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Tribodynamics of the Piston Compression Ring Conjunction

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The piston ring pack accounts for a disproportionate amount of the total engine losses (up to 25% of the parasitic losses, with the compression ring alone accounting for approximately 5% of the total engine losses) [1]. Challenges for low carbon future, coupled with widespread use of internal combustion engines for the foreseeable future and increasing global population of vehicles motivates the engineers to improve upon engine efficiency. The current investigation explores the effect of piston ring pack dynamics on the frictional losses in internal combustion engines.

The compression ring undergoes a multitude of complex motions during the engine cycle. These motions are prescribed by the contact reaction, gas pressure loading, ring tension and inertial forces. These forces excite a plethora of ring's modal responses and can induce a number of undesired phenomena such as ring flutter, twist, rotation and jump, all of which can adversely compromise its sealing functionality.
The dynamic behaviour of the compression ring is a prerequisite for improving its tribological with the cylinder liner conjunction during the engine cycle. The transient nature of the contact conditions would also provide an insight into the mechanisms contributing to frictional losses, thus engine inefficiency. The applied conditions; ring loading and piston kinematics, as well as ring geometry and topography are key parameters for tribological study of the conjunction which require prediction of generated contact pressures, film thickness, thus the determination of load carrying capacity and frictional and errant dynamics' power losses.

Euler's beam theory in the form of dynamics stiffness method is utilized for the modelling of ring behavior in bending in its *xz* and *xy* principal planes, as well as in torsion and axial extension-compression. The beam is discretized into discrete elements and the solution is found through direct integration of governing equations in the time domain. A 2D hydrodynamic model is used to obtain the pressure distribution in the piston ring cylinder liner conjunction, determining the load carrying capacity and frictional power loss, depending upon lubricant availability. The model also takes into account effect of surface topography and thus asperity interactions in generation of any boundary friction. The 2D Reynolds equation is discretized numerically using Finite Difference Method (FDM). Lubricant rheological state equations for viscosity and density variation with pressure under assumed isothermal conditions are also used.

Boundary conditions are necessary for the solution of Reynolds equation. For outlet boundary conditions Swift Stieber [2,3] (or Reynolds) boundary conditions are used as they take into account the continuity of flow at the lubricant film rupture point, thus for the piston ring conjunction [4].

References

[1] Andersson, B.S. "Company's perspective in vehicle tribology", Proc. 18th Leeds-Lyon Symposium, Elsevier Sci., 1991

[2] Swift, H.W. “The stability of lubricating films in journal bearings”, J. Instn. Civ. Engrs., 223, 1932, pp. 267-288

[3] Stieber, W. “Das Schwimmlager: Hydrodynamische Theorie des Gleitlagers”, VDI-Verlag, 1933

[4] Morris, N., Rahmani, R., Rahnejat, H., King, P. D. and Fitzsimons, B., “Tribology of piston compression ring conjunction under transient thermal mixed regime of lubrication”, Tribology International, 59, 2013, pp. 248-258