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S. Wojciechowski, M. Wiackiewicz, G.M. Krolczyk

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S. Wojciechowski[1], M. Wiackiewicz[2], G.M. Krolczyk[2*]

[*] Corresponding author: g.krolczyk@po.opole.pl,

[1] Faculty of Mechanical Engineering and Management, Poznan University of Technology,

3 Piotrowo St., 60-965 Poznan, Poland, email: sjwojciechowski@o2.pl,

[2] Faculty of Mechanical Engineering, Opole University of Technology,

76 Proszkowska St., 45-758 Opole, Poland, email: g.krolczyk@po.opole.pl, marek.wiackiewicz@gmail.com

Summary

The study presents an analysis of relations between the instantaneous tool displacements and surface roughness formed during ball end milling of surface with inclination towards the tool's axis. A novel experimental method for the estimation of ball end mill's working part vibrations, considering displacements correlated with the geometrical errors of tool-toolholder-spindle system and deflections caused by milling forces has been proposed. The experiments have been conducted on hard-to-cut low carbon hardened alloy steel. Milling tests involved the use of monolithic ball end mills varied in terms of overhang l values. In the first stage, the finishing machining of inclined surface with variable cutting speeds v_c was carried out. During the experiment, the instantaneous tool's joining part displacements have been measured with the application of laser displacements sensor. Subsequently, in order to obtain the tool's tip instantaneous displacements, the analytical extrapolation method has been proposed. In the next stage, the machined surface roughness has been measured with the application of stylus and optical profile meters. The investigations show that the value of tool's overhang significantly affects the mechanisms of surface roughness generation during finishing ball end milling. In case of milling with the rigid tool (l = 35 mm), the surface roughness is strongly correlated with kinematic-geometric model, as well as with geometrical errors of machining system. Nevertheless, in case of milling with the slender tool (l = 85 mm), the surface roughness formation is mainly affected by the tool's working part dynamic deflections caused by milling forces.

Key words

Surface topography; precise milling; tool displacements; surface roughness; dynamics.

1. Introduction

Precise machining is a technology which enables the obtainment of very high machined surface texture, defined by the parameters of geometrical product specification (GPS). The obtainment of high surface quality is in turn strictly correlated with the improved performance and tribologic properties of the manufactured part [1,2]. According to Dornfeld and Lee [3], precise machining is usually being carried out with the uncut chip thicknesses h contained within the range of 1 μm < h < 0.1 mm. During, this technology the material's decohesion mechanism is not only depended on the chip shearing phenomenon on the tool rake face but also by the ploughing and edge phenomena concentrated on the flank face [4,5], as well as the micro-pores, fractures and grain boundaries of