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DISCUSSION

T. L. Merriman[1]. I would like to complement the author for his contribution on this complex subject. My first comment is with respect to the practical range of application of the authors results. The reader notices, by comparing Fig. 2 and Fig. 7, that as the speed of the bearing was increased, the lubricant film increased substantially such that the effect of surface roughness on contact stresses was greatly diminished. By calculating the dimensionless U parameter for several practical bearing geometries at various speeds, such as given in Tables 1 and 2 attached to this discussion, one finds that the U values are equivalent or higher than that given in Fig. 7. For example, a common electric drill motor would have $U = 13 \times 10^{-11}$ as compared to the authors $U = 11 \times 10^{-11}$ in Fig. 7. The conclusion is that for many bearings of practical application the lubricant film overwhelms any surface roughness effects.

Table 1 Calculation of average rolling velocity (u, m/s) for various bearing geometries

Ball radius, m	Pitch dia, m	Bearing speed, rpm			
		300	1800	3600	30,000
0.001	0.008	0.06	0.38	0.75	6.28
0.002	0.016	0.13	0.75	1.51	12.57
0.003	0.024	0.19	1.13	2.26	18.85
0.004	0.032	0.25	1.51	3.02	25.13
0.005	0.040	0.31	1.88	3.77	31.42
0.006	0.048	0.38	2.26	4.52	37.70
0.007	0.056	0.44	2.64	5.28	43.98
0.008	0.064	0.50	3.02	6.03	50.27
0.009	0.072	0.57	3.39	6.79	56.55
0.010	0.080	0.63	3.77	7.54	62.83

A second comment concerns the range of surface roughness considered. The author concludes, and I concur, that for the cases considered the surface roughness did not significantly affect the depth at which the maximum shear stress occurred. There are some tribological applications, however, that would employ machine components of significantly higher roughnesses than highly polished bearing races. A finely ground surface, for example, could have an $R_a = 0.17$ μm (or greater), which the author indicated would create a maximum shear stress at the surface and reduce fatigue life. My thought therefore is that although bearing life is not strongly affected by typical roughnesses, certainly there may be other machine components that would be affected, particularly if the component is in a dry contact or boundary lubricated regime.

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Table 2 Calculation of dimensionless speed parameter, (U)

Variable speed electric hand tools	13×10^{-11}
washer/dryer electric motor	80×10^{-11} to 160×10^{-11}
router, or aerospace bearing	1300×10^{-11}

Author's Closure

The author would like to thank Mr. Merriman for his in-depth discussion of the paper. The speed considered in the analysis is lower than the speeds that bearings in everyday machine components are operating. However, as the analysis indicated for a typical surface roughness, as the speed was increased the effect of surface roughness became negligible. Therefore, in order to investigate the conditions under which the surface roughness became important the speed was reduced. The authors also agrees with the discusser that many machine components have surface roughnesses that are significantly higher than the surface roughness considered. However, one of the objectives of this study was to compare the fluid models effects on the internal stresses of rough surfaces. Although there is a condition considered in this study where the surface roughness was substantially increased (doubled) for a moderate load and speed, which showed that the maximum shear stress occurred on the surface. I agree with Mr. Merriman that this study seem to indicate that typical surface roughness do not significantly effect the fatigue life of bearings. However, this certainly is not the case for the dry contacts.

