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A Review of Parametric Optimization of Plasma arc cutting process of SS 310

KEYWORDS

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ABSTRACT This paper deals with the parametric optimization of the plasma arc cutting process of ss 310. Plasma arc cutting process is the non conventional thermal process which is applicable to perform various operations such as cutting, welding, coating etc. The parametric optimization of the process can be done the of different materials using different optimization techniques such as taguchi, full factorial method. Parameters should be considered for optimization are cutting speed, cutting current, standoff distance, cutting voltage, plasma gas pressure and gas flow rate and to analyze their effect on response parameters such as surface roughness, material removal rate and kerf width. ANOVA (analysis of variance) can be performing to obtain the contribution of each parameter and to identify the parameter which has a significant effect on the performance characteristics.

I. INTRODUCTION

Nowadays a variety of non conventional thermal processes are being used for the cutting of a variety of materials having a high strength and high melting point which cannot be satisfactorily cut by the conventional methods of cutting . these non-conventional methods includes oxy fuel cutting, laser cutting, abrasive water jet cutting and plasma arc cutting. These methods have different advantages such as the narrow cut, better cut profile, flat edges less work piece deformation, high feed rates etc.

In plasma arc cutting a plasma gas is used as a heat source. Plasma is nothing but a state of substance which is obtained by supplying a tremendous amount of energy to any gas or when a gas is subjected to a high electric field. For example when a certain heat is supplied to the ice it melts and get converted in to the liquid, again more heat is supplied liquid become vapor or gas, further more heat is supplied to the gas the ionization of gas will occur and it will be converted into a plasma- a highly electrically conductive gas.

PLASMA ARC CUTTING PROCESS

Plasma arc cutting process was developed at the end of 1950s, at that time it was applicable for the limited materials such as high alloy steel and aluminum but today it is used to cut a variety of materials such as Stainless steel, manganese steel, titanium alloys, copper, magnesium, aluminum and its alloys and cast iron including non- alloy and low alloy steels due to its narrow heat affected zone and high cutting speed.

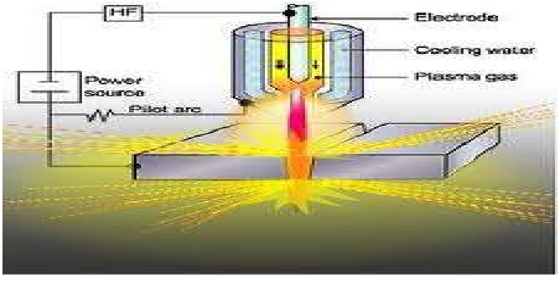

Fig. 1: Schematic diagram of plasma arc cutting

Plasma arc cutting process uses a constricted arc formed by plasma gas as a heat source. In this process an electric arc is generated between the electrode and the work piece, where the electrode acts as a cathode and work piece is taken as anode.

The plasma gas will expand with the high velocity through the nozzle at the same time an electric current is passed through this gas with the help of a tungsten electrode due to which a high intensity plasma arc is generated. This plasma arc is then transferred to the surface being cut turning some of gas to the plasma. This plasma arc has a sufficient energy to melt or vaporize the surface being cut and move very fast to flow the molten metal away from the cut.

In plasma arc nozzle there is a space between the outer periphery of the electrode and an inner periphery of the nozzle where the plasma gas get heated and ionized which leads the plasma to expand in volume and pressure greatly. Thus plasma gas comes out of nozzle with very high velocity and high temperature.

1.Introduction to grade 310

Grade 310 is a medium carbon austenitic stainless steel and applicable for high temperature applications such as furnace parts and heat exchangers. It can be used at the moderate temperatures up to 1150°C in continuous service, and 1035°C in intermittent service.

2. Applications of Grade 310/310S Stainless Steel

Typical Applications Grade 310/310S is used in kilns, radiant tubes, tube hangers for petroleum refining, steam boilers, coal gasified components, lead pots, , refractory applications, burners and combustion chambers, muffles, food processing equipment, cryogenic structures, annealing covers, fluidized bed combustors, thermo wells

3. Properties of Grade 310/310S Stainless Steel

These grades are highly corrosion and oxidation resistant.These grades contain 25% chromium and 20% nickel. Grade 310S is a lower carbon version, less prone to embrittlement service. Due to the high content of chromium and nickel these steels are applicable in reducing sulphur containing H2S. They are widely used in moderately carburising atmospheres, as encountered in petrochemical environments. For more severe carburising atmospheres other heat resisting alloys should be selected. As itsuffers from thermal shock Grade 310 is not recommended for frequent liquid quenching. Due to its toughness and low magnetic permeability, it is often used in cryogenic applications.

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4. Chemical Composition of Grade 310/310S Stainless Steel

Grade	C	Mn	Si	P	S	Cr	Ni
310	.25	2.0	1.5	.045	.030	26	22

5.Mechanical Properties of Grade 310

Grade	Tensile strength	Yield strength 2% proof	Elongation (% in 50mm)	Hardness	
				Rockwell	Brinell
310	515 MPa	205 MPa	40	95	217

II. LITERATURE RE VIEW

Milan kumar das et al [1] investigated the parametric optimization of plasma arc cutting process of EN 31 steel. Three process parameters viz. cutting current, gas pressure and standoff distance are taken in to consideration and experiments have been conducted based on L27 orthogonal array. Response parameters such as material removal rate and surface roughness of machined surface are measured for every experimental runs. For minimum surface roughness and maximum MRR process parameters are optimized using Taguchi method along with grey relational analysis. The analysis of variance is performed to find the contribution of each process parameter on the performance characteristics and concluded that the gas pressure is the parameter has a significant effect whereas the other parameters viz. cutting current and standoff distance are less effective.

Subbarao chamarthi et al [2] investigated effect of parameter on cutting of 12 mm thick plate of Hardox 400 through PAC. In this study the high tolerance voltage, cutting speed and plasma flow rate are considered as the main parameters and their effect on the unevenness of the surface to be cut is evaluated. The design of experiment (DOE) is used to identify the significant parameter in order to define geometry of cut profile. After selecting a proper values of process parameters of plasma arc cutting process as a result of experimental investigation an unevenness of the surface is obtained. The analysis of variance (ANOVA) is performed in order to identify the parameters which clearly define the unevenness quality attributes. From the analysis of results it is concluded that the unevenness of the surface can be reduced by reducing the cutting speed also shown that the cutting quality can be improved by changing cutting voltage and plasma flow rate.

Bogdan Nedik et al [3] analyzed the quality of cut in plasma arc cutting. In plasma arc cutting process the quality of cut is defined using standard EN ISO 9013. In this paper the samples of 15 mm thick plates of S235 were used to create 17 cuts. The significant parameters taken in to consideration are cutting speed and cutting current. The experimental results are found consistent with theoretical consideration and previous experimental results. It is concluded that the best quality of cut can be obtained by increasing the cutting speed by 20% than the tablet speed value.

Yaha hisman selic et al [4] cut the sheet material S235JR using the CNC plasma cutting machine at different cutting speeds, cutting current, and arc voltage and measured the effect of variation on temperature distribution, hardness , thickness of heat affected zone and surface roughness of the material after cut. From the results of the experiments he had concluded that the quality of plasma CNC machine depend on the cutting current, cutting speed, arc voltage and material thickness. To get the best surface roughness the cutting current and the cutting voltage kept low and cutting speed must be high for the thin sheet and while using CNC plasma machine prevent hardness increase, and have a minimum HAZ. While the thickness of the cutting sheet increase the cutting current must be increase and cutting voltage is to be decrease. However this leads to decrease in corresponding cutting speed.

Tetyana Kevka et al [5] investigated the effect of nature of gas on the plasma arc cutting of mild steel. In this paper the study is been carried out on the influence of the nature of gas on the arc behavior and the cutting performance of mild steel. Usually the plasma arc cutting system is operated on steam has been modified to usage of different plasma gases. Experimental results are obtained from the cutting of 16 mm thick mild steel plate at 60 A with steam, nitrogen, air, and oxygen as the plasma gases. From the experimental results it is concluded that the steam as the plasma gas will generate more energy than other gases for the same current value and the plasma jet generated is much narrowed when nitrogen and air is used as plasma gases.

K. Salonitis et al [6] investigated experimentally the plasma arc cutting process in order to assessing the quality of cut. The quality of cut is assessed by measuring the conicity, edge roughness and size of heat affected zone (HAZ). The input parameters considered are cutting power, cutting speed, cutting height and plasma gas pressure. The statistical analysis is performed in order to determine the contribution of each parameter in the obtained quality of cut. The regression analysis is done to develop empirical model in order to describe the effect of parameters on the quality of cutting. Using the design of experiment and analysis of variance it is found that the surface roughness and conicity are mainly affected by the cutting height, whereas the heat affected zone (HAZ) is mainly influenced by the cutting current.

Miroslav Radovanovic et al [7] had done a modeling of the plasma arc cutting process using Artificial Neural Networking (ANN). Aimed to develop the ANN mode to predict the ten point height of irregularities (Rz) taking input parameters such as cutting speed, cutting current and plate thickness. After prediction of data the accuracy of ANN has been validated. Using this model one can select the machining conditions which correspond to the cutting region with minimal surface roughness.

Abdul Kadir Gullu et al [8] investigated the variation in structural specification occurred in the AISI 304 and St 52 carbon steel after cut by the plasma arc. As per the experimental results it is found that the burning of particulars and distribution amount were increased when the cutting is carried out using speed and it is observed that the hardness will decreased from the outer surface toward the core while the hardness at the outer surface affected by the high temperature is increased.

E. Gariboldi et al [9] investigated the quality of cutting on pure titanium sheet through high tolerance plasma arc cutting process under various cutting conditions. The 5mm thick sheet of pure titanium is cut at the various feed rates and with the adaption of oxygen or nitrogen as cutting and shielding gas. While the oxygen is used as the cutting gas the oxidation reaction will occur and result in higher feed rates and unevenness and kerf width of better quality were achieved.

W. J. Xu et al [10] used the hydro magnetically confined plasma arc to cut ceramic plates. From the experiments and

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analysis the characteristics of hydro magnetic confined plasma was explored. The effect of secondary confinement on arc properties, on cutting quality and optimal process parameters were determined. In this paper author conducted various experiments using water constricted arc, magnetic constricted arc and hydro magnetic constricted arc. after analyzing the result of experiments it is concluded that by using the hydro magnetic constricted arc a reduced kerf width and improved cut quality on ceramic surface is achieved. Theoretical and experimental results both have proven the feasibility and validity of the newly advanced hydro magnetic confined PAC.

III. CONCLUSION

Following conclusions are derived from above literature survey

1. In plasma arc cutting process gas pressure is the parameter has a significant effect whereas the other parameters viz. cutting current and standoff distance are less effective.
2. The steam as the plasma gas will generate more energy than other gases for the same current value and the plasma jet generated is much narrowed when nitrogen and air is used as plasma gases.
3. Surface roughness and conicity are mainly affected by the cutting height, whereas the heat affected zone (HAZ) is mainly influenced by the cutting current.
4. While the oxygen is used as the cutting gas the oxidation reaction will occur and result in higher feed rates and unevenness and kerf width of better quality were achieved.
5. For the thin plate of work piece material cutting current and cutting voltage should be decrease and cutting speed should be increase for better surface roughness.

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