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ELASTOHYRODYNAMIC LUBRICANT FILM FORMING OF DIFFERENT BEARINGS

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ABSTRACT

The formation of the lubricant film between the mating bearing surfaces is called the elastohydrodynamic (EHD) mechanism of lubrication. The two major considerations in EHD lubrication are the elastic deformation of the contacting bodies under load and the hydrodynamic effects forcing the lubricant to separate the contacting surfaces while the pressure of the load is deforming them.The lubricant film thickness between two contact surfaces can be related to bearing performance. The thickness of the generated film depends on operating conditions such as velocity, load, lubricant viscosity and the relationship of pressure to viscosity.Analytical relationships have been developed for calculating minimum and average film thickness for successful bearing performance.

In this study film thicknesses of two different bearing under the same condition is investigated.

Keywords: Elastohydrodynamic lubrication, film thickness, angular contact ball bearing, spherical roller bearing

1. THE GEOMETRIES OF SPHERICAL ROLLER AND ANGULAR CONTACT BEARINGS

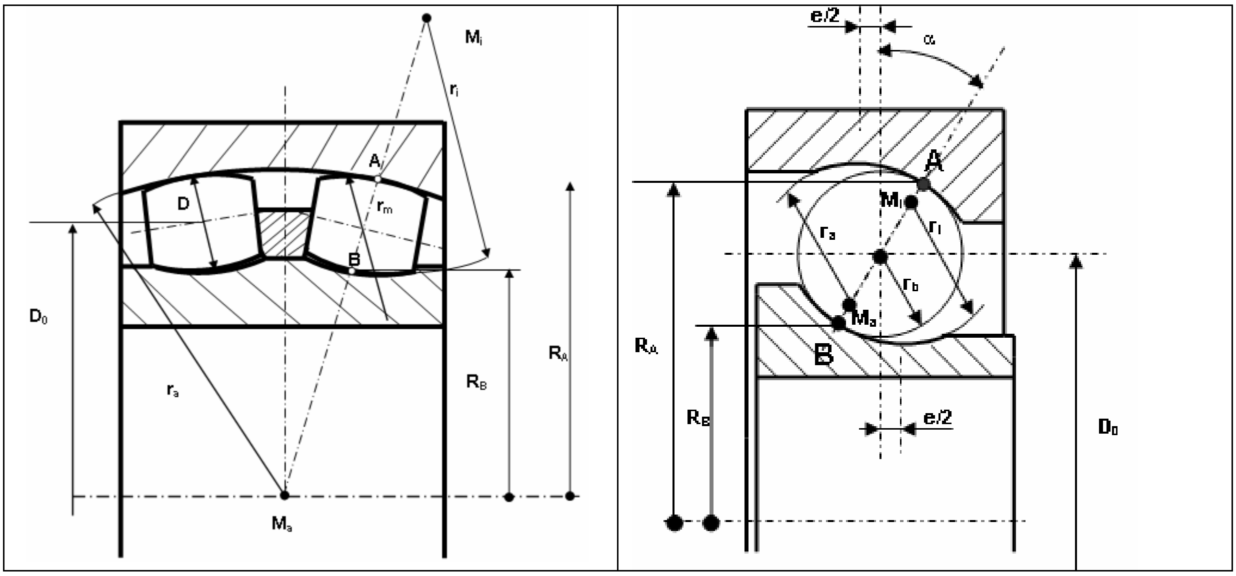


Figure 1. The geometries of spherical roller and angular contact bearings respectively [4,5,8].

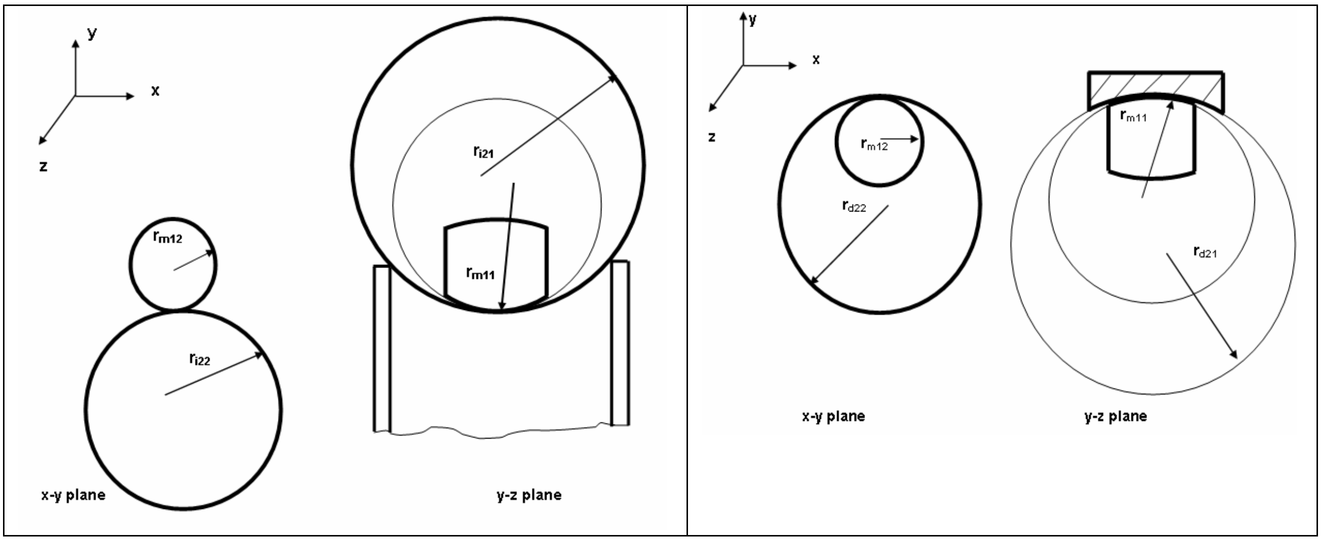


Figure 2. The equivalent curvatures between the inner ring and roller and the outer ring and roller for spherical roller bearing [5].

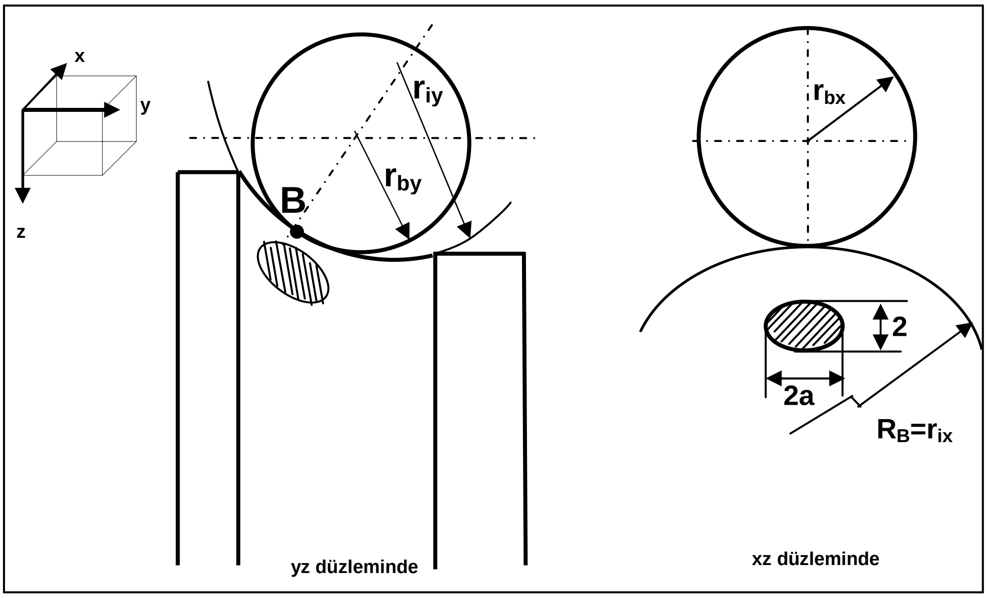


Figure 3. The equivalent curvatures between the inner ring and ball for angular contact ball bearing.

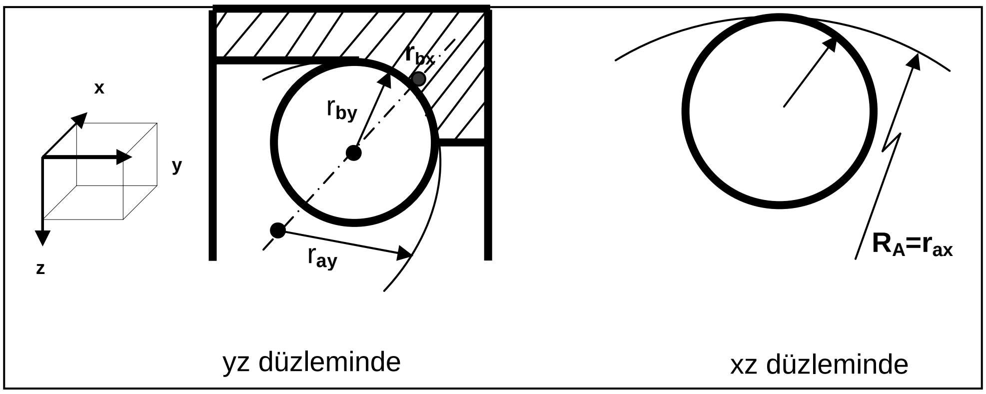


Figure 4. The equivalent curvatures between the outer ring and ball for angular contact ball bearing.

2. ELASTOHYDRODYNAMIC LUBRICATION THEORY

There are four kinds of lubrication regimes (izoviscos-rigid, piezoviscos-rigid, izoviscos-elastic and piezoviscos-elastic) at elliptic contacts [6]. In this approach elastic-piezoviscous regime has been used. ($g_E \neq 0$, $g_V \neq 0$)

Elastic-Piezoviscous Regime: This is the regime of *hard EHL*. The elastic deformation of the surfaces can be orders of magnitude larger than the thickness of the film and the lubricant viscosity can be orders of magnitude higher than its bulk value Hamrock and Dowson [7]. The related equations are mentioned below:

$$g_H = \psi(g_V, g_E, \kappa) \tag{1}$$

$$g_{H\min} = 3{,}42 \cdot g_V^{0{,}49} \cdot g_E^{0{,}17}\left[1 - e^{-0{,}68\kappa}\right] \tag{2}$$

$$g_H = \left(\frac{W}{U}\right)^2 \cdot H \tag{3}$$

$$g_V = \left(\frac{G \cdot W^3}{U^2}\right)^2 \tag{4}$$

$$g_E = W^{8/3} \cdot U^2 \tag{5}$$

$D_0=R_A+R_B$ (Figure 1) (6)

$\text{Cos}\alpha=(\ell_m\text{-}c/2)/\ \ell_m=1\text{-}c/(2\ell_m)$ (7)

$\ell_m=r_i+r_a-2r_b$ (for angular contact ball bearing) (8)

$l_m = r_i + r_a - 2(r_a - D_o/2) = r_i - r_a + D_o/2$ (for spherical roller bearing) (9)

Film thickness parameter:

$$H = h_0 / R \tag{10}$$

Load parameter:

$$W = F / E^{'}.R.L\,, \qquad E^{'} = \frac{2}{\dfrac{1-\nu^2{}_1}{E_1} + \dfrac{1-\nu_2^2}{E_2}} \tag{11}$$

Speed parameter:

$$U = \mu_o.\tilde{u} / E^{'}R\ , \qquad \tilde{u} = \frac{|\omega_a - \omega_i|\left|D_o{}^2 - (2.r_b)^2\right|}{4.D_o} \tag{12}$$

$$r_{bx} = r_{by} = r_b \tag{13}$$

Materials parameter:

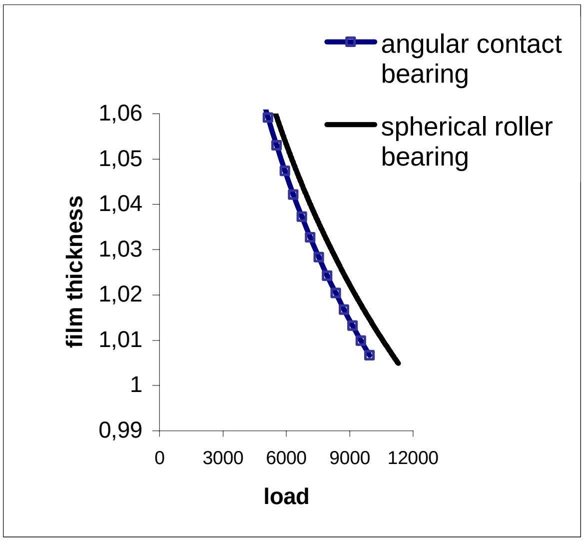
$$G = \alpha.E^{'} \tag{14}$$

Table 1.Film thicknesses of two different bearing .

Film Thickness	*For Angular Contact Ball Bearing* $(h_{\min} = R_x.H_{\min})$	*For Spherical Roller Bearing* $(h_{\min} = R_x.H_{\min})$
The film thickness between the inner ring and ball or roller	$\frac{2r_b(D_o - 2r_b.\cos\alpha)}{2D_o}.H_{\min}$	$\frac{D(D_o - D.\cos\alpha)}{2D_o}.H_{\min}$
The film thickness between the outer ring and ball or roller	$\frac{2r_b(D_o + 2r_b.\cos\alpha)}{2D_o}.H_{\min}$	$\frac{D(D_o + D.\cos\alpha)}{2D_o}.H_{\min}$

3. RESULTS

In this study the geometry and EHL film thickness of two different bearings have been compared. Film thickness decreases appurtenant to load and increase to viscosity for two different bearing.



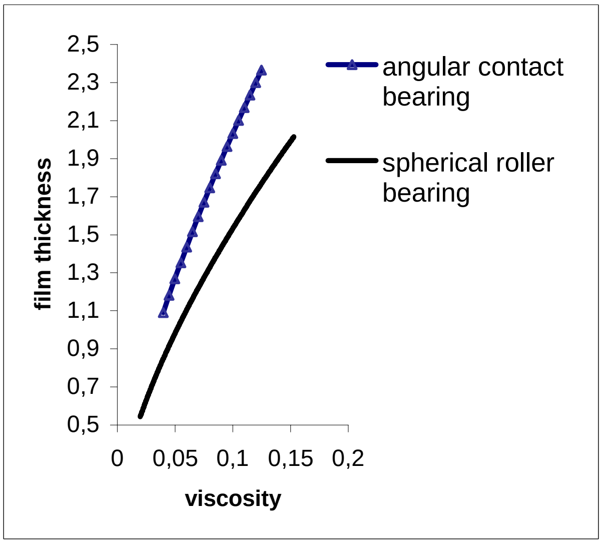


Figure 5. Relation between film thickness and load. Figure 6. Relation between film thickness and viscosity

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