

BOUNDARY FILM LUBRICATION THROUGH ADVANCED HALOGENATION TECHNIQUES:

OXIRANE ACID SCAVENGING & ORGANO-METALLIC SUBSTITUTION

MPC's lubrication technology is based on Tribologic methods that improve lubricity and load carrying capacity by improving surface characteristics and creating a stable, chemical, corrosion-controlled, halide boundary film. The keystone of MPC's product line is MT-10 Metal Treatment™, a blend of highly refined oils and proprietary additives that contain no solid lubricants, chlorinated solvents, or phosphate compounds. Its active components react with each other and the contacting asperities of the metallic surfaces to provide five mechanisms of improvement:

1. Advanced chemical boundary film formation through reactive chemical bonding.
2. Ring opening, oxirane acid scavenging and advanced corrosion inhibition.
3. Organo-metallic substitution of surface metal and free radical reactionaries.
4. Improved surface smoothness and rolling out of irregular contacting asperities.
5. Re-hardening and latticular reconstruction of initial contacting metal surfaces.

The process of advanced boundary film formation is accomplished with an advanced combination of halogens that are controlled and rendered noncorrosive to the base metals of the system. These halogens pose no threat to the ozone layer or waste oil recovery systems due to their origins and long-chain molecular lengths. They initially react under thermal conditions with the organo-metallic reagents to form surface attaching compounds, thereby limiting and controlling the formation of halides from the base metals.

These surface-attaching reagents, or "electronegative compounds," seek out and affix themselves to the lower surface areas, referred to as micropores and fissures, as all metals are crystalline in structure and exhibit a lattice-type matrix. This complex process also incorporates Van der Waal forces and dipole-dipole surface reactions. During this process, surface lapping and asperity (irregular microscopic contacting and opposing surfaces) roll-out is also achieved, yielding improved spread characteristics of the surfaces. Due to the increase of film strength by the filling of the micropores and fissures, along with thermal modification of the asperities, the result is a gradual rolling out, or flattening, of the metal asperities, rather than a breaking off or chip-away process, which would create metallic debris in the lubricant leading to abrasive wear from wear metal particles. The resulting improvement in the opposing metal surfaces further increases the fluid film strength, which is dependant on the degree of surface roughness and viscosity. Viscosity, however, is a lesser consideration when incorporating boundary additives or halogenation techniques.

In general, boundary friction and wear consist of two components, a shear or adhesion component and a plowing or deformation component. Consider the following equation:

$$F_s = S A_r$$

Where 'Fs' is the shear component, which predominates except when asperities sink too deeply into a boundary lubricant film or a soft opposing surface. When movement or sliding occurs, the shear friction force depends on the shear resistance per unit area, 'S', of any "boundary film" in the real load-supporting area between asperities. Dividing by the load, 'W' gives the shear contribution to the friction coefficient, becoming independent of total load and apparent area of contact:

$$f_s = S * A_r / W = S / T_p \text{ or } S / P_e$$

The boundary film shear resistance, 'S', is assumed equal to the plastic flow shear stress, 'Tp', of an ideal elastic, plastic solid. Such a solid gives shear stress independent of strain and strain rate at strains sufficiently large enough to cause plastic flow. The conditions that produce the "glass transition" from liquid to plastic-like behavior are dependent on the viscosity of the material at normal temperatures and pressures and the variation of viscosity with temperature and pressure. In other words, glass transition depends strongly on chemical composition.

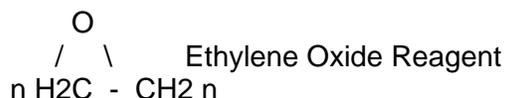
The results show that liquid lubricants act like plastic solids in the films between asperities. Therefore, $S = T_p$ in the previous equation, and the friction coefficient is T_p/P_p or T_p/P_e . Since T_p is a weak function of temperature and pressure, and P_p or P_e are independent of apparent contact load, the frictional coefficient for a given combination of lubricant and sliding surfaces tends to be independent of operating conditions.

Elasto-hydrodynamic lubrication (ELH) on an asperity scale deposits film material between sliding surfaces in "micro-rheodynamic" (micro-RHD) lubrication. As one surface slides, each asperity carries with it an aggregation of MT-10. Sufficient pressure and temperature is developed within the film to elastically deform the asperity and to force MT-10 between the surfaces or into the micropores and fissures. During this time, high thermal conditions involving pressure and asperity contacts initiate a rehardening of the surfaces and a quenching and cooling by the oil to establish this process. A thermal restructuring of these asperity contact areas creates a deviation from the normal crystalline structure of the metal, expanding it into an austenitic crystalline pattern, which is more loosely structured and allows the MT-10 to impregnate the actual lattice of the metal, endowing it with new hardness and frictional properties upon cooling.

Organo-metallic substitution is a technique developed and designed to inhibit the process of halide formation from the base metals of the system under reaction. For example, instead of the halogen reacting with the iron in the system to form iron halides, a boundary surface salt, it reacts with a reagent having very similar properties to the iron atom itself, thereby forming an organo-metallic complex without scavenging the target metal surface itself, and depleting the metal in a chemically corrosive wear syndrome. The process is very similar or analogous to the saponification of organo-metallic compounds in the manufacturing of greases. During this reaction, or saponification, compounds react at a certain catalytic temperature and exchange characteristic components to form new compounds. These new chemical compounds are then used

to aid in a boundary regime by providing an added protection to the actual surfaces being lubricated.

Ring opening oxirane acid scavenging and corrosion inhibition is another chemical technique developed by MPC to neutralize acids and inhibit oxidation and corrosion. This technique involves the use of specifically engineered complex ethylene oxide: oxirane rings, that possess reactive reagents which will cause a cleavage of the ring when encountering acids or strong alkalines. These reactions occur in the presence of both anionic- and cationic-type catalysts. Anionic catalysts can include alkoxide ions, hydroxides, metal oxides, and some organo-metallic derivatives while Lewis acids and protonic reagents initiate cationic reactions.



This entire process comes together to perform in a manner that is not equaled by any other process or product in the marketplace. The lubricity, load carrying capacity, surface improvement, and wear reduction are greatly improved, while corrosive aspects of halogenation are virtually eliminated.

References:

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