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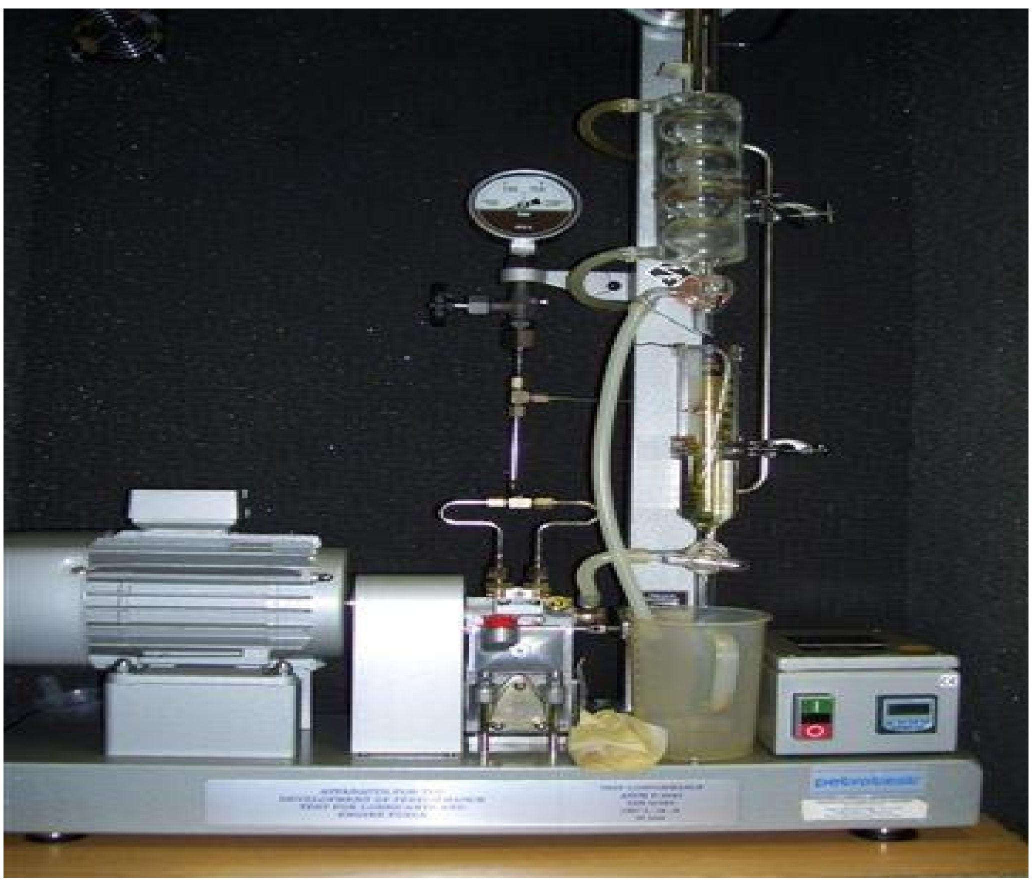
Shear Stability and Test Methods Discussed

Polymers used as viscosity modifiers in oil have three critical attributes: improved viscosity index, enhanced thickening efficiency, and appropriate shear stability. Shear stability predicts the performance of polymer degradation under shear stress and, as a result, viscosity decreasing under actual operating conditions as a compressor oil, hydraulic fluid or motor oil. While simple test methods readily measure VI and thickening efficiency, the polymer shear stability is testing is more elaborate and is generally measured by the Sonic Shear Test-ASTM-D2603-01 or Mechanical Shear Test (ASTM D6278) or Kurt Orbhan. ***It is our conclusion that the mechanical test method simulates the real shear stress and because of this is best suited for prediction of performance of polymers in real applications***.

Polymer containing oil is sheared by passing 170 ml through a diesel-injector nozzle and a two –cylinder fuel injection pump system for 30 cycles. Kinematic viscosities are measured on the sheared and unsheared oil. Samples in accordance with ASTM D445 at 100° C. PSSI is calculated from the viscosity results generated.

$$PSSI = \frac{\eta^1 - \eta^2}{\eta^1 - \eta^3} \times 100$$

Where η^1 is viscosity on unsheared oil, η^2 is the viscosity of the sheared oil, η^3 is the viscosity of the base oil.



Ultrasound waves do not directly interact with the polymer molecules, but produce physical phenomena in liquids that create conditions to drive chemical reactions. The effect of ultrasound on polymers may be best explained by fatigue and cavitation. The very high local temperature and very high local pressure could be the reason for the cleaving of the chemical bonds between carbon atoms in polymer molecules randomly distributed in the oil. The stress appears in randomly distributed micro areas, however, it does not simulate the real dynamics and conditions in steady shear flow. This situation is very far from real conditions.
In the mechanical shear stress test, the PSSI is calculated from the viscosity change after the oil has been cycled through and injector nozzle according to ASTM 6278. Every liquid has some measure of viscosity; therefor, the fluid velocity profile in the pipe is distorted from the ideal scenario where the viscosity is equal to zero. The flow of Newtonian fluids will exhibit a sticking effect on the walls of the pipe. The velocity is zero at the pipe wall and increases parabolically (when laminar) with flow, reaching a maximum at the pipes center. Turbulent flow is similar to the laminar flow velocity profile. It is clear that laminar or turbulent flow is accompanied by real shear stress. Polymer molecules are distributed throughout the liquid and any cross section including a polymer molecule can be described by the same, parabolic flow profile. In these conditions, the velocity at the upper end of the molecule, nearest the parabola's focus will be greater than the flow velocity a the lower end, farther from the focus.

This is a classic condition of shear stress on a polymer molecule. At the beginning of flow, we have coils of polymer molecules, which start to uncoil in the flow direction. Randomly, some part of these molecules will keep positions and some will be destroyed by shear stress. In the mechanical device a large number of cycles (passing through injector nozzle) occur and a some polymer molecules will be destroyed under shear stress. Because of the same condition of flowing through the nozzle (pressure, temperature) the results are reproducible and the main point that the condition of flowing and polymer degradation simulate the real flow in engines and can be used for prediction of polymer shear stability.

To have your polymer tested, please contact Functional Products. To review our line of lubricant additives, click Applications Chart or you may request a hard copy by calling our offices. All technical data sheets are on our web site. www.functionalproducts.com