Novel insight into tribology of carbon black soot particles in engine oils

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Soot particles are the byproduct of fuel combustion and exhaust in a vehicle that contaminates the engine oil. Here we investigate the effect of soot particles on engine oils using EN 52100 ball and disk in Ducom High Frequency Reciprocating Rig (HFRR). Carbon black was used as a surrogate for engine soot and it was mixed at 5 % w/w of an engine oil. Friction test were conducted at 100 deg C using HFRR. Results showed an increase in wear due to carbon black in 0W20, 5W30 and 10W40. Carbon black increased the friction of 0W20 and 10W40 by 14 % and 17%, respectively. However, it decreased friction of 5W30 by 14%. Above results on carbon black were obtained on smooth steel substrate without prior adsorption of surface active molecules from an engine oil. Friction test of carbon black on steel surface with surface active molecules from 0W20 revealed that friction and wear were 4.5 % and 7.5 % higher compared to steel surface without surface active molecules. Wear images (Fig. 1) indicated that surface active molecules on steel would transform the carbon black's smoothening effect (Fig. 1B) to severe ploughing (Fig. 1C). Interaction of carbon black with surface active molecules adsorbed on steel surface is detrimental. Same test was repeated on the worn steel surface with surface active molecules from 0W20. Friction increased by 7 % compared to smooth steel surface with surface active molecules. However, there was no change in wear. This study shows that severity of damage by carbon black depends on the condition of the steel surface prior to test. Carbon black shows poor tribological behavior on worn steel surface with adsorbed surface active molecules compared to smooth steel surface with surface active molecules or smooth steel surface without surface molecules from engine oil.