Title of PhD thesis-

Tribological investigation with textured piston rings to improve the performance of IC engine lubricated with fresh and silicate complexes nanomaterial blended oils

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Abstract-

In internal combustion (IC) engines, the piston ring-cylinder liner interface plays a critical role in the efficient engine performance and exhaust emissions. It is an established fact that IC engines are prime emitters of greenhouse gases, which are responsible for environmental issues. The frictional behaviour of the interface of the piston ring/liner is significantly linked to fuel consumption and emissions. Since couple of decades, attempts are being made by the research community to enhance the IC engines performance using various techniques such as design/modification of the thermodynamic cycles, employing light weight components, use of additives/nano materials in the lubricative oils, modification of the surface topography of the piston ring and cylinder liner etc. Since recent past, the surface texture has evolved as a technology that is being used by the investigators across the globe to address the tribological issues of conformal and nonconformal lubricated contacts found in various machines. It has been established that certain surface textures and profiles employed on the piston ring have proven beneficial. Therefore, conducting further research on IC engine performance by conceiving and employing the new surface topography on the piston ring and cylinder liner and blending promising nanomaterials in the lubricant, are vital task.

The objectives of this thesis were set: (i) mathematical modelling of lubricated interface employing textured top compression piston ring for exploring the friction reduction; (ii) experimental study for IC engine performances using textured top compression piston rings; (iii) performance study of IC engine using silicate complexes (Mg6.SiO10.(OH)8) nano-material blended lubricating oil; and (iv) synergistic effects of silicate complexes nano-materials blended lubricant and textured top compression piston ring on the performances of IC engine.

Based on the numerical simulations, it is found that the textured piston ring significantly improved the engine performance parameters (increase in minimum oil film thickness and reduction in power-loss) in comparison to the conventional parabolic-shaped piston ring. The textured piston ring led to an increase (up to 7.2%) in the minimum film thickness and an 11% reduction in power-loss as compared to the conventional (untextured) piston ring. The textured piston ring yielded overall best performance; however, iv in the vicinity of the top dead centre and in the middle of the strokes, the results were quite favourable. The experimental investigations revealed that the presence of micro-textures on the piston ring reduced the fuel consumption in the range of 2% - 4%, the brake-specific fuel consumption minimized in the range of 4% - 7% and the brake thermal efficiency enhanced up to 7%.

The experimental investigations with the synergistic effect of textured piston ring and nanomaterial blended lubricant showed promising results as the fuel consumption reduced in the range of 1.5% - 4.5%, brake-specific fuel consumption minimized in the range of 4.5%-6.5%, and thermal efficiency increased in the range of 5%-7%. In the case of nanomaterial blended lubricant, fuel reduction was observed in the range of 1% - 3%, brake-specific fuel consumption in the range of 1%-5%, and thermal efficiency increased in the range of 1%-5%. Moreover, the CO emission reductions were observed in the range of 7%-10% and HC emission reduction in the range of 3.4%-6.5% with the synergistic effect. On the other hand, HC emission reduction was found in the range of 1.5%-4% in the case of nanomaterial blended engine oil.