A Study of Elastohydrodynamic Lubrication under the Influence of Surface Roughness and Application to Gears

Abstract

In machinery applications, lubrication plays a critical role in ensuring reliable operation and extended service life of components. The purpose of this work is to present the mechanisms of lubrication, and primarily that of Elastohydrodynamic (EHD) lubrication, as multi-factorial phenomena, focusing particularly on the influence of roughness of the lubricated surfaces and temperature, factors which have often been neglected in previous studies. Moreover, the importance of detailed tribological study in the design of machine elements is emphasized, in this case the study pertains to spur gears. The study is conducted computationally, by modeling and solving the problem based on the finite difference method.

The work begins with a comprehensive introduction to lubrication principles and the variety of lubricants used in industrial applications. This is followed by an examination of the fundamental mechanisms governing fluid lubrication. Subsequently, EHD lubrication is studied separately, including its characteristics and the parameters that affect it.

For accurate modeling of the multi-factorial nature of EHD lubrication of non-conformal surfaces and for solving the fluid dynamics problem, the Reynolds equation is presented and explained as the fundamental equation governing the problem. The finite difference method is then presented, and the approach to solving the Reynolds equation is explained.

Surface roughness, as a key parameter affecting lubrication, is thoroughly analyzed. Specifically, the characteristic quantities and parameters influencing surface texture are explained, and the importance of correct measurement of the active surface for modeling is emphasized.

With these theoretical tools, the work presents a computational model that solves the problem of one-dimensional EHD lubrication under the influence of roughness.

To highlight the importance of roughness and correct measurement of its profile, a parametric study is conducted with three different roughness measurements, from which valuable conclusions are drawn. Additionally, another parametric study is carried out to demonstrate the importance of the ambient temperature at which the lubricant operates.

Finally, utilizing the conclusions from all of the above, a tribological study of a pair of spur gears is conducted for their critical operating phases.

Key Words:
[Lubrication Theory, Elastohydrodynamic Lubrication, Roughness, Finite Difference Method (FDM), Fluid Mechanics, Computational Methods, Spur Gears]