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RESEARCH CONCERNING QUALITY MEASURING AND CHECKING FOR SURFACES WORKED BY MEANS OF CLASSIC AND NON-CONVENTIONAL TECHNOLOGIES

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Abstract: This paper presents theoretical and experimental research about surface quality measuring and checking, in order to build the active parts of the thermoplastic materials injection dies made by the author, during the finalization of doctorate thesis and research contract with S.C. „MECORD" S.A. Oradea.

1. INTRODUCTION

Surface quality, expressed by the roughness parameter R_a, is one of the main factors of the technological parameters setting for the electrical discharge working of the thermoplastic materials injection dies. As much as in the case of conventional working methods, the surface quality is determined by the micro-geometric aspect (surface roughness) and the physical aspect (structure and properties of the surface layer).

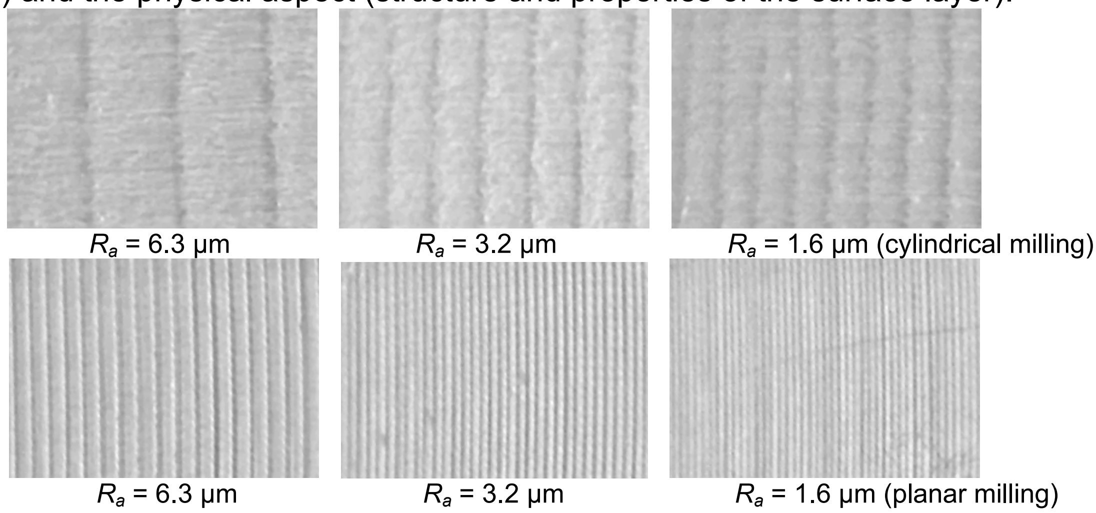


Fig.1.a. *Quality of the milled surfaces.*

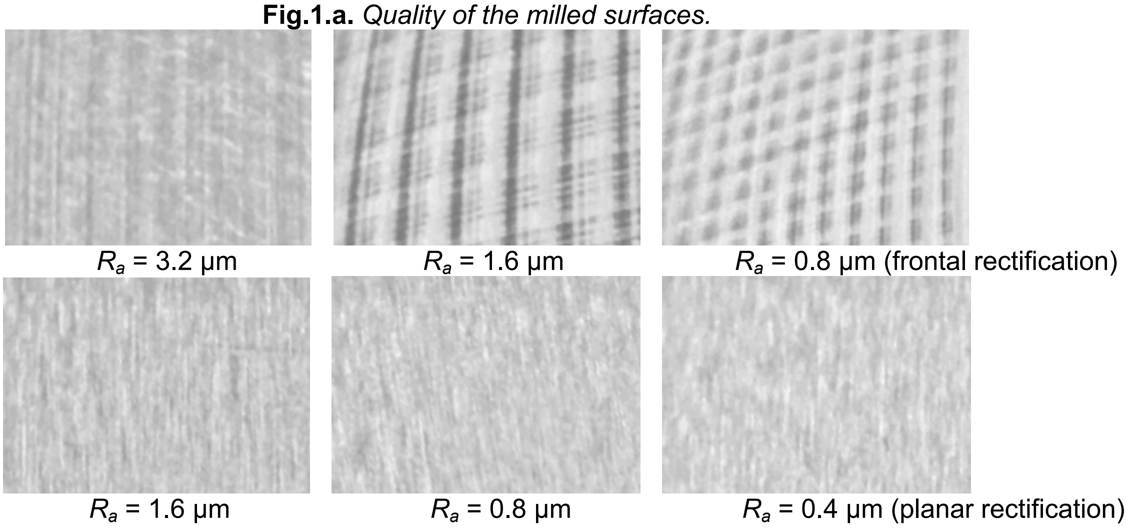


Fig.1.b. *Quality of the rectified surfaces.*

Fig.1 shows the quality of different surfaces worked by milling (a) and rectification (b), magnified 10x by means of the CITIVAL microscope from the Study of Materials Laboratory (Managerial and Technological Engineering Faculty). These roughness values are often used in the building of thermoplastic materials injection dies. The experimental research has been carried out during the finalization of the author's doctorate thesis and of the research contract with S.C. „Mecord" S.A. Oradea.

When making thermoplastic materials injection dies by means of electric discharge working, the right setting of the working parameters is very important: the current intensity, the impulse time, the pause time, the electrode material, the type of washing, pressure and polarity. In terms of choice of these parameters, the accuracy and quality of the injected pieces are achieved according to the specific requirements. Here, the roughness of the worked pieces is assessed in comparison with the chipping worked surfaces, by means of the *filling factor* R_v, which results from the following relation:

$$R_v = \frac{A_n}{A_r} \tag{1}$$

where A_n is the nominal surface area and A_r is the real surface area. The value of this ratio is about 0.46 ÷ 0.49, compared with 0.4 ÷ 0.6 for chipping. It is to be emphasized that the electrical discharge worked surfaces roughness is determined according to the micro-craters density on the worked surface unit; the greater the ratio is, the better roughness is achieved, and the thermally influenced layer is thinner.

The micro-irregularities height is determined by measuring R_{max}, R_z or R_a. It results that the non-homogeneity surface ratio and micro-craters overlapping get values 2.5 ÷ 7 times greater than in the case of chipping working.

The modified structure of the superficial layer, resulting from the temperatures that occur during the electrical discharge working process, is usually thin. Two distinct layers apart from the metal base can be observed (fig.2): a white layer of depth H_A, which consists of a melted and re-solidified metal layer that incorporates liquid phase diffused elements of the tool-electrode and elements from the dielectric decomposition in the energy discharge channels, and a second layer of depth H_{zit}, which is the thermally influenced zone by transformations in solid state.

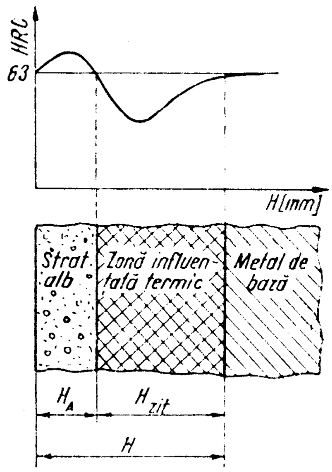


Fig.2. *Superficial layer after electrical discharge working.*

The roughness of the electrical discharge worked surfaces does not vary with the direction of micro-irregularity measuring, as for the chipping worked surfaces, so it can be determined in any direction. It is to be mentioned that the material hardness does not count when using electrical discharge machining; this is why it is recommended that the thermal treatment operations should be carried out before working or, at least, the induration and annealing operations should take place after the chipping coarse grinding should, and then should come the electric discharge pre-finishing and finishing; if necessary, these operations can be followed by cavity polishing.

2. WORKED SURFACE QUALITY MEASURING AND CHECKING METHODS

The following methods are used to measure and check the quality of the surfaces worked by either classic chipping methods or by non-conventional technologies:

- initial visual inspection;
- comparison with standardized gauges;
- contact methods;
- non-contact methods.

2.1. Initial Visual Inspection

This operation can be carried out by examining the worked piece in good lighting conditions, with naked eye or by means of a magnifying glass. The direction of the light should be taken into account in order to observe any process signs or scratches (fig.3).

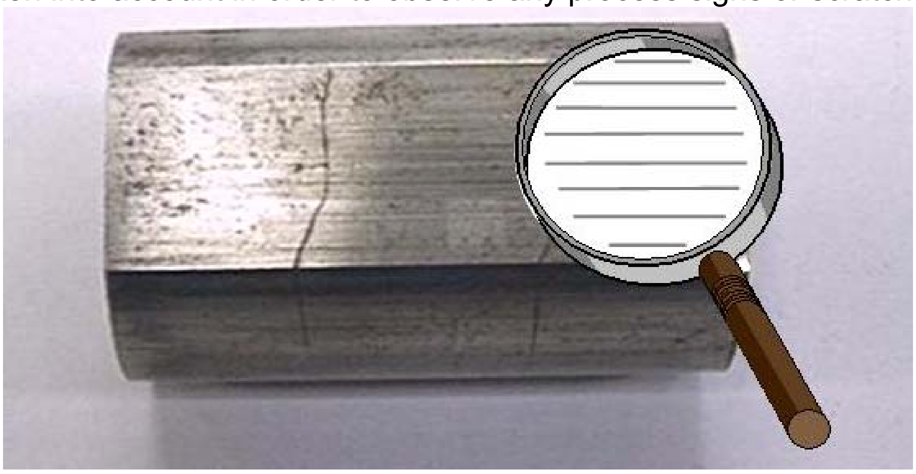


Fig.3. *Visual inspection with magnifying glass.*

2.2. Comparison with Standardized Gauges

These standardized gauges (roughness gauges) are made by means of both classic and non-conventional methods, to be used for chipping and non-conventional working processes, as well as for the injected thermoplastic materials pieces (fig.4, fig.5).

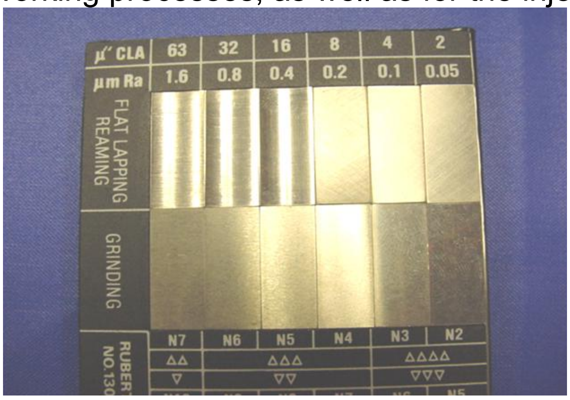


Fig.4. *Roughness gauge for chipping worked surfaces.*

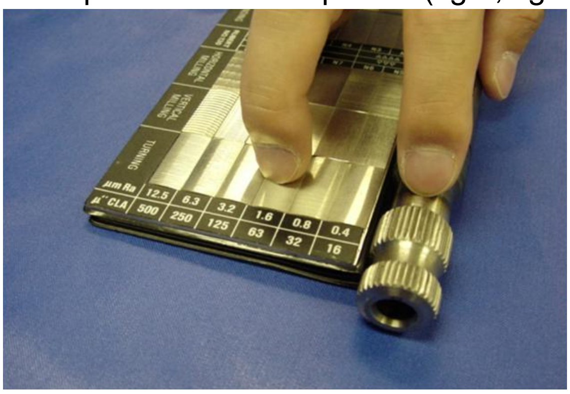


Fig.5. *Checking of the surface quality of an axle by comparison and feeling.*

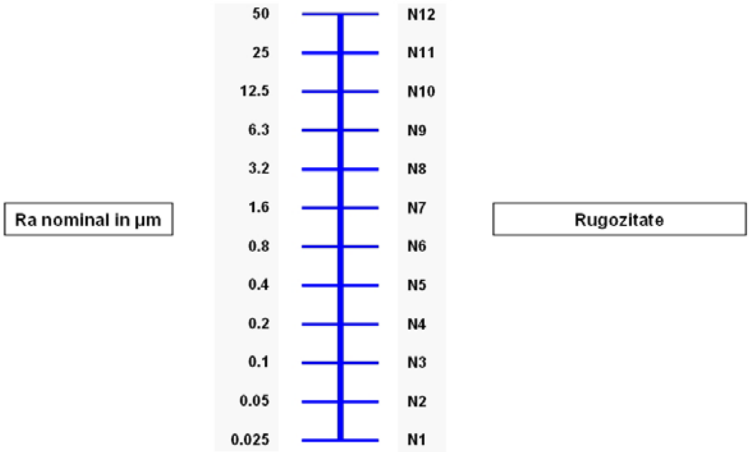


Fig.6. *Correspondence between the nominal roughness Ra and the gauge worked surface.*

Ra represents the quality of the surface obtained by milling, turning, planing, rectification, super-finishing and lapping..

2.3. Contact Methods

Fig.7 shows the principle of the contact instruments, and fig.8 shows the principle of a device based on inductive sensing head.

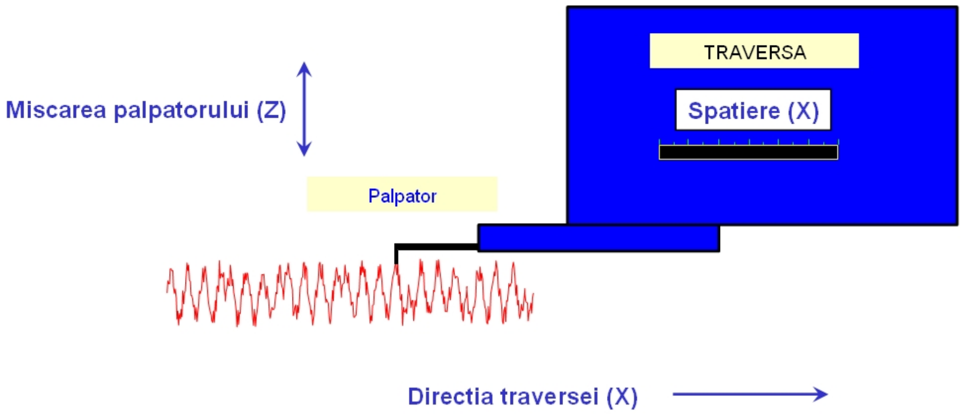


Fig.7. *Principle of contact instruments.*

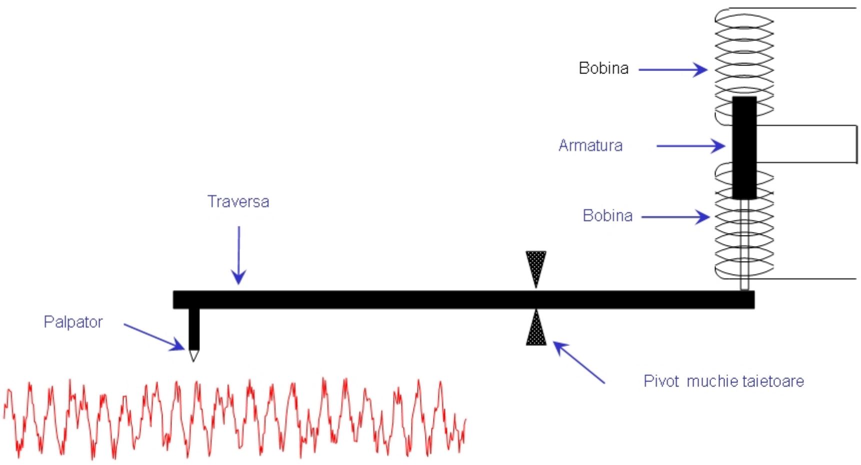
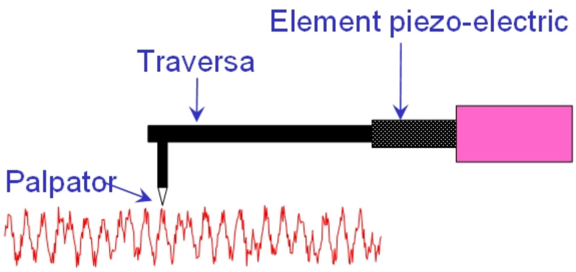


Fig.8. *Principle of the inductive sensing head.*

The contact instruments can be fitted as well with piezoelectric sensing heads; their principle is shown in fig.9.



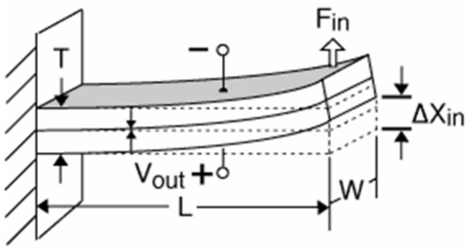


Fig.9. *Principle of the piezoelectric sensing head.*

The instruments with piezoelectric sensing heads are small and portable, are made with simple electronic components and are adequate for the situations where the sensing head makes small movements. However, the measuring range is slim, the linearity is reduced and the piezoelectric element is sensitive to humidity and temperature variations.

A modern method of sensing the movements of the sensing head consists in the use of laser. The working principle of the laser interferometer device is shown in fig.10.

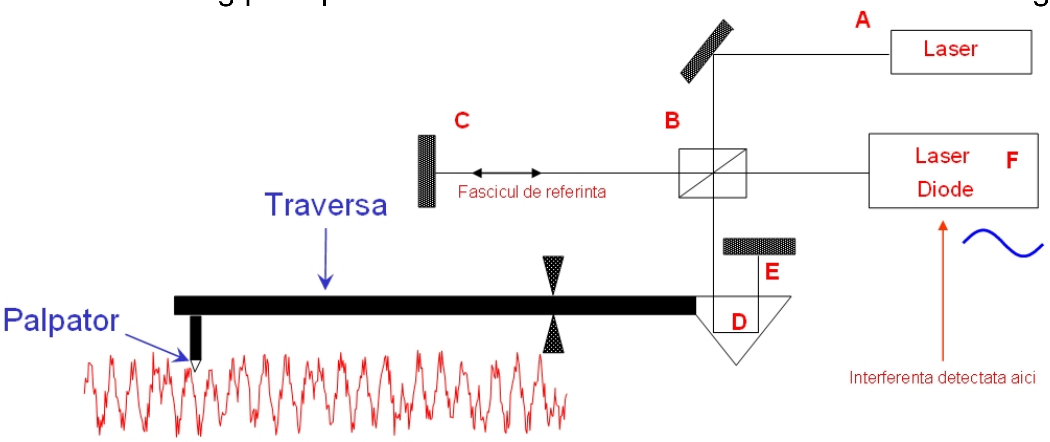


Fig.10. *Laser interferometer sensing head.*

These transducers feature high accuracy and linearity, wide measuring range and high resolution no matter of the head movement. The pins have various shapes; the most usual are the conical shapes (fig.11) and the truncated pyramid shapes (fig.12).

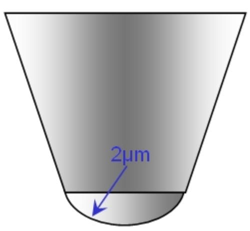


Fig.11. *Conical pin.*

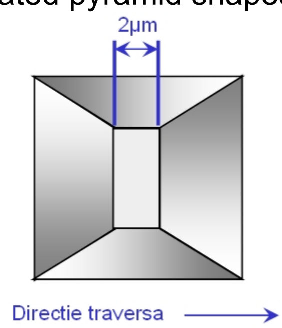


Fig.12. *Truncated pyramid shaped pin.*

Tab.1 shows the standardized values of the pin radius (ISO 3274):

Tab.1. *Standard pin radius (ISO 3274).*

λ_c [mm]	λ_s [mm]	λ_c / λ_s	r_{tip} [µm]	Maximum distance between probes [mm]
0.08	2.5	30	2	0.5
0.25	2.5	100	2	0.5
0.80	2.5	300	2*	0.5
2.5	8	300	5**	1.5
8	25	300	10**	5

*) for surfaces with Ra > 0.5µm or Rz > 3µm, r_{tip} = 5µm may be used without any significant influences over the measurement result;
**) for 2.5µm and 8µm cut-off it is almost certain that the attenuation of the characteristics resulted from the mechanical sensor filtering with the recommended radius value will be outside the defined range; in this case, a small variation of the pin radius or shape would have a negligible effect over the calculated parameters of the profile to be measured.

2.4. Contact-free Methods

The above described methods require direct contact between the control device and the piece to be measured/checked. Lately there is a tendency to eliminate the direct contact and to replace it with laser dispersion. Fig.13 shows the measuring principle of the contact-free laser instrument.

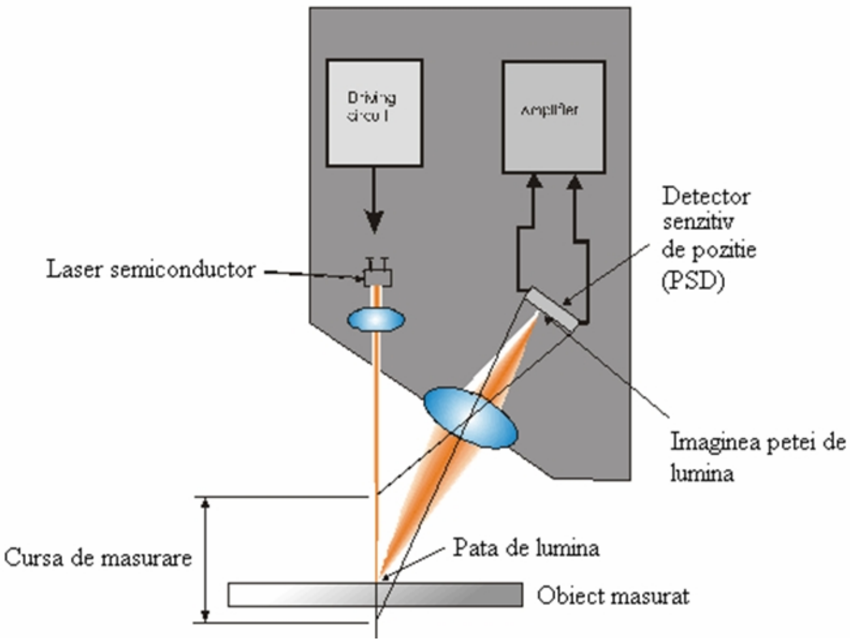


Fig.13. *Working principle of the contact-free laser instrument.*

Some of the advantages of this method are: high measuring speed, declivity up to 90°, low cost. However, some of its disadvantages are the variation of the lighted area, shaded spots, limited resolution.

3. EXPERIMENTAL RESEARCH FOR QUALITY MEASURING/CHECKING OF THE SURFACES WORKED BY ELECTRICAL DISCHARGE

When the active parts of a thermoplastic materials injection die are made, often a certain surface quality is required, and it might even happen that several different roughness values should be required in the same active part. Fig.14 shows some of the most used values of die active part roughness (2.8 ÷ 17 µm)

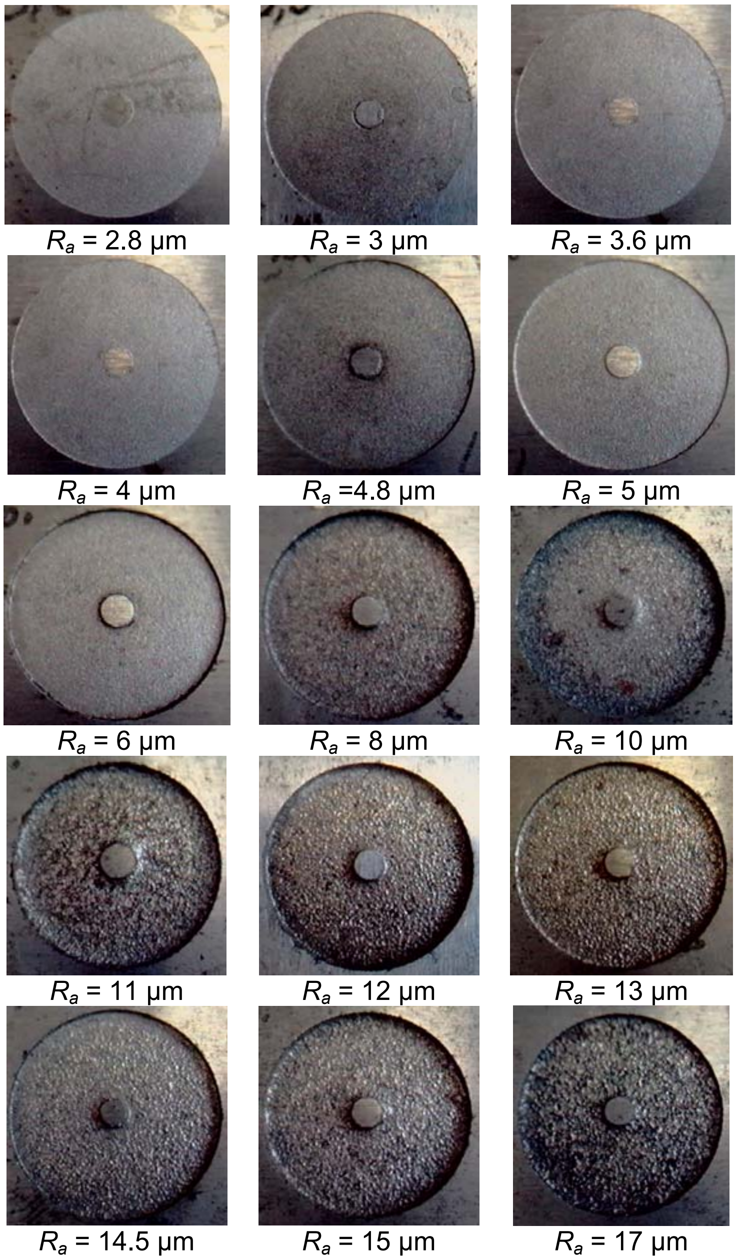


Fig.14. *Frequently used roughness values for thermoplastic materials injection dies – magnified 10x on the CITIVAL microscope.*

The experimental research has been carried out on a hardened steel probe Cr120 at 62 HRC, with a tool-electrode made of electrolytic copper Ø20mm, by means of an electric discharge machine ELER-01-GEP-50F from the Non-Conventional Technologies Laboratory, TCM cathedra. Direct polarization has been used, and washing has been done by injection. The mean values of the micro-irregularities R_a were measured with a SURTRONIC 25 instrument. After calibration (fig.15), the gauges from fig.14 were measured. Fig.16 shows the measuring device that indicates 3.66 µm.

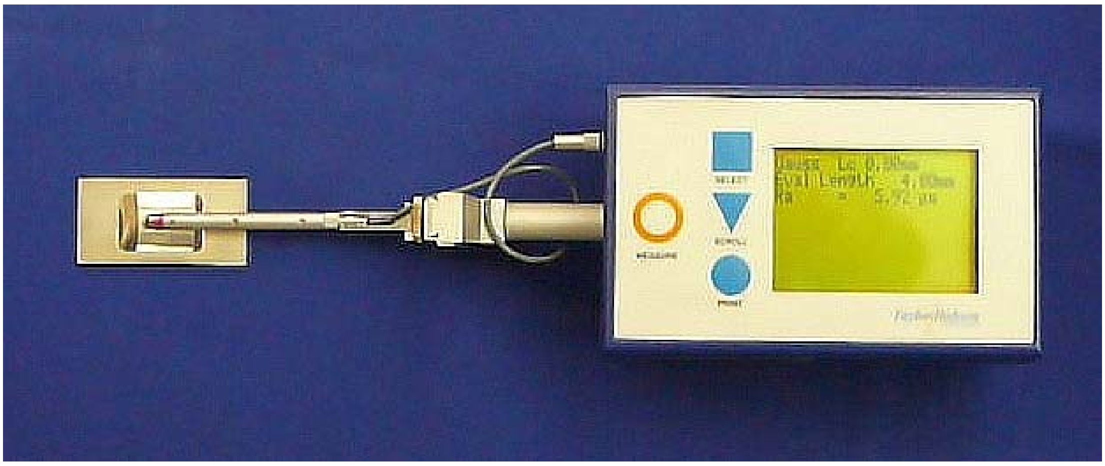


Fig.15. *Calibration of the roughness meter.*

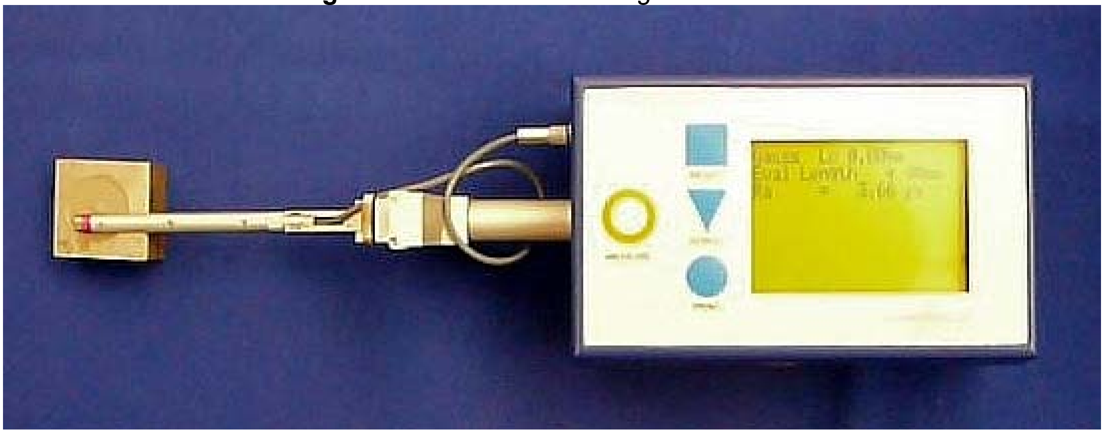


Fig.16. *Measuring of an electrical discharge worked piece.*

4. CONCLUSIONS

The research carried out during the doctorate thesis and the research contract allowed the design and making of roughness gauges sets for frontal and lateral surfaces, that can be used for electrical discharge working of the thermoplastic materials injection dies and for measuring/checking of the active parts roughness, according to the machine operating conditions.

For the dies that require polished active parts surfaces, a machining allowance of 0.01 ÷ 0.04 mm is left on all cavity surfaces, which will be removed by means of super-finishing operations with diamond pastes of various granulations.

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