5:EFFECT OF BASE OIL COMPOSIOTION

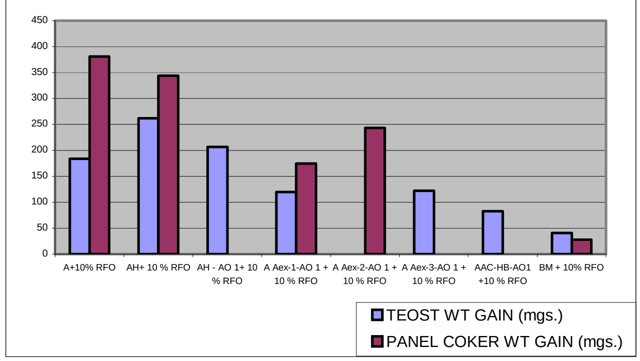
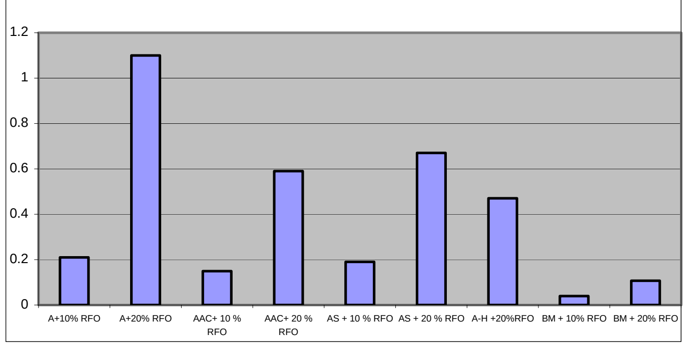


Fig.5 depicts the effect of base oil composition on the deposit-forming tendency of various experimental blends. Results indicate that contrary to known theoretical considerations, base oils with more polar components (AH and Aaex) - in this case could not bring about perceptible reduction in deposits. However, between AH and AAex, the later are slightly better. However, AAC-HB - a blend made out of new generation detergent and heavy base oil combination with antioxidant- could improve the detergency in TEOST almost on par with BM blend. These set of experiments underline the importance of right kind of base oil composition in controlling deposits.

2.FILTERBILITY DATA:

FIG 6: FILTERABILITY DATA



Filterability test is an in-house test procedure which comprises of aging of candidate blend with known amount of fuel and then filtration at hot condition to measure the weight gain of the dried filter paper. As observed in TEOST & Panel coker tests, there is a marked difference in percent sediments yielded by A and BM thus underlining the difference in detergent potential of A and BM blends. However, AAC, in this case also shows consistent promise as exhibited in the TEOST and Panel Coker tests. Thus, AAC is a good candidate to bridge the gap between A and BM with respect to fuel asphalt tackling efficiency.

FIG 7: EFFECT OF ANTI-OXIDANTS ON %SEDIMENTS

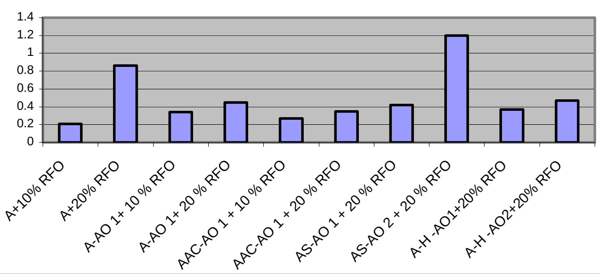


Fig 7 depicts the effect of effect of antioxidants on various experimental blends towards fuel asphalt tackling efficiency as reflected in filterability experiments. Addition of AO-1 antioxidant at AAC blend could really improve the asphalt tackling efficiency almost to the tune of BM blend.

Thus, the combined inference of TEOST-Panel Coker and Filterability experiments is that AAC-AO-1 combination is the most promising towards fuel asphalt tackling efficiency from the that of A blend level and almost on par with BM. In other words, this combined laboratory test protocol could conclusively and consistently throw a promising candidate with good fuel asphalt tackling credentials for next stage of engine test evaluation.

<u>3. EMERGING TEST PROTOCOL</u>

From the foregoing, it is evident that the following plausible test protocol-------

TEOST, Panel Coker and Micro oxidation experiments concurrently at the first stage followed by filterability experiments on select blends at the second stage

would throw up promising candidates with good fuel asphalt tackling efficiency for engine test validation. This protocol, as is seen in the above discussion, could effectively discriminate the detergents, anti-oxidants and base oil composition for the screened property and thus will prove a handy tool.

<u>4.ENGINE TEST VALIDATION:</u>

Single cylinder engine test evaluation, though not very much comparable to the real time situation that trunk piston engine oils encounter, is in progress on base blend A and most promising candidate deduced from the above mentioned test protocol-AAC+AO-1. Though this single cylinder engine test is basically designed to for operating on HSD, we have incorporated some fuel contamination into the candidate blends to attain real time severity.

CONCLUSIONS

- Fuel asphalt, when comes in contact with TPEO through un burnt fuel/blow-by, plates out as black deposit on engine parts-called "Blackening"
- No standard test methods available to assess the fuel asphalt tackling efficiency of engine oils
- An attempt was made to develop a laboratory test protocol for assessing asphalt tackling efficiency comprising of TEOST, Panel Coker and Micro oxidation experiments concurrently at the first stage followed by filterability experiments on select blends at the second stage.
- Through this protocol, various detergents, anti oxidants and base oil compositions were screened.
- Test protocol could deduce some promising candidate, out of a plethora of options investigated with consistent discrimination.
- Single cylinder engine test validation of promising candidate emerged out of the test protocol is in progress.

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