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Hybrid surface modification for improved tribological performance of IC engine components – a review

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Abstract

The worldwide increase in demand for automotive sectors requires improved components life cycle, fuel economy and emission control. However, the occurrence of high temperature and variable loading on contact surfaces of internal combustion (IC) engine causes excessive friction results into reduced component life cycle, degrades emission level and fuel economy too. A small improvement in tribological performance and oil sealing through surface modification can able to enhance the functional performance of IC engine components significantly. Hence, in this work, a detailed discussion on the comparison of different hybrid surface modification techniques such as coatings, textures, and nanoparticles can work synergistically to improve the tribological performance of IC engine components. The process capabilities, limitations, and their effect on tribological performances of IC engine components are also presented. An analysis of surface texture parameters such as geometry, dimension, motion parameters, surface roughness, and oil transport mechanism is done to know the effects on the performance of the IC Engine. Further, the hybridization of different processes with nanoparticles (metallic, metallic oxides, carbon nanoparticles) is briefly presented. Finally, the effect of modified surface chemistry and characterization such as asperity, topography, microhardness, residual stress, and adhesive strength characteristics is also related to the tribological performances of IC engine components.

Keywords

hybrid surface modification, tribology, internal combustion engine, texturing, coating

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Introduction

A surface modification practice involves altering the surface topography and material characteristics through physical, thermal, mechanical, and chemical action by coating, texturing or combining them, that is, hybridization of processes. It is possible to form ordered surfaces through traditional texturing methods such as mechanical micromachining, electric discharge machining (EDM), laser beam machining (LBM), electron beam machining (EBM), and surface coating processes such as physical and chemical vapor deposition (PVD and CVD) and thermal spray.[1–4] Getting multi-functional features from a traditional or, single process is very much complicated. Therefore, the application of hybrid surface modification is strongly recommended. A hybrid surface modification combines the advantages of more than one process to fabricate multi-functional surfaces and synthesize material for superior mechanical leverage, thermal stability, wettability, and tribological properties.[3–6] Many applications are available in the field, such as in biomedical, automotive, machine tool, and aerospace.[2] Among other applications, the automobile industry and related internal combustion (IC) engine applications have gained special attention because of increasing life standards, limited source of energy and better fuel economy, tribological losses, and release of poisonous emissions such as CO, HC, CH_4, and NOx, which disrupt the environment through global warming and product life cycle issues.[7,8] The application of surface modification with spherical dimples on IC engine components like piston ring cylinder liner (PRCL) can be visualized in Figure 1.

Nanomaterials (metals, oxides, and carbon nanoparticles) with texturing and coating are transforming the field of surface modification through innovation by providing exceptional qualities in coatings, lubricants, etc., to reduce friction and wear characteristics.[5,9] Therefore, the research community constantly strives to reduce friction and wear characteristics of IC engine components

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