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Four-year study of roughness patterns using weekly calibrations

Márcia A.F. Destro, Francklim Barbosa, Fábio Dondeo Origo, Alvaro José Damião *

LMSO-IEAv-DCTA, São José dos Campos, Brazil

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ABSTRACT

In order to evaluate the stability and reproducibility of roughness measurements, calibrations of the same roughness standard were held over four years. Calibrations were performed in the Laboratório de Medição de Superfícies Ópticas (LMSO), on Mondays, between late January to early December every year. Here are presented and analyzed the calibration results and also the measurements of lab temperature and relative humid, at the time of calibration, in order to assess if there is any correlation between these influence factors in the obtained results. The LMSO lab is accredited by INMETRO (Brazilian NMI).

1. Introduction

Repeatability and reproducibility are essential to maintain the calibrations and measurements reliability in accredited laboratories. Interlaboratory comparisons (ILC) complete the validation of these results. Laboratory Measurement of Optical Surfaces (LMSO), IEAv-DCTA, performs roughness standards calibration and roughness measurement of optical surfaces [1–3].

Calibrations were performed in the same artifact in order to track the instrument performance and to assess the results uniformity, all Mondays, between late January and early December of the last ten year. These calibrations are internally named "intermediate calibrations". In this paper are presented the results obtained in the last four years. The equipment was acquired in 2009.

2. Materials and methods

A Taylor Hobson PGI 1000, calibrated with a glass hemisphere Taylor-Hobson, 80 mm, TH1108 (certificate of calibration 47321, Taylor Hobson Calibration Lab, UKAS 0026, May, 2009) was used for calibrations.

Calibration results prior to 2009 were obtained with Marh Perthen S8P equipment. This instrument used a standard depth of the valley as calibration reference.

The artifact used in calibrations was a periodic roughness pattern from Mitutoyo model 178–602, serial number 131 923. The roughness pattern was also calibrated by INMETRO, the Brazilian NMI, sometimes in this period.

The environmental conditions were: temperature (20 ± 1) °C and relative humidity of (50 ± 20)% RH. The LMSO calibration procedure defined initially that five measurements would be carried out for each calibration. From the beginning of 2012, 10 measurements were performed for each calibration.

After the equipment thermalisation, measurements were made using the LMSO roughness measurement procedure. The ten measurements that composes a result are based on the ISO 4278 (1996), for periodic roughness profiles.

A 3D image of the roughness gauge was obtained in 2011 (Fig. 1). The data were obtained using a 10 μm step in *Y* direction. The area measured was 6 mm (*X*) by 1 mm (*Y*). Grooves in *Y* direction can be noticed, as two patterns were superimposed [4].

3. Results and discussion

The figures below represent the results of measurements carried out in 2010. Measurement results of Ra (Fig. 2), Rz (Fig. 3) and Rzmax (Fig. 4) are shown.

The measurements uncertainty is not presented in the graphs, to simplify the visualization. The uncertainty declared by LMSO is 4% for all parameters and it has similar values compared to literature [5,6].

It can be noticed that Ra, Rz and Rzmax results do not have a pattern or trend as a function of time.

The 2011 results are presented in Figs. 5–7. It can be observed that there were no significant changes in relation to the previous year measurements.

Measurements of Rz and Rzmax presented trend to decline throughout the year. In order to assess whether there was temperature and/or relative humidity influence, from 2012 on the data

* Corresponding author.
E-mail address: damiao@ieav.cta.br (A.J. Damião).

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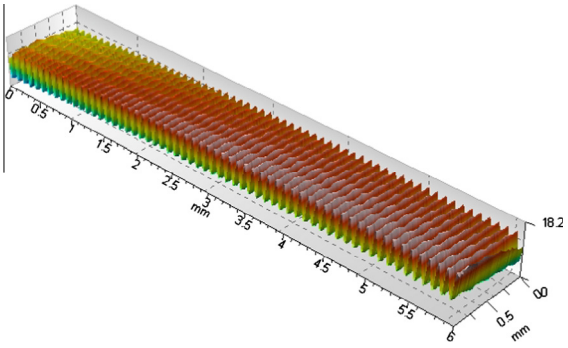

Fig. 1. The 3D roughness pattern image using 10 micrometer *Y* step.

from the environmental condition were registered. Figs. 8–10 show the results of Ra, Rz and Rzmax and Figs. 11 and 12 the respective data of temperature and relative dampness at the time of measurement in 2012.

The relative humidity in the laboratory (Fig. 12) presented increased throughout the year. A slight downward trend appeared in the results of Rz and Rzmax. Considering the type of equipment and the standard used, it was not expected a association between roughness parameters and the relative humidity. Then it was decided to continue the registration for another year, to better assess the influence of these parameters.

In 2013, until the middle of March, the roughness standard was being calibrated at INMETRO. During this period, another roughness standard was used. The results of 2013 calibrations and laboratory conditions are presented in Figs. 13–17.

Unlike observed in 2012, the relative humidity decreased over 2013, while the mild downward trend in Rz and Rzmax remained. In order to quantify the dependence of Ra, Rz and Rzmax on the laboratory temperature and humidity, using the data collected from 2012, 2013 and 2014, the Canonical-Correlation Analysis was done. Temperature and Humidity were considered as independent variables whereas Ra, Rz and Rzmax where treated as dependent variables. On Table 1 it may be observed that all the absolute values of the correlation factors are far from the value '1', suggesting that there is no correlation between Ra, Rz and Rzmax with the parameters Temperature and Humidity.

It must be noticed that the city of São José dos Campos, where the LMSO is located, is bounded by the Paraiba River and is located

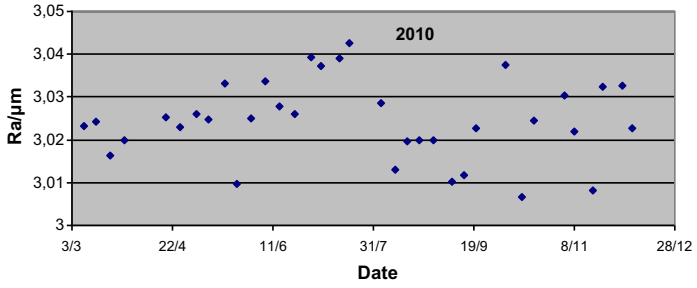

Fig. 2. Ra calibration results for 2010.

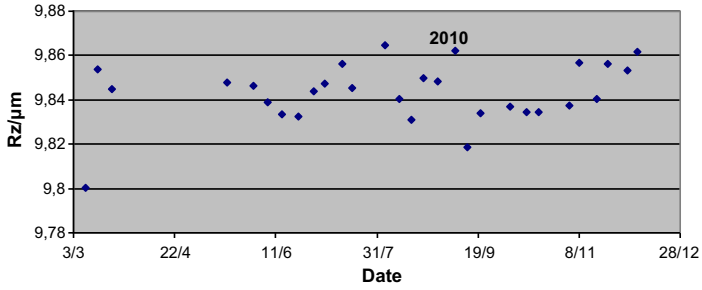

Fig. 3. Rz calibration results for 2010.

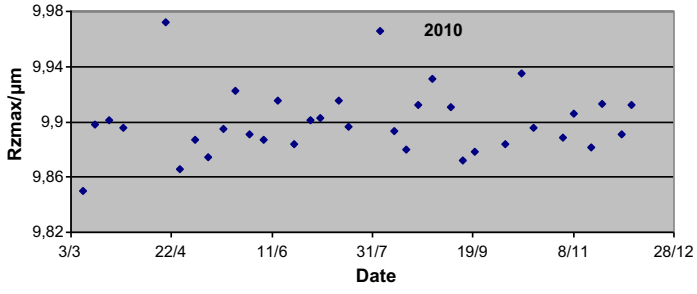

Fig. 4. Rzmax calibration results for 2010.