Comparative Study of the AWJ Cutting Geometry using the 3D Point Measuring Method versus 3D Scanning of the Surfaces

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Abstract: *The abrasive waterjet cutting (AWJ) method is a modern and very a useful technology cause it uses a different technique of cutting the material, more different than the classic way of cuting in which a tool takes contact with the part that needs to be cut. In order to asses the surface resulted after cutting, the kerf width, the surface has to be analysed on both sides of the cut, both on the part and the counterpart. In this paper it is presented a comparative study on a C45 part cutted using AWJ and, the surface resulted is first measured using a 3D measuring arm that measured the surface in points per surface and, second, using a more modern technology, the 3D scanning device. The same surface has been measured with this two different technologies and the results are compared and presented in this paper.*

Keywords: *Abrasive water jet (AWJ), kerf width, geometry of cut, 3D measuring of surface, 3D scan.*

1. Introduction

The abrasive waterjet (AWJ) cutting method is, as mentioned in the abstract, a modern method for cutting different types of materials, from glass, rocks, steel to, even, titanium. The way of cutting the material is one aspect of the situation, the other one is the way of analysing and measuring the resulted surface. In order to have more accurate results, the techonology used for analysing the surface, the kerf width, is of vital importance. The geometry of cut is one of the most important factors in analysing and determining the quality and precision of cut when using AWJ technology.
In this paper it is presented a comparative study on a C45 part cutted using AWJ and, the surface resulted is first measured using a 3D measuring arm that measured the surface in points per surface and, second, using a more modern technology, the 3D scanning device. The same surface has been measured with this two different technologies and the results are compared and presented in this paper.
Studies regarding the field of waterjet cutting have been made by authors like Srivastava et.al. [1], Marcu et. al.[2], Filip et.al. [3], Hereghelegiu et.al [4], and also Hreha et.al. [5].

2. Work method and experimental setup

2.1 Abrasive Water Jet (AWJ) Machine

The experiments were conducted using an abrasive waterjet (AWJ) cutting machine - *Bystronic ByJet Pro L* - presented in Figure 1.

Fig. 1. Bystronic ByJet Pro L water jet cutting machine;

2.2 Part cutting

First of all, the part that was cuted was a 50x50x20 mm part made from a C45 plate, as presented in figure 2. The parameters for the cutting regime used for cutting the C45 part are presented in table 1.

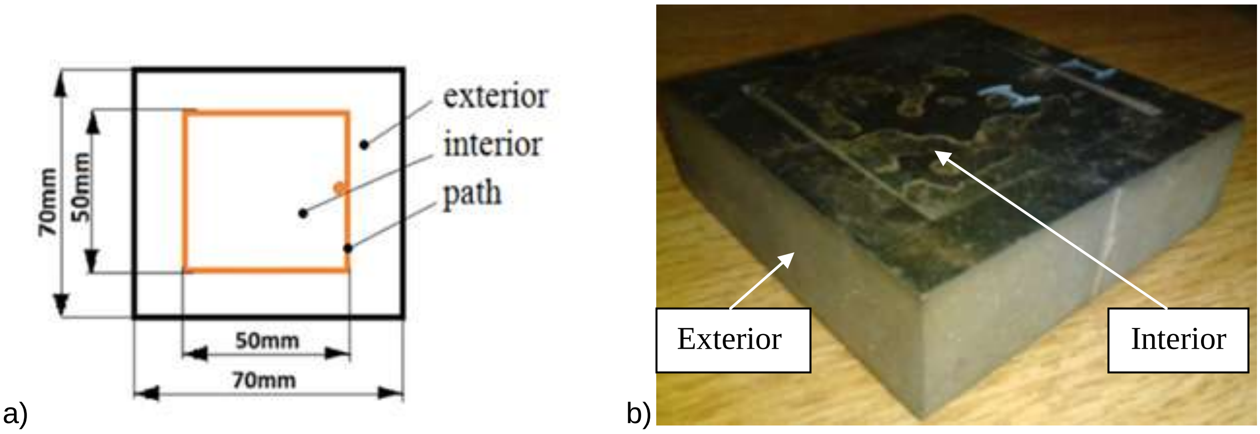


Fig. 2. a) Design for cutting, b)The cutted C45 part

In order to take notice of how the surface has modified after cutting, we had to analyse, in parallel, both the interior and the exterior of the kerf, as presented in figure 2.

Table 1: The selected cutting regime parameters

Parameters	Value selected
Breakthrough time	13 s
Breakthrough pressure	3600 bar
Abrasive material used	GMA Garnet 80 Mesh (300-150 micron)
Quantity of abrasive material	342 g/min
Cutting pressure	3600 bar
Cutting speed	45 mm/min
Interior sapphire nozzle	0,28 mm
Exterior nozzle	0,8 mm

2.3 Method of measuring

After cutting the steel part, both the interior and the exterior, as presented in figure 3, were analysed, in order to determine the exact geometry of the surfaces. For analysing, two different methods were selected:

- measuring the surfaces in points per surface to describe the surface, using a 3D measuring arm
- scaning the surfaces to get a 3D version of the part, using a 3D scanner

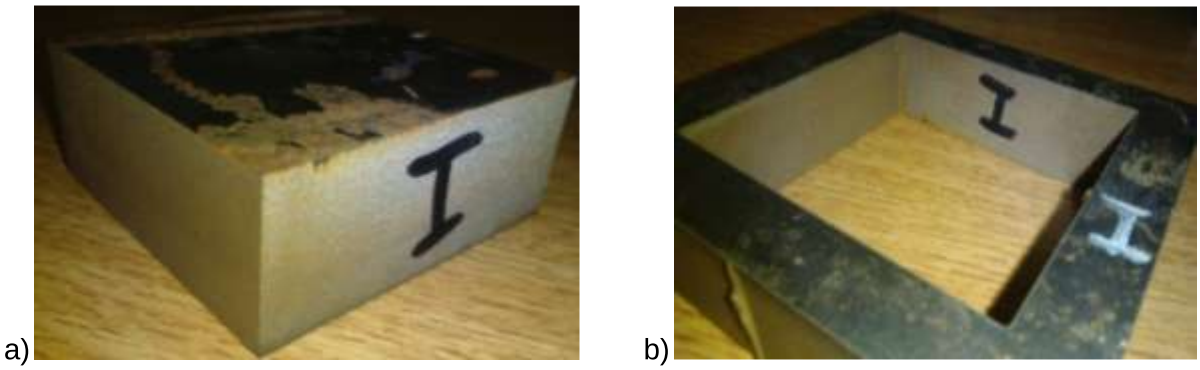


Fig. 3. a) Interior of the cutted part, b) Exterior of the cutted part

The way of numbering, measuring and analysing the surfaces is presented in figure 4. The way of analysing is in this position and the interior (I1-4) with the exterior (E1-4).

Fig. 4. The way of numbering and analysing the surfaces on the C45 part

2.3.1 Using the 3D measuring arm

After cutting the steel part, for both the interior and the exterior, as presented in figure 3, in order to determine the exact geometry of the surface, there were measured a total of 30 points on each surface, using a 3D measuring arm, as presented in figure 5a and b. The 30 measurements were divided on 3 rows, 10 measurements on each row, as presented in figure 5c.

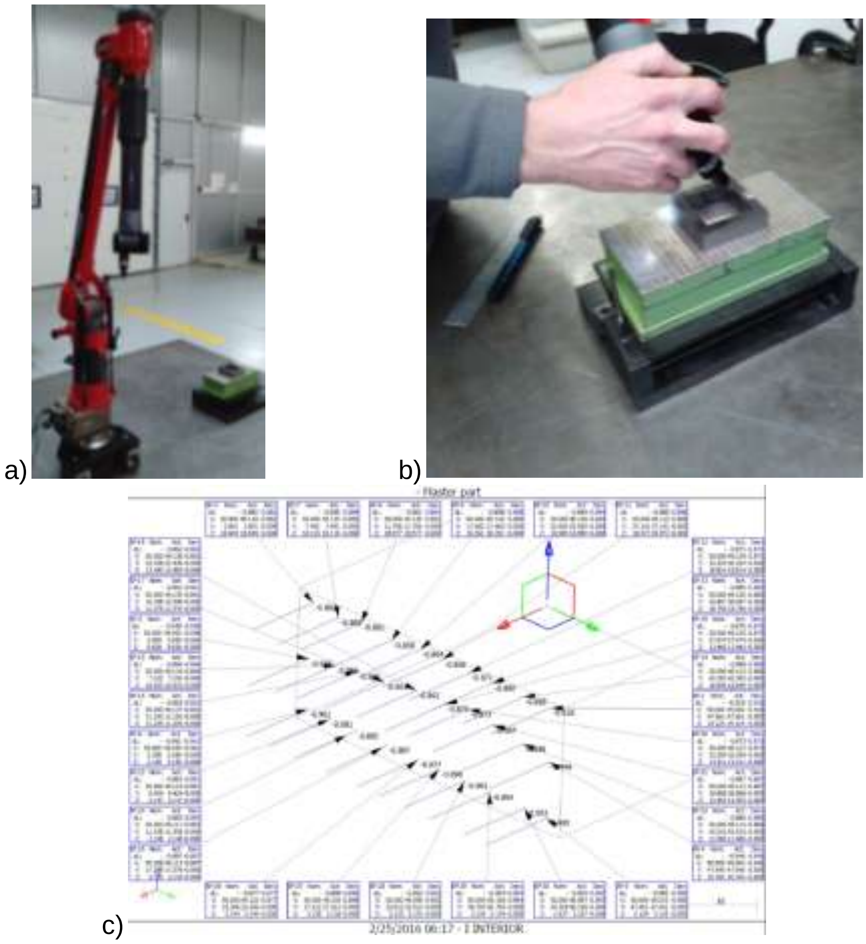


Fig. 5. a) Cimcore Infinite 3D measuring arm, b) Measuring the part, c) The way of measuring the part

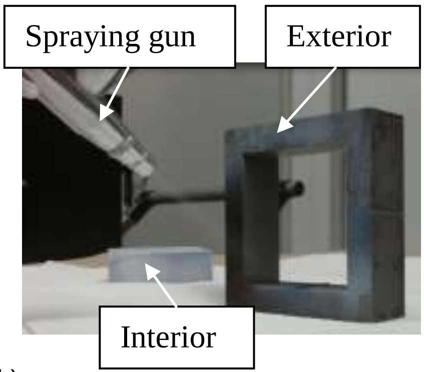
2.3.2 Using the 3D scanner

The 3D scanning is a state-of-the-art technology that, by recording the images and matching them to build a virtual image of the scanned object, succeeds in copying the look and feel of the scanned object and transposing it into the virtual environment. The scanner used for this research is presented in figure 6a.

In order to make the part visible for the scanner, a layer of white titanium based spray had to be applied, making it of a lusterless white, which doesn't reflect the light anymore. The process of spraying can be seen in figure 6b.

Also, after spraying, the part is set on the machines rotative board and the automatic scanner does it's job and scans the part, as presented in figure 6c, and the part is beeing then transfered to computer to be processed and analysed.

a) 

b) 

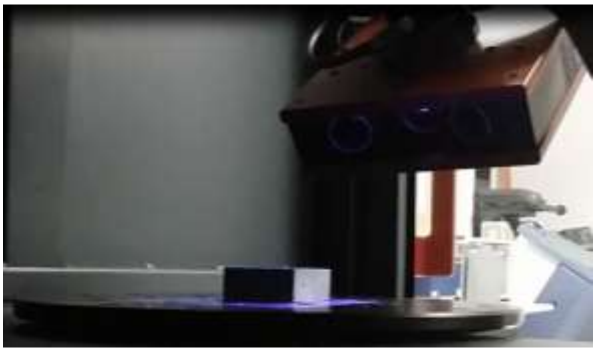
c) 

Fig. 6. a) *GOM ATOS ScanBox 4105*, b) Spraying the parts with titanium based spray paint, c) Scanning the parts

The result after scanning the surfaces of the C45 part, both interior and exterior, made as an assembly, can be observed in figure 7.

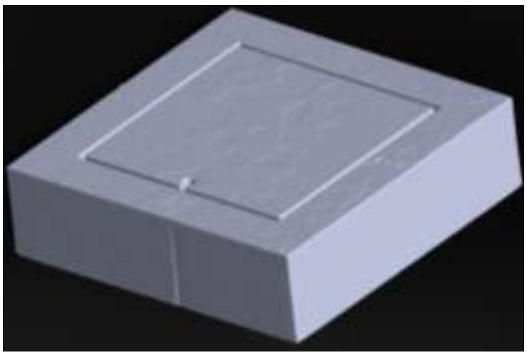


Fig. 7. The C45 3D scanned assembly (interior + exterior)

3. Results after measuring and analysing the surfaces

After measuring and scanning every surfaces, as mentioned before, the values were obtained, centralised and analysed. In both cases, the opposite surfaces were analysed one with another, exterior with interior, generating some results that presented two different values: the minimum kerf width and the maximum kerf width.

3.1 Results after measuring the surface using the 3D measuring arm

Regarding the measures that were made using the 3D measuring arm, after finishing the measurements and analysing the results, the minimum and the maximum kerf width are presented for all surfaces, as one can observe, in table 2.

Table 2: Results after measuring the surfaces using the 3D measuring arm

Surfaces	**Kerf width**	
	min [mm]	**max [mm]**
S1	0.733	0.988
S2	0.752	0.989
S3	0.731	0.971
S4	0.733	1.031

3.2 Results after measuring the surface using the 3D scanner

Regarding the analysing made after scanning the surfaces using the 3D scanner, a table similar with the one made with the results for the other method of measuring the surface was made. The table with the results can be observed in table 3.

Table 3: Results after measuring the surfaces using the 3D scanner

Surfaces	**Kerf width**	
	min [mm]	**max [mm]**
S1	0.61	1.16
S2	0.63	1.59
S3	0.60	1.15
S4	0.69	1.15

After obtaining the results from both of the methods of measuring and analysing the C45 part cutted using AWJ, two graphics have been made to describe the differences in the measured values, both for the minimum value of the kerf width and also for the maximum value of the kerf width, as one can observe in figure 8 a and b.

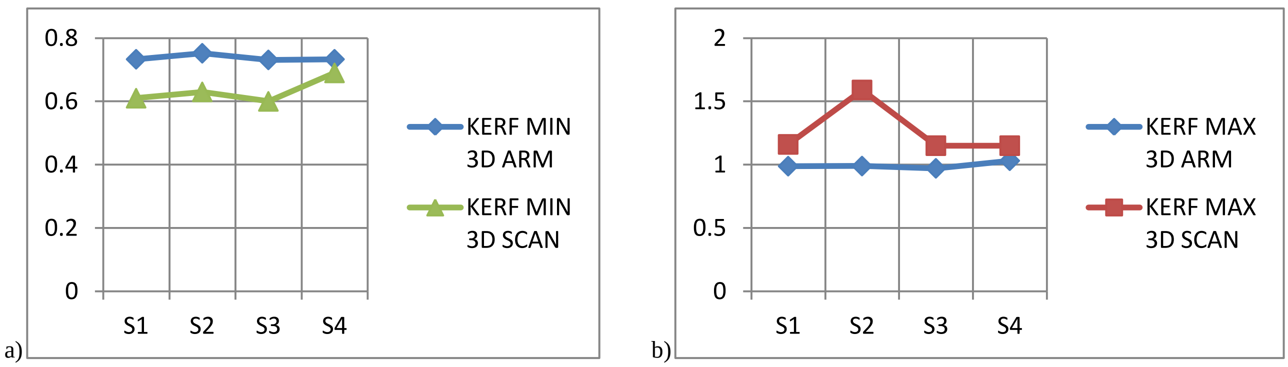


Fig. 8. Analysing the kerf width in both of the analysed cases (using the 3D measuring arm and also using the 3D scaner): a) Kerf width minimum values, b) Kerf width maximum values.

4. Conclusions

After analysing all the results of the described experiments, realised for a part cutted from a specified material (C45), the following conclusions can be highlighted:

a) The results for both measurements are aproximatelly close, but a slight difference can be observed in both the minimum and maximum values, for both measurements;

b) Using the 3D measuring arm is a less precise method because it uses a ball tipe tip for taking the measurements on surfaces, and the tip sometimes can be bigger and doesn't take the measurements corectlly;

c) The 3D measuring arm takes points on surface, and the process is random, possibly missing the bigges or the smalles kerf width values;

d) Using the 3D scanning method is the most precise method because it transforms the C45 part into a 3D part that can be viewed very precise;

e) Analysing the measurements made using the 3D measuring arm, as one can observe, the biggest kerf width 1.031 mm and, the smallest kerf width 0.731;

f) Analysing the measurements made using the 3D scanner, as one can observe, the biggest kerf width 1.59 mm and, the smallest kerf width 0.6.

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