Surface roughness measuring in case of electro-erosion processed work pieces

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Abstract. Electroerosion is a manufacturing process for working difficult to machine materials. The paper describes a miniature punching die for perforation and cutting obtained from X15 using electro-erosion. This type of material cannot be processed using regular technologies because of its properties such as high hardness and complexity as well as protection against superficial layer damage. The manufacturing process provides a high quality and dimensional precision of the finished product. It is presented a digital surface roughness meter and the functional schematic of the PGI system. Also there are presented different roughness measurement variants as well as the graphical representation and the bearing area curve. There are emphasized the variations of the parameters in the 4 measurement points as well as the variation of the c coefficient. Finally the Ra, Rq and Rz parameters are analysed.

1. Introduction

The electro-erosion manufacturing process provides high precision material removal using controlled thermal energy of electric discharges which remove material through melting and vaporization [1], [2].

Electro-erosion allows processing of materials that are very complicated or even impossible to process using traditional technologies:

- ferrous alloys (steel, cast iron, etc.), hard alloys/exotic materials, metallic carbides, non-ferrous metallic materials (copper, aluminum, bronze, etc.), electricity conducting composite materials and so on;
- plastic or ceramic materials cannot be processed;
- the resulting pieces can have a wide range of shapes and dimensions;
- the work piece is not deformed during processing since there is no direct contact with the electrode and hence there are no pushing forces; the temperature influence in the work zone is reduced by use of dielectric liquid in which the work piece is immersed ;
- since material removal is performed through melting and vaporization, the surface finish is very good, without burrs [3], [4];
- complex shapes can be obtained since the machines are computer-controlled;
- repeatability is very high and precision is within the order of microns;

The presence of irregularities on the work piece surface exposes a series of disadvantages, especially in severe functioning conditions: decrease of actual contact surfaces, increased friction, reduced resistance to alternate tensions, reduced sealing and modifications in the actual work piece dimensions [5]. On the other hand, the absence of these irregularities affects the oil grease on the contact surface [6]. Under these assumptions, the surface roughness is determined as function of processing speed, contact surface size, load size and characteristics, precision and geometric shape. Another factor is the work piece design, which will be the scope of the main surface roughness parameters analysis in case of electro-erosion processing [7].

2. Theoretical aspects

Surface roughness is measured using surface roughness test meters that can provide both analogue and digital readings; they convert the vertical displacement of the touch sensor into proportional changes of the electrical output which requires amplification up to 2,000,000 in order to measure 0.01μm displacements.

Depending on the functioning principle, there are two types of analogue transducers:

- position based: provide displacement proportional signal even when the sensor is stationary; the output depends on the vertical sensor position; the advantage provided is accurate shape;
- movement based: provide output signal only when sensor is moving (depending on speed); zero when stationary;

For digital transducers the PGI system was used in order to allow reduced dimensions and increased measurement interval than HeNe laser interferometer measurement. The PGI system is comprised of an optical fascicle separation unit positioned on the pivoting arm as mobile interferometer element [8], [9]. The wavelength is the measuring reference, depending on ambient conditions. The interference pattern is detected by means of four photodiodes, which allows interpolation of output signal with resolution of 0.8nm in 12.5mm domain.

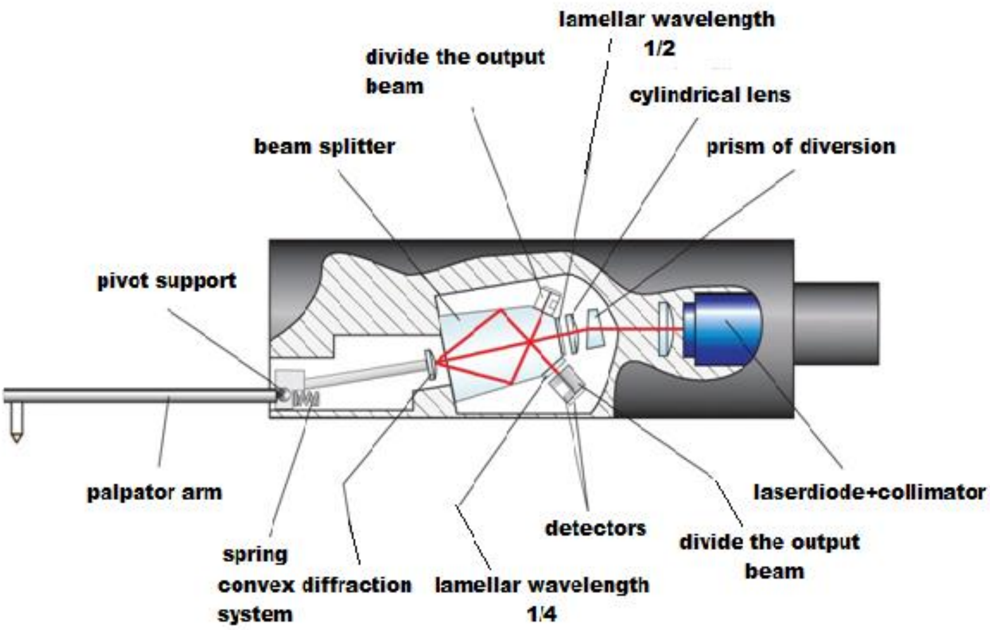

Figure 1. PGI measurement system functional schematic

The output electrical signal is the combination of the touch sensor and arm displacement from the surface level. In order to achieve the correct output signal for the analysed profile the system should travel a parallel path to the surface [10], [11].

3. Roughness measurement. Conclusions

A punching die for perforation and cutting of Aluminum rolling profiles (presented in the following figures) was used in surface roughness measurements.

Figure 2. Complex die for perforation and cutting of Aluminum profiles

Figure 3. Shape of the cut in the Aluminum profile

The die is manufactured from X15 through the electro-erosion technological process.

For measuring the roughness the following measurement surfaces and directions were used depending on the surface roughness tester type and measurement performances [12]:

Figure 4. Measurement surfaces 1 (1 red dot) and 2 (2 red dots)

Figure 5. Measurement surfaces 3 (3 red dots) and 4 (4 red dots)

The resulting measurement curves are:

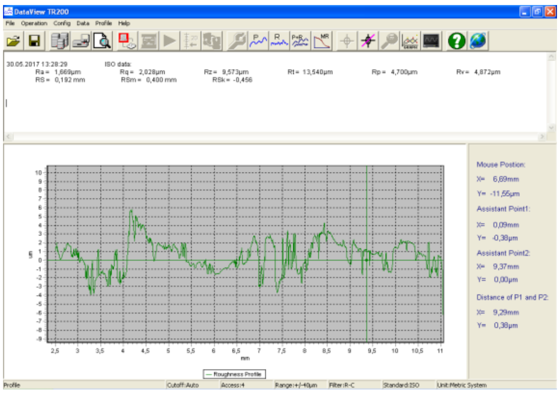

Figure 6. Surface 1 (1 red dot) measurement

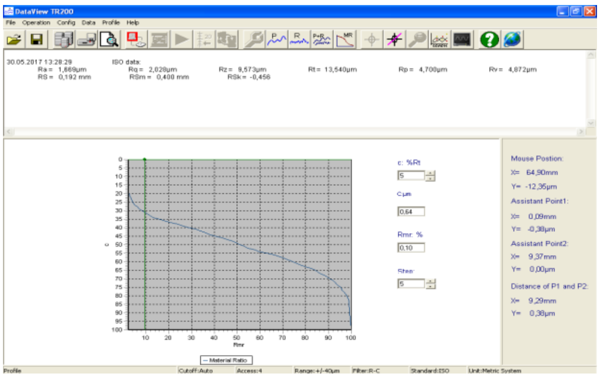

Figure 7. Surface 1 bearing area curve

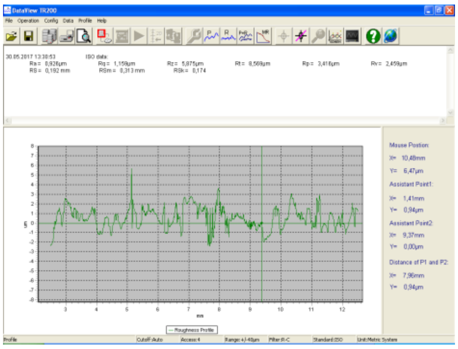

Figure 8. Surface 2 (2 red dots) measurement

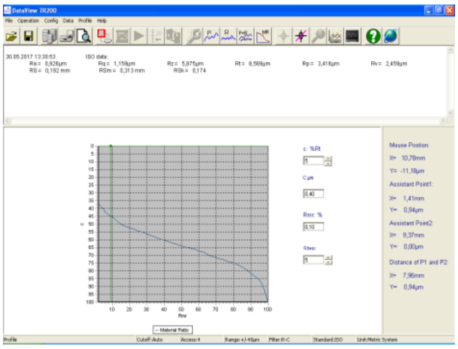

Figure 9. Surface 2 bearing area curve

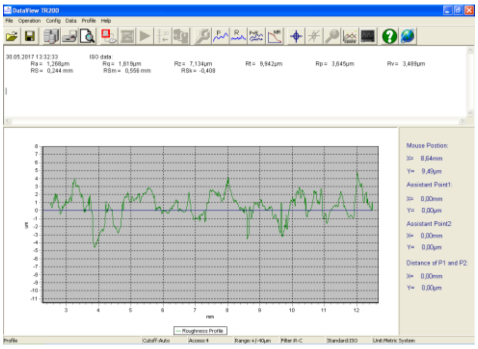

Figure 10. Surface 3 (3 red dots) measurement

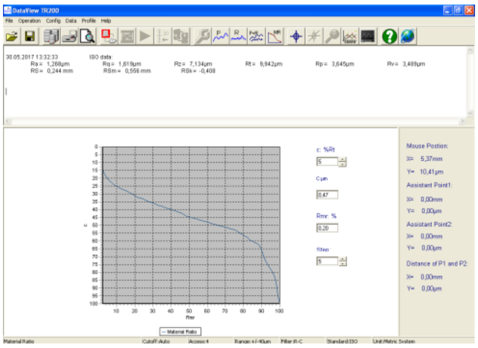

Figure 11. Surface 3 bearing area curve

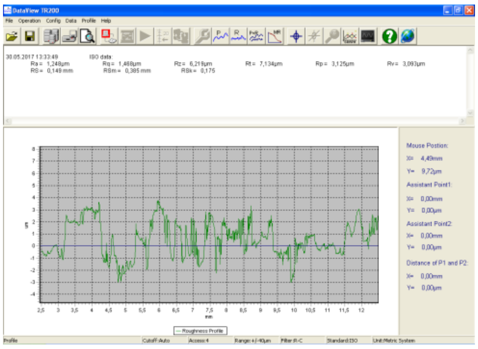

Figure 12. Surface 4 (4 red dots) measurement

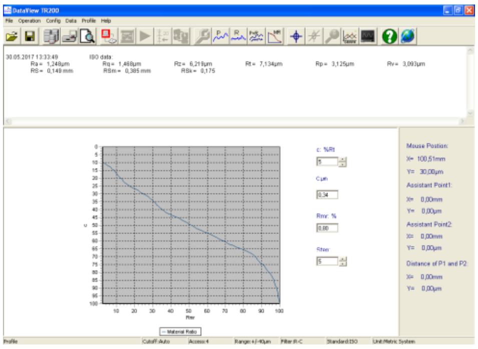

Figure 13. Surface 3 bearing area curve

The digital surface roughness tester and the setup for measurement of the given product are shown in the following pictures:

Figure 14. Surface roughness tester

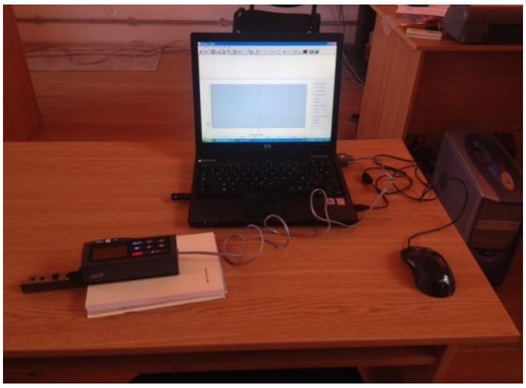

Figure 15. Measurement setup [13]

The variation of Ra, Rq, Rz in the 4 measurement points is presented in the following diagrams:

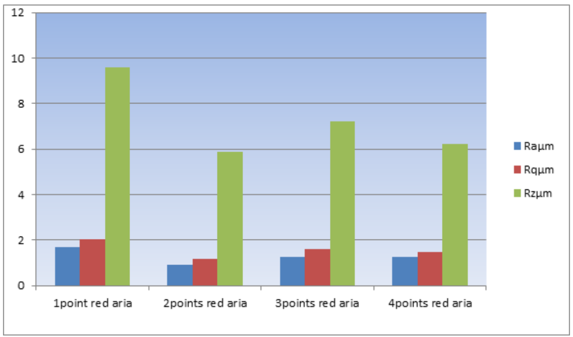

Figure 16. Variation of Ra, Rq, Rz parameters

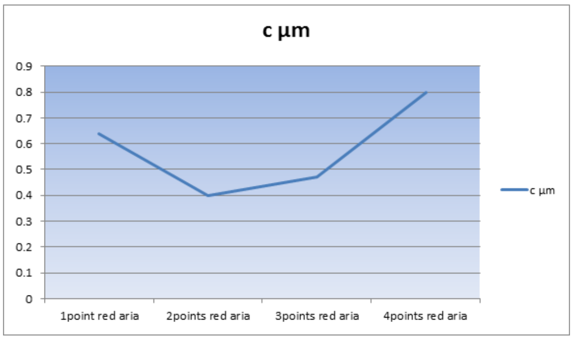

Figure 17. Variation of c coefficient

The variation of Ra, Rq, Rz parameters is within the limits presented in relevant literature. Also the variation of the bearing curve coefficient is within the limits indicated by the electro-erosion technological process specifications [14], [15].

References

[1] Balc, N., Berce, P., Gyenge, C., 2006, *Non-conventional Technologies*, Ed. Alma Mater, Cluj Napoca,.
[2] Balc, N., 2001,*Non-conventional Technologies*, Ed., Dacia
[3] Balc, N., Berce, P., Ancău, M., 2000, *Non-conventional Technologies.*
[4] Picoș,C., Coman, C., Dobre, N., 1979, *Non-conventional Technologies*.
[5] Taylor Hobson Ltd, Exploring Surface Texture – *A Fundamental Guide To The Measurement Of Surface Finish.*
[6] Taylor Hobson Ltd, Basic Surface Finish Filters - *Basic Surface Finish Parameters*.
[7] Micro – Top Consulting Engineering & Service S.R.L., *Course In Applied Metrology*.
[8] J. Paulo Davim, 2010, *Surface Integrity In Machining, Springer*-Verlag, London Ltd,pp.45-46.
[9] Whitehouse, David, 2012, *Surfaces And Their Measurement*, Boston, Butterworth-Heinemann. ISBN 978-0080972015.
[10] Degarmo, E. Paul; Black, J.; Kohser, Ronald A.,2003, *Materials And Processes In Manufacturing* (ed. 9th), Wiley, p. 223, ISBN 0-471-65653-4.
[11] Wen-Ruey Chang; S. Matz, Safety Science, October, 2000*, The Effect Of Filtering Processes On Surface Roughness Parameters And Their Correlation With The Measured Friction*, Part I: Quarry Tiles Volume 36, Issue 1, , Pages 19–33.
[12] Roughness Tester PCE-RT 1200, https://www.pce-instruments.com/english/measuring-instruments/test-meters/roughness-tester-pce-instruments-roughness-tester-pce-rt-1200-det_56329.htm
[13] Munteanu, A., Cioata, F., 2017, *Modern Measuring Devices And Systems*, Ed. Performantica, Iasi, , ISBN 978 -606-685-548-8.
[14] Nanu, A., 2003, *Non-conventional Technologies*, vol.I, Timișoara, Ed. Augusta,.
[15] Nagâț, Gh., 1998, *Compendium of Non-conventional Technologies*, Iași, Ed. Rotaprint.