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KNOWLEDGE MANAGEMENT IN THE LASER CUTTING PROCESS

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Abstract - In order to be effective and efficient in the life of any organization, knowledge is a valuable resource that must be carefully managed. The Knowledge Management process can prove to be a daunting challenge because of the illusive and personal nature of the Knowledge Resource. It is for this reason that an integrated and uniform tool is required in the field. The paper proposes the implementation of the Knowledge Management Platform in order to optimize of a Laser Cutting System for 6mm Mild Steel.

Keywords **-** laser cutting, roughness, experimental model, knowledge, knowledge management, knowledge management model, knowledge management platform, mathematical model.

I. INTRODUCTION

KNOWLEDGE is seen as an essential and sustainable source of competitive advantage [1] in the highly competitive and ever more integrated business "habitat" of today. Because of this consideration it is of paramount importance that organizations undertake coordinated and sustained efforts in order to manage this valuable resource.

Knowledge Management is a process of creating, acquiring, capturing, aggregating, sharing, and using knowledge, wherever it resides, to enhance organizational learning and performance [2], [3]. Knowledge Management involves the management of the relationship between tacit-the know-how possessed by individuals-and explicit knowledge-the systemically documented know-how that becomes available to everyone in the organization [4]. The ultimate goal of knowledge management should be to provide and convert tacit knowledge to explicit knowledge to transform the capacity of individuals within the organization to use information strategically and apply higher-order thinking to an informed decision-making process.

The purpose of the paper is to propose a tool, the Knowledge Management Platform, based on a knowledge management model that will aid in the optimization of the laser cutting procedure. The laser cutting procedure is a knowledge intensive undertaking that involves considerable amounts of tacit and explicit knowledge.

II. LASER CUTTING

1) Laser Cutting Description and Principles of Laser Cutting

Laser is a beam of monochromatic coherent radiation. This means that it comes from a source (called a Resonator) that produces (emits) radiation (light or even in the invisible spectrum) of in-step waves of identical frequency, phase, and polarization. Laser light is generally a narrow-wavelength light; yet, there are lasers that emit a broad spectrum of light, or emit different wavelengths of light simultaneously [5].

A diagram of a laser beam released system is shown below (Fig. 1.)

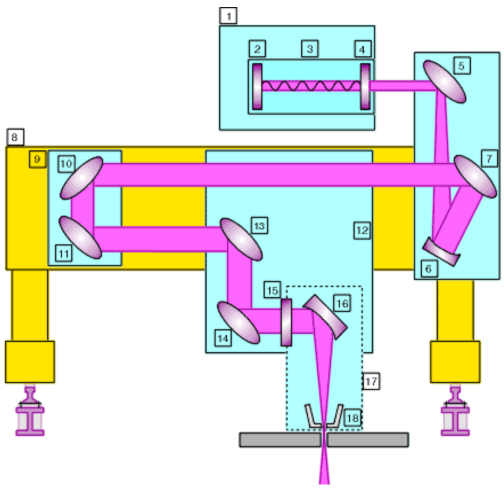

Fig. 1. Diagram of a laser beam released system [6].
(1)CO2 laser resonator; 2) rear mirror; 3) gas excitation generates single wavelength light; 4)output mirror; 5) polarizing mirror; 6) telescope mirror; 7) beam bender; 8) machine gantry; 9) constant beam length carriage; 10) beam bender; 11) beam bender; 12) cutting carriage; 13) beam bender; 14) adaptive mirror; 15) window; 16) focusing mirror; 17) cutting head; 18) cutting nozzle.)

A laser system is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "laser" originated as an acronym for "light amplification by stimulated emission of radiation" [7].

Focused by a system of mirrors and lenses, and assisted by the high-velocity flow of some kind of gas surrounding it, the powerful beam is released through the cutting nozzle and can melt away the material it attacks.

The focusing device consists of either a parabolic mirror or a zinc-selenide lens which brings the laser beam to a focus at a single point (Fig. 2.). Depending on the laser beam power, a power density of more than 107 W/cm^2 is achieved at the focus point.

The focal length represents the distance between the focal point and the focusing optics.

According to the requirements of the material, the focal point is positioned above, on or below the material surface. The power density heats up the material instantly, melting it and partially vaporizing it. The molten mass is removed away from the kerf by the gas jet flowing through the cutting nozzle.

The work-piece is cut from the sheet by the cutting head that is moved over the metal sheet following the pre-programmed pattern (G-Code) of the CNC machine.

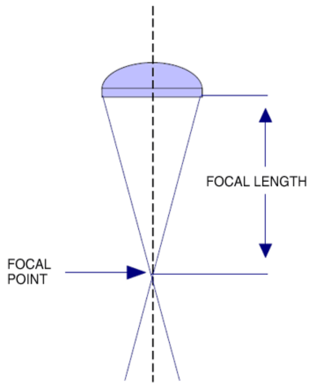

Fig. 2. Focal length [5]

The technology of laser cutting is typically used for industrial manufacturing applications, but is also starting to be used by small businesses, schools and hobbyists. By computer, laser cutting is directing the output of a high-power laser, at the material to be cut. The material then either burns, melts, vaporizes away or is blown away by a jet of gas [8] leaving an edge with a high-quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials.

2) Laser Cutting Methods

There are two main cutting methods, which depend on the type of the material to cut:

a) Fusion Cutting (high pressure cutting):

i. *The material is fused by the energy of the laser beam;*
ii. *The gas, in this case nitrogen at high pressure (10 to 20 bar), is used to blow away the molten material from the kerf;*
iii. *The gas jet also protects the focusing optics from splashes.*

The presence of nitrogen protects the cut edges from oxidation and is mainly used with stainless steel, aluminium and their alloys.

b) Oxidation Cutting (laser torch cutting):

i. *The material is heated by the laser beam to combustion temperature;*
ii. *The gas, in this case oxygen at a medium pressure (0.4 to 5 bar), is used to oxidize the material and to drive the slag out of the kerf;*
iii. *The gas also protects the focusing optics from splashes;*
iv. *A large part of the energy for the cutting process is supplied by the exothermic reaction of the oxygen with the material.*

Cutting method B is the quickest one and is used for the cost-effective cutting of carbon steels [5].

3) Experimental tests

In order to analyze the influence of the process parameters on roughness parameters and to obtain a complex relationship to show roughness variation according to these parameters, a series of experiments have been performed under the experimental plan. Each output value of measured roughness is the average of the five passes of pick-up [9].

Feed rate, gas pressure, power, frequency, efficiency and nozzle focus are the main process parameters that can be changed. The output parameters that give the end product quality is assessed using the international standards for thermal cutting (such as roughness (Rz), dimensional deviation from perpendicularity and tilt (p), rounding-off upper edge of the cut (r), craters, deviation from form and position etc.) [10]. This study was realized on a laser system Mazak Super Turbo-X 48 Mk2 1800 W CO2, to cut 6mm mild steel.

To investigate the influence of roughness we created a model that shows the dependence upon the cutting parameters.

Attempts to measure surface roughness had been performed on:

a) *Work-piece OL 52, 1250x2500x6;*
b) *Machine tool: Mazak Super Turbo-X 48 Mk2 1800W;*
c) *The measured parameter of surface roughness were R_z in μm;*
d) *Mitutoyo SV-C 600 as measuring tool and Surfpak-SV 1.500 software for analyse.*

The experimental tests were based on 2^6 factorial plan applied on an experimental model such as Design of experiments (DOE) or Matlab [11]. Such experiments or studies are called factorial experiments because we are interested in the effects of two or more factors on the response variable.

In factorial experiments, the data can be split into sub-samples corresponding to each possible combination of levels of the different factors. The effects of the factors can be analyzed by comparing the different sub-samples appropriately. We introduced the process parameters (feed rate, gas pressure, power, frequency, efficiency and nozzle focus) chosen into the machine's best quality limits.

TABLE 1
EXPERIMENTAL DATA

Std	Run	A v	B p	C P	D F	E R	F NF	Resp. Rz
25	1	2000	0,6	1600	600	100	-1	18.822
40	2	2300	1,2	1800	400	90	1	12.594
24	3	2300	1,2	1800	400	100	-1	11.295
38	4	2300	0,6	1800	400	90	1	22.928
8	5	2300	1,2	1800	400	90	-1	13.42
36	6	2300	1,2	1600	400	90	1	16.516
4	7	2300	1,2	1600	400	90	-1	15.509
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
31	62	2000	1,2	1800	600	100	-1	14.572
18	63	2300	0,6	1600	400	100	-1	12.226
53	64	2000	0,6	1800	400	100	1	33.603

Than the model generates all the possible combination of the different factors that generates a level of Rz. The last column represents the response (Rz) that has been measured for each case indicated [12].

It has been analyzed the influence of laser parameters on roughness to obtain a complex relationship to show roughness (Rz) variation according to these parameters and to minimize the Rz and maximize the feed rate. The settings for input parameters were choose based on the pre experimental tests.

Using ANOVA analysis upon the roughness model obtained, we can find influences of each parameter and concordance of the model. We can also get a more reliable model by taking into consideration the inter-influence of the parameter [13], [14].

With this model we can find for any desired value of Rz the right combination of laser machine parameters.

III. KNOWLEDGE MANAGEMENT MODEL AND PLATFORM

1) Knowledge *Management Model*

The Knowledge Management Model was developed based on a vast literary review of existing models, Knowledge Management Process Model [15], Knowledge Wheel [16], Practical Knowledge Management Model [17], Knowledge Management Lifecycle [18], and starting from the premise that knowledge is the only source for sustained competitive advantage in manufacturing organizations [1].

The model postulates the locus of knowledge at the heart of the organization and the amount of it readily available to all interested stakeholders is defined as the Knowledge Quantum.

The model (Fig. 3.) presents the organization under the influence of various external forces, both related to the general environment in which the organization operates (political, social, legal etc) and to the specific business area (suppliers, clients, competitors etc.). The organization is viewed as a knowledge generating entity, under the continuous pressure of knowledge decay, and consists of three main elements.

The Knowledge Support Elements and the Knowledge Management Process and all its steps: K Generation, K Refinement, K Sharing, K Dissemination, K Utilization, K Measurement are the Knowledge Quantum.

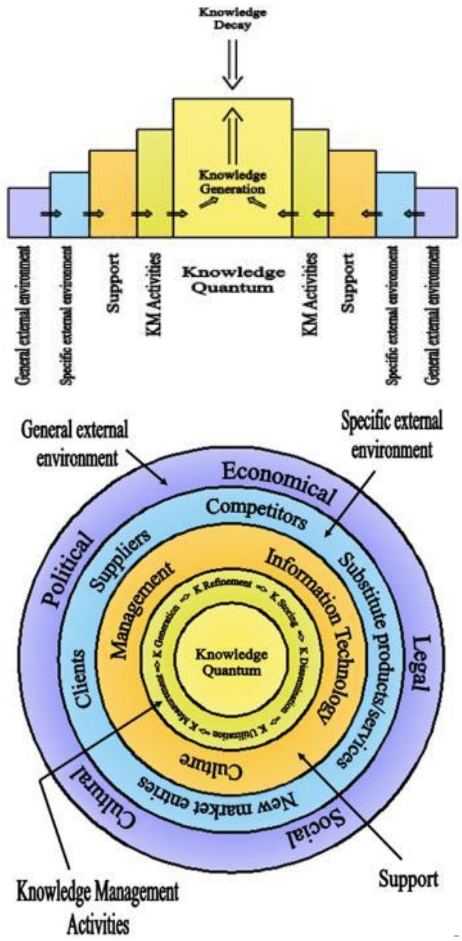

Fig. 3. Knowledge Management Model [19]

The Knowledge Quantum is the entirety of knowledge both tacit and explicit [1] existent at the level of the organization, in individuals, data repositories and processes both formal and informal. In today's knowledge economy this resource represents the primary source of competitive advantage [16], [17]. Although the importance of organizational knowledge [18] has been acknowledged by most if not all the competitors on the economic stage, it is still very poorly managed. Few companies take into account the necessity to actively manage knowledge, and even fewer have in their organizational chart formally defined structures responsible for such a task.

Based on the model all knowledge linked to the laser cutting process must be easily understandable and available to stakeholders at the moment they require it.

For the proper implementation of the model in a practical setting there must be a close link between it and information and communication technology. This is because of the critical role that technology plays in enabling and supporting the practice of knowledge management thru information systems and social support [2]. Many other researchers have also highlighted the need for close integration between knowledge related activities and technology Schmidt (2005), Mihalca & all (2008). For achieving this goal the authors propose the creation and implementation of a Knowledge Management Platform.

2) Knowledge Management Platform

The Knowledge Management Platform (KMP) is designed with the goal of integrating knowledge management processes with information and communication technology thus improving the organizational knowledge quantum and by direct consequence organizational performance. The platform will be an online tool that can be accessed by all members of the organization. It will be comprised of an Employee Knowledge Hierarchy that will evaluate individual knowledge contribution, the APQP Advanced Product Quality Planning procedure which represents a roadmap for product and process design, the Q and A section which will facilitate communications between organizational stakeholder, and the Educational, Extracurricular Activities, Recommendations elements that will foster knowledge growth and dissemination.

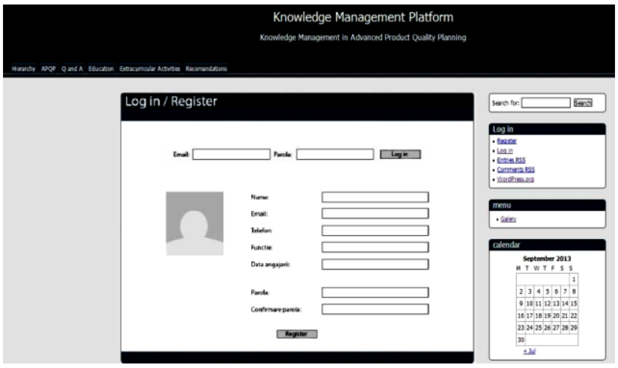

Fig. 4. Knowledge Management Platform [19]

Within the APQP section the laser cutting process shall be designed and all the elements that influence it and the way they do so will be presented for the benefit of the process stakeholders.

The main criteria of interest in relation to the laser cutting process are (Fig. 4.):

1. *Types of laser cutting (Oxygen, Nitrogen;*
2. *Dimensions and Materials – different types of materials and dimensions available in the company;*
3. *Cutting pattern – a platform of pattern options already imported or linked to a modeling software;*
4. *Input Parameters (feed rate, gas pressure, power, frequency, efficiency and nozzle focus);*
5. *Output parameters (roughness (Rz), dimensional deviation from perpendicularity and tilt (p), rounding-off upper edge of the cut (r), craters, deviation from form and position etc).*

IV. CONCLUSION

The Knowledge Management Platform is an essential tool in the Knowledge Management arsenal. Thru its use it promotes an open and collaborative organizational culture which will facilitate improved results for the company as a whole by distributing knowledge across the entire enterprise bypassing geographical, departmental and personal boundaries. It removes capacity and sets out a clear set of rules by which the "game" is to be played.

The Knowledge Management Platform aids practitioners in various manufacturing fields achieve improved effectiveness and efficiency in their endeavors by distributing knowledge across the entire enterprise. The KMP is most effective when implemented in big enterprises that may have production distributed across the world and that work with highly connected knowledge. As a result the principles embedded in the KMP that foster connectivity and knowledge sharing with the goal of achieving an improved knowledge represent the guarantee of improved organizational performance.

Within this paper the case is made in relation to the laser cutting process but it may have possible implementations in relations to all product and process development activities.

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