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Thermographic method for metallic surface roughness evaluation

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Abstract

The aim of this paper was to investigate the possibility of using a thermographic camera for metallic surface roughness evaluation. First, the surface of a metal plate containing 6 rectangular areas of known roughness was illuminated using an infrared source. Next, the reflected radiation temperature of those 6 areas was measured. Finally, the root mean square temperature for each of the areas was computed and compared with reference surface roughness value. Experiments were repeated for different infrared radiation source position relatively to the metal plate.

1. Introduction

Surface roughness is a physical property describing small scale variations of height of that surface. Several parameters can be used to quantify it [1, 2]. The most common is the average roughness R_a which can be measured according to the principle shown in Fig. 1 and next calculated based on eq. (1), as the arithmetical mean deviation of the surface height versus a reference level, over a measurement length *L*.

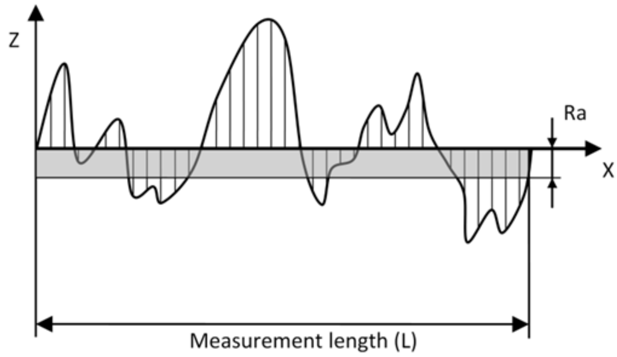

Fig. 1. *Average roughness R_a measurement principle*

$$R_a = \frac{1}{L}\int_0^L |Z(x)|dx \qquad (1)$$

Regardless of the parameter used to quantify roughness, in industry, at different stages of components machining, roughness control is used for parts dimensions validation, conformity check and generally, for quality control. Roughness control methods can be generally divided into two main groups [2]: qualitative, based on optical or tactile appearance comparison versus a reference sample or quantitative, with 2D or 3D surface measurement. Measurement methods include solutions from contact, stylus based profilometry to contactless optical methods based on microscopy, interferometry or laser triangulation. In this paper, the authors investigated the possibility of using thermography for roughness evaluation.

2. Measurement setup and measurement results

The schematic of the measurement setup used during experiments is presented in Fig. 2. A reference metal plate containing 6 rectangular areas of known roughness (Fig. 3), from C10 to C320 according to the PN-67/H-83140 standard, was illuminated using a halogen lamp which acted as an infrared radiation source. After finding experimentally the optimum illumination angle - small angles below 20° yielded the best and repeatable results, the radiation reflected from the plate surface was captured using a cooled InSb thermographic camera and recorded as temperature. Next, for each of the 6 areas, the root mean square temperature was calculated and compared with surface roughness. The process was repeated for several IR source-metal plate distances, from 8 cm to 22 cm. The results obtained during those experiments are presented in Fig. 4.

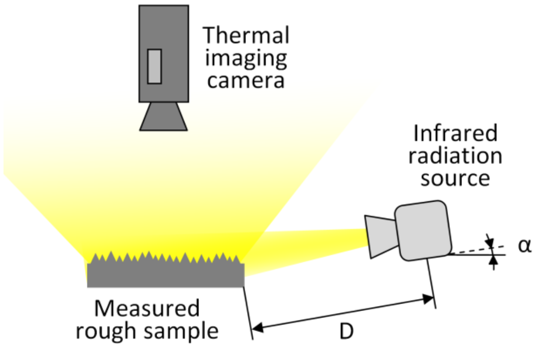

Fig. 2. *Setup for thermographic roughness evaluation*

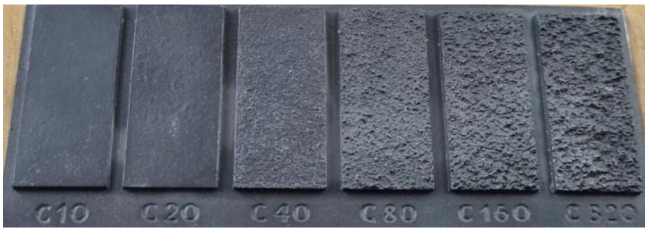

Fig. 3. *Roughness reference plate*

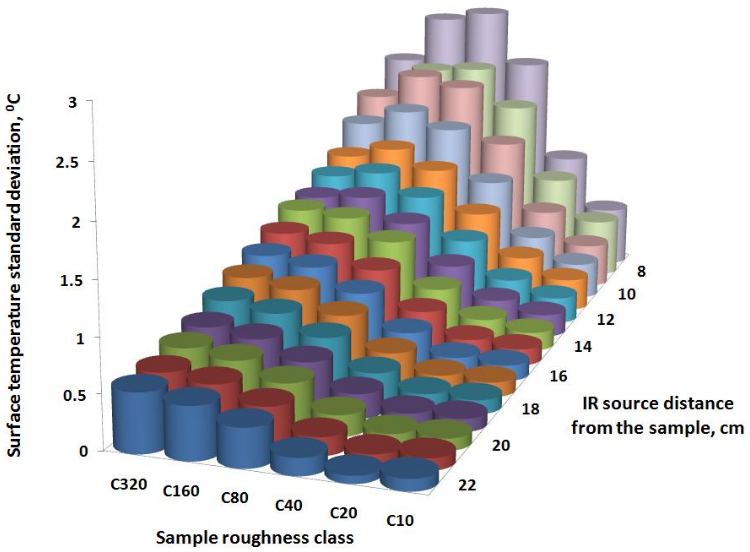

Fig. 4. *Measurement results: correlation between surface roughness and recorded area RMS temperature*

3. Conclusions

The aim of this paper was to investigate the possibility of using a thermographic camera for metallic surface roughness evaluation. Based on obtained results, a correlation between surface roughness and measured reflected RMS temperature was demonstrated. As shown during experiments, the key was a low infrared radiation incidence angle and an optimum distance between the IR source and the tested plate, providing an uniform incident radiation distribution. The presented results are an encouragement for further research in that area.

REFERENCES

[1] *Quick guide to surface roughness measurement*, Mitutoyo, Bulletin No. 2229.

[2] D. L. Butler, "Surface Roughness Measurement", *Encyclopedia of Microfluidics and Nanofluidics,* pp. 1-7, Springer Science+Business Media New York 2014.