R. David Whitby

# Fuel-efficient additives

*Lower viscosity, thermal stability and improved detergency are among the properties increasing the mileage in today's cars.*

With the skyrocketing costs of gasoline and diesel fuel, one of the main market drivers for automotive engine and transmission lubricants is improved fuel efficiency. Several approaches are being used to formulate lubricants that contribute to increased mileage. These include lower-viscosity multigrade oils, better oxidative and thermal stability oils that retain their lubricating properties for longer and improved dispersion, and detergency for better control of soot and oxidation products.

One of the most productive ways of obtaining fuel efficiency benefits is friction-modifying additives. These are a special class of boundary lubricant additives that are very effective at controlling friction and wear, provided the temperature is not high enough to cause either additive decomposition or desorption from metal surfaces. The most potent types are effective down to zero sliding speed (no oil wedge), where they reduce the coefficient of static friction significantly.

There are two types of friction modifiers:

- **Friction reducers**. These provide higher lubricity and lower coefficients of friction. Typical compounds are long-chain molecules with highly polar groups to anchor the molecule to the metal surface. The best products result in lower heat generation and, therefore, less wasted energy.

- **Friction enhancers.** These provide a high static coefficient of friction in automatic transmissions that require a fast lockup to avoid excessive clutch slip and consequent wear. Additives to enhance static and low sliding speed friction include detergents, sulphides and other compounds, which are attracted to the surfaces but provide little lubricity.

Friction reducers enable smoother gear changes but can result in excessive slip and wear of clutches if taken to extremes. Carefully balancing combinations of antiwear and friction-reducing additives with those that promote high coefficients of static friction result in transmission fluids that provides a positive lockup when the clutch is applied but which aren't too harsh.

Conventional friction reducers are fatty oils, acids and amides, organophosphorous acids and esters and molybdenum-based compounds, particularly molybdenum dialkyldithiocarbamates (MoDTC). Recently, some additive manufacturers are developing improved friction modifiers and additive combinations to achieve even better fuel efficiency.

For example, Lubrizol has been using a Friction Torque Test (FTT) rig to screen new friction modifiers before using them in fully formulated engine oils which are tested for fuel efficiency in the CEC-L-54-T-96 M111FE engine test. Lubrizol has developed a "premium organic" friction modifier that has given better results than oils containing MoDTC in the engine test.

Infineum has investigated the performance of MoDTC compounds when they're combined with zinc dialkyldithiophosphate (ZDDP) antiwear additives, using a Mini Traction Machine (MTM) and atomic force microscopy (ATM). When MoDTC was added to a preformed ZDDP film on a steel surface, the thickness of the film dropped immediately before stabilizing. After one hour of rubbing in the MTM, the coefficient of friction was lower than either the ZDDP or MoDTC films alone.

Similar results were obtained with mixed ZDDP and calcium sulphonate detergent films when MoDTC was added. Infineum concluded that MoDTC is a very effective friction modifier when rubbed on antiwear film surfaces, but the friction reduction efficiency depends strongly on the roughness and nature of the surface and the rubbing conditions.

AkzoNobel has investigated tertiary fatty amines as friction modifiers, using the High-Frequency Reciprocating Rig (HFFR). Better lubrication and friction reduction was obtained with saturated alkyl chains compared with unsaturated alkyl chains. AkzoNobel believes this is due to the lower solubility of saturated chains in highly paraffinic mineral oils and better absorption on metal surfaces.

Methylated amines were found to be better than alkoxylated amines because the smaller polar head contributes to a better amine film. More ethoxylation was not good for lubricity because the bigger head disrupted the packing and continuity of the amine film.

The improved understanding of the mechanisms of action of friction modifiers is certain to lead to further developments and, eventually, to engine and transmission oils with even better fuel efficiencies. TLT

*David Whitby is chief executive of Pathmaster Marketing Ltd. in Surrey, England. You can contact him at* ***pathmaster@dial.pipex.com.***