Investigation on a Replica Step Gauge for Optical 3D Scanning of Micro Parts

A. Cantatore[1], L. De Chiffre[1], S. Carmignato[2]

[1]*Department of Mechanical Engineering, Technical University of Denmark, Building 425, Produktionstorvet, DK-2800 Kgs. Lyngby, Denmark*

[2]*Dipartimento di Tecnica e Gestione dei Sistemi Industriali, Università di Padova, Stradella San Nicola 3, 36100 Vicenza, Italy*

acan@mek.dtu.dk

Abstract

This work deals with investigation of the stability over time and surface cooperativeness of a calibration artefact intended for optical scanner verification. A replica step gauge with 11 grooves, made of bisacryl material for dental applications (luxabite) and previously fabricated was studied. The stability over time of the step gauge was evaluated by repetitive measurement campaigns over a period of eight months, using measurements taken with a tactile CMM and with an optical scanner. Surface cooperativeness was investigated by measuring artefact grooves and pitch and comparing results with tactile measurements. Results demonstrate good stability of the step gauge and material transparency good cooperativeness, which is compensated when a unidirectional strategy is followed.

1 Introduction

A replica step gauge (Figure 1) with eleven grooves, 42 mm total length, made of bisacryl material for dental applications (luxabite) and previously presented in [1] has been investigated, mainly focusing on stability over a period of eight months and surface cooperativeness with a laser scanner. Good stability and high surface cooperativeness have to be assessed when proposing new artefacts for testing optical scanners [1-3].

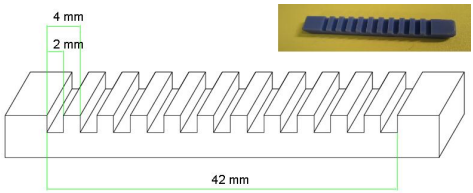

Figure 1: 42 mm miniature step with 2 mm reference step length and 4 mm pitch [1]

2 Stability investigation

Stability of the replica step gauge has been evaluated by carrying out measurements on a Zeiss MC850 tactile coordinate machine with MPE=(2+L/400)µm (L in mm) over a period of eight months. Tests have been performed in February, June, September and October 2009. Groove widths have been measured, by taking six single measurements on each groove side wall. Average values and related uncertainties have been evaluated for each groove. Uncertainties have been evaluated following GUM guidelines and considering the following contributes: MPE, artefact form error, temperature effect and repeatability. Results demonstrate a good stability of the step gauge over the eight months (Figure 2), with maximum expanded uncertainties of ±10µm.

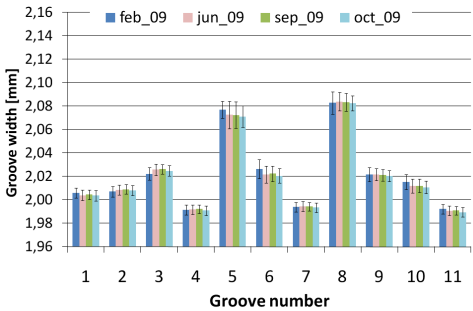

Figure 2: Replica step gauge stability over eight months on tactile CMM (average ± uncertainty values, k=2)

3 Cooperativeness investigation

Cooperativeness has been analyzed on an optical Q640 3D laser scanner from 3Shape. Reference measurements on groove widths have been taken using the tactile

CMM already employed to verify artefact stability. Fifteen single measurements on each groove side wall have been carried out. Comparison between tactile and optical measurements on the eleven grooves performed in October 2009 is shown in Figure 3, Top.

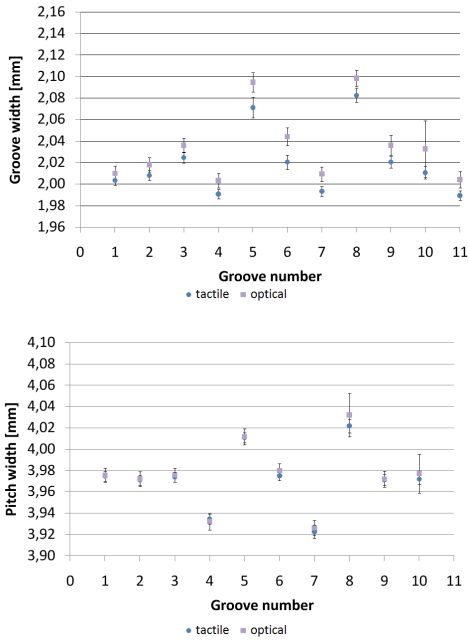

Figure 3: Comparison between tactile and optical measurements on the step gauge taken in October 2009; Top) groove width; Bottom) pitch. Average values and measuring uncertainties (k=2) are reported.

Measurements taken on the resulting scans are larger than those obtained with the tactile CMMs, indicating translucency of the material to laser light. This translucency has been quantified by computing the average deviation between optical and tactile values and a range of 6-23 µm was preliminary determined. Measurements of the replica step gauge pitch (nominal value = 4mm) have also been performed with the tactile CMM and the optical laser scanner and compared (Figure 3, Bottom reports measurements in October 2009). An adequate agreement between tactile and optical measurements is obtained (values are comparable), but optical

measurements are characterized by higher uncertainties (maximum expanded uncertainty = ±20µm while ±10µm have been obtained with the tactile CMM).

4 Conclusions

An investigation on a replica step gauge for optical scanner accuracy verification has been carried out. Stability over a period of eight months has been verified using a tactile CMM and material cooperativeness has been documented by comparing measurements carried out with the tactile CMM and an optical scanner. Two measurands have been considered: groove width, taken on a bidirectional strategy and pitch, obtained through a unidirectional strategy. Tactile and optical measurements of replica step gauge groove width assess low cooperativeness, due to translucency of the material to the laser light and preliminary quantified in a range of 6-23 µm. This deviation is compensated in step gauge pitch measurements are performed following a unidirectional strategy. Deviation between optical and tactile groove measurements can be regarded as a systematic error, to be used for correcting the bidirectional measurement results on this material.

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References

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