ASPECTS REGARDING MECHANIZED THERMAL PLASMA CUTTING OF METALLIC MATERIALS – CARBON STEEL

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Abstract: The purpose of this paper is to present an up to date analysis concerning the status of mechanized thermal cutting procedures, which have to be taken into account when settling the manufacturing technology in industrial usage. In particular, this paper refers to the plasma thermal cutting procedures, which tend to be chosen by a large number of manufacturers that take into account very carefully the fragile balance between manufacturing costs and final product selling price. Thermal cutting definition refers to melting or burning cutting procedures applied on the base material by using the help of a thermal source. Among these classes of procedures, there are oxy-fuel cutting, electric arc, plasma and laser cutting. When classifying thermal cutting procedures, there were taken into account the achievements regarding quality levels specified inside SR EN ISO 9013:2003 Norm that refer to the mechanized cutting conditions. Prior to economical issues, quality conditions stipulated into standards or manufacturing norms have to be taken into consideration. Cutting accuracy, chamfer angle, surface roughness cutting width and thermally influenced area size are just some of the factors that determine the future working procedure. It is certain that the achievement of the quality. The mechanized cutting procedures are characterized by advantages and disadvantages that conditions stipulated into standards or manufacturing norms can be done only by using CNC automatic cutting machines have to be taken into consideration when settling the manufacturing technology.

Keywords: mechanized thermal plasma cutting, CNC cutting machines, quality criteria

1. Introduction: Thermal cutting - carbon steel

The purpose of this paper is to present an up to date analysis concerning the status of mechanized thermal cutting procedures, which have to be taken into account when settling the manufacturing technology in industrial usage. In particular this paper refers to the plasma thermal cutting procedures which tend to be chosen by a large number of manufacturers that take into account very carefully the fragile balance between manufacturing costs and final product selling price.

Thermal cutting definition refers to melting or burning cutting procedures applied on the base material by using the help of a thermal source. Among these classes of procedures there are oxy-fuel cutting, electric arc, plasma and laser cutting.

In order to determine the industrial usage of carbon steel thermal cutting, a classification is presented in figure1 regarding the base material thickness.

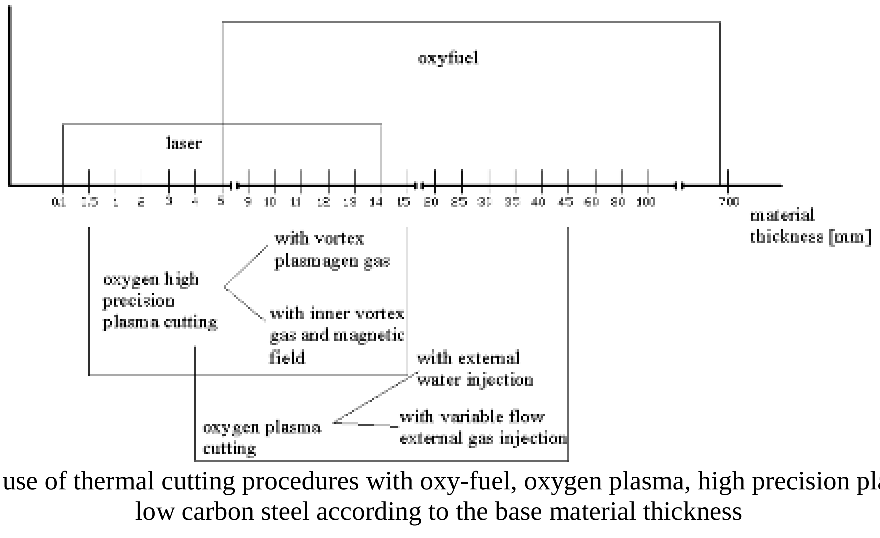

Figure 1.The use of thermal cutting procedures with oxy-fuel, oxygen plasma, high precision plasma and laser for low carbon steel according to the base material thickness

Considering figure 1 following conclusions can be drawn:

- inside low material thicknesses range (0.1 – 0.5 mm) only Laser cutting can be used;

- inside material thicknesses range (0.5 – 12 mm) there can be used thermal cutting procedures such as: Laser, High Definition Plasma (High Definition Plasma HYPERTHERM HALSUYAMA - HTPAC), oxygen plasma with external gas injection (KAMATSU, TANAKA and KOIKE) or oxy-fuel cutting;

- inside material thicknesses range (15 – 45 mm) oxygen plasma such as HYPERTHERM or KAMATSU, TANAKA, KOIKE or oxy-fuel cutting can be used;

-above material thicknesses range 45 mm, only oxy-fuel cutting can be used.

When classifying thermal cutting procedures in figure1, there were taken into account the achievements regarding quality levels specified inside SR EN ISO 9013:2003 [1] Norm that refer to the mechanized cutting conditions.

2. Comparisons between mechanized plasma cutting procedures and other thermal cutting procedures

The quality levels that can be achieved with mechanized thermal cutting machines are presented below, in table 1 [1].

Table 1.Quality levels and areas where mechanized thermal cutting procedures can be used

	Procedure type	Quality levels				Thickness range
		Chamfer angle	Rz	f	h [mm]	
1	Oxy-fuel cutting	< 1°	< 20 µm	<0.02x l	< 0,1	5 ÷ 700 mm Carbon steel
2	Classical cutting with Ar; H_2; N_2 plasma	2° ÷ 8°	< 50 µm	<0.04 x l	< 0,3	5 ÷ 120 mm Stainless steel 5 ÷ 150 mm Aluminum
3	O_2 plasma cutting	< 2°	< 50 µm	< 0.04 x l	< 0,3	5 ÷ 45 mm Carbon steel
4	Laser cutting	< 0,2°	< 20 µm	< 0.01 x l	< 0,1	0,1 ÷ 12 mm All materials

Referring in particular to plasma mechanized cutting, taking into account the quality HPTAC class I criteria and the levels shown in figure 2 and table1, the cutting edge quality can be defined by:

-Cutting edge chamfer angle (α; $\beta \leq 2°$);

-Medium surface roughness $R_Z \leq 50$ µm for a measured length of 13 mm

-Smoothness f ≤ 0.04 x material thickness;

-Downside cutting burrs h ≤ 0.3 mm.

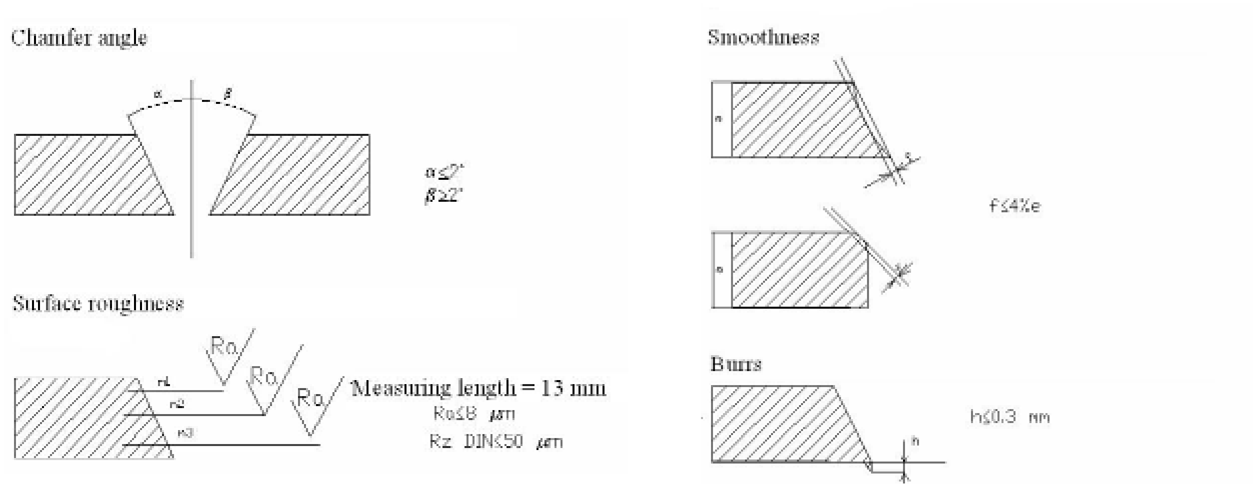

Figure 2.HPTAC class I quality criteria and levels

From table1 analysis it can be concluded that laser mechanized cutting procedure is clearly superior to other procedures but it has practical applicability almost exclusively inside 0.1 – 12 mm thicknesses range, although nowadays there are laser machines that are able to cut 25-35 mm material thicknesses (figure3) [2].

Figure 3 also presents superiority of plasma cutting procedure regarding speed when comparing oxygen plasma to laser when cutting between 6 and 25 mm base material thickness.

In plasma cutting procedure case, a constricted arc (plasma arc) locally melts the base material. Consequently, the material can be ejected with high speed and it creates the cutting path [3].

The increased level of energy concentration together with the very high plasma arc temperature (10.000 - 14.000 K) makes possible the cutting of metals and metal alloys electrically conductive (such as high allied, stainless or refractory steel, aluminium, copper, titanium and their alloys etc.) which cannot be cut by using oxy-fuel procedures.

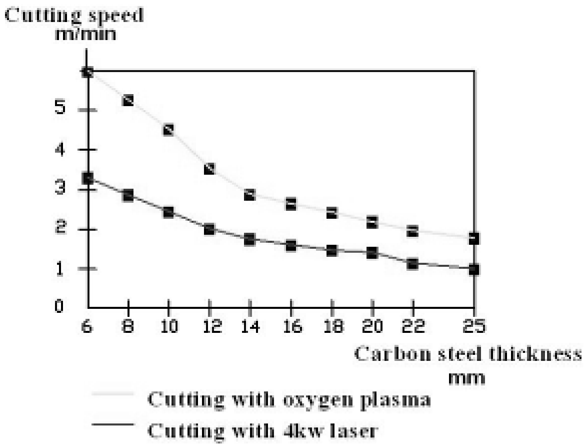

Figure 3.Cutting speed comparison according to the material thickness when using plasma and laser procedure

The plasma thermal cutting procedure as well as the other mentioned cutting procedures is characterized by advantages or disadvantages which have to be taken into consideration when choosing the appropriate cutting process. In table 2, there are some issues welding specialists deal with when choosing the appropriate cutting process.

Table 2.Thermal cutting procedures - advantages and disadvantages

Cutting Procedure	Advantages	Disadvantages
Oxy-fuel Cutting	High material thickness (> 500 mm), Low investment and operating cost level, cutting in any position, multiple burning devices on the same cutting machine	Only low carbon steel can be cut, Low cutting speeds when cutting above 30 mm material thickness, deformations, large thermally influenced area, stresses under heat action, cut quality influenced by surface condition.
Plasma cutting	High cutting speed and accuracy, Small thermally influenced area Investment moderate costs, Easy to work with cutting device.	High chamfer angle of the cutting edges when using classic plasma cutting procedure
Laser cutting	High cutting speed and accuracy for low thickness material, material savings, very low thermally influenced area, very low deformations and stresses, no limits in cutting shapes.	There are some materials that cannot be cut (e.g. copper), very high investment costs high maintenance cost, low material thicknesses <20 mm.

Prior to economical issues, quality conditions stipulated into standards or manufacturing norms have to be taken into consideration. Cutting accuracy, chamfer angle, surface roughness cutting width and thermally influenced area size are just some of the factors that determine the future working procedure [4]. It is certain that the achievement of the quality conditions stipulated into standards or manufacturing norms can be done only by using CNC automatic cutting machines as presented in figure 4 [5].

These machines are from the designing point of view a gantry, which includes specialized components such as railway path, transversal framework with cutting devices (plasma) and NC computer unit, thermal source (plasma generator).

Figure 4. Plasma CNC automatic cutting machine

Main technical specification of CNC cutting machine are cutting rail path length [mm], cutting width [mm], cutting material thickness min-max [mm], positioning speed [mm/min], continuous adjustable cutting speed [mm/min], cutting path accuracy.

CNC functions are straight cuts in coordinates, automatic alignment of the cutting device towards the cutting material, nesting program for important material savings, automatic rotation of the cutting part towards Ox and Oy axes, automatic cut for scaled or mirrored parts, standard or complex shape library, auto diagnosis messages, return to cutting path, automatic return to program start or cutting path, cutting mode selection (manual, automatic, step by step trial), cutting kerf.

3. Conclusions

The mechanized cutting procedures are characterized by advantages and disadvantages that have to be taken into consideration when settling the manufacturing technology.

Mechanized plasma thermal cutting procedure is for sure an option that should be taken into consideration by the future manufacturer; also by knowing and applying the above mentioned technical characteristics, significant performances given by these CNC machines regarding the cutting precision, the cutting speed and the complex shapes, can be achieved. Moreover, by taking into consideration other series of parameters such as plasma gas type and cutting parameters, it can be concluded that, normally, the mechanized thermal plasma cutting produces a decrease in manufacturing costs since no other mechanical machining is necessary.

Therefore, the final product is more competitive. Still, if cutting quality is not as good as expected, manufacturing costs are expected to increase. There may be higher costs both for the material and for the reworking as a result of the extra material presence towards the finite dimension of the part.

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