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EFFECT OF PROCESS PARAMETERS ON STRUCTURAL STEEL USING PLASMA ARC CUTTING: A REVIEW

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Abstract: *Plasma arc cutting is thermal cutting process that makes use of a constricted jet of high temperature plasma gas to melt and separate metal. The effect of process parameters (cutting current, cutting speed, gas pressure and stand-off distance) will be studied on response parameters (material removal rate, kerf width, bevel angle, straightness) by designing and performing the detailed experiments using orthogonal array (OA). Process performance data for various parameters will be analyzed using ANOVA. In this paper, the research and progress in plasma arc cutting process parameters of different steel materials are critically reviewed from different perspectives.*

Key words: *Plasma Arc Cutting, Structural Steel, Process Parameters, MRR, DOE, ANOVA.*

I. INTRODUCTION

Plasma cutting was developed at the end of the 1950s for cutting high-alloy steels and aluminium. It was designed to be used on all metals which, due to their chemical composition, could not be subjected to oxy-fuel cutting owing to its extremely high cutting speeds especially with thin materials and narrow heat-affected zone. The technique is also used today for cutting non-alloy steels and low-alloy steels.

Plasma arc cutting is a thermal non-traditional cutting process. Plasma arc cutting process operates on direct current, straight polarity having electrode negative with a constricted transferred arc as shown in Figure 1.

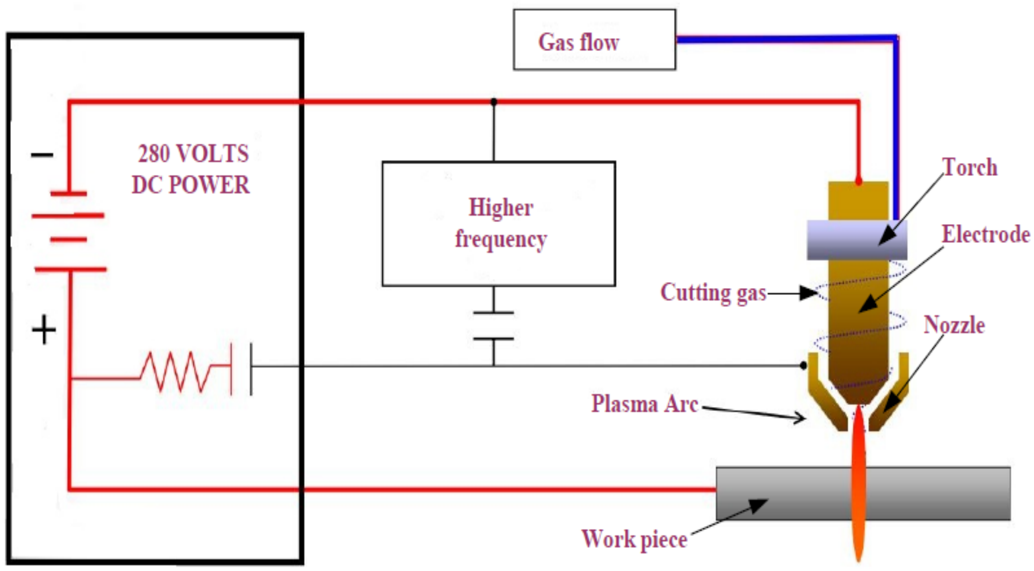

Figure 1: Plasma Arc Cutting Schematic Diagram

In plasma arc cutting process, heated gas is transformed into a plasma gas, resulting in extremely high temperatures. To establish the arc, a low-current pilot arc is initiated by a high-voltage, high-frequency discharge between the electrode and nozzle of the torch. Air/Gas from the power supply is used to force the pilot arc out of the nozzle orifice. Once the pilot arc has been established, the work piece needs to be brought into the circuit. The important step is converting the pilot arc (between the electrode and nozzle) into a “transferred arc” between the electrode and the work piece. As the torch approaches the work piece and the pilot arc contacts the plate, the nozzle and work piece start to share the plasma current. The power supply forces all the current to go through the work piece and increases the current to the cutting level and melting a specific area of metal with the heat of a constricted arc, then removing the molten material with high-velocity jet of hot ionized gas expelled from the nozzle orifice of the cutting torch and cut the material. After the cutting is completed, the plasma cutting arc is removed from the work piece and the electrical circuit is open which stops flowing current.

II. LITERATURE REVIEW

H.Ravi kumar and et.al[1] employed Taguchi's L9 orthogonal array to design the cutting trials and presented grey based technique for order of preference by similarity to ideal solution (TOPSIS) analysis (GTA) for designing the cutting parameters. They studied the effects of input parameters air pressure, cutting speed and arc current on the surface roughness and bevel angle by cutting 21Cr ferritic stainless steel using plasma arc cutting. They concluded that the GTA method was efficient in designing the optimal setting of cutting parameters for as - air pressure: 5.5 bar, cutting speed: 1000 mm/min, arc current: 60 A and stand-off distance: 1 mm. From ANOVA, it was concluded that major cutting parameters affecting the responses as cutting speed (46.88%), followed by the arc current (27.60%) and air pressure (14.92%).

Milan kumar and et.al [2] conducted an experiment on EN 31 Steel using process parameters gas pressure, arc current and torch height to influence effect on material removal rate and roughness characteristics and analyzed experimental reading through ANOVA and grey relational analysis. They concluded that highly effective parameter is gas pressure, whereas arc current and torch height are less effective factors for the response.

K. P. Maity and et.al [3] proposed Composition of response surface methodology and grey relational analysis coupled with principal component analysis to evaluate and estimate the effect of machining parameters feed rate, current, voltage, torch height on the responses kerf, chamfer, dross and surface roughness on the cutting of AISI 316 stainless steel. They concluded that torch height as well as interaction of torch height with feed rate is the most influencing parameters.
J. KECHAGIAS and et.al [4] conducted an experiment on St37 mild steel plates using DOE (L9 OA) and ANOVA. They studied the effect of process parameters cutting speed, arc ampere, pierce height and torch standoff distance on bevel angle. They concluded that the arc ampere is the most important parameter that affects the right bevel angle by 58.7%, the torch standoff distance affects the right bevel angle by 15.7% and the cutting speed 19%.

Subbarao Chamarthi and et.al [5] used DOE (2^3 full factorial with 2 replicates) for the experiment for cutting of Hardox-400 material using plasma arc cutting and analyzed the data by ANOVA. They studied the effects on unevenness of surface by varying process parameters cutting speed, plasma flow rate and arc voltage and concluded that the most influencing parameter is cutting speed and Unevenness can be reduced by reducing the cutting speed.

Yahya Hisman Celik[6] cut S235JR sheet materials (4, 6, and 8mm thick), used in pressure vessels, using the CNC plasma cutting machine at different cutting speeds, amperes, and arc voltages and observed effect on temperature distribution, surface roughness, heat affected zone and hardness and concluded that: 1) The ampere and arc voltage for thin sheets must be low and cutting speed must be high to get the best surface roughness, prevent hardness increase, and to have minimum HAZ. 2) The current must be increased, and the arc voltage must be decreased as the thickness of the material to be cut increases. However, extensive sheet thickness causes the cutting speed to decrease. 3) At lower cutting speed conditions, the surface being cut is exposed under high temperature for a longer time.HAZ increases when cutting speeds decrease and decreases when cutting speeds increase. 4) Surface roughness can decrease by reducing cutting speeds.

K. Salonitisa and et.al [7] carried out an experimental study of the plasma arc cutting of S235 mild steel in order to identify the process parameters that influence the most the quality characteristics of the cut (surface roughness, heat affected zone and conicity of the cut) by DOE (L9 OA) and ANOVA. They selected process parameters cutting speed, cutting current, gas pressure and cutting height and concluded that the surface roughness and the conicity are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current.

BEGIC Derzija and et.al [8] studied the effect of the cutting parameters on kerf width and surface roughness in plasma cutting of low alloy steel (EN 10025), and hence obtained the optimum ranges of cutting speed and plasma gas pressure. They concluded that kerf width decreases with increasing plasma gas pressure, while it slightly changes with increasing cutting speed and surface roughness decreases by increasing plasma gas pressure and changes very slightly with increasing cutting speed.

John Kechagias and et.al [9] conducted an orthogonal matrix experiment L18for the cutting of St37 mild steel plates using plasma arc cutting and measured the right bevel angle and optimized according to the process parameters using an analysis of means and an analysis of variances. They concluded that the arc ampere is the most important parameter that affects the right bevel angle by 50.89%, the torch standoff distance affects the right bevel angle by 15.9% and the plate thickness by about 6.22%.

Abdulkadir Gullu and et.al [10] cut AISI 304 stainless steel and St 52 carbon steel by plasma arc and investigated the variations of structural specifications occurred after cutting. The effect of process parameters cutting speed, cutting height, material type and plasma gas pressure on heat affected zone and hardness was studied and it was concluded that after cutting, in the areas near to outer surface of the part hardness increased, around 250–350 HV, and it decreased towards to the core of the material and the area of 0.399–0.499 mm of stainless steel materials and 0.434–0.542 mm of carbon steel materials were more affected by heat according to cutting speed.

III. CONCLUSION

1. From the literature review, it is concluded that work has been done on plasma arc cutting of different structural steel materials like S235 mild steel, EN 10025, St37 mild steel and Hardox-400 and other steels like 21Cr ferritic stainless steel, EN 31 Steel, AISI 316 stainless steel, AISI 304 stainless steel and St 52 carbon steel.

2. Based on the experiments, the effect of selected input parameters on the output responses like kerf width, surface roughness, bevel angle, unevenness of surface, temperature distribution, and heat affected zone and hardness were studied.
3. The most influential process parameters for the above mentioned experiments are cutting speed, cutting current, standoff distance and gas pressure.

IV. GAP IDENTIFICATION

1. Experiments can be done on different structural steel materials like Structural Steel of grade IS 2062 / IS 5986 or High strength low alloy steels which are used for structural applications.
2. The effect of input parameters on material removal rate (MRR) can be studied.
3. Optimization of the parameters can be done using Taguchi method, Response surface methodology or Grey Relational Analysis.

V. FUTURE WORK

1. The effect of air plasma arc cutting process parameters on cutting of structural steel IS 2062 E250 BR material which is suitable for welded, bolted and riveted structures and for general engineering purposes.
2. The detailed experiments will be performed on the basis of orthogonal array (L9 OA) and the parameters like material removal rate (MRR), kerf width (top and bottom), bevel angle, straightness will be measured by varying cutting current, cutting speed, gas pressure and stand- off distance.
3. The process performance data will be analyzed for various parameters using ANOVA and the optimum combination of process parameters will be obtained.

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