OPTICAL SURFACE ROUGHNESS MEASUREMENT OF MACHINED SURFACES**

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Received June 30, 1989

Abstract

An optical method is described that makes measurement of surface roughness of machined parts in a wide roughness range possible. The apparatus based on a diode laser can be mounted on CNC machining centers as diagnostic tool for checking tool wear. Principles of operation and calibration results are described.

Introduction

Control of uniformity of surface roughness of machined parts is of major importance for automated mass production. Furnishing highly productive machining centers with diagnostic measurements can diminish rejects. Change of surface roughness in serial production is mainly due to tool wear. Therefore an early warning of surface roughness change is highly desirable.

A relatively simple optical method to control uniformity of surface roughness in a wide roughness range, and a measuring head that can be mounted on CNC machining centers was developed and will be described. Calibration results and some hints on its application will be given.

Principle of operation several optical methods are known for surface roughness measurement [1—6]. However, most of them suffer from the limitation that they measure roughness within a relatively small range, or they are very sophisticated and expensive.

In the present optical setup shown in Fig. 1 alternative processing of the emerging signals from the same measuring head make significant extension of the measurement range possible.

The surface to be tested is moving perpendicularly to the optical axis in the focal region of the focusing objective and the backscattered light is sensed by the detectors. Empirically it was found that both in the case of smooth and of rougher surfaces the ratio of the average *AC* component to the *DC* component of the signal of detector D_2, which is normalised by the *DC* component of the signal of detector D_1 shows good correlation with *Ra*

** Dedicated to Prof. J. Giber on the occasion of his 60th birthday.

of the surface. The lens L_2 reimages the illuminated part of the surface on aperture A. With the surface moving forward and away focus the image size changes drastically just as the signal of detector D_2 which is normalized by the signal of D_1. $S=\left(\frac{A\hat{}C_2}{D\hat{}C_2 D\hat{}C_1}\right)$. The distance of the optical head from the measured surface is kept constant by a polished slide, which allows moving

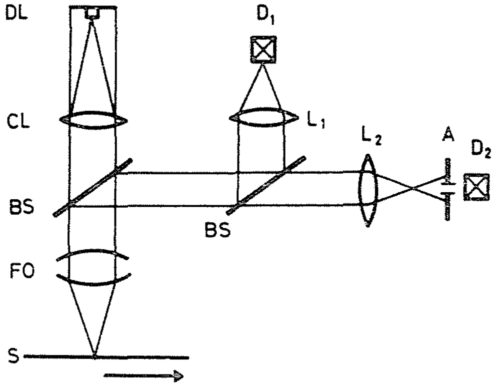

Fig. 1. Optical setup of the measuring head DL diode laser, CL-collimating lens, BS-beam splitter, FO-focusing objective, S-surface to be tested, D_1; D_2-detectors, L_1; L_2-lenses, A limiting aperture

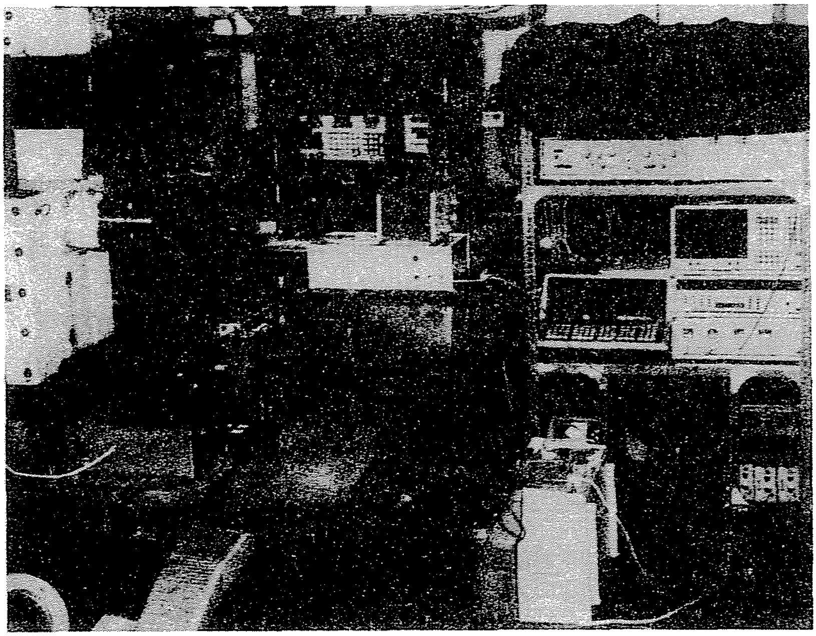

Fig. 2. Photo of the equipment

the head up and down to keep the focal plane of the head at the average surface of machined part. The measuring equipment is shown in the photo of Fig. 2.

Experimental results

Test measurements were carried out on a flat etalon series. The measurements were carried out on each sample nine times in the surface roughness range of $Ra = 0.05$—10 μm. The RMS values were below $2 \cdot 10^{-2}$ at every measurement. Scanning velocity was $1 \frac{\text{mm}}{\text{s}}$, and the scanned length was 10 mm.

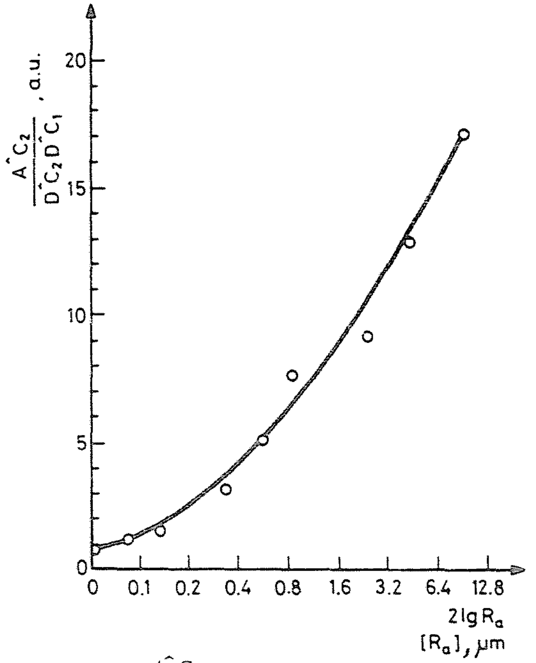

Fig. 3. $\frac{A\hat{}C_2}{D\hat{}C_2 D\hat{}C_1}$ as function of Ra values

Figure 3 shows the measured values $\frac{A\hat{}C_2}{D\hat{}C_2 D\hat{}C_1}$ as a function of Ra.

By means of the equipment lathe-turned internal surface of steel pipe was tested at different powerfeeds and two depth of cuts.

The technological parameters were

a) at rough cutting
depth of cut: $a=2$ mm
power-feed: $s=0.2;\ 0.25;\ 0.3;\ 0.35;\ 0.4\ \frac{\text{mm}}{\text{turn}}$
r.p.m.: $650\ \frac{1}{\text{min}}$

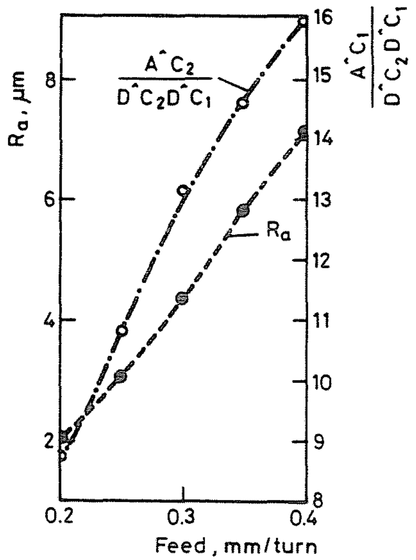

Fig. 4a. Rough cutting $a=2$ mm

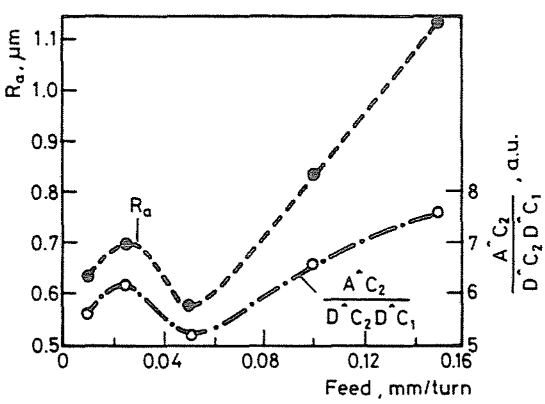

Fig. 4b. Sleeking $a=0.2$ mm

b) at sleeking
dept of cut: $a=0.2$ mm

Power-feed: $s=0.018;\ 0.025;\ 0.05;\ 0.1;\ 0.15\,\frac{\text{mm}}{\text{turn}}$

r.p.m.: $650\,\frac{1}{\text{min}}$

The measured values of $\frac{A\hat{}C_2}{D\hat{}C_2D\hat{}C_1}$ are shown in Fig. 4a, b, as function of power-feed. Ra value of the turned pipe, measured by a stylus instrument are shown as well.

Conclusion

This "semi-contact" optical method is suitable for examination of surface roughness of machined parts on CNC machining centers. By pre-setting upper and lower values of the processing signal indication of rejects is possible. The measuring head can be easily mounted onto the tool holder. In this case for practical purposes an infrared transmitter can forward the data from the measuring head for further processing.

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