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INVESTMENT AND DECISION ELEMENTS FOR THERMAL OR WATER JET CUTTING MACHINE

BY

BRUNO RADULESCU[*] and MARA-CRISTINA RADULESCU

“Gheorghe Asachi” Technical University of Iaşi,
Faculty of Machine Manufacturing & Industrial Management

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Abstract. This paper is presenting the important aspects of thermal cutting and water jet cutting process that are distinguished from processes called "mechanical" by the lack of contact and reaction between part and tool.

Key words: thermal cutting, water jet cutting, decision elements.

1. Introduction

As in all industries, there is an inverse relationship between the level of investments and working time and more generally, the "direct costs" they achieve. The following article makes possible to situate the orders of magnitude of the sums involved for cutting machines (at least in the current state of the art).

The OXY cutting, plasma cutting and laser cutting are based on the melting point of the material to be cut (full thickness) and on the displacement

[*]Corresponding author; *e-mail:* bruno_radulescu@yahoo.com

of the melt front along a path which defines the shape of the part (Harničárová *et al.*, 2010).

The water jet cutting is not based on the merger and cannot be described as thermal cutting, but it is frequently associated with these processes in that it is based on the movement of an impact point and it is implemented by means similar enough and close a number of applications developed.

2. Investment and Decision Elements

We can realize that the comparison between the different cutting methods give very different results depending on the criterion considered "major" for this comparison.

Review compared the performance of various thermic processes and to compete with mechanical (punching, nibbling etc.) is certainly necessary at first, but this is not enough.

Often the technical nature of the considered cutting operation fixes almost immediately the type of the tool or of the process to use. In addition, it is useful to involve less fundamental concepts such as flexibility of implementation which is characterized by the following properties (Groover, 2010):

- Exceptional ability to expand the range of work. Take, for example, a workshop equipped with a laser that can normally cut steels from 0.5 to 4 mm thick and is the subject of specific requested parts of stainless steel 6 mm. The ideal process might be plasma, but the workshop in question attempt to lower speed, to solve his problem with the equipment available.
- Cutting small series of parts. Able to cut parts in small series or even the unit without excessively penalizing the cost is very important. It is the case of prototype parts, and it becomes even very important especially if it takes several corrections, followed by cutting tests, before reaching the final piece. On all these points, thermic cutting is much more interesting than punching for example, where the implementation and the possible modification of a punch / die set corresponds to the time and cost usually very high.
- Very short response. The current technical and economic conditions id imposing that the promptness of part delivery is sometimes critical. High speed operation helps to meet this need, but flexibility / speed of implementation and programming is a more important factor.

2.1. Problem of Subcontracting

Any company with manufacturing cutting problems can either equip itself with such a machine or use the subcontracting especially if these types of operations are recurrent.

Conversely, for a maintenance workshop (or "maintenance" section of a large company), this choice can stand up, because there usually interest to equip the maintenance workshops with cutting means to improve the time response, possibly even with an increase of the expense (investment ratio / usage in general is low).

Apart from this example for maintenance, a cost-benefit analysis for the possible implementation of cutting equipment requires consideration of all the following:

- value of the machine installation and civil engineering;
- value of the stock of goods or raw materials to fulfill all the possible demands;
- handling, storage, removal of finished parts, on the one hand, waste and pollutant gases, on the other hand;
- finally, and this is crucial, acquisition of related know-how, both in the office methods for preparing templates or cutting programs and in the workshop at the machine operators.

3. Elements of Cost of Cut

The various elements mentioned in paragraph 2 shall be linked with the cost of parts. This paragraph gives the relevant data about it.

The cost of a cut piece depends mainly (Berglund, 2006):

- the cost of the material, generally of metal;
- the cost of gas and, more generally, consumables;
- the cost of electrical energy for powering the laser source, the generator and the plasma cutting machine;
- the labor cost (including amortization).

3.1. Cost of Metal

The weight of the parts is easy to calculate, but that is not enough, and we need to integrate the problem of the metal losses (Harničárová *et al.*, 2010).

The proportion of the metal losses is rarely below 15% by weight of raw metal for large workshops where the quantities processed makes efficient the existence of a preparation office. It must, arrange the parts on the sheet of raw material to optimize the use of material.

For smaller workshops, the operator is supposed to ensure the distribution itself, but the resources and time available rarely allow him a satisfactory optimization, and percentage of the metal losses is between 25 to 30%.

At the metal losses, it should be added, molted metal and expelled during the formation of the kerf, for thick cut by oxy-cutting, or plasma. This factor is far from being negligible in the overall cost.

3.2. Cost of Gas or Other Fluids Used

Oxycutting. Each manufacturer provides a list of settings and consumption that can serve as a basis for calculation, but the cost can be calculated also in relation to oxygen consumption (liters) per square centimeter cut surface.

Table 1 shows the oxygen consumption by the thickness e for a oxycutting machine.

Table 1

Oxygen consumption

Thickness e (mm)	Oxygen consumption (L/cm^2)
e<50	0.5 - 1
50<e<150	1 – 1.5
150<e<300	1.5 - 2
e>50	2.5

Plasma cutting. As oxycutting, the scales provided by the manufacturers of torches are starting points. They can also be confirmed on site, because the plasma cutting systems are equipped with flow meters.

Laser cutting. Include assist gas for cutting head, but also the gas used for the laser source itself and need to be periodically renewed or supplemented. Each manufacturer specifies in its schedules and operating instructions quantities needed.

As for plasma cutting, electric energy consumption must be taken into account because the efficiency is very poor. A laser of 1000 W nominal power may well ask 50 or 60 kW on the grid supply.

Water jet cutting. The most important element is electricity needed for the pump unit for water (flow rates from 5 to 10 L / min).

If we are using an abrasives injection in water, their cost must then respond to counting on the consumption of the abrasives materials used (150 to 400 g / min) (Institut Maupertuis, 2011).

3.3. Cost of Labor, Including Depreciation

This chapter will include salaries (of course, with social security) depreciation costs are included (machinery, buildings etc.).

Cutting speed selected will be the starting point, but we must be careful not to take it as it is, because the use of the machine coefficient (or rate of operation) must intervene. This factor is intended to highlight the times when the operator cannot effectively cut (during a day, for example). It is expressed in percent and has eq. (1):

$$\frac{\text{time actually cutting}}{\text{time spent by the operator on site}} \tag{1}$$

It's most typical values for a production shop are from 15 to 20% and 80 or 90% for the very modern workshops and with high degree of organization.

Involving the utilization factor to its correct value is absolutely fundamental, because its influence on the calculated cost is considerable.

In the field of production, only engineers with experience of one or two years can adopt a ratio almost certain, although it is necessary to periodically check for, on the one hand, the overestimation and, secondly, to verify the operator.

Table 2
Coefficients using a cutting machine

Work preparation	One cutting head	Two cutting heads
Left more or less to the operator	15-30	40-50
Preparation by a methods office.	50-60	60-90

These coefficients are used to increase or to decrease substantially the level of labor used operating and especially motivation to operate without loss of time.

3.4. Cuts Quality

In thermal cutting, changes in operating parameters can significantly modify aspects of cut obtained.

In oxy cutting, differences in the speed of feed, up to 20% compared to the optimal speed, lead either to rough cut edges or striated (but can be strong enough) or a very smooth and including flatness errors.

4. Conclusions

As a synthesis and taking into account all factors that may affect the cost of a cut, it becomes clear that they are very interdependent.

We can, for example, choose two very different methods to arrange the parts to be cut within the format of a raw sheet.

We can consider the savings in material or falls with very small gaps between parts.

To avoid the risk of intersecting lines cut, the operator is then constrained to one or two courses to white to verify their absence.

Another solution, if the series of parts allow, is to have a planning office providing to the operator programs for CNC.

In the first case, the operator will lose time (long operating time), in the second, the operating time can be short, but the period of preparation could be long (generally, this preparation is in masked time, that is while the machine continues to cut according to a previous program).

We can consider the savings in preparation time, either by the operator or by the preparation office, but it must accept loss of material with a much higher percentage of loss. The operator, in effect, to be sure not to have parts or intersecting cuts, is required to provide "large" loss of materials to avoid a white check.

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ELEMENTE DE DECIZIE ÎN ACHIZIȚIA UNEI
MAȘINI DE DEBITARE TERMICĂ SAU CU APĂ

(Rezumat)

Lucrarea de faţă prezintă elementele necesare identificării deciziei de achiziție a unei masini cu decupare termică sau cu apă, procese care sunt diferite de prelucrările prin aschiere clasice.