# Abstract

Rolling bearings are widely employed in mechanical systems/assemblies to support and guide the rotating/oscillating rotors energy efficiently. Among the family of rolling bearings, about 80% bearings employed in machines, mechanical systems, and appliances have been found to be ball bearings due to their involved low friction, low noise, and simplicity in lubrication with grease. Among the ball bearings, radial ball bearings are largely used due to their efficient functioning even in presence of combined loadings (with axial and radial loads). It is also found that approximately 90% of the rolling bearings are grease lubricated because of their better leak resistance, seal ability from dust and dirt, and reasonably good tribological behaviours at the economical cost. Inadequate lubrication has been reported as one of the major reasons of bearing failures, accounting around 43% of the total bearing failures. Thus, improving lubrication in rolling bearings by enhancing lubricants' availability/retainability in the vicinity of the contacts of races and rolling elements is a vital task for achieving better tribo-dynamic performances and life of rolling bearings. Moreover, large amount of the lubricant, particularly grease is normally pushed aside from its track by the rolling elements during their motions (rolling/ sliding) or thrown away due to the centrifugal action. This forces the bearings to operate in the starved lubricating condition. Moreover, the displaced greases hardly return back to the balls' tracks on their own due to their high yield strength as compared to oils. Hence, exploring the techniques for enhancing effective lubrication by improving the retainability of greases at (and in the vicinity of) the contacts between balls and races to improve the overall performance behaviours of ball bearings is a vital research task.

Hence, it is planned to develop new micro-grooved and textured radial ball bearings keeping in core about how to improve the effective lubrication for reducing the frictional torque, vibrations and fatigue life by enhancing lubricant retainability. Thus, in this work it is proposed; (a) To develop a radial ball bearing by introducing a micro-groove on the outer race for enhancing the lubricant retainability/availability and consequently improving the tribo-dynamic performances (i.e., increase in lubricating film thickness, decrease in frictional torque, and reduction in vibrations) and fatigue life, (b) Compare tribo-dynamic performances of micro-grooved and conventional radial ball bearings employing three different grades of lithium soap-based greases (NLGI grade 000, 2 and 3) to understand the effectiveness of the grease grades in lubrication, and (c) Explore the tribological and vibrational effect of micro-textures present in the vicinity of contacts formed between the race and balls in radial ball

bearings and also to understand the effect of micro-textures on the extended/fatigue life of ball bearings.

The experiments have been carried out employing an indigenously designed test rig. It is found that in radial ball bearings possessing micro-groove on stationary outer race, has yielded reduction in frictional torque by 15-30%, decrease in overall vibrations (RMS velocity) in the range of 14-41%, and about 11% reduction in the capacitance (i.e., up to 11% increase in the film thickness) as compared to conventional bearings at various operating parameters. Also, the experiments carried out to check the life of the micro- grooved bearings, indicate improvement in fatigue/extended life in micro-grooved bearings i.e., longer life as compared to the corresponding conventional cases. Furthermore, the effect of different grades of greases (NLGI 000, 2 and 3) have also been explored on the micro-grooved bearings at different operating parameters. In micro-grooved bearings about 11-19 % reductions in capacitance (i.e., improvement in film formation), 14-26% lower frictional torque, 10-24 % reduction in temperature rise and 9-23 % lower vibration level have been observed as compared to the conventional bearings. Moreover, the reduction in vibration level in micro-grooved bearings using higher grease grades (2 and 3) is better as compared to that using 000 grade grease, but the reduction in frictional torque with low grease grade (000) is higher due to less viscous heating loss.

At the last, the thesis reports effect of circumferentially created micro-dimples in vicinity of the contact region on the inner race of a deep groove ball bearing to enhance the availability of grease at the ball and race interfaces. The experimental results show significant improvement in film thickness formation in terms of capacitance (i.e., 10-17% reduction in capacitance) and also, 4.8-24.5 %, 10-28 % and 14-23% reduction in overall RMS vibration level, frictional torque and bulk temperature rise respectively. Moreover, significant enhancement in bearing life also has been achieved in presence of micro-dimples as compared to the conventional cases.

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