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Analyzing Surface Roughness of an Auto-Truck Cylinder After Several Running Hours

Daniela Voicu[1], **Ramona-Monica Stoica**[2], **Radu Vilău**[3]

Abstract: Present paper aims to present the measuring process and results regarding roughness of the inner surface of a truck cylinder, according to standard (STAS 6635-87). To that purpose, it was used a Surtronic S-Series roughness tester, with a stylus able to measure within the range 400 µm. According to the before-mentioned standard, there were performed 4 measurements on the same circular line, each one shifted by 90 degrees to the previous. The process was repeated on eight functional areas characteristic to the cylinder (entire length was divided into eight equal parts). With the use of measured values, it was possible to analyze whether the cylinder's inner surface had proper roughness according to specific standards, even after several functioning cycles.

Keywords: roughness; cylindrical surface; functioning cycles

1. Introduction

Roughness is the characteristic of a surface, defined by deviations in the direction of the normal vector of a real surface from its ideal form (Mitutoyo, 2016). The effect of roughness in automotive industry and not only consists in the arisen of higher friction coefficients between moving parts and improper surface characteristics. The importance of such an analysis is on one hand determined by the fact that cylinders are one of the most critical engine components which have to meet highest requirements, and on the other hand by the characteristic itself (roughness) which is important to be determined and has a significant influence on mechanical assembly functioning in general.

Within present paper, surface roughness was analyzed for an auto-truck cylinder liner, made of cast iron alloys, which has completed several functioning hours (Murashov, 2020).

Surtronic S-Series roughness tester (Taylor Hobson Homepage), with a stylus performing a skidded surface profile measurement.

[1]Eng. PhD, Dunarea de Jos University of Galati, Romania; Address: 47 Domnească Street, Galati, Romania, Tel.: +40.372.361.103, Corresponding author: daniela.voicu@mta.ro.
[2] Eng. PhD, Military Technical University "Ferdinand I", Bucharest, Romania, 39-49 George Cosbuc Blvd, Sector 5, Bucharest, 050141, Romania, Tel.: (+40) 21 335 46 65, (+40) 21 335 70 60, E-mail: ramona.stoica@mta.ro.
[3] Eng. PhD, Military Technical University "Ferdinand I", Bucharest, Romania, 39-49 George Cosbuc Blvd, Sector 5, Bucharest, 050141, Romania, Tel.: (+40) 21 335 46 65, (+40) 21 335 70 60, E-mail: radu.vilau@mta.ro.

2. Experimental Research

Before conducting any experiment, it was verified the roughness tester. For that, it was mounted the stylus, which is automatically controlled by the tester, and has a horizontal movement along the tested product. The type of stylus only allows roughness measurement, without determining the shape of surface.

In order to verify the proper functioning of the tester, it was used a standard sample of 5.81 µm, Figure 1 provided by the manufacturer.

Following the first measurement, used to calibrate the tester, it was obtained a measuring error of 3% which was eliminated by two means: by selecting a different filter and by modifying the stylus position so that its longitudinal axis is parallel to the tested surface. The initial filter selected was type 2CR, (SR EN ISO 4287:2003) with Gaussian filter (among its properties, it can be mentioned the capacity to consider data, before and after defining the position of stylus, when calculating average line. The cut-off value (UPR) is determined by distribution width of Gauss curve. The effect, for selected filter value, is 50% of maximum bandwidth. Gaussian filter eliminates half of first cut-off of the analyzed profile, and half of the last cut-off) (Mitutoyo, 2016).

Figure 1. Standard Sample

The calibration process allowed to stand out the proper usage of the tester, however, for each new position of the stylus on cylindrical surfaces it is required a new calibration of the tester because of the imposed parallel position between stylus and tested surface.

Considering the roughness values required for honed surfaces, such as the cylinder bore of a truck, values which are indicated in specialty literature, the tester was set to a 0.4 µm roughness in order to perform the calibration, preceding the actual measurement which was performed along the longitudinal axis of the cylinder's inner surface. The error obtained was 0%, which means there was no difference between estimated roughness and actual value. In conclusion, all subsequent measurements were performed with the tester set to 0.4µm.

Roughness measurement of cylinder bore was conducted according to standard indications presented in Figure 2 (STAS 6635-87).

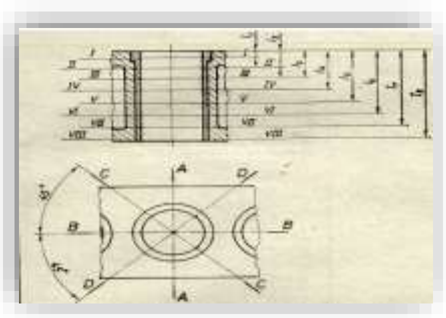


Figure 2. Standard Indications

As it can be observed from Figure 2, there are considered 8 areas (noted from I to VIII) along the length of cylinder submitted to experimental research, and 4 positions/planes (A-A...D-D) shifted at 90 degrees from each other.

In Fiure 3 it is presented the analyzed cylinder which was placed on a special prismatic surface to ensure a horizontal position.

Figure 3. The Analyzed Cylinder

In Figure 4, it is presented the disposal manner of stylus on cylinder bore, as well as the connection between roughness tester and laptop.

Measured data were stored and subsequently processed due to the tester software, named TalyProfile, which was installed on the laptop (Murashov, 2020).

Figure 4. The Connection between Roughness Tester and Laptop

3. Results

The results obtained from measurements, displayed on tester's LCD, are presented in Table 1. The same table contains measuring errors, which were obtained as a consequence of the difference between the set value of 0.4 µm and measured value.

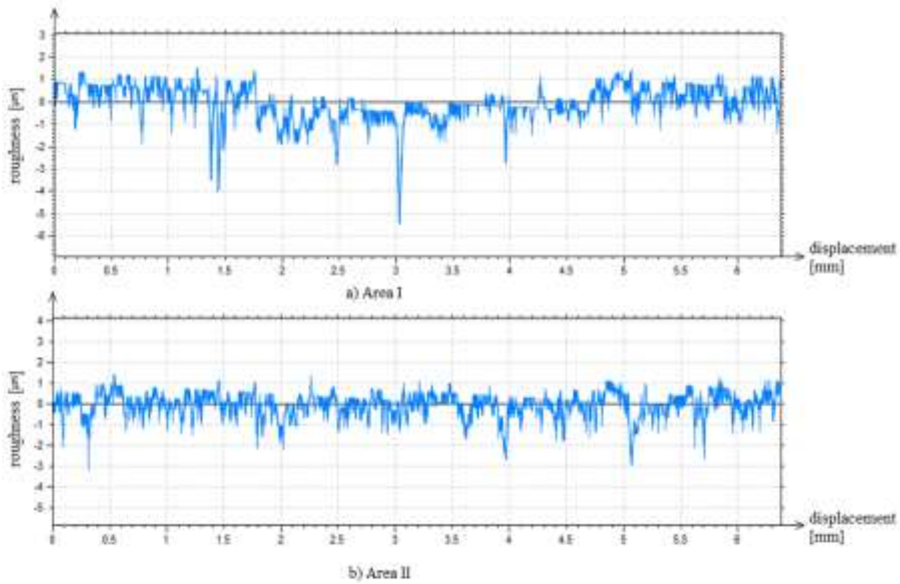
All results represent the average value of roughness in case of the entire length of cylinder.

Table 1. Results Obtained from Measurements.

Position of measurement		Calibration value	Measured value	Error
A-A	I, II, III, IV, V, VI,VII, VIII	0.4	0.4	0.0%
B-B	I, II, III, IV, V, VI,VII, VIII	0.4	0.4	0.0%
C-C	I, II, III, IV, V, VI,VII, VIII	0.4	0.4	0.0%
D-D	I, II, III, IV, V, VI,VII, VIII	0.4	0.4	0.0%
A-A	I, II, III, IV, V, VI,VII, VIII	0.4	0.4	0.0%

By connecting the roughness tester to the laptop, the dedicated software allowed to plot graphs depicting the variation of roughness values for each measured point, 8 areas multiplied by 4 points on each one.

For example, in Figure 5 and Figure 6 there are presented results of measurements for all 8 areas, corresponding to section A-A. This means that the first graph contains values of surface roughness in case of area I, section A-A; the second graph is specific to area II, section A-A, and so forth that the eight graph presents roughness values of cylinder liner in case of area VIII, section A-A. The stylus displacement on cylindrical surface was set to 6 mm. All figures are disposed in order, starting from cylinder head, where piston rings come in contact with cylinder bore, and down to the bottom of cylinder liner.



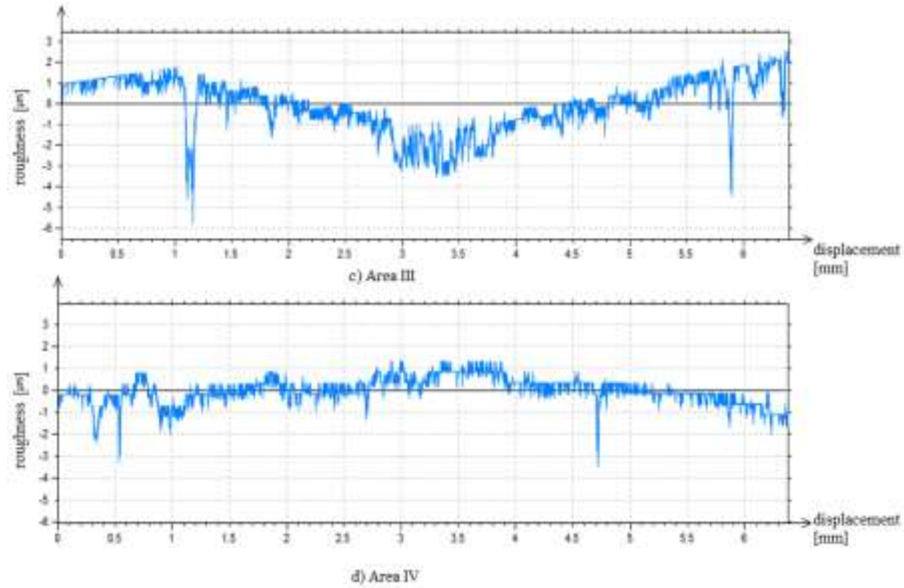


Figure 5. Results of Measurements for Areas I-IV, Section A-A of Cylinder

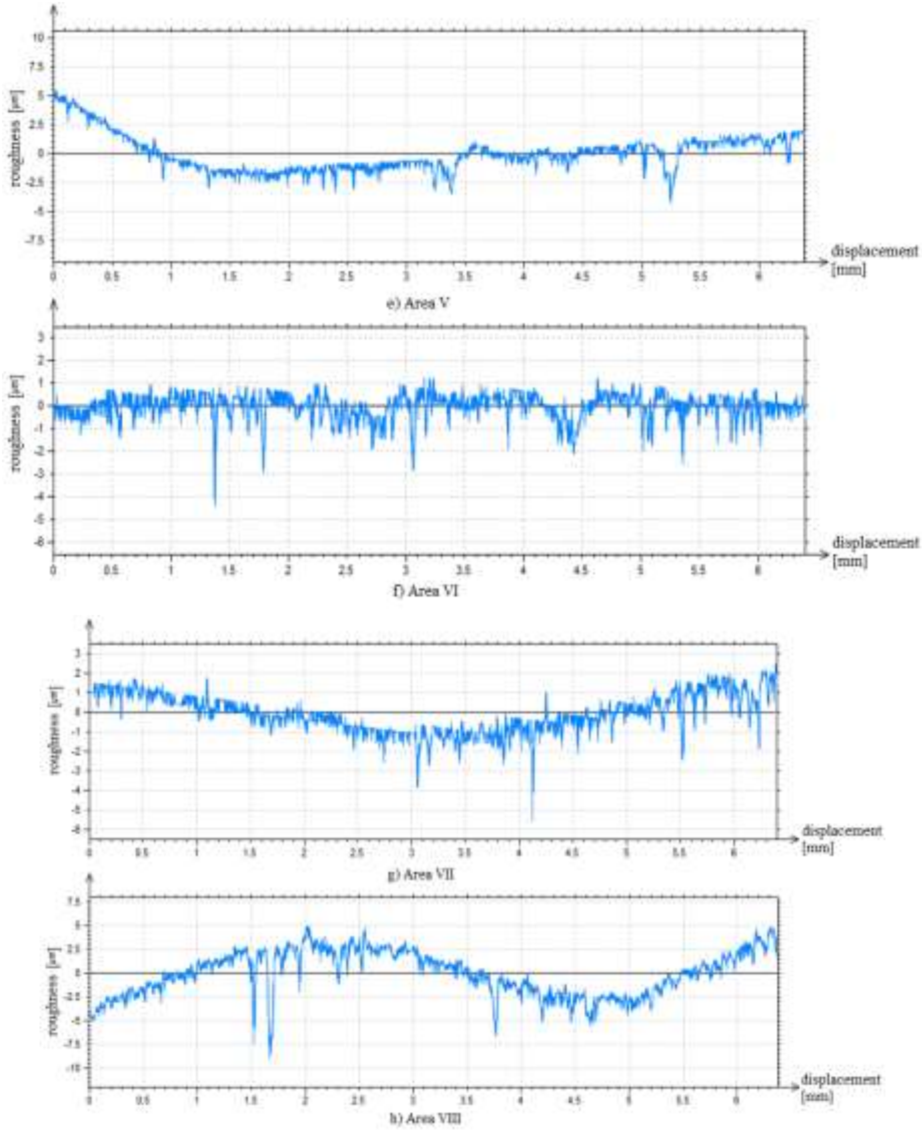


Figure 6. Results of Measurements for areas V-VIII, Section A-A of Cylinder

In order to compare the roughness values obtained in case of the analyzed cylinder to reference values, according to (Dimkovski, 2016), the profile of a honed surface characteristic to a Volvo truck engine ranges between -5 μm and 1.17 μm, as depicted from fig. 7. Thus, results that roughness values of analyzed cylinder, after several cycles of working, is appropriate for most of the liner surface. Still, there are few areas where abnormal wear is observed, such as area VIII and extreme parts of areas III, V and VII, where roughness values reach 5 μm.

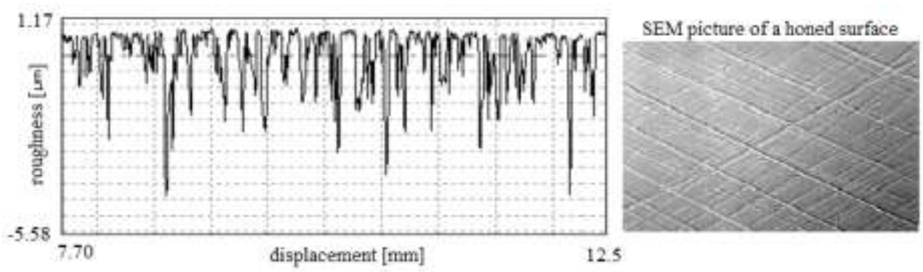


Figure 7. Roughness of a Volvo Truck Cylinder Liner (Dimkovski, 2016)

4. Conclusions

The analysis of results depicted in graphs from Figure 5 and Figure 6, as well as from the values comprised in Table 1, highlights that there are few differences between measured values in case of each one of the 8 areas analyzed. Moreover, differences are more visible where piston rings come in contact to cylinder bore, which was expected.

However, roughness values obtained from measurements have shown that on the entire length of cylinder, the inner surface complies with technological request indicated by specialty literature.

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