Tribological investigation of organic and inorganic friction modifiers with varying quantities of dispersants

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Abstract

Friction modifiers are one of most important additives in formulated lubricants for reducing parasitic frictional losses in boundary and mixed regimes of lubrication. A significant amount of energy is lost due to generated friction in internal combustion engines. These losses account for 15% of energy losses, which can rise to 20-30% in urban driving cycles, of which 40-55% are due to piston-cylinder system [1], where 30% of all these losses have been shown to occur during piston reversal at the TDC in transition from compression to power stroke, where the regime of lubrication is predominantly mixed or boundary [2].

Friction modifiers can be widely categorised as organic and inorganic. Inorganic friction modifiers are further differentiated into amphiphilic surfactants and organo-molybdenum compounds, whilst the organic friction modifiers are generally functionalised polymers [3]. Other additives, such as dispersants also play an important role in the growth and removal of tribo-films [4]. The energy required by the additives to bond or adsorb to surfaces to form a tribo-film can be presented in terms of activation energy. The current paper investigates the interaction of dispersant on friction modifier performance.

Eight lubricants with different organic and inorganic friction modifiers with dispersant concentrations are used. The relative performance of these samples is investigated using a precision reciprocating sliding-strip tribometer at different surface temperatures and applied pressures, representative of the piston compression ring-cylinder liner conjunction. The tribometer activates the boundary active species and a tribo-film is formed, which is then characterised topographically and elementally using white light interferometry and X-ray photoelectron microscopy. The tribo-film is also characterised mechanically at asperity level with lateral force microscopy, using an AFM, where a nanoscale hemispherical tip of measured radius is used to measure friction for a normal applied loads. This topographical, elemental and asperity level characterisation of a tribo-film is used to explain the frictional performance of the oil samples at a component level. Figure 1 shows the results of friction measurement with lateral force microscopy of the surface before tribometry.

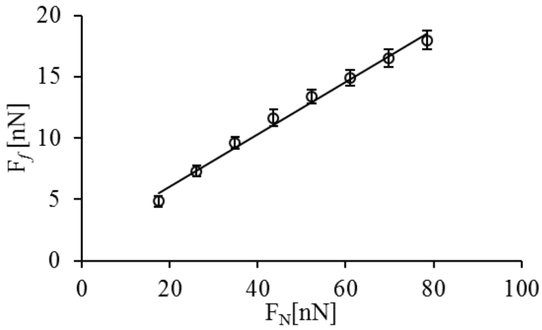

Figure 1: Lateral force microscopy measurement of friction force at various normal loads before tribometry testing

The high temperature slider rig testing shows significant differences in frictional behaviour of inorganic and organic friction modifiers in the presence of a dispersant. These differences only become apparent at elevated temperatures.

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