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EXPERIMENTAL INVESTIGATION OF PROCESS PARAMETER IN PLASMA ARC CUTTING OF SS410

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Abstract: In this paper literature has been studied in context to parametric optimization of Plasma Arc Cutting Machine. Plasma cutting is a manufacturing process is leading in developing in arc cutting process which is higher productivity and Good in quality. Nitrogen is used as a shielding gas in the PAC. The shielding gas can influence the cut strength, ductility, and toughness and corrosion resistance. By Plasma arc cutting it is possible to cut is very easy. Optimization of the parameter will be carried out by full factorial method. We will use Stainless Steel 410 material which is more use in filler material, Food processing equipments, chemical containers and Heat exchangers. S.S 410 plates with Dimensions 100mm x 100mm x 2.5mm with straight cut. The parameters are the most important factors affecting the quality, productivity and cost of cutting. Where the input parameters are Voltage, Cutting current, Standoff distance and Output parameters are Material Removal Rate, Kerf width, Bevel angle value. In this study the effects of different parameters on Kerf width, Bevel angle and MRR will be predicted. A plan of experiments based on Full Factorial techniques has been used to acquire the data.

Keyword:Plasma Arc Cutting, SS 410, Full Factorial Method, ANOVA.

I. INTRODUCTION

Plasma Arc Cutting (PAC) is a material removal process in which the material is removed by directing a high velocity jet of high temperature ionized gas on the work piece. The relatively narrow plasma jet melts the work piece material in its path. Because of the high temperature involved, the process can be used on almost all materials including those which are resistance to oxy-fuel gas cutting. Plasma is mixture of free electrons, positively

charged and neutral atoms. It can be obtained by heating a gas to a very temperature so that it is partially ionized.

The plasma torch confines the plasma forming gas in an arc chamber, and the arc supplies a large input of electrical energy. The central zone of the plasma reaches a temperature of 15000° C and is completely ionized. Much of the heating of the gas takes place in constricted region of the nozzle duct, resulting in high velocity gas exit. [8]

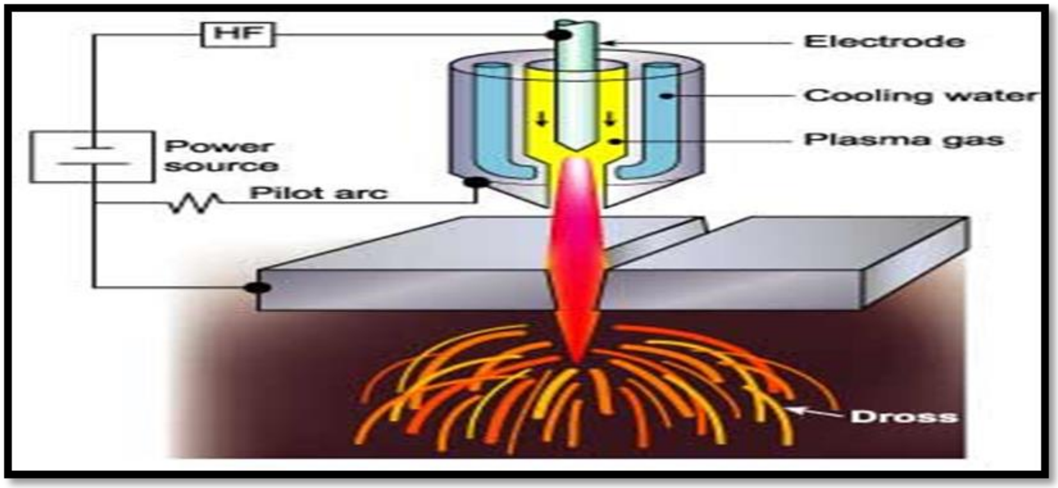


Figure 1.1: Plasma Arc Cutting [2]

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 1.2.

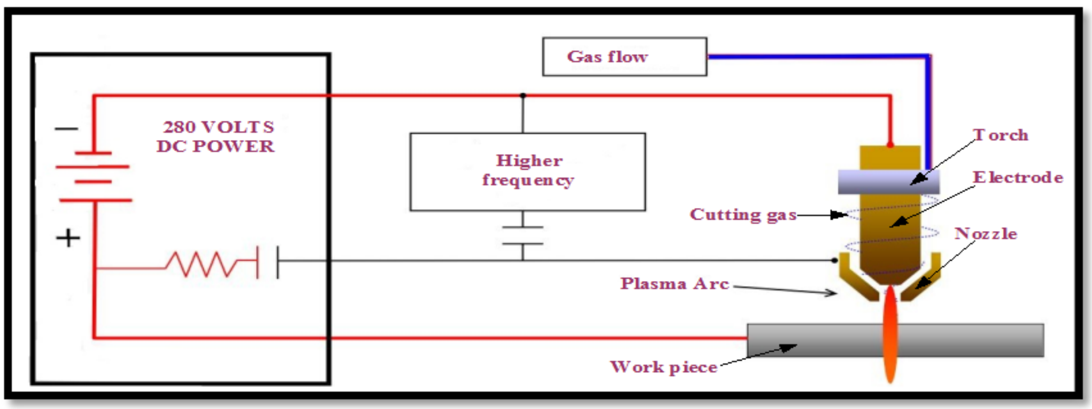


Figure 1.2: Plasma Arc Cutting Schematic Diagram

The machining technologies based on the thermal effect of plasma have an important place in the field of unconventional technologies. Plasma cutting is a process cutting is a process that is used to cut stainless steel, manganese steel, titanium alloys, copper, magnesium, aluminium and its alloys and cast iron and other metals (or sometimes other materials) using a plasma torch. In any plasma arc cutting process, heated gas is transformed into a plasma gas, resulting in extremely high temperatures. In this process, an inert gas (in some units, compressed air) is blown at high speed out of a nozzle, at the same time an electrical arc is formed though that gas from the nozzle to the surface being cut, turning some of that gas to plasma. To establish the arc, a low-current pilot arc is initiated by a high-voltage, high-frequency discharge between the electrode and 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 complete, the plasma cutting arc is removed from the work piece and the electrical circuit is open which stops flowing current. At present the plasma arc machining is the most modern machining technologies used in the industry such as machines manufacturing, chemical, nuclear and pressure vessel. Plasma can also be used for plasma arc welding.

II. LITERATURE REVIEW

Milan kumar*et al* [1] were investigates the effects and parametric optimization of process parameters for plasma arc cutting (PAC) of EN31 steel using grey relation analysis. Three process parameters viz. gas pressure, arc current and torch height are considered and experiments are conducted based on L_{27} orthogonal array (OA). Process responses viz. material removal rate (MRR) and surface roughness parameters of the machined surface are measured for every experimental runs. For maximum MRR and minimum surface roughness characteristic process parameters are optimized based on Taguchi method coupled with grey relational analysis. Analysis of variance (ANOVA) is performed to get the contribution of each process parameters on the performance characteristics and it is observed that gas pressure is significant process parameters that affect the responses. Rectangular block of 80 mm × 15 mm and 10 mm height made of EN 31 steel which is a high carbon alloy steel with high degree of hardness, compressive strength and abrasion resistance is selected as work piece.

The main effects plot that parameter A (gas pressure) is the most significant parameter, while B (arc current) also has a quite significant effect on the response. But parameter C (torch-height) has almost no effect. Hence the optimal process parameter combination for maximum material removal rate and maximum roughness characteristics of PAC is given as middle level of gas pressure, highest level of arc current and highest level of torch height.

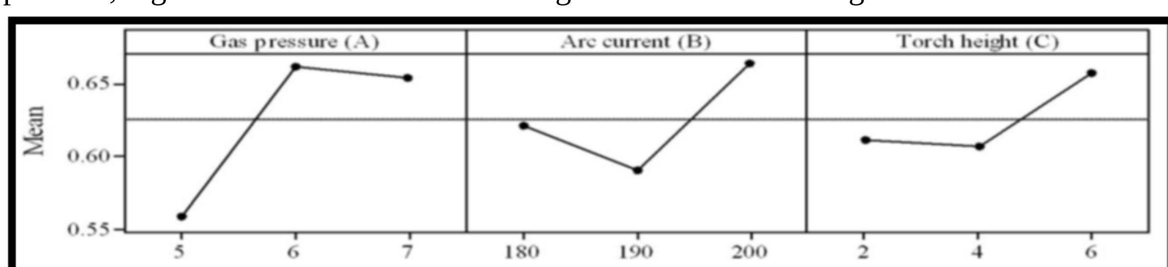


Figure 2.1: Main effects is plot for mean of grey relational grade [1]

Based on ANOVA, the highly effective parameters is gas pressure, whereas arc current and torch height are less effective factors within the specific test range.

K. Salonitis and S. Vatousianos [2] have investigated experimentally in the present paper for assessing the quality of the cut. The quality of the cut has been monitored by measuring the kerf taper angle (conicity), the edge roughness and the size of the heat affected zone (HAZ). This work aims at evaluating processing parameters, such as the cutting power, scanning speed, cutting height and plasma gas pressure. A statistical analysis of the results has been performed in order for the effect of each parameter on the cutting quality to be determined. The regression analysis has been used for the development of empirical models able to describe the effect of the process parameters on the quality of the cutting. The cutting height has the strongest effect on the quality characteristics and especially on conicity and on the surface roughness of the cut.

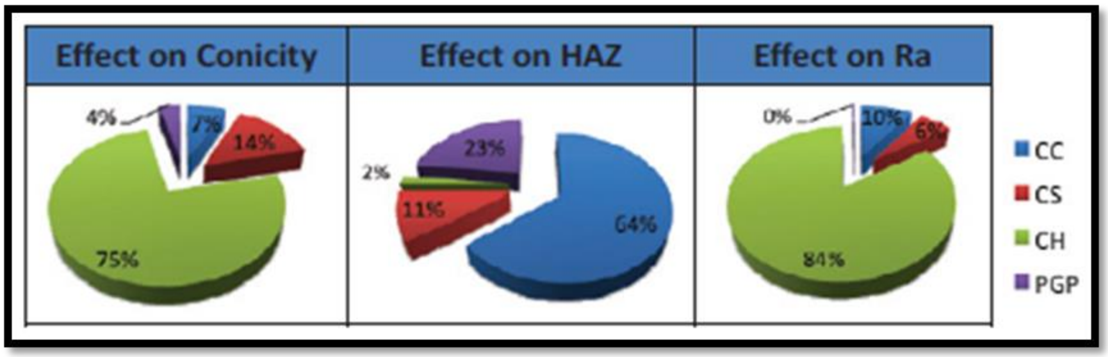


Figure 2.2: Effect of process parameters on Conicity, HAZ and Ra [2]

The regression analysis is done to develop empirical model in order to describe the effect of parameters on the quality of cutting. Using design of experiments and analysis of variance, it was found 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.

R. Biniet *al* [3] were conducted experiment on 15mm thick mild steel sheets metals using process parameters like arc voltage and cutting speed, plasma gas flowrate, shield gas flowrate and shield gas composition are to influence effect on kerf position and shape are evaluated. They revealed that cutting speed and arc voltage affect the kerf formation mechanism and their interaction is also important in defining the inclination of the cut. They also concluded that by reducing the arc voltage, i.e. the standoff distance, the thermal stress on the torch components, especially the electrode and the nozzle, increases, thus accelerating their wear. This trade-off can be taken into account by adding some suitable constraints to the parameters domain and beyond the arc voltage, the cutting speed showed a noticeable effect. In particular, results obtained in the last experimental stage allowed one to observe that unevenness can be reduced by reducing the cutting speed. They were shown that very good quality can be achieved for all the sides by varying the cutting speed and the arc voltage only.

SubbaraoChamarthi*et al* [4] were worked on plasma arc cutting (PAC) that makes use of a constricted jet of high-temperature plasma gas to melt and separate (cut) metal. They had used 12mm plate thickness Hardox-400 which was cut by high tolerance voltage, cutting speed and plasma gas flow rate included as process parameters in the analysis and their effect on unevenness of cut surface is evaluated. Despite the value selected for rate included as process parameters, the analysis shows that Hardox-400 plates can have different profiles, depending on the specific side considered. 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. They found that very good quality can be achieved for all the sides by varying the cutting speed, plasma flowrate and arc voltage only and they optimized minimum unevenness for 12mm Hardox plate is 421 micron t optimum value of 70L/Hr plasma flow rate, 125 V voltage and 2100 mm/min cutting speed.

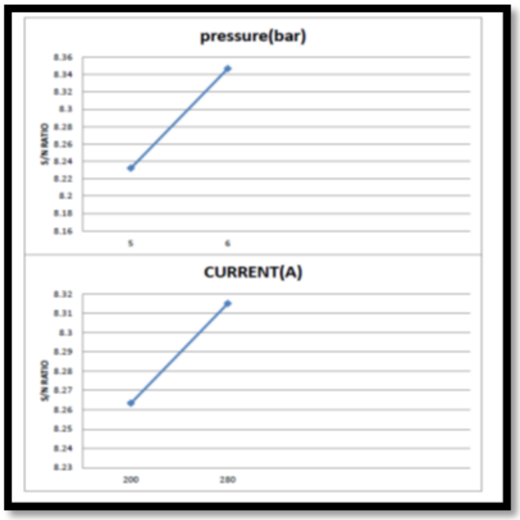
R. Bhuveneshet *al*[5] were shown that manufacturing companies define the quality of thermal removing process based on the dimension and physical appearance of the cutting material surface. Therefore, the roughness of the surface area of the material cut by the plasma arc cutting machine was importantly considered. Plasma arc cutter selco Genesis 90 was used to cut standard AISI 1017 Steel of 200mm × 6mm manually based on the selected parameters setting. The material removal rate (MRR) was measured by determining the weight of the specimens before and after the cutting process. The surface roughness (SR) analysis was conducted using Mitutoyo CS-3100 to determine the average roughness value (Ra). Taguchi method was utilized to achieve optimum condition for both outputs studied. The microstructure analysis in the region of the cutting surface is performed using SEM. The results reveal that the SR values are inversely proportional to the MRR values. The quality of the surface roughness depends on the dross peak that occurred after the cutting process. Based on the experimental results several conclusions for manual plasma arc cutting machine can be highlighted as below:

- Generally the SR values are inversely proportional to the MRR values.
- The dimensions of the dross determine the quality of plasma arc cutting in terms of surface roughness.

Vinay Kumar S. *et al*[6]with increase in competition in market and to attain high accuracy now days the non conventional machining are become lifeline of any industry. One of the most important non conventional machining methods is Plasma Arc Machining. This work discusses Taguchi based parametric study for power and kerf optimization combination of input variables for the set conditions. The main objective was the best combination of solution for maximizing the Material Removal Rate (MRR) and for minimizing the Surface Roughness with Taguchi Method.The parametric effect on kerf and power consumed in PAM in which parameter Cutting speed, Thickness, Arc Voltage and Arc Current have influence on kerf and power and also the mean response and S/N curve depicts the optimum values. This work helps in tuning the PAM process for better accuracy with less kerf accordingly.

Sandeep Patel and AmitPrakashKashyap[7]were investigated experimentally in the present paper for assessing the quality of the cut. The quality of the cut has been monitored by measuring the MRR (material removal rate). The Plasma arc cutting process is utilized to cut plates from 12mm thick mild steel sheets metals. And the evaluating process parameters, such as the Gas

Pressure, Current, Cutting Speed, and Arc Gap while maintaining other parameters such as Kerf (width of cut) & materials thickness fixed throughout the experiment. The Design of Experiments (DOE) technique is used in order to outline the main parameters which define the geometry of the cut profile, as well as its constancy (i.e. stability). Eventually the Taguchi method is used to investigate the optimum process parameters for achieving maximum material rate. The optimum value has been determined with the help of main effect plot and ANOVA table. The Regression equation for MRR has been developed with the help of Minitab 15 Software.



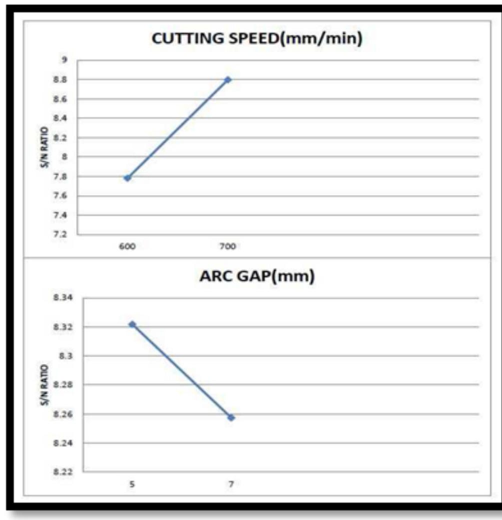


Figure 2.3: Effect of Pressure & current On MRR [7]

Figure 2.4: Effect of Cutting speed & MRR [7]

Based on the screening experimental results, the Taguchi method was selected for the DOE. Within Taguchi method, the experiments are performed as per standard orthogonal arrays while the optimum level of input process parameters (control factors) is decided on the basis of a statistical analysis of the experimental results. The tool used in the Taguchi method is the orthogonal array (OA).

As per analysis, the significant parameter for optimum MRR calculation is Cutting Speed. Using design of experiments and analysis of variance, it was found that the MRR is mainly influenced by Cutting speed.

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IV. CONCLUSION

Following Conclusion is Derived From Above Literature Survey

- 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.

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- Surface roughness and conicity are mainly affected by the cutting height, whereas the heat affected zone (HAZ) is mainly influenced by the cutting current.
- 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.
- For the thin plate of work piece material cutting current and cutting voltage should be decreases and cutting speed should be increases for better surface roughness.

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