Abstract

Gearsets play vital role in the transmission systems of industrial machines and vehicles (buses, trucks, earth moving machinery, loco-engines, cars, marine engines etc.). Therefore, there is increasing demand for hard and efficient working gearsets possessing very high gear transmission density and long life for use in several mechanical systems. In this situation, the improvement in the tribological performance at the gear teeth interfaces is needed for preventing the surface failures and controlling the vibration. Elastohydrodynamic, mixed or boundary lubrication regimes occur between the contact of the mating teeth surfaces of gearsets due to its high non-conformity. This increases friction at the teeth contacts. Thus, the existence of effective lubricating film at the gear teeth interfaces is necessary to avoid the gearsets operation under mixed/boundary lubrication regime even in the existence of starved lubrication at elevated loads and slow speeds. It is worth noting here that since recent past, the tribological performance in gearsets operating in boundary lubrication regime is being improved by employing nano-lubricants, extreme pressure additives and increase in teeth surface hardness and surface finish. It is widely reported by the researchers that the improvement in tribological behaviour at gear teeth interfaces leads to reduced dynamic problems and increased life/reliability of gear transmission systems.

After the emergence of surface textures as technology, the researchers are exploring to improve the tribological and vibration behaviours of conformal and non-conformal contacts using different surface textures. These studies have shown significant reductions in the friction and vibration. However, careful selection of various texture parameters such as texture density, depth, dimensions, and texturing methods are extremely important to achieve the significant improvement in tribodynamic performance of tribological elements. Therefore, the objective of this research work is to explore the tribodynamic behaviours of textured (involving vertically

oriented ellipsoidal, horizontally oriented ellipsoidal and hemisphere dimples) teethed gear pairs experimentally and numerically for enhancing the performance parameters in comparison to conventional teethed gear pairs operating at the same parameters under fully flooded/starved lubricating conditions.

The tribological and vibrational behaviors of conventional and textured spur gear pairs have been experimentally explored under fully flooded and starved lubricating conditions at different operating parameters. Three different textures on gears' teeth profiles were created by placing the dimples of vertically oriented ellipsoidal, horizontally oriented ellipsoidal and hemisphere in the zigzag patterns using nanosecond pulsed fiber laser. Tribological parameters (contact resistance, temperature rise and surface topography) and vibration (in time and frequency domains) were obtained, compared, and analysed. The results revealed significant reduction in vibration amplitudes, increase in contact resistance, decrease in temperature rise and less damage of mating surfaces in the presence of textures. Moreover, the texture involving vertically oriented ellipsoidal dimples has yielded the best results. Further, to explore the critical role of texture on the tribodynamics of gearsets, accelerated testing has been done. Experimental investigation of the tribodynamic behaviour of spur gearsets has been done by employing conventional and textured teeth (presence of variable size micro-cylindrical dimples increasing from PCD to tip/root) from comparison perspective. The micro-cylindrical dimples of non-uniform diameters were fabricated using chemical etching on the gears' teeth surface. The vibration results obtained employing conventional and textured gearsets have been compared and analysed in time and frequency domains. Moreover, the surface topography and temperature rise have been measured. Based on the experimental results, it is found that in the presence of texture on gear teeth, the vibration amplitudes, oil film temperature rise and teeth surface damage have substantially reduced.

Furthermore, the synergistic effects of surface texture and Molybdenum disulphide (MoS_2) blended grease have also been explored on the tribodynamic performance of spur gearsets. It was decided to use the texture involving the best performing vertically oriented ellipsoidal dimples, which was explored and established for oil lubricated textured gearsets. The experiments were performed at different applied torques and a pitch line velocity of 4 m/s keeping in mind the practical application of the results. Contact resistance, vibrations, temperature rise and surface topographies have been measured and analysed. Substantial increase in contact resistance and reduction in vibration amplitudes at gear mesh frequency were found in the presence of texture. Reduction in interfacial temperature rise and less damage to teeth surface were also observed.

Numerical investigation on performance behaviour of elastohydrodynamically lubricated concentrated line/teeth contacts of gearset incorporating surface texture (ellipsoidal dimples) have also been done. In the numerical analysis, the Reynolds and elasticity equations have been solved simultaneously and discretized using finite difference method considering cavitation effect. The performance parameters (film thickness, coefficient of friction, side leakage and dynamic coefficients) have been numerically investigated and analysed for varying input data. The results show that the textured line contact having ellipsoidal dimples yields substantial increase in minimum film thickness and reduction in friction coefficient as compared to the conventional contact. The side leakage has also decreased in the presence of surface texture. Overall, the textured contact has shown much better static performance among all the cases. It has also shown better dynamic coefficients in comparison to conventional contacts.