ANNALS OF THE UNIVERSITY OF ORADEA
Fascicle of Management and Technological Engineering
ISSUE #3, DECEMBER 2014, http://www.imtuoradea.ro/auo.fmte/

BEST CUTTING METHOD OF A MATERIAL USING THE DECISION SUPPORT SYSTEM

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Abstract – Taking decisions by intuition, knowing that the decision will affect the whole production process or the whole company, it's not the best way of management. That's why it's important to have a computer-based information system that supports organizational or business decision-making activities. Decision Support Systems (DSS) serve the management, operations and planning level of an organization and are helpful for making decisions, which may be rapidly changing and not easily specified in advance. In order to choose the best cutting method of a metallic material, we're going to use the decision support system.

***Keywords* -** laser cutting, roughness, experimental model, decision support system, alternatives and criteria, FRISCO formula, users, Joomla! 1.5

I. INTRODUCTION

THE proposed decision support system allows the decision maker to choose the best alternative out of a set of possible interventions, based on a group of custom-defined criteria.

The system allows the use of an indefinite number of alternatives and criteria. Underlying the Decision Support Systems (DSS) is an innovative approach that combines two well-known algorithms: the hierarchic-analytic process, used mainly in operations management, and the advanced multi-criteria analysis based on the FRISCO formula. A detailed description of this combined algorithm may be found in the work of Grecu and Denes [1].

The developed algorithm requires good mathematical abilities from the user, and this can therefore limit the real-life applicability of the proposed decision support system. In order to make it easier to use the DSS and increase the number of potential users, the DSS was implemented online with a user-friendly interface. For this purpose, an extension for the content management system Joomla! 1.5 was developed. It can be easily integrated into any website created with Joomla! 1.5 [2]. The purpose of our approach is to offer a finite tool to decision makers by leaving the computational part to the server. We are thus allowing users to concentrate on planning issues rather than having to understand the formulas that lie behind the algorithm.

II. CUTTING METHODS OF A METALLIC MATERIAL

1) Comparison of primary metal cutting processes

There are required many different metal cutting technologies dependant on the individual needs of a customer. Every major metal cutting systems has inherent advantages and disadvantages.

Cutting metal is a complex and lengthy task, especially when the metal cutting job calls for a tight tolerance or an odd shape that can't be cut using conventional sawing. Then, metal processors or fabricators usually prefer one of the main four cutting systems. There is a fifth system that combines laser cutting and water jet cutting, but we will not unfold this hybrid system. The primary metal cutting systems include [3]:

a) Laser cutting process

i. Description

Laser cutting systems have long had the prestige of cutting component parts with less than a 0.005" (127 μm) tolerance. In gas lasers, CO_2 is mixed with other gases, nitrogen and helium, to form a lasing medium. Yttrium-aluminum-garnet (YAG) crystals containing neodymium ions are used as the lasing medium in solid-state lasers (Fig. 1.).

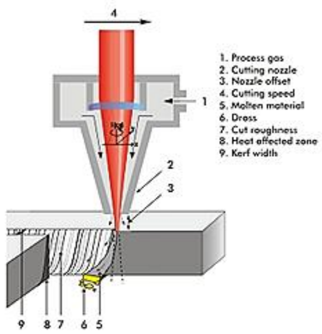

Fig. 1. Laser cutting system [4]

ii. Advantages of laser cutting

Laser cutting is the best metal cutting system if producing an accurate cut and creating the narrowest heat-affected zone are major concerns. It can be efficient from one-inch thick carbon materials and up to a half-inch thick specialty metals. Laser cutting systems typically use less consumables than plasma or oxy-fuel cutting systems. Precision capabilities continue to progress.

i. Disadvantages of laser cutting

Laser systems characteristically have a higher capital cost than plasma, oxy-fuel, and water-jet systems. They are not normally adequate to cutting material thicker than 0.5 inches (12.7mm) and have difficulty cutting reflective metals like copper and aluminum, where a major portion of the laser energy can be reflected away from the cut.

b) Abrasive water jet cutting process

i. Description

Water jet cutting machines pressurize a stream of water up to 60,000 pounds per square inch (42184174.8 kg/mp). This makes the water strong enough to cut a lot of metals. Abrasive water jet systems introduce an abrasive, usually garnet, into the water stream as it leaves the nozzle. Combining the high-pressure water with the abrasive produces a stream that can cut more materials than the plain water jet without the abrasive additive. Manufacturers often develop water jets with the head submerged in a water table to reduce the noise produced by this process. In Fig. 2. is described a diagram of a water jet cutter

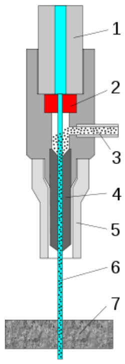

Fig. 2. Diagram of a water jet cutter [5] (1. high-pressure water inlet, 2. jewel (ruby or diamond), 3. abrasive (garnet), 4. mixing tube, 5. Guard, 6. cutting water jet, 7. cut material)

ii. Advantages of water jet cutting

Water jet cutting produces little heat-affected zone reducing the need for some secondary finishing. Additionally, water jet cutting systems cost less than laser cutting machines. They are well suited for high-performance metals.

iii. Disadvantages of water jet cutting

Water jet technology cuts slower than both plasma and oxy-fuel cutting processes, reducing material processing productivity. Additionally, water jet technology has a higher entry cost than plasma or oxy-fuel cutting machines.

c) Oxy-fuel (flame) cutting process

i. Description

Formerly, numerous metal processors only used oxy-fuel for cutting carbon steel. Today, oxy-fuel technology is still the principal process for cutting metal plate for most metal processors. This process uses oxygen, gases and acetylene to produce a controlled flame.

This process is the best choice for end-users requiring inexpensive cutting through carbon steel and most alloys. Oxy-fuel cutting is easily able to produce near-net shapes. The bad part is that oxy-fuel cutting creates a heat-affected zone (HAZ) around the cut that must be removed by additional machining. Nevertheless, after the cutting is finished, it is possible to remove the HAZ through an annealing process.

ii. Advantages of Cutting Using Oxy-fuel

Oxy-fuel cutting employs multiple-torch capacity that is advantageous in high production runs. Oxy-fuel cutting is an excellent choice for metal cutting that will be attended by machining activities since it often requires secondary operations to produce a satisfactory finished product.

iii. Disadvantages of Cutting Using Oxy-fuel

Compared to the other cutting systems, oxy-fuel cutting is slower and materials cut by oxy-fuel are easy to spot since they display a large heat-affected zone. When a processor is looking to be able to minimize tolerances on the cut, they will more likely select plasma, water jet, or the laser cutting processes over oxy-fuel cutting. Since oxy-fuel cutting is just not capable of holding the tight tolerances other metal cutting processes can

d) Plasma arc cutting process

i. Description

Plasma arc cutting (PAC) may be the favored cutting technology for many fabricators, metal processors toll, processors and service centers. However, historically, plasma cutting was considered to be a low tolerance cutting process and also low cost.

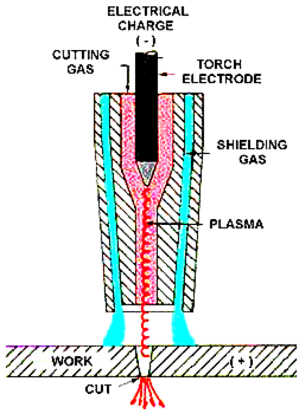

Fig.3. Plasma arc torch cutting [6]

Plasma arc cutting uses a high-speed electrically charged gas jet to cut metals. Plasma cutting is often performed at extremely high temperatures, sometimes reaching 50,000° Fahrenheit (27760° Celsius). Currently, PAC is capable of cutting metal plate up to 6.0" (152.4 mm) thick.

Plasma arc cutting system components routinely include a cutting torch, a DC power supply, a cutting gas supply, a control system, a coolant system (usually water or air) for the torch and torch parts, and leads that connect the torch, gas, power and coolant with each other (Fig. 3.).

Since water is cheaper than gas, a variation, water-shielded PAC, costs less to operate. Water shielding has a number of advantages as reducing both top-edge material rounding and the amount of irritating smoke and fumes generated when cutting without the water.

There is an elevated level of interest in high-tolerance PAC, sometimes also known as fine-plasma cutting or high-definition. High-tolerance PAC can be used to cut metals from ~0.035" to 0.375" (0.889 – 9.525 mm) thick. Some process users are reporting that high-tolerance plasma arc cutting produces a cut quality competing that of laser cutting and that it can be produced with less cost. Long-term use will bear out or invalidate these claims.

ii. Advantages of plasma cutting

Compared to oxy-fuel cutting, plasma cutting is faster and is capable of cutting thicker materials. Considering the cost it is typically less costly than both than the laser and water jet cutting processes.

Plasma cutting systems using nitrogen can easily cut stainless steel, nickel and aluminum and the ones using oxygen are more appropriately used to cut carbon products.

iii. Disadvantages of plasma cutting

The main disadvantage is that plasma cutting creates a large heat-affected zone in the area surrounding the cut. Under-water cutting minimizes the size of the heat-affected zone. The resolidified metal that forms at the bottom of the cut (dross) is a potential issue for processors using plasma cutting since it frequently forms during plasma cutting.

2) Deciding which metal-cutting system is best

It is often a difficult analysis because there are so many variables to be considered when making a decision on the right cutting system to use. The metal processor and, to some degree the end-user of the material, must consider few issues like: cutting speed, operating costs, asize of heat affected zone, access to secondary machining processes, edge cleanliness, degree of tolerance required, number and types of metal to be cut, capital investment, etc.

The question “Which metal cutting system is best?" has no one overall answer. The factors that are very important to one metal processor will be completely different from those of another depending on their customers’ needs. The “best" metal cutting process depends on the material to be cut and the final application of it. No one cutting system is superior to another in all major comparison categories already named.

III. THE WORKING PRINCIPLE OF THE DSS

For exemplification it is used a hypothetical situation for a decision in a situation for choosing the best cutting method of a material, with five decision alternatives and five selection criteria. First, the user is requested to enter the number of criteria (Fig. 4) and specify (Fig. 5.) the name of each criterion (C1 – C5).

Then a quadratic matrix is generated and the user has to compare each criterion against the others. One can choose whether each criterion is more important, equally important or less important than other criteria (Fig. 6.). It is important to remember that the relationships between criteria are the choice of the decision maker.

This choice can be based on sociological studies, public surveys, urban planning goals, academic literature reviews or other specific needs. This step basically establishes a hierarchy of the chosen criteria and each criterion is given a weight.

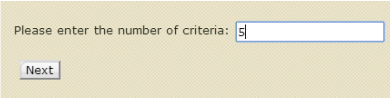

Fig. 4. Functioning of the DSS - criteria

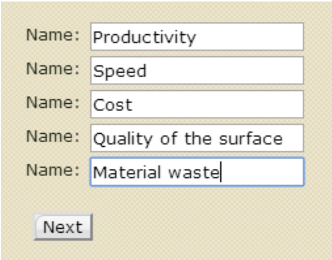

Fig. 5. Functioning of the DSS – criteria

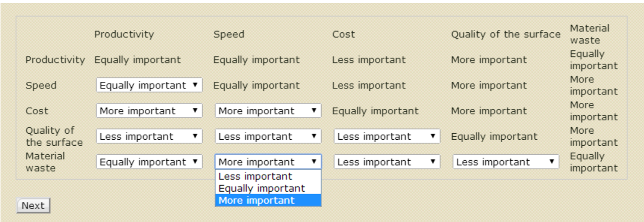

Fig. 6. Functioning of the DSS - comparison

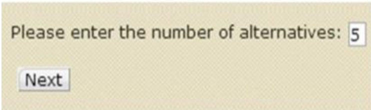

Fig. 7. Functioning of the DSS – alternatives number

Then, the user is asked to enter the number of decision alternatives (Fig. 7.), to define/name them (Fig. 8.) and then to compare each alternative against the others based on how they satisfy each criterion (Fig. 9). For example, when the alternatives are compared considering the criterion “Quality of the surface”, the cheaper alternative is considered “more important”.

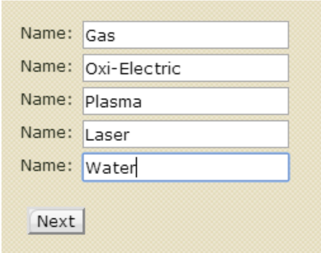

Fig. 8. Functioning of the DSS – alternatives name

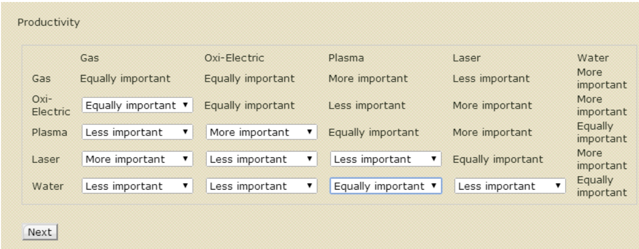

Fig. 9. Functioning of the DSS - criteria

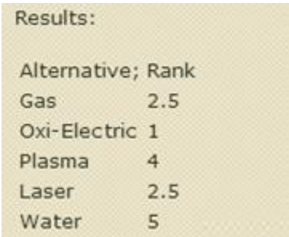

Fig. 10. Functioning of the DSS - results

The software then uses the encoded mathematical algorithm and returns the optimal solution, as shown in Fig. 11. This allows the decision maker to make an informed decision, based on specific needs and the particularities of each cutting method, rather than intuition[7].

IV. CONCLUSIONS

The developments in the last decade will guide us in understanding the coming evolution of decision support technologies. Changes will occur in technologies and in the implementation environment—users are becoming more sophisticated and more demanding, organizations are becoming more complex yet more agile and flexible, and global regulatory and competitive factors rapidly change, affecting the design and use of these tools. The future will offer surprises, to be sure, but certain trends can be observed. The practice of building Decision Support Systems can benefit in many ways from the increased availability and growing sophistication of Web technologies. These technologies provide platform-independent, remote, and distributed computation and the exchange of complex multimedia information. System maintenance is simplified and centralized, letting end users focus on problem analysis and decision making. While there is significant promise in the idea of Web-based Decision Support Systems, there are also some important challenges that must be overcome. We need to solve technological, economic, and social and behavioral challenges to realize the benefits the Web can provide as a platform for building DSS.

The proposed decision support system allows decision makers to choose the best alternative out of a set of possible ones, based on a group of custom-defined criteria. The system allows the use of an indefinite number of alternatives and criteria. However, in this paper there was presented a scenario with five possible decision alternatives and five selection criteria.

As the proposed DSS allows the decision maker to define his/her own set of decision alternatives and selection criteria, it has a virtually ubiquitous applicability, being adaptable for all decision scenarios where it is required to choose from a list of alternatives, based on a set of criteria. The proposed decision support system speeds up the decision making process and increases the quality of the management process.

Underlying the proposed DSS is an innovative approach that combines two well-known algorithms: the hierarchic-analytic process, used mainly in operations management, and the advanced multi-criteria analysis based on the FRISCO formula. The developed algorithm requires good mathematical abilities from the user, and this can therefore limit the real-life applicability of the proposed decision support system. In order to make it easier to use the DSS and increase the number of potential users, it was implemented online with a user-friendly interface.

Further research may mean creating a series of databases with recommendations based on knowledge, in order to guide the user when choosing the decision criteria and their importance for the project.

V. ACKNOWLEDGEMENTS.

This work was supported by the strategic grant POSDRU/159/1.5/S/133255, Project ID 133255 (2014), co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007 – 2013

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