Influence of Surface Location within Depth of Field on Measuring by a Conoscopic Holography Sensor Integrated in a Machining Centre

G. Valiño[1], J.C. Rico, P. Zapico, P. Fernández, S. Mateos

[1] Dept. of Manufacturing Engineering, University of Oviedo, Campus of Gijón, 33203 Gijón (Spain), gvr@uniovi.es.

ABSTRACT

In this work, a Conoscopic Holography (CH) sensor integrated in a Machining Centre (MC) was used for analysing how the measurements taken are influenced by the location of the digitized surface within depth of field (DOF). With this aim, two different digitizing strategies were conducted on a stepped specimen with flat surfaces. In the first strategy each step of the specimen was located at different positions within DOF whereas the CH sensor was kept at a constant height along the scanning of all steps. In the second strategy the sensor height was adapted so that each step was scanned at the same distance within DOF. The comparison between both strategies was performed by calculating the discrepancies between measurements taken by the CH sensor and those obtained by a touch probe (TP) also installed in the MC. Finally, the study provides a series of recommendations for practical application of the sensor.

Keywords: Conoscopic Holography; depth of field; non-contact digitizing; on-machine measurement.

1. Introduction

Industrial use of commercial scanners like non-contact digitizing systems has grown significantly in recent years with a wide range of applications that go from dimensional metrology to reverse engineering [1]. Apart from avoiding contact with the object to be measured, the main advantages over contact systems are the ability to capture small geometries and complex shapes as well as the high speed for points acquisition. Additionally, the portability of non-contact systems offers the possibility to be installed on different equipment such as coordinate measuring machines (CMM), coordinate measuring arms, machine tools or production systems, which certainly favours its industrial application.

Currently, there exist numerous non-contact techniques for surface digitizing, such as those based on triangulation laser which are more deeply analysed and disseminated every day [2-4]. However, the performance of other technologies has not been fully described yet. This is the case of Conoscopic Holography (CH).

CH is an interferometric technique based on the double refractive property of birefringent crystals. It was first described by Sirat and Psaltis [5] and patented by Optimet Optical Metrology LTD. When a polarized monochromatic light ray crosses the crystal, it is divided into two orthogonal polarizations, the ordinary and extraordinary rays, which travel at different speeds through the crystal. The speed of the ordinary ray is constant. However, the speed of the extraordinary ray depends on the angle of incidence. In order to make both rays interfere in the detector plane, two circular polarizers are placed before and after the crystal. The interference pattern obtained in the detector has a radial symmetry, so that all the information is contained in one radius. Therefore, given an appropriate calibration, it is possible to calculate the original distance to the light emitting point from the fundamental frequency of one of the signal rays.

Potential of CH as a valuable alternative to current well-established technologies (laser triangulation or photogrammetry) has led researchers to work on analysing the performance of CH sensors under different scanning conditions [6-11]. Malet and Sirat [6] stated that the performance of a conoscopic system can be influenced by the depth of field, speed and transverse resolution. Sirat et al. [7] denoted characteristics of CH like accuracy and repeatability, good behaviour for a wide variety of materials and for slope surfaces measuring. The ability of CH for digitizing highly sloped surfaces was also highlighted by Ko and Park [8]. Furthermore, CH sensor performance is affected by surface properties, as it was highlighted by Lathrop *et al.* [9] who analysed different types of biological tissues to demonstrate that the nature of surface