CRITICAL TO A GEAR'S OPERATION is the lubrication type and method of application. Lubrication is a science and for new applications consulting with the supplier/manufacturer is advisable.

As we are all aware, gear tooth meshing action subjects the tooth flank contacting surfaces to destructive damage. Lubrication should alleviate this damage, improve the efficiencies and dissipate the heat. These surfaces that are subject to friction, even when properly lubricated, can generate enough heat to raise the temperature of any high spots beyond their melting point.

Under a number of different conditions, lubrication should slow and even prevent this deterioration. Assisting the work of the lubrication is the selection and treatment of the gear's material, including the geometry of the teeth, surface finish, and application of the lubricant in the correct quantity and location. The lubrication film thickness must reduce the possibility of service failure from scuffing, tooth flank fatigue failure, micropitting and pitting in and of itself. The lubricant's function is to reduce the frictional resistance and thereby improve efficiency, and as a consequence, generate less heat. It is now several decades since the common belief was that just adding oil or grease between the mating surfaces would bring about the desired result.

The Exxon Company lists three P's as the challenge for industrial lubricants “Performance, Protection, and Prevention.” When the friction is reduced there will be a corresponding reduction in the wear rate, and corrosion, scoring and welding, and an improvement in oxidation resistance.

In an enclosed gear system it is also essential to promote the rheology of oil and provide resistance to water contamination. An enclosed gear unit is constantly breathing in the surrounding atmosphere and then expelling it, leaving moisture behind along with oxidation. With the exception of hypoid gears, all other gear teeth have pure rolling contact at the pitch line, and in all other positions, a sliding action. Hypoids have some sliding even at the pitch line and their early introduction was hindered by the lack of a suitable lubricant.

Conditions and the type of tooth form affect the lubricant selection, including the pitch velocities, the loads, ambient and operating temperatures, humidity, oil change periods, and compatibility of seals and paints. In the theory of lubrication between any two surfaces that have relative motion there exists either a thick film (hydrodynamic) or thin film (boundary). The former is associated with the sliding action. Elasto-hydrodynamic is the term associated with a film’s thickness present with rolling action.

Rheology is the term for the study of a lubricants flow, deformation, and its viscosity. The theory considers four conditions that can exist at the point of contact between two mating surfaces. These are hydrodynamic, elastohydrodynamic (EHD or EHL), Boundary, and Quasihydrodynamic.

In the first condition the oil film is thicker than the roughness. The contact stress does not significantly deform the contacting surfaces. In the second condition the oil film is considered to be the same thickness as the roughness of the two surfaces. In the contact zone elastic deformation takes place with high-speed gears, this must be taken into consideration. The EHD film is the result of the elastic deformation of the surfaces and the lubricant's hydrodynamic action. The third condition boundary is the most complex. This is the thin film in which surface to surface contact takes place. There are five classes of boundary lubricants and they include polar and Extreme Pressure. In the EP a boundary film is formed by the chemical reaction between the anti scuff additives and the metal surfaces. This condition is frequently found when the gears are open and slow running. The film thickness may be less than the surface roughness. The film must withstand greater mechanical stress and higher temperatures than the bearings. The last condition is a transition stage between boundary and EHD conditions. The surface-to-surface contact increases with the film thickness reduction. The accepted Blok’s Contact Temperature Theory states: “Scuffing will occur in gear teeth that are sliding under boundary-lubricated conditions when the maximum contact temperature of the gear teeth reach a critical magnitude.” Tests have concluded that it is more important for the lubricant film to minimize the generation of heat - thereby reducing the lubricant's temperature rise - than selecting a lubricant for its potential in heat removal. The lubricant film thickness and temperature will determine the effectiveness of the lubrication.

Gear teeth function in three temperature zones. They start in an ambient condition that continues to rise from the friction until a steady state is reached. At this level the heat entering the gear equates with the heat leaving the gear. The distribution of the heat is affected by the lubrication. We have contact and bulk temperature; the latter is calculated at the contact points along the contact path. It is the temperature that is considered to be in equilibrium attained by the gear teeth prior to entering the mesh, and it can be significantly higher than the lubricant. During the meshing, each tooth face will experience a sudden temperature rise, and 80 degrees F is not unusual. The temperature is restricted to the immediate contact area, so almost immediately the temperature is dissipated into the gear and is known as the Flash temperature.

Proper lubrication reduces frictional resistance and heat and thus improves the gear efficiency.

ABOUT THE AUTHOR:

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