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On-machine non-contact roughness verification system based on Conoscopic holography

Pablo Zapico, Gonzalo Valiño *, J. Carlos Rico, Víctor M. Meana, Pedro Fernández

Department of Construction and Manufacturing Engineering, University of Oviedo, Campus of Gijón, 33203, Gijón, Spain

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A B S T R A C T

The surface quality verification of mechanical components is an essential activity in many applications where surface performance plays an important role in the functional behaviour of the part. Although many of the verification techniques commonly employed are based on the use of contact roughness profilometers, there are some limitations related to the morphological filtering effect associated to the stylus tip radius, as well as the difficulty in using these type of styli to carry out on-machine surface verification. The use of non-contact digitizing techniques helps to overcome some of these drawbacks, although the verification of surface quality using these non-contact systems still requires the development of scanning and data processing procedures similar to those described in the international standards for contact probing techniques. This work analyses the use of a non-contact sensor, based on Conoscopic Holography and integrated in a 3-axis machining centre, applied to the verification of the surface roughness of parts machined by face and cylindrical milling processes. After the calibration of the integrated system, a high-frequency noise filtering procedure specifically designed for roughness verification is proposed. The results demonstrate the feasibility of the system for verifying surface roughness grades from N5 to N12 in the two milling processes. Finally, specific filtering recommendations for each roughness grade of both milling processes as well as a surface verification procedure are provided.

1. Introduction

Quality of mechanical parts is generally considered as a combination of dimensional and geometrical accuracy and a good surface finish. Among other properties, surface finish may affect component's fatigue and corrosion endurance, hardness and heat transfer capability [1–3], becoming an essential issue in the case of moulds, dies and mechanical implants. On the other hand, surface finish also affects interaction between different components working together in a mechanism, especially when a good fit and lubrication ought to be assured between two sliding surfaces to attenuate vibrations, wear and noise during their operation [4,5].

In the case of machined parts, it is well known that by adjusting the process parameters, different grades of surface roughness can be achieved [1,5,6]. Nevertheless, roughness verification becomes essential when high surface quality is required. Thus, the standard ISO 4287 defines how to evaluate surface quality by means of numerous roughness parameters associated to the surface topography [7]. Whereas there are surface evaluation methods based on visual and/or haptic perception by an operator, other quantitative methods based on instrumental measurements provide more objective and accurate approaches. Nowadays, many instrumental systems based on different technologies [2,4] (e.g., mechanical, optical, electrical, pneumatic, hydraulic, etc.) classified into contact or non-contact systems are used.

One of the most widespread contact method uses a stylus touch probe ended with a small-radius spherical tip (typically from 2 μm to 10 μm) that is slid on the surface to register vertical fluctuations as the tip moves. Surface profiles are then extracted and several geometrical analysis and mathematical filtering is performed to calculate roughness parameters. Despite this technology is commonly used for reference measurements, it is not absent of drawbacks. Displacement of the stylus can cause damage to the measured surface, especially when using a diamond tip and testing a soft material [8]. Moreover, this contact measurement procedure in combination with the tip radius causes a morphological filtering effect on the digitized geometrical information of the profile [9]. Other weaknesses are the lack of accessibility to verify complex geometries (e.g., gearboxes or bearings [3,8]), a slow velocity of measurement [10] and the difficulty to automate the measurement

* Corresponding author.
E-mail address: gvr@uniovi.es (G. Valiño).

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