Quality improvement of ball-end milled sculptured surfaces by ball burnishing

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Abstract

In this paper, the use of the ball burnishing process to improve the final quality of form tools (moulds and dies) is studied. This process changes the roughness of the previously ball-end milled surfaces, achieving the finishing requirements for plastic injection moulds and stamping dies. Ball burnishing can be easily applied in the same machining centres as those used for milling. In this way, both lead times and production costs can be dramatically reduced.

Both the burnishing system and its main parameters are taken into account, considering their influence on finishing. Workpiece surface integrity is ensured due to the surface smoothing effect of process and the associated cold working. Examples of different materials, machined surfaces, and industrial applications are explained, with respect to the maximum and mean surface roughness achieved.

The main conclusion is that using a large radial depth of cut in the previous ball-end milling operation, together with a small radial depth during burnishing can produce acceptable final roughness. Savings of production times are high, as burnishing is applied using the maximum linear feed of the machine, while milling must be made at moderate feeds. Moreover, ball burnishing NC programming is less critical and needs less care in its definition than CAM for milling.

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1. Introduction

Roller and ball burnishing (also known as surface plastic deformation processes) are methods for improving metal surface finishing, 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 up to a certain extent. Roller burnishing is applied to cylindrical workpieces both on external and internal surfaces, using tools similar to roller bearings. Main applications are automotive crankshafts, inner and outer bearing races, bogies axles, etc. In these cases, roller burnishing is performed on the same lathes where workpieces were machined, as shown in [1–4].

Plastic deformation causes roughness peaks 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 influence of the normal force, material mechanical properties and geometrical shape of asperities on final roughness are considered. Therefore, a main aim of the ball burnishing is focused on the roughness reduction. This is the main reason for it to be applied on moulds and dies [6]; in this work the Response Surface Methodology is used to select the optimal parameters. 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 produced on tempered steels (DIN 1.2379-AISI type D3). For hot stamping dies (forging), treated steel up to 40–42 HRC is the more common material. In injection moulds, high tempered steels (AISI H13) hardened at more than 50 HRC are used [11,12].

A further purpose of this process is achieving compressive residual stresses on and underneath the workpiece