International Journal of Advance Research in Engineering, Science & Technology(IJAREST),
ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2, Issue 6, June- 2015, Impact Factor: 2.125

# A Review on Plasma Arc Cutting (PAC)

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***Abstract***
*This paper describes a variety of fundamental research on plasma arc cutting (PAC) process parameters which the authors have recently performed. Plasma arc cutting process is the non-conventional thermal process which is applicable to perform various operations such as cutting, welding, coating etc. Plasma arc cutting is machining process where material is cut by plasma arc. In this review the research and progress in plasma arc cutting process parameters of different materials are critically reviewed from different perspectives. Some important plasma arc cutting processing parameters and their effects on MRR and surface roughness are discussed. This paper deals with the review of papers by authors.*

***Keywords:*** *Plasma Arc Cutting (PAC), Process Parameters, Optimization, Design of Experiment (DOE), ANOVA.*

## 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 include 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 gets 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 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.

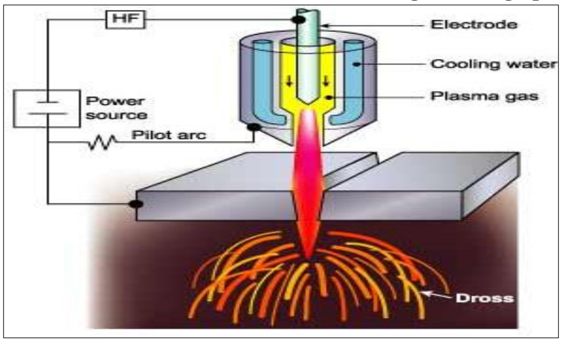


Fig.1: Schematic diagram of plasma arc cutting

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.

## II. LITERATURE REVIEW

**Milan kumar das and et all [1]** were conducted experiment on EN31 steel using process parameters like gas pressure, arc current and torch height to influence effect on material removal rate and roughness characteristics. They developed empirical graph of response surface methodology and finally they worked on chip morphology. They analyzed their experimental reading through ANOVA and grey relational analysis. They found that highly effective parameter is gas pressure, whereas arc current and torch height are less effective factors for the response.

**Abdulkadir Gullu and et all [2]** were experiment carried out on AISI 304 stainless steel and St 52 carbon steel have been cut by plasma arc and the variations of structural specifications occurred after cutting has been investigated. From the experiment they found that, it has been seen that burning of particulars and distribution amount were increased when the cutting was performed using the speeds which are upper or lower limits of the ideal cutting speeds proposed by the manufacturer of the machine tool. They had determined that the hardness from the outer surface to the core decreased, while the hardness near to the outer surface which affected by the high temperature occurred during cutting increased. Thus they revealed that 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.

**W.J.Xu and et all [3]** were conducted experiment on ceramic during plasma arc cutting. They measured cutting qualities by varying process parameter the flow rate of injected water and the magnetizing current using nozzles of different diameters. From the experiment they found that both water constriction and magnetic constriction of plasma arc forms a three dimensional constriction with improved shape and uniformity of the arc column and hydro magnetic constriction is capable of improving arc stability.

**E.Gariboldi and et all [4]** were conducted experiment to improve the quality of cuts performed on titanium sheets using high tolerance plasma arc cutting (HTPAC) process. They were investigated under different process conditions like using several feed rates in the dross-free feed rate range and with the adoption of oxygen or nitrogen as cutting and shielding gases. They found that when oxygen was used as cutting gas higher feed rate and geometry attributes (unevenness and kerf width) of better quality were achieved due to the oxidation reaction. The quality features of the cutting edge of HTPAC of commercially pure titanium were integrated with considerations on micro structural features related to the formation of a wide layer severely affected by plasma-induced thermal cycle and by interaction with the cutting gas. They showed that temperature measurements during the passage of the torch defined the thermal cycles of the cutting process in several locations of the sheet. These are characterized by high heating rates (above 2000 K/s within the HAZ) and low cooling rates (150–580 K/s within the HAZ). They were applied to simulate the thermal effects of the material interaction with the torch in the case of slow cuts with oxygen by analytical model. A comparison between predicted thermal cycles, experimental measurements and microstructural observations confirmed the reliability of the estimation in terms of extension of microstructural modifications.

**R.Bini and et all [5]** were conducted experiment on 15mm thick mild steel sheets metals using process parameters like arc voltage and cutting speed, plasma gas flow rate, shield gas flow rate and shield gas composition are to influence effect on kerf position and shape are evaluated. They revealed that 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 and et all [6]** 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 used12mm 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 these parameters, the analysis shows that Hardox-400 plates can have different profiles, depending on the specific side considered. They used expert 8.0.7.1 software in order to clearly identify the main parameters, which define the unevenness quality attribute. They found that very good quality can be achieved for all the sides by varying the cutting speed, plasma flow rate and arc voltage only and they optimized minimum unevenness for 12 mm Hardox plate is 421 micron at optimum value of 70L/Hr plasma flow rate, 125 V voltage and 2100 mm/min cutting speed.

**K. Salons and et all [7]** were concluded 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.

**T Kavka and et all [8]** were concluded that 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.

**Bogdan Nedic and et all [9]** 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 area has a place for further research and improvements.

**Miroslav Radovanovic and et all [10]** had done a modeling of the plasma arc cutting process using Arti_cial 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.

## III. CONCLUSION

Following conclusions are derived from above literature review.

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. 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.
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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