THE STUDY OF THE SPECIFIC ENRGY VARIATION AT THE PERFORATION THROUGH THE ELECTOR-HYDRAULIC METHOD OF THE POLYGONAL HOLES

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ABSTRACT

This paper presents the mode of the determination and the study of the variation of the minimum specific energy to the electro-hydraulic perforation of the polygonal holes in the semi-finished products from aluminum.

KEYWORDS: elector-hydraulic, energy, deformation, polygonal holes

I. GENERAL CONSIDERATONS

The electro-hydraulic perforation and cutting method of the pieces in/from metallic materials and in generally of plastic deformation, is still used in the industry, although this method has a lot of advantages, when compared with the classical methods, especially in the case of production of unique pieces and small series, of pieces with complex shapes, which are being done simultaneously through cutting and forging operations. Because of these reasons, throughout the paper, the authors have decided to combine the determination of the minimum effective energy necessary for the drilling of polygonal holes in the aluminum semi-finished and with the minimum effective energy corresponding to the area, volume and the mass of the waste obtained at perforation [1 - 4].

II. EXPERIMENTAL RESULTS

In the laboratory of cold pressure technology, from de Faculty of Mechanical Engineering, Mecatronics and Management, there is an installation of deformation through electro-hydraulic impulses, with which it has been determined the minimum energy necessary for the perforation of polygonal holes in aluminum semi-finished. For this operation, it has been used a electro-hydraulic discharge chamber with a volume of $1dm^3$ and aluminum semi-finished with the thickness of 0,5 mm,1 mm, and 1,5 mm. The experiment was made for two different situations [1]:

a) without the energy amplifier, with the symbol F in the paper, when the distance between the thread of priming of the load to the semi-finished was 40 mm;

b) with the energy amplifier, with the symbol C in the paper, which was a cone with the top angle of 600 and from the height of 100mm, which had the role to concentrate the obtained pressure through electrical discharge of the energy accumulated in the condenser battery, towards the place of the hole perforation in the semi-finished. In this case the distance between the explosive thread and the semi-finished was 140 mm.

The effective values of the minimum energy obtained after the experimental determinations? For the two modes of deformation (without the amplifier F and with the amplifier C) and for the thickness of the three materials, shown in fig. 1 and 2. In fig. 3, the variation of the ratio C/F can be seen, between the minimum energy when using amplifier C and the energy when the pressure amplifier F was used. The area of the polygonal holes was kept constant and was equal with 60 mm, and the diameter of the exit of the amplifier bore was 20mm.

Table 1. ***Effective values of the energy E, used to drill polygonal holes in the sheet of aluminum with the area p = 60 mm = constant; The capacity of the condenser battery C = 70 μF***.

Gros. mat. s, mm	Mod de def.	Triangle		Square		Pentagon		Hexagon		Dodecagon		Circle	
		E	C/F	E	C/F	E	C/F	E	C/F	E	C/F	E	C/F
0,5	F	365	0,60	350	0,54	340	0,52	330	0,52	324	0,51	320	0,50
	C	216		190		180		172		166		160	
1,0	F	590	0,72	555	0,69	540	0,68	530	0,67	526	0,66	520	0,65
	C	425		385		370		360		348		340	
1,5	F	835	0,79	790	0,74	770	0,74	760	0,73	740	0,72	710	0,69
	C	665		590		570		560		533		495	

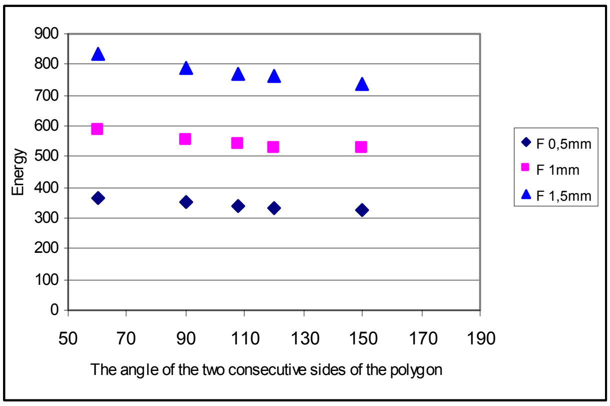

Fig.1. ***Variation of the effective energy E, in Joules, used for the electro-hydraulic drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation without the pressure amplifier, of the aluminum semi-finished.***

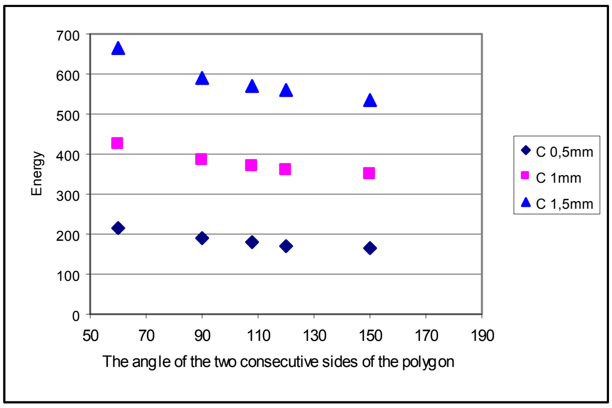

Fig. 2. ***Variation of the effective energy E, in Joules, used for the electro-hydraulic drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation with the pressure amplifier, of the aluminum semi-finished.***

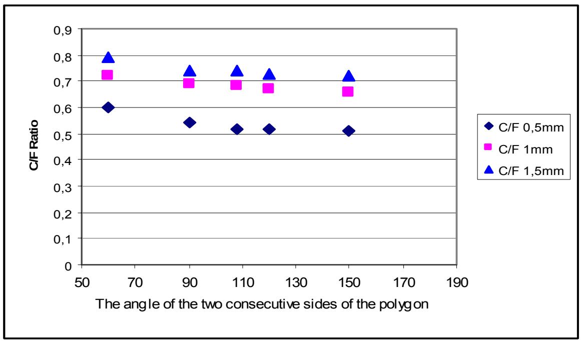

Fig. 3. ***Variation of the ratio C/F between the minimum values of the energy at perforation of the polygonal holes. regarding the angle of the two consecutive sides of the polygon***

In chart 2 there are given the minimum specific energy values $E_{s,}$ according to the area of the waste, in J/mm^2 and in fig. 4,5 and 6 there are presented the graphs for the minimum specific energy $E_{s,}$ for the case when it was used without the energy amplifier (case F), with the energy amplifier (case C) and with the ratio C/F.

Table 2. The minimum specific energy values E_s' in J/mm^2,used for the drilling of polygonal holes in the aluminum sheet with the area p = 60 mm = constant; The capacity of the condenser battery C = 70 μF.

Thic. mat. s mm	Meth of defor.	Triangle		Square		Pentagon		Hexagon		Dodecagon		Circle	
		E	C/F	E	C/F	E	C/F	E	C/F	E	C/F	E	C/F
0,5	F	2,10	0,59	1,55	0,54	1,36	0,52	1,27	0,52	1,15	0,51	1,11	0,49
	C	1,24		0,84		0,72		0,66		0,59		0,55	
1,0	F	3,40	0,72	2,46	0,69	2,17	0,68	2,03	0,68	1,87	0,66	1,81	0,65
	C	2,45		1,71		1,49		1,38		1,24		1,18	
1,5	F	4,82	0,79	3,51	0,74	3,10	0,74	2,92	0,73	2,64	0,72	2,47	0,69
	C	3,83		2,62		2,29		2,15		1,90		1,72	

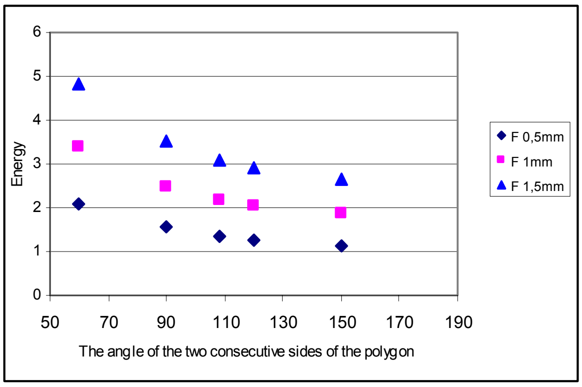

Fig. 4. ***Variation of the specific energy E_{v},, in J/mm^2, used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation without the pressure amplifier***

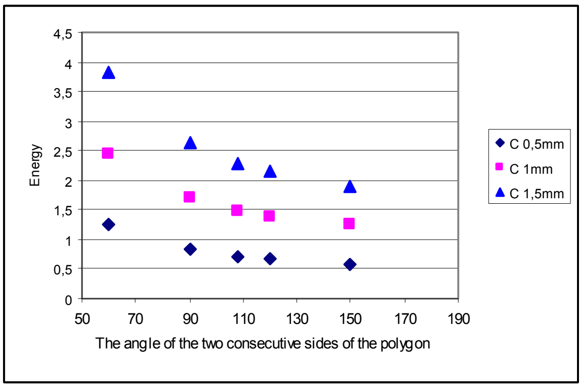

Fig. 5 ***Variation of the specific energy E_{v},, in J/mm^2, used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation with the pressure amplifier***

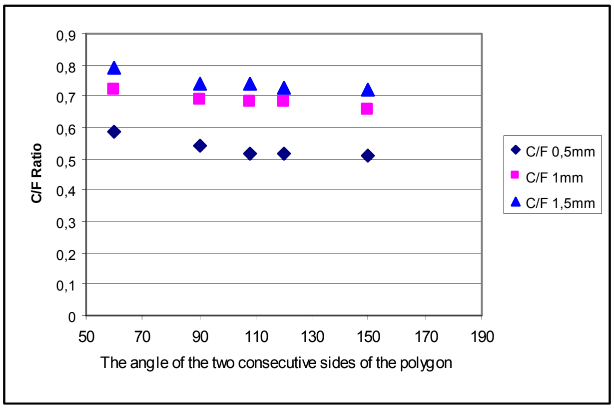

Fig. 6. ***Variation of the C/F ratio, the minimum energy for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon.***

Table 3. ***Effective values of the energy E_v,in J/mm^3, used to drill polygonal holes in the sheet of aluminum with the area p = 60 mm = constant; The capacity of the condenser battery C = 70 μF.***

Thic. mat. s mm	Meth of defor.	Triangle		Square		Pentagon		Hexagon		Dodecagon		Circle	
		E	C/F	E	C/F	E	C/F	E	C/F	E	C/F	E	C/F
0,5	F	4,21	0,59	3,11	0,54	2,73	0,53	2,54	0,51	2,31	0,51	2,23	0,49
	C	2,49		1,68		1,45		1,32		1,18		1,11	
1,0	F	3,40	0,72	2,46	0,69	2,17	0,68	2,03	0,67	1,87	0,66	1,81	0,65
	C	2,45		1,71		1,49		1,38		1,24		1,18	
1,5	F	3,21	0,79	2,34	0,74	2,06	0,74	1,95	0,73	1,76	0,71	1,65	0,69
	C	2,55		1,74		1,53		1,43		1,26		1,15	

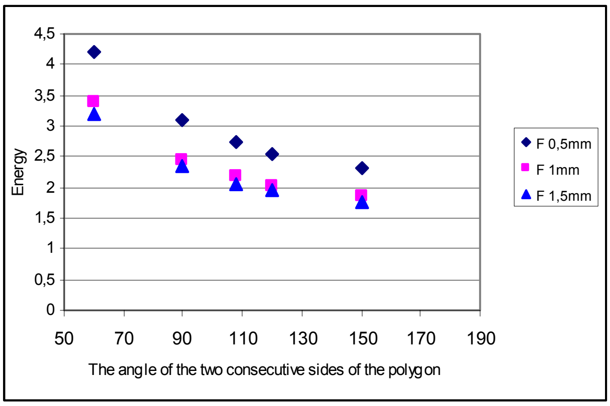

Fig. 7. ***Variation of the specific energy E_v,, in J/mm^2, used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation with the pressure amplifier***

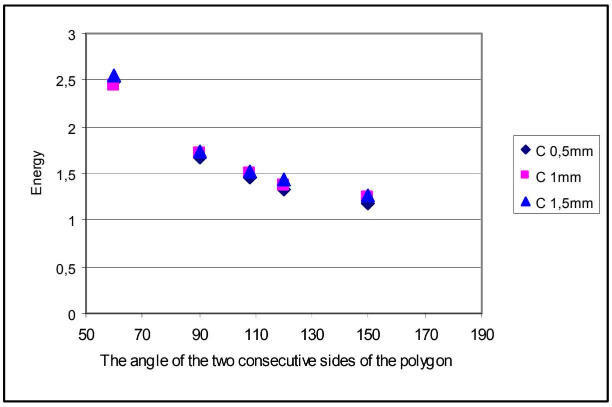

Fig. 8. ***Variation of the specific energy E_v,, in J/mm^3, used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation with the pressure amplifier***

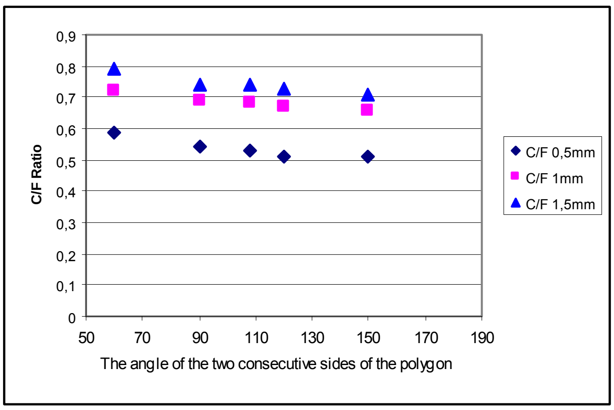

Fig. 9. ***Variation of the C/F ratio, the minimum energy for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon.***

Table 4. Effective values of the energy E_m,in KJ/g, used to drill polygonal holes in the sheet of aluminum with the area p = 60 mm = constant; The capacity of the condenser battery C = 70 µF.

Thic. mat. s mm	Meth of defor.	Triangle		Square		Pentagon		Hexagon		Dodecagon		Circle	
		E	C/F	E	C/F	E	C/F	E	C/F	E	C/F	E	C/F
0,5	F	1,56	0,59	1,15	0,54	1,01	0,52	0,94	0,52	0,85	0,51	0,82	0,49
	C	0,92		0,62		0,53		0,49		0,43		0,41	
1,0	F	1,26	0,72	0,91	0,69	0,80	0,68	0,75	0,67	0,69	0,66	0,67	0,65
	C	0,90		0,63		0,55		0,51		0,46		0,43	
1,5	F	1,15	0,82	0,86	0,74	0,76	0,73	0,72	0,73	0,65	0,72	0,61	0,69
	C	0,94		0,64		0,56		0,53		0,47		0,42	

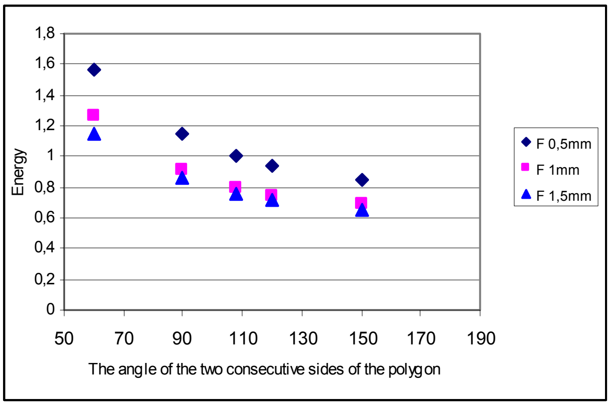

Fig. 11. ***Variation of the specific energy E_m, in KJ/g , used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation with the pressure amplifier*.**

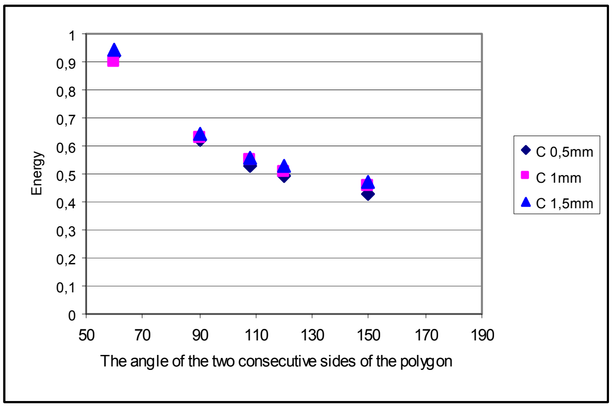

Fig. 10*. Variation of the specific energy E_m, in KJ/g , used for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon in the case of perforation without the pressure amplifier*.

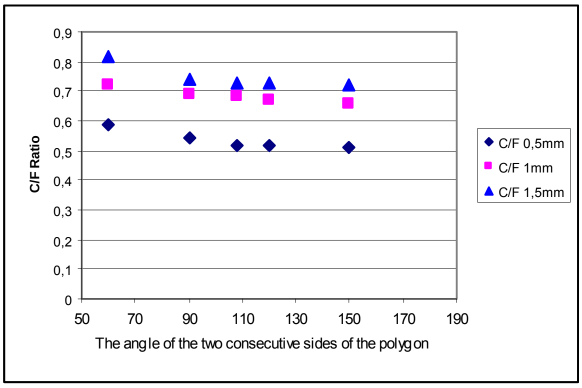

Fig. 12. ***Variation of the C/F ratio, the minimum energy for the drilling of polygonal holes regarding the angle of the two consecutive sides of the polygon.***

In Table 3 there are given the minimum specific energy values E_v, according to the volume of waste, in J/mm^3 and in fig. 7,8 and 9 there are presented the graphs for the minimum specific energy E_s, for the case when it was used without the energy amplifier (case F), with the energy amplifier (case C) and with the ratio C/F. Also, in table 4 there are given the minimum specific energy values E_m, according to the weight of the waste, in J/mm^3 and in fig. 10, 11, and 12 there are presented the graphs for the variation of specific energy E_v, for the case when it was used without the energy amplifier (case F), with the energy amplifier (case C) and with the ratio C/F. It is obvious that the both specific energy, E_v şi E_m, give results which resemble.

III. CONCLUSIONS

From the analysis of the data from charts 1-4 and from the fig. 1-12, the following conclusions have been withdrawn:

1. The minimum perforation energy value decreases with the increase of the number of sides of the polygon, when the cutting conditions for the material become considerably better, thanks to the increase of the waste area, but especially because of the increase of the angel between the sides of the polygon [1-6].
2. Not only in the case without the energy amplifier (case F), but also in the one with the energy amplifier, the largest variation for the minimum energy takes place at angles between 60^0 and 90^0, at the transformation from an equilateral triangle to a square, when the increase of the waste area is noticeable. The same thing happens for specific energy.
3. For all the cases, the efficiency of the usage of the pressure amplifier is grater in the case of small thickness materials.
4. Minimum specific energy values E_v and $E_{m,}$ when the pressure amplifier is used, it does not depend on the thickness of the material, having almost the same value for all the 3 thicknesses of the studied material. Actually the both energy are equal, the form of the variation graph is identical for the both cases. The separation of the waste material takes place in both cases thanks to the inertia force which applies on th material waste.
5. The values of the specific energy E_v and E_m, when the pressure amplifier is not being used, they are smaller when thicker materials are used, this fact is explained by the bigger stiffness of the material waste, which through this, makes the conditions for cutting better.
6. the specific energy consumption, decreases with the increase of the angle between the polygon sides, when the area of the waste increases. Besides the increase of the waste area, which makes it absorb more force, the waste becomes more flexible and it strains easier over the cutting edges of the active perforation plate, which also brings a decrease in energy consumption once with the increase of the waste area. Also, the cutting conditions for the material, becomes better and more uniform with the increase of the number of sides of the polygon.
7. The thickness of the material has a great influence on the minimum energy values E_v and on the minimum specific energy E_m, only in the case of straining without the energy amplifier. When the energy amplifier is used, the variation curves for the three material thicknesses used in the study, the curves overlay.
8. For the study cases, the angle between the polygon sides, has a smaller energy influence upon the energy consumption, the polygon shape has a determined influence on the specific energy values, which give the bore area of the active perforation plate.

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