The effect of ball burnishing on heat-treated steel and Inconel 718 milled surfaces

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Abstract In this paper the use of the ball burnishing process to improve the final quality of Inconel 718 surfaces is studied. This process changes the roughness and residual stresses of the previously end milled surfaces, achieving the finishing requirements for engine components. Both the burnishing system and main parameters are taken into account, considering their influence on finishing. Workpiece surface integrity is ensured due to the compression effect of this surface enhancement process and its associated cold working. Results of different tested pieces are discussed in relation to the maximum and mean surface roughness achieved microstructure and surface hardness. Results of heat-treated low carbon mould steel P20 (32 HRC) are compared with those for the nickel alloy Inconel 718 (solution treated and age hardening, 40 HRC). The main conclusions are that using a large radial width of cut in the previous end milling operation, together with a small radial width of cut during burnishing can produce acceptable final roughness. And compression cold working is higher and deeper in the Inconel 718 than in the steel case.

Keywords Ball burnishing · Finishing · Ball-end milling · Heat-resistant alloys · Inconel 718

1 Introduction

Within the group of surface plastic deformation processes, roller and ball burnishing are methods for improving metal surface roughness, surface hardness and dimensional accuracy. These are cold-working processes that do not involve material removal, and that produce work hardening of the part surface. Roller burnishing is applied to cylindrical workpieces both on external and internal surfaces, using tools similar to roller bearings. Its main applications are automotive crankshafts, inner and outer bearing races, bogies axles, etc. [1–4]. Plastic deformation causes roughness peaks (asperities) to flow towards the valleys, creating a new topography. The aspect of the final surface becomes a combination of the previously machined one and the effect of burnishing. A model is described in [5], where the influences of the normal force, material mechanical properties and geometrical shape of asperities on final roughness are considered. Therefore, the main aim of the ball burnishing is focused on the roughness reduction. This is the main reason to be applied on moulds and dies; in [6] the optimal parameters for burnishing of moulds are discussed. In this application, the burnishing process is applied on the same machining centre where the surfaces were milled. This procedure is also applied in some applications on aluminium parts [7–10]. Usual materials for stamping dies are nodular cast irons (GGG70- ASTM 100–70–03, 280 HBN) for punches and dies, with block inserts made on tempered steels (DIN 1.2379- AISI type D3). For hot stamping dies (forging), heat-treated steel up to 30–42 HRC is the more common material. In injection moulds, high-tempered steels (AISI H13) hardened at more than 50 HRC are used [11, 12] together with heat-treated steels (AISI P20). The final aspect of surfaces is mirror-like on steels, and poorer on iron castings due to the graphite particles. A further purpose of this process is to achieve compressive residual stresses on and underneath the workpiece surface. The affected layer ranges from 2 to 10 μm [6, 10]. This is specially interesting in heat-resistant alloys (nickel-based alloy such as Inconel 718 and cobalt-