ABSTRACT

Dimethyl Ether (DME) has been known as a ultra clean smokeless fuel for diesel engines for over a decade now. A significant challenge is to ensure full lifetime for the diesel engine injection equipment when handling the low boiling point DME as this fuel has very low viscosity and lubricity.

Pressurised lubricity evaluators show that boundary lubrication additives increase DME lubricity significantly but recent work indicate that adequate performance in quasi-boundary lubrication is necessary for reducing the wear effectively in real pumps. In this regime where the pump surfaces are only separated by a few molecular layers fuel molecular structure and viscosity seem to be important properties.

Earlier work showed that addition of low lubricity alkanes raised the high lubricity of a boundary lubricant to an even higher level. In the present work the long linear alkane n-hexadecane was added to DME in different proportions. The lubricities of the blends do not show any minimum but reflect the lubricity of pure n-hexadecane. It is not conclusive whether DME is a boundary or a quasi-boundary lubricant but clarifying tests are currently in progress.

INTRODUCTION

Dimethyl ether (DME) is an ultra clean diesel fuel that does not form particulate matter during the combustion even at low NOx levels [1]. A very significant issue is that the diesel engine injection equipment tends to break down prematurely due to extensive wear when handling DME. The poor lubrication abilities of the low boiling point DME can be explained by its low viscosity and lubricity. The viscosity of DME was established in [2] to be about 20 times lower than that of diesel oil. The lubricity of DME was measured in [3] to be very poor so the pump break-downs could be explained.

Poor lubricity is a well known problem with low sulphur diesel oil. The currently used lubricity evaluator for diesel oil is the high frequency reciprocating rig (HFRR), a ball on disk wear test expressing the lubricity of a fluid as the resulting wear scar diameter (WSD) on the ball in microns. The pressurised HFFR method [3] also established that the addition of very small amounts of anti wear agents to DME will raise the lubricity significantly. It appears that a high lubricity level is not sufficient for ensuring full lifetime of the pumps in the case of the low-viscosity DME [4]. Testing linear alkanes of different lengths in a pressurised HFRR apparatus revealed that the paraffins show increasing lubricity with increasing molecule length [5,6]. Computer simulations using molecular dynamics have shown that longer alkanes are able to include more atoms into the asperity
contacts than are shorter ones which increases their lubricity [7]. When a few monolayers are left between the surfaces each lubricant layer is squeezed out individually accompanied by jumps in the pressure curve indicating that the lubricant is no longer a fluid but rather a semi-solid. As it seems that the squeeze out of the last monolayers between surfaces is fluid dependent a new lubrication regime could be defined: Quasi-boundary lubrication. In other words it is the bulk fluid contribution to the lubricity whereas the adsorbed anti wear additive dominant in boundary lubrication [5].

RESULTS AND DISCUSSION

In the present study it was chosen to blend DME with n-hexadecane in proportions from zero to 100 percent. The lubricity results using a pressurised HFRR test [3] are shown in figure 1B. In figure 1A the results from [8] are shown. The blends of a aromatics and white oil show a lubricity minimum as shown by curve a) in the figure. Apparently the aromatics are good boundary lubricants whereas the white oil is a better quasi-boundary lubricant. If the fluids were active in the same lubrication regime a straight line illustrated by curve b) in the figure should be expected. Figure 1B shows that the blends of DME and n-hexadecane do not present any significant lubricity minimum. It appears that the lubricity is dictated by the n-hexadecane in nearly any concentration. The reason for this could be that the minimum is less visible here than in [8] because n-hexadecane is a very good quasi-boundary lubricant which overrules the DME performance as a boundary lubricant. Another explanation could be pollution of the n-hexadecane by boundary lubricants which would dominate the lubricity outcome completely.

CONCLUSIONS

Blends of n-hexadecane and DME do not show a significant lubricity minimum apparently due to the dominance of the alkane in the quasi-boundary lubrication regime. The test results seem to indicate that the chosen fluids are not active in the same lubrication regime. Clarifying tests are currently in progress.

ACKNOWLEDGMENT

IMS acknowledges financial support from the European project AFFORHD.

REFERENCES