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COST CALCULATOR FOR WATER JET, LASER AND PLASMA MACHINING

Silvia FERENȚ-PIPAȘ, Mariana DINDELEGAN, Bogdan PĂDUREAN,
Emilia CIUPAN, Cornel CIUPAN

Abstract: This article talks about the calculation of production costs and the roughness after cutting for water jet, laser and plasma cutting processes. It is created a program that calculates productions costs, using empirical mathematical relations for calculating the feed rate and the roughness obtained after cutting.

Key words: Cost, calculator, cutting, waterjet, plasma, laser.

1. INTRODUCTION

The program is designed to give the user an overview of the production costs of the three modern cutting processes and the level of quality that can be achieved for groups of materials that have been studied in this research: aluminum, carbon steel and stainless steel.

The software is designed to be used by two types of users.

User "basic", which will introduce the following inputs: material type and thickness and length or perimeter that the user have to cut. The input will be processed by the software that will choose the optimal parameters for which to calculate the total cost of production and the quality obtained after cutting.

The "expert" is intended for experienced users, they have the possibility to establish and modify the process parameters.

2. UNDERLYING THE PROGRAM

First, the program uses three databases to calculate the total production cost obtained by summing up all the costs that make up the total cost of production.

The amounts of these costs are: 23.68 euro for water jet, 48.34 euro for laser and 20 euro

for plasma. The user will have the option to view those databases and modify them.

3. THE PROGRAM INTERFACE

On the interface of the program we find two buttons: "Basic User" and "Expert User", like in the figure 1.

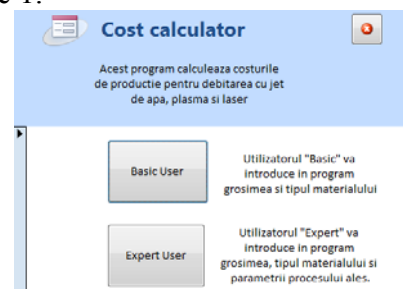


Fig. 1. The interface of the program

4. „BASIC USER”

Basic version has the following options: select the type of cutting material (aluminum, stainless steel or carbon steel), material thickness and enter the length or perimeter of the piece. (Figure 2)

For the basic user, the program uses three databases, made on experiments, which includes the values of the roughness and the cutting speed depending on the material

thickness. With these values are calculated the time of production, then the cost per piece.

After the introduction of the input data, the program will responses, as shown in figure 3. The program will display the processing time, resulting roughness and production cost per piece.

Fig. 2. Choice of input data for "Basic User"

Proces	Timp de prelucrare (ore)	Rugozitate obtinuta (μm)	Costul de productie (euro/buc)
Jet de apa	0.54	4.15	17.62
Jet de plasma	0.23	6.75	4.63
Fascicul laser	0.55	7.2	26.36

Fig. 3. The response generated by the soft for "Basic User"

5. „EXPERT USER”

For "Expert User", the user will have the following options: choosing the type of material, its thickness and length or perimeter of the piece (figure 4), just as the "Basic User".

After inserting this data, the user will choose the type of process for which will be carried out the calculation of production costs. By pressing the "Water", "Laser" or "Plasma", the user chooses one of the processes studied.

After providing this information, the program goes to the expert that requires the user to specify additional data to calculate production costs as accurately.

5.1 The calculation of parameters for water jet cutting and abrasive agent

Once it has chosen the way "Expert User", options "Water" program offers a choice of nozzle diameter and cutting speed. (Figure 5)

Fig. 4. Choice of input data for "Expert User"

Fig. 5. The choice of input data for "Expert User"- Water.

Depending on the diameter of the nozzle, the program will choose water, abrasive and electricity consumption. These data will help to calculate the cost of production.

Roughness is calculated with the following relations:

For aluminum:

$$R_z = 7.2263 - 0.75854 * A - 0.0088842 * B + 0.00140727 * A * B + 0.026654 * A^2 + 0.0000022981 * B^2 \quad (1)$$

For stainless steel:

$$R_z = -2.29430 + 0.25680 * A - 1.61882E - 003 * B + 3.17039E - 003 * A * B \quad (2)$$

For carbon steel:

$$R_z = 1.64788 - 0.27907 * A - 0.0052305 * B + 0.00349728 * A * B + 0.016415 * A^2 + 0.00000098088 * B^2 \quad (3)$$

Where:

R_z - cut surface roughness [μm];

A - material thickness [mm].

v - feed rate [mm / min];

Time is calculated with the following equation:

$$T = \frac{L}{v \cdot 0.06} \quad (4)$$

5.2 The choice of parameters for laser cutting

The option "Laser" offers a choice of the type of gas used for cutting, nozzle diameter, pressure and cutting speed. (Figure 6)

Fig. 6. The choice of input data for "Expert User"-Laser

The gas consumption it will be calculate with the following equation:

$$Q = 0.385 \times D^2 \times \sqrt{P} \quad (\text{m}^3/\text{ora}) \quad (5)$$

Where:

D - diameter of the nozzle [mm];

P - pressure [bar].

Roughness is calculated based on the feed rate and the thickness of the material, with the following relations:

For aluminum:

$$R_z = 19,40135 - 3,86636 * A - 4,63617E - 003 * B + 6,47180E - 004 * A * B + 0,31205 * A^2 + 4,32337E - 007 * B^2 \quad (\mu\text{m}) \quad (6)$$

For stainless steel:

$$R_z = 7.82012 - 1.33523 * A - 8.21829E - 005 * B - 1.78648E - 004 * A * B + 0.16630 * A^2 + 1.25659E - 008 * B^2 \quad (\mu\text{m}) \quad (7)$$

For carbon steel:

$$R_z = 15,05401 - 2,97733 * A - 2,52508E - 003 * B + 4,63356E - 004 * A * B + 0,22258 * A^2 + 1,91875E - 007 * B^2 \quad (\mu\text{m}) \quad (8)$$

Where:

R_z - cut surface roughness [μm];

A - material thickness [mm];

B - feed rate [mm/min].

5.3. Calculation of parameters for plasma arc cutting

By pressing the "plasma" button, the program allows selecting the type of gas used and enter values for the diameter of the nozzle, the pressure used, feed rate, voltage and intensity of the electricity. (Figure 7)

Fig. 7. Choice of input data for "Expert User"-Plasma

Electricity consumption is calculated with the following equation:

$$E = I \times V \quad (\text{Kw}) \quad (9)$$

Where:

E - electric energy consumption [kW];

I - electric current intensity [A];

V - voltage electric current [V]

Plasma gas flow rate is calculated using the following equation:

$$Q = 0.385 \times D^2 \times \sqrt{P} \quad (\text{m}^3/\text{ora}) \quad (10)$$

Where:

Q - plasma gas flow rate [m3/hour]

D - diameter of the nozzle [mm];

P - pressure [bar];

To calculate the surface roughness, depending on the thickness of the material, the feed rate, the intensity and voltage of the electric current are using the following relations:

For aluminum:

$$R_z = 4.49523 + 0.063001 * A + 0.00117139 * B + 0.0086853 * C + 0.000092633 * D \quad (\mu\text{m}) \quad (11)$$

For stainless steel:

$$R_z = 9,01636 + 0,092317 * A - 5,14047E - 003 * B - 0,016807 * C - 3,54797E - 005 * D \quad (\mu\text{m}) \quad (12)$$

For carbon steel:

$$R_z = 4,97797 + 0,055344 * A - 3,34442E - 003 * B - 6,43650E - 003 * C + 1,98440E - 005 * D \quad (\mu\text{m}) \quad (13)$$

Where:

R_z - cut surface roughness [μm];

A - material thickness [mm];

- B - intensity of the electric current [A];
 C - voltage of the electric current [V];
 D - feed rate [mm / min].

6. THE RESULTS DISPLAYED BY THE PROGRAM

For each cutting processes, the program will display the following results: processing time, measured in hours, the surface roughness in μm and cut production costs in euro. (Figure 8)

The screenshot shows a software window titled 'Expert apa' with a subtitle 'Otel carbon'. Below the title bar, there is a section labeled 'Jet de apa'. It contains three rows of data, each with a label, a text input field, and a unit:

Label	Value	Unit
Timp de prelucrare:	0.56	ore
Rugozitate obtinuta:	2.65	μm
Costul de productie:	28.69	euro/buc

Fig. 8. Displayed results by the soft

7. CONCLUSION

This software is designed to be used by two types of users: those who want to know what it would cost for a particular type of material with a certain thickness and more experienced users who have possibility to enter the parameters of cutting process, then calculates the cost of production of the product.

CALCULATOR DE COSTURI PENTRU PROCEDEELE DE DEBITARE CU JET DE APĂ, LASER ȘI PLASMĂ

Rezumat: În acest articol este prezentat un program care calculează costurile de producție pentru procedeul de debitare cu jet de apă, plasmă și fascicul laser. Acest program este creat pentru a-i oferi utilizatorului o vedere generală asupra costurilor de producție a celor trei procedee de debitare moderne și a nivelului de calitate care poate fi atins pentru grupele de materiale care au fost studiate în cadrul acestei cercetări: aluminiu, oțel carbon și oțel inoxidabil.

Silvia FERENȚ-PIPAȘ, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, silvia2shine@yahoo.com, Muncii Boulevard, no 103-105.

Mariana DINDELEGAN, Computer Science Teacher, Economic College "Iulian Pop" Cluj-Napoca, mdindelegan@yahoo.com, Emil Isac street, no 19.

Bogdan PĂDUREAN, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, bogdan_ciprian_pad@yahoo.com, Muncii Boulevard, no 103-105.

Emilia CIUPAN, Lecturer Ph.D, ec. Inf., Technical University of Cluj-Napoca, The Faculty of Machine Building, Departament of Management and Economic Engineering, Emilia.Ciupan@mis.utcluj.ro, Muncii Boulevard, no 103-105.

Cornel CIUPAN, Prof. Dr. Ing., Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, Cornel.Ciupan@muri.utcluj.ro, Muncii Boulevard, no 103-105.

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