Impact of shot peening on the surface layer properties of components made of selected alloy steels

Abstract

The paper addresses the theoretical and technological aspects of shot peening process. The experiment was based on changing the pressure parameter while keeping the other process settings unchanged. Corrosion resistant steels of austenitic (AISI 304) and martensitic (AISI 413) structures were used as test materials. These steels were presented as alternatives (used at Sulzer Turbo Services) to superalloys in the manufacture of components such as gears, crankshafts, spring clamps, hydraulic brakes, and most importantly turbine blades. In order for them to achieve comparable properties to superalloys, it is necessary to modify their surface layer properties and performance characteristics, which was achieved with the shot peening process. This was also the main scientific objective of this dissertation. In addition, the technological parameters of peening process leading to an increase in the operating properties of machine elements made of alloy steels were determined. Furthermore, the existence of relationships between the parameters of shot treatment and the studied properties was determined.

This research focused on determination of microhardness with regard to studied materials, their geometric structure, XRD analysis, including grain size and stress determination, as well as microscopic and fatigue analysis on the basis of rotary bending and studies of resistance to abrasive wear and cavitation erosion. The dissertation presents the results of individual tests and experiments for two steels and different pressure values during shot peening as well as a comparison of these results, which allowed their comparison and mutual correlations to be established.

The increase in pressure during shot peening process changed the morphology and geometric structure of the surface layer, as well as the mechanical properties. However, this was different for various materials used in the tests. Martensitic steel achieved higher values of microhardness, both on the surface and on the cross-section, while lower values of roughness, coefficient of friction, cumulative weight loss, erosion depth or erosion velocity compared to austenitic steel. AISI 304 steel at lower microhardness values had higher roughness, which in turn resulted in lower resistance to abrasive and cavitation wear. Nevertheless, changes were observed in the steel properties of both steel grades compared to the reference steels (without any additional treatment).

However, an in-depth analysis of the results showed that infinite pressure increases during the peening process did not lead to increasingly better outcomes. The most advantageous option turned out to be the use of an intermediate pressure value of – 0.3 MPa. The research results can be used to develop a surface layer finishing technology in a manufacturing plant using shot peening for component modification.

Keywords: shot peening, surface layer, austenitic steel, martensitic steel, microhardness, roughness, XRD, rotary bending, abrasion, cavitation