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A Review paper on Experimental Investigation of Plasma Arc Cutting by Full Factorial Design

Jainish A. Patel[1], Karan H. Patel[2], Chirag B. Prajapati[3], Montu D. Patel[4], Rakesh B. Prajapati[5]

[1,2,3,4] U.G. Student [5]Asst.Professor

[5] Department of mechanical engineering SAL, Ahmadabad.

Pateljainish07@gmail.com[1], karanpatel1994@live.in[2], prajapatichirag342@gmail.com[3], patelmontu777@gmail.com[4], rakeshprajapati2409@gmail.com[5]

Abstract-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 304 material which is more use in filler material, Food processing equipments, chemical containers and Heat exchangers. S.S 304 plates with Dimensions 250mm x 125mm x 6mm 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 speed, Standoff distance and Output parameters are Material Removal Rate, Kerf width, Surface Roughness value (RA value). In this study the effects of different parameters on Kerf width, Surface Roughness value and MRR will be predicted. A plan of experiments based on Full Factorial techniques has been used to acquire the data.

Key words: PACM, S.S 304, Surface roughness test, full factorial method.

I. INTRODUCTION

Plasma arc cutting (PAC) is a non-conventional manufacturing process capable of processing a variety of electrically conducting materials. Stainless steel, manganese steel, titanium alloys, copper, magnesium, aluminum and its alloys and cast iron can be processed. The plasma process for cutting was developed approximately thirty years ago, for metals difficult to be machined through conventional processes. It uses a high-energy stream of dissociated, ionized gas, known as plasma, as the heat source.

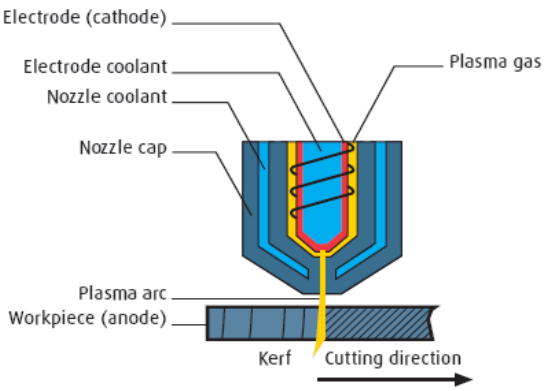

FIG-1 PLASMA ARC CUTTING

PAC process is characterized by an electric arc established between an electrode and the work piece. The electrode acts as the cathode, and the work piece material acts as the anode. {2} Plasma cutting is an industrial process that is essentially controlled by the operator who uses recommendations given by the manufacturers of the cutting equipment. Those recommendations, however, reflect the point of view of the manufacturers' business, which includes not only selling the cutting torches but also the consumables. Yet, the manufacturers' recommendations usually lead to solutions that are technically sound in terms

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of cutting quality, but do not necessarily correspond to the most cost-effective solutions to the user's point of view. The efficient manufacture of high-quality plate components is quite difficult task. One of the easiest methods of contour cutting steel is Oxy-fuel cutting. With respect to Oxy-fuel cutting, laser cutting, abrasive water jet cutting, and plasma cutting are new attractive advanced processes for contour cutting of plate. They have numerous advantages, namely, a narrow cut, a proper cut profile, smooth and flat edges, minimal deformation of a work piece, the possibility of applying high feed rates, intricate profile manufacture and fast adaptation to changes in manufacturing programs. {7} As a result, the user attempts to optimize the cutting operations by trial-and-error every time it is needed to setup the existing equipment for a new different task. This requires the development of full studies and applies theoretical and experimental researches among all the technological system's links, in order to establish (chose) the optimal processing variability.

II. LITERATURE SURVEY

E. Garibaldi et.al was performing the high tolerance, plasma arc cutting of a 5mm commercially pure titanium sheet was investigated under different process conditions, in particular using several feed rates in the dross-free feed rate range and with the adoption of oxygen or nitrogen as cut gears. Due to the reduced interaction with the plasma-beam related to higher feed rates when oxygen was used, the geometrical features (unevenness and kerf width, measured on both sides of the cutting edges due to their asymmetry) revealed a better quality for this set of cuts. In any case, according to DIN 2310 standard quality Class I was obtained for all the performed cuts, thus confirming the opportunity to use this process for the achievement of good cutting quality on titanium sheets. In the authors' opinion, the quality features of the cutting edge of HTPAC of commercially pure titanium from a geometrical point of view need to be integrated with the considerations on the functional requirements for the cutting edge and on economical considerations that are partially correlated to micro structural modifications occurred at the cutting edge. As a matter of fact micro structural features of the titanium sheet were severely affected by the thermal cycle brought about by the plasma torch pass-by and by interaction with the cutting atmosphere in a wide layer. The thickness of this layer, related to the position along the cutting edge, overcame 1mm for cuts performed using nitrogen and for the slowest cut with oxygen. All cutting edges displayed an external layer of oxide, resulting from interaction with oxygen also when both cutting and shield gases were nitrogen. In the cases of cuts performed with oxygen as cutting gas, under the oxide (25–50 _m thick) a layer of _-case of relatively high hardness and brittleness was found. Two sets of temperature measurements in different locations during the passage of the torch allowed to follow the thermal cycle due to the cutting process and to make some considerations about the micro structural alterations observed. In particular, high heating rates were detected. Far lower cooling rates were measured, well below the lower limit reported in literature to obtain phase from the back transformation of _-phase, not observed in the examined specimens. A model was applied to simulate the thermal effects of the material interaction with the torch in the case of slow cut with oxygen. A comparison between modeled thermal cycles, experimental measurements and micro structural observations confirmed the opportunity to clearly identify the region of at least partial transformation of primary _-phase by means of a simple etching on metallographies ally prepared specimens and to have a rough estimation of its width by a simple thermal model.

Abdulkadir Gullu. Et.al In plasma cutting operations, the parameters, namely the type of material cut, cutting gas, cutting speed, etc., Are the effects on cutting conditions. The results below were obtained according to the experiments. Similar results were obtained for the same group of materials having different thickness, physical and mechanical properties. It was determined that after cutting, in the areas near to the outer surface of the part hardness, increased, around 250–350 HV, and it decreased towards to the core of the material. The amount of material removed from cutting area is proportional to thickness. The cutting gap becomes small in thin material, bigger in thick material. When the graphics showing cutting results which were prepared according to the side speeds proposed by the machine tool manufacturer and material type and thickness, it can be seen that these proposed speeds are more suitable. This shows that the manufacturing company determined these speeds after doing some experimental tests. Moreover, the least burr occurs when the proposed speeds were used. The area of 0.399–0.499 mm of stainless steel materials and 0.434–0.542 mm of carbon steel materials was more affected by heat according to cutting speed.

K. Salons et.al finds That the scope of the present paper was the experimental study of the plasma arc cutting in order to identify the process parameters that influence the most the quality characteristics of the cut. Four process parameters were examined, namely the cutting speed, the cutting current, the plasma gas pressure and the distance of the plasma torch from the work piece surface (cutting height). The quality characteristics that were assessed included the surface roughness, the heat affected

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zone and the conicity of the cut geometry. Using design of experiments and analysis of variance, it was found that the surface roughness and the concerti are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current.

Subbarao Chamarthi et.al was performing that Cutting speed increases or decrease inversely proportional thickness of plate. The cutting speed reduces results in an excessive amount of molten metal which cannot be completely removed by the momentum of the plasma jet. First of all, three process parameters like Voltage, Plasma gas and cutting speed than DOE are taken on the based DOE experiments are carried out. Then ANOVA analyses are done and after optimization experiments are carried out. It was found out that the arc voltage is main parameter and it influences all the aspects related with the cut quality rather than the effect on the arc power, beyond the arc voltage the cutting speed showed a noticeable effect. Results obtained in the experimental stage allowed one to observe that unevenness can be reduced by reducing the cutting speed. Eventually, it was shown that very good quality can be achieved for all the sides by varying the cutting speed, plasma flow rate and arc voltage only. As recorded optimized minimum unevenness for 12 mm Hardox plate is 421 microns at optimum value of the 70L/Hr plasma flow rate, 125 V voltage and 2100 mm/min cutting speed.

T Kavka et.al published that this paper is devoted to the experimental study of the effect of gas type and flow rate on properties of transferring arc and cutting phenomena. Three gases, mostly used for arc cutting of mild steel were considered, namely air, nitrogen and oxygen. Moreover, a plasma gas originated from a liquid with significantly different thermo physical properties was also investigated. The study involved the following steps: a theoretical examination of properties of acid gases, experimental study of the generated arcs, analysis of cutting performance and the energy balance of the cutting process. The predominance of nitrogen in air explains the similarity in plasma properties and cutting performance for both gases. They exhibited the same voltages, the smallest arc diameters and the narrowest kerfs among the studied cases. Despite the significant difference in gas and arc properties, oxygen and steam cutting exhibited similar features. For both gases kerfs had a bell-shaped geometry and were much wider than for nitrogen or air cutting. Similar cutting performance is a result of different phenomena. In steam cutting, a wider kerf was caused by higher energy density in the plasma and better ability of radial heat transfer from the arc center towards the material in the kerf. In oxygen cutting, oxidation of the material played a significant role and the energy input originated from oxidation increased with the plasma gas flow rate. It was shown that under study conditions 20% of supply oxygen reacted with the cut material with a release of 3.4 KJ per gram of oxygen. In steam cutting, despite the rather high oxygen content, oxidation did not take place. Bounded-free oxygen was necessary to provide the reaction of oxidation. However, most of the oxygen flowed into the cold outer region, where it was bounded either with hydrogen or with carbon. An increase in the plasma gas flow rate can facilitate improvement of cut quality for all gases because it increases both energy and momentum density.

Bogdan Nedic et.al knows that Plasma cutting is an unconventional technology that represents the best relation between cost and quality value for money for most of the standard ports and small series production types. In addition, the processing speed is far greater than the technology of machining, and quality is comparable to the laser cutting technology. Plasma cutting process may be used to cut any conductive material, including carbon steel, stainless steel, aluminum, copper, brass, cast metals and exotic alloys. Obtained experimental results are consistent with theoretical considerations, as well as previous experimental results. The best quality is obtained increasing the speed by 20% of tablet speed value, which indicates that in this are have a place for further research and improvements.

B.M. Colosimo et.al published that the HTPAC is a very promising thermal coating technology which combines high productivity with good cutting quality. However, this process is deeply influenced by several variables. The operating conditions have to be carefully optimized through parameter adjustment in order to obtain top quality results. In this paper, two sequential experimental designs were performed and analyzed in order to investigate the effect of the main process parameters on the output unevenness, in a real cutting application. The analysis confirmed that the HTPAC response is difficult to predict and has a complex behavior. It was found out that the arc voltage is the main parameter and it influences all the aspects related with the cut quality. Rather than the effect on the arc power, its proportionality with the standoff distance seems to be the true responsible for its importance. In fact, the bottom of the kerf, which has been identified as the critical zone, suffers from an excessive distance from the arc hottest part. On the other hand, 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 accelerate their wear. This tradeoff can be taken into account by adding some suitable constraints to the parameters domain. 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

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speed. However, care has to be taken in order to not exceed the limit of square edges and step into the zone of negative bevel cut.

III. CONCLUDING REMARKS

In this literature survey of PAC processes the effect of various cutting parameters is investigated. Following conclusions are found from the investigation.

1. The amount of material removed from cutting area is proportional to thickness. The cutting gap becomes small in thin material, bigger in thick material.
2. Cutting speed increase or decrease inversely proportional thickness of the plate.
3. An increase in the plasma gas flow rate can facilitate improvement of cut quality for all gases because it increases both energy and momentum density.
4. The surface roughness and the concerti are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current.

IV. ACKNOWLEDGEMENTS

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