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Microstructural Alterations in Wear Resistant Cylinder Running Surfaces

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The future development of motor engine design and technology governs the increasingly demanding requirements on materials in terms of friction and wear properties. In order to reduce emissions and achieve economical and environmentally sound solutions thermal sprayed coatings are an option to manufacture wear resistant and low-friction cylinder running surfaces.

The good wear characteristics of these coatings are related to structural, productional, and topographical properties. Thus hard phases which are either introduced by alloying (e.g. C for carbides) or by the atmosphere (e.g. O for oxides) during spraying are related to a sufficient strength. Open machined pores in the layered microstructure function as oil storage capacity and, therefore, benefit hydrodynamic lubrication. Finally the alteration of the microstructure in different contact zones reveals the ability of the material to adjust to the current load situation. Previous studies have shown that in diverse tribosystems an in-situ formation of a nano-crystalline layer together with mechanical mixing maintains long-lasting wear resistant surfaces with low wear rates.

This investigation compares results from cylinders that have been run in a road test motor as well as in an engine test rig. Cylinder bores undergo mechanical and thermal loads of different extents. The relevant piston ring positions to fully describe the tribosystem are to be named as combustion chamber (CC), top dead centre (TDC), stroke and bottom dead centre (BDC). The highly demanding conditions are therefore high thermal stresses, as in the area of the combustion chamber, increasing mechanical loading due to the decreasing relative velocity of the piston ring in the dead centres as well as sliding wear conditions in the stroke. Transmission electron microscopy (TEM) has been used to analyse these contact zones in terms of microstructural alterations.

Nanocrystalline surface layers up to a thickness of 100 nm occurred in all areas of contact whereas subsurface zones revealed differing microstructural changes. Thus the influence of thermal impact and different mechanical load conditions is evident.