A Literature Review On Plasma Arc Welding And Cutting Processes

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Abstract- *Plasma arc welding is a non-conventional form of welding which can be applied to almost any existing metals. It is one of the important arc welding processes used in electronics, medical, automotive, ship building and aerospace industries due its high accuracy and ability of welding any hard and thin materials. The various process parameters in plasma arc welding such as plasma gas flow rate, torch height, front weld width, back weld width etc. Though PAW is more complex and requires more expensive equipment compared to other commercial arc welding processes. The plasma arc cutting process was developed for difficult to machine materials in order to overcome the inefficiency and ineffectiveness of conventional machining method when it come to complex shape and work piece. Plasma cutting is a process that cut through electrically conductive material by means of jet of hot plasma. This paper is literature review of various theoretical and experimental studies by different researchers over the years. A Section of the paper also deals with the detailed review of plasma arc welding and cutting processes based on existing literature content.*

Keywords- Plama arc welding, Plasma arc cutting, Keyhole, Welding current, Welding speed, Torch height, Plasma gas flow rate.

I. INTRODUCTION

Plasma arc welding:

Plasma arc welding (PAW) is an arc welding process in which coalescence of metals is produced by a constricted arc between a non-consumable electrode and the work piece (transferred arc mode) or between the electrode and the constricting nozzle (non transferred arc mode). Pressure is not applied, and filler metal may or may not be added. The arc is concentrated in a column of ionized plasma issuing from the torch. While the orifice gas (also known as plasma gas) provides some shielding, it is normally supplemented by a separate source of shielding gas. Shielding gas may be a single inert gas or a mixture of inert gases. Plasma arc welding is essentially an extension of gas tungsten arc welding (GTAW), but utilizes a slightly different mechanism to deliver the heat for welding. Like GTAW, plasma arc welding uses a non-consumable electrode; however, the plasma arc welding torch differs from the GTAW torch in that it has a nozzle that creates a gas chamber surrounding the electrode. The arc heats the orifice gas that is fed into the chamber to a temperature at which it becomes ionized and conducts electricity. This ionized gas is defined as plasma.

Plasma issues from the nozzle orifice at a temperature of about 16 700°C (30,000°F), creating a narrow, constricted arc pattern that provides excellent directional control and produces a very favorable depth-to-width weld profile. Plasma arc welding can be used to join most metals in all positions. While it has many similarities to gas tungsten arc welding, it has additional features that make it the process of choice for many industries. The automotive industry uses PAW for air-bag assemblies, exhaust systems, and torque converters. The aerospace community uses PAW for many airframe components, fuel-storage vessels, guidance systems and repair of gas turbine components. In the medical industry, catheters, batteries, surgical tools and other medical instruments are routinely fabricated by PAW. The electrical industry also uses PAW to great advantage to fabricate filaments and connections Because of the numerous similarities between plasma arc welding and gas tungsten arc welding , an understanding of the GTAW process is helpful in appreciating the many comparisons of the two processes made in this. More detailed information is provided in this on the areas in which plasma arc welding differs from gas tungsten arc welding. Also discussed in this are plasma arc welding equipment and materials, process variations, applications, procedures, techniques, and weld quality.

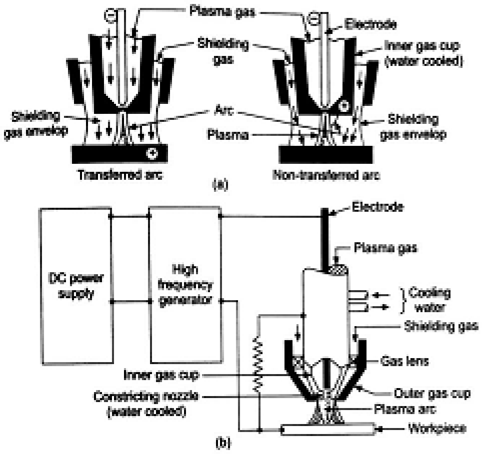

Figure1 (a) Principle of PAW using Transferred arc and Non-Transferred arc (b) PAW setup

Process variations:

Plasma arc welding can be performed in all positions with limitations similar to those of gas tungsten arc welding. Through its several variations-high-current and low-current melt-in modes, the keyhole mode, hotwire welding, variable polarity plasma arc welding, and surfacing-the process offers fabrication flexibility and economy while maintaining weld joint quality and reliability. All metals weldable with the gas tungsten arc welding process can be satisfactorily welded with the plasma arc process; therefore, few exceptions are required in the establishment of weldment acceptance specifications.

Melt-in welding:

Mechanized melt-in plasma arc welding is very popular, especially for welding the small, intricate components of medical equipment, lighting instruments, batteries, wires, and bellows. It is also commonly used for applications in which the greater energy concentration improves overall weld quality. The plasma arc melt-in mode is often the preferred method for welding in components when the initial energy burst of arc initiation in gas tungsten arc welding would tend to melt through or vaporize these thin sections. In many applications, microprocessor controls are used to regulate, via feedback loops, parameters such as initial current, upslope, pulsation, downslope, and final current.

High-Current Mode:

Welding procedure specifications for high-current welding in the range of 50 A to 500 A often use the melt-in mode, which produces a weld similar to that obtained with conventional gas tungsten arc welding. The melt-in mode is generally preferred over the gas tungsten arc process in mechanized applications for consistent control of weld quality. Again, due to arc stability and stiffness, arc penetration into the weld joint is more controlled and welding time is reduced. The high-current melt-in mode of the plasma arc welding process is widely used for welding and cladding operations in pipe and tube mills, as well as in the aerospace and nuclear industries. The welding of cover passes on keyhole welds is also an important application.

Low-Current (Microplasma) Mode:

The low-current melt-in mode of plasma arc welding is typically called microplasma. While there is no firm differentiation of high or low current values, users typically consider microplasma as operating in the range of 0.1 A to 20 A, using precise current control. Modern inverter power sources provide a very stable and controllable arc at low currents for welding thin materials. A pilot arc provides a reliable means of transferred arc initiation at these low current levels. The columnar arc produces uniform bead contours in edge joints with manual and automated welding. Applications include the welding of turbine blades,

Gas turbine rotor seal teeth edges, bellows, pacemakers, diaphragms, electronic components, and many of the fabrications using thin material. Plasma arc welding is often the economical choice over laser welding for these applications because initial equipment costs and operating costs are lower. The low-current mode is also a superior substitute for many applications that previously required brazing.

Keyhole welding:

In the plasma arc keyhole welding mode, the orifice gas flow rate is gradually increased after the weld pool is established to displace the molten metal and form a hole (the keyhole). The hole fully penetrates the base metal. As the plasma arc torch moves along the weld joint, metal flows from the leading edge of the keyhole, around the plasma stream, and to the rear where the weld pool progressively solidifies. Appropriate combinations of plasma gas flow rate, arc current, and weld travel speed must be coordinated to produce the keyhole.. The principal advantages of keyhole welding are that it makes very high quality, complete-penetration welds on most thicknesses in a single pass, and normally does not require the beveling of the plate edges before welding. Plasma arc keyhole welding is generally performed in the flat position on material thicknesses ranging from 1.6 mm to 9.5 mm (1/16 in. To 3/8 in.).

However, with appropriate welding conditions, keyhole welding can be done in any position and on some metal thicknesses up to 19 mm (3/4 in.). The open keyhole provides an escape path through its liquid edges for impurities to flow to the surface and gases to be expelled before solidification of the weld pool. The maximum volume of the weld pool and the resulting underbead root surface profile are largely determined by the force balance between the welding position, surface tension of the molten weld metal, the plasma arc current, and the velocity of the ionized gas exiting the orifice.

The high-current keyhole welding technique operates just below conditions that would actually cut and expel metal rather than weld. For cutting, a slightly higher orifice gas velocity blows the molten metal away.

In welding, a lower gas velocity allows surface tension to hold the molten metal in the joint. Consequently, orifice gas flow rates for keyhole welding are critical and must be closely controlled. Orifice gas flow of less than 0.62 W/min (1.3 ft3/h) is normally recommended, depending on the size of the orifice in the constricting nozzle. Plasma arc keyhole welding is best when performed in an automated mode because of the requirement for the accurate control of travel speed, plasma gas flow, and wire feed speed. The continuing development of more accurate and reliable mass-flow controllers continues to provide improvements to the precise control of the plasma gas during welding that is critical to successful keyhole welding.

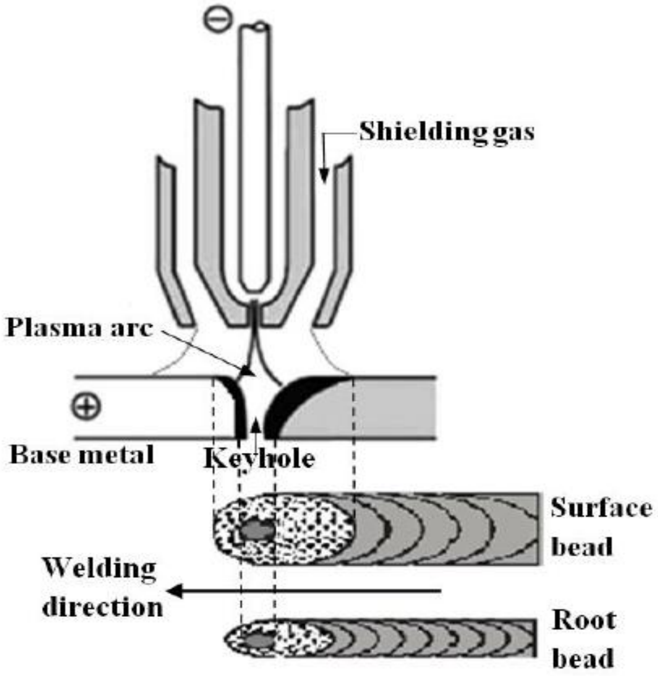

Figure 1.c.Keyhole welding

Advantages of PAW

- Power consumption is low
- Welding speed is high, so it can simply utilize to join thick and hard work pieces.
- Penetration rate and strong arc are high.
- It can function at little amperage.
- The arc arrangement doesn’t affect by the distance among tool as well as the workpiece.
- By using this method, the more steady arc can be produced.

Disadvantages of PAW

- The process is noisy.
- Equipment cost is high.
- High expertise labor required.
- Radiation is more.

Applications of PAW

- PAW can be used in industries like aerospace as well as marine
- PAW is used to join stainless tubes and pipes
- This type of welding is mostly applicable for electronic industries.
- PAW is mainly used to fix tools, mold and die.
- PAW is used to coating otherwise welding on the turbine blade.

Plasma arc cutting:

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 aluminium but today it is used to cut a variety of materials such as Stainless steel, manganese steel, titanium alloys, copper, magnesium, aluminium and its alloys and cast iron including non- alloy and low alloy steels due to its narrow heat affected zone and high cutting speed.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.

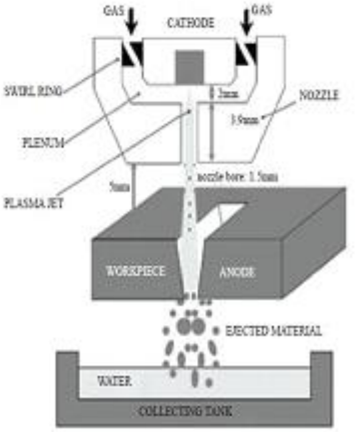

Figure 2 the principle of the plasma cutting

Process variations:

The major difference between a conventional PAC process, which utilizes the basic system components described earlier, and other process variations is that the conventional PAC torch uses only a single gas, and the orifice in its tip represents the only gas exit. Because these torches do not incorporate any secondary gas, they must be liquid cooled.

Gas-shielded plasma arc cutting:

It utilizes the traditional plasma gases plus a secondary gas that forms a shield around the plasma arc. The torch design provides special passages for this secondary gas. The functions of the secondary gas are to:

- Assist the plasma in blowing away molten metal
- enable faster and cleaner cuts
- provide better cooling of the torch front end
- reduce accumulation of metal spatter on the torch
- reduce top-edge rounding of the work piece
- permit easier piercing
- minimize double arcing

In gas-cooled, rather than liquid-cooled, torches, it is the secondary gas that provides the cooling action. The choice of secondary gas can also affect cut quality, cutting speed, and the amount of smoke and fumes produced during the PAC process.

Water-shielded plasma arc cutting:

It is a variation of the gas-shielded process that is only used in mechanized applications. The water, which can be provided from standard plant water systems at a rate of 0.63 to 0.95 L/min (10 to 15 gal/h), is substituted for the secondary gas in torches designed for this type of operation. Using a water shield, rather than a gas shield, is less expensive, because water is virtually free. It also results in reduced top-edge rounding, a reduced amount of smoke and fumes, and a clean, shiny, cut surface.

Water-injection plasma arc cutting:

It is similar to the water-shielded process, except that the water is forced into the plasma stream, at approximately 1.26 L/min (20 gal/h), just after the arc exits the tip orifice and just before it leaves the ceramic piece on the front end of the torch. The impinging water increases the constriction and density of the plasma arc, resulting in improved cut squareness and increased cutting speed. Because of the entry of water at the tip orifice in a water-injection torch, the quality of water is more critical than that used in water-shielded cutting. A plant water system that has high levels of dissolved minerals may require water softeners in conjunction with the system in order to avoid rapid deterioration of part lifetimes. Water-injection cutting is only used in mechanized setups.

Advantages of PAC:

- Small risk of changing the shape of the metal (called distortion)
- Precise cutting
- Slag-free cuts when working with aluminum, stainless steel and carbon steel
- Works in all positions
- Fast process
- Works across many types of metals

Disadvantages of PAC:

- Creates a small bevel (7 degrees – approximate)
- Electrical shock risk when not operating safely
- Requires a clean air source – some now come compressors built in
- Needs electricity to operate so not completely portable
- Not cost-effective for very thick steel

Applications of PAC:

Plasma arc cutting can be used to cut any metal. Most applications are for:

- carbon steel
- aluminum
- stainless steel

It can be used for stack cutting, plate beveling, shape cutting, and piercing.

II. LITERATURE REVIEW

K.Tsuchiya et.all [1] carried out preliminary research for further development of some plasma arc welding methods for thick plate above 10mm.Large plasma torch and the control equipment designed to be proof against up to 1000A with straight polarity connection have been fabricated. In plasma arc welding of 16mm thick mild steel plates, weld beads were produced as burn through or incomplete penetration beads. When the plates were backed up with copper plates, unstable plasma arc and sometimes series arcing occurred and resulted in a defective bead.

Kunio Narita [2] investigated the effect of different welding parameters of plasma arc welding process on the shape of welds and consistency of defects in the flat, vertical and overhead positions of mild steel pipes of thickness 6.4mm and outer diameter 406.4mm.

Bharathi et.all [3] explains that Plasma Arc Welding (PAW) is an ancient art dating back to the Bronze Age. The paper states that PAW produces a stable, inherently strong joint that cannot be matched by other welding methods. The PAW process is quite similar to the Tungsten Inert Gas (TIG) welding process, but PAW has a number of critical advantages over TIG welding. In PAW, the arc is constricted by a cooled gas nozzle.. In turn, increases the welding speed by around 20% in soft-plasma welding. PAW also saves time and costs at the same time as ensuring deeper penetration. The tungsten electrode has a much longer service life because it is enveloped in the protective plasma gas

G Shanmugavelayutham et.all [4] evaluated the electro thermal efficiency of a DC arc plasma torch and temperature and thermal conductivity of plasma jet in the torch. The effect of nitrogen in combination with argon as plasma gas on the above properties were investigated

G. Ravichandran [5] carried out thermal analysis of molten pool formation and solidification for keyhole welding using Plasma Arc Welding has been done using Finite Element Method.

Yaowen Wang et.all [6] addressed the problems involved in the automatic monitoring of the weld quality produced by plasma arc keyhole welding. The acoustic signal of plasma arc welding was acquired by using a condenser microphone at high speed and analyzed with the aid of computers. It is shown that the overall AC power of the acoustic analysis, especially the low frequency part (0±100 Hz) of the acoustic signal power spectra, greatly varies with the variation of status of the weld pool.

Y. F. Hsiao et.all [7] studied the optimal parameters process of plasma arc welding (PAW) by the Taguchi method with Grey relational analysis was studied. SUS316 stainless steel plate of thickness 4mm and the test piece of 250mm x 220mm without groove was used for welding. Torch stand-off, welding current, welding speed, and plasma gas flow rate (Argon) were chosen as input variables and Welding groove root penetration, Welding groove width, Front-side undercut were measured as output parameters.

Jukka Martihainen [8] investigated the possibilities and the technological conditions for welding structural steels, especially high strength steels, reproducibly and with high quality. The investigation comprises butt welding with an I-groove in the flat, horizontal – vertical and vertical positions and root welding of thick plates in the flat position. It was shown that mechanized plasma keyhole welding is a very useful method for structural steels.

A. Dudek et.all [9] proposed a research method for diagnostics and determination of temperature and shape of plasma arc used for surface treatment of 40Cr4 steel with TiO2 coating. The surface of samples, previously coated with ceramic coating was re-melted with plasma arc. For investigations of arc shape the high-resolution modern visible light camera and thermo vision camera was used. The temperature distribution in plasma arc with percentage quantity of temperature fields was determined. The arc limiting profiles with isotherms was also determined.

Y. M. Zhang et.all [10] monitored the keyhole and the weld pools simultaneously from the back side of the workpiece. Bead-on-plate and butt-joint welds were made on 3 mm thick stainless steel (304) plates in the flat position. It was found that once the keyhole is established, the width of the keyhole does not change with an increasing welding current and a decreasing welding speed.

Milan kumar das et.all [11] 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 et.all [12] 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 et.all [13] 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 et.all [14] 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 micro structural observations confirmed the reliability of the estimation in terms of extension of micro structural modifications.

R.Bini et.all [15] 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.

Subbarao Chamarthi et.all [16] 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 et.all [17] 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 et.all [18] 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 et.all [19] 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 et.all [20] had done a modelling 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.

Kimiyuki Nishiguchi et.all [21] investigated factors which predominate series arcing in plasma arc welding. The results reveals that when the nozzle end of the plasma torch is covered with oxide film , the cathodes spot of series arc is easily formed with the help of oxide film, resulting in the great reduction of the current capacity

Michalec et.all [22] conducted a comparative study of PAW and laser Beam Welding (LBW) of steel sheets after nitro-oxidation. Steel sheets treated by nitro-oxidation in comparison to material without surface treatment possess increased mechanical properties and enhanced corrosion resistance. The study was conducted to find ways to reduce the high initial costs of LBW and to find an adequate counterpart from the arc welding sphere. The visual inspection of the joints welded by PAW revealed a significant presence of undercuts, whereas the macroscopic analysis confirmed the absence of porosity in the weld joint. But the tensile tests proved that PAW joints had great mechanical properties .The LBW joints had more consistent micro-hardness trend along the measured length, whereas the PAW joints exhibited a continuous decrease of the micro-hardness towards the base material. The macroscopic analysis proved a three-times-wider HAZ in PAW joints. This was caused by the higher thermal density of the laser beam distributed into the narrower surface in comparison to plasma arc welding.

Kaushish et.all [23] gives the following as the working principle for the basic conventional form of Plasma Arc Welding (PAW): In PAW a DC power source having voltage about 70V is used. The workpiece and the nozzle are connected to the positive terminal and the tungsten electrode is connected to the negative terminal, a non-consumable tungsten electrode is used to initiate an arc between itself and the work piece. This arc is called transferred arc. Or it forms an arc is formed between the electrode and the water-cooled nozzle .In PAW coalescence is produced by the heat obtained from a constricted arc set-up between tungsten electrode and the workpiece giving temperatures between 8000 to 25,000° C. The temperature depends on the plasma used. Such high temperatures are attained by forcing the arc through water-cooled nozzle. This reduces the arc diameter, which in turn increases the current density. This finally results in the increase in pressure, temperature and heat intensity of the arc. Argon is the most commonly used plasma gas and shielding gas. Helium or a mixture of argon and helium is also used .

Choon man lee et.all [24], The study carried out the machining characteristic using Non transferred type Plasma arc cutting machine of AISI 1045 steel and Inconel 718 and conclude that the torch approached the vertical the preheating temperature also increased and angle of torch was 71^0 proper preheating was obtained for AISI steel with Plasma arc cutting machine Cutting force decreased by up to 61% and 51% in comparison with Conventional machine and Laser assisted machine also Surface roughness improved up to 79% and 5% in comparison CM and LAM as the spindle rotation increase the cutting force reduce and surface roughness increase. For Inconel 718 with PAM the cutting force decreased 57% and surface roughness improved up to 82% Compare CM and Compare to LAM the cutting force increased up to 9% and surface roughness increased up to 4% and concluded that Plasma assisted machine can be more efficient Thermal assisted machining method.

Balaganesh et.all [25] investigated the effect speed, current, arc height, pressure of Plasma Arc Cutting (PAC) on E250 Mild Steel Material by using Taguchi design methods and ANOVA analysis for Machining time, Hardness and Surface roughness. They found that by selecting the proper process parameters one can achieve proper cutting quality, hardness will be better for maximum pressure and arc height, medium current and speed, roughness will be better for maximum pressure and arc height, medium current and speed, machining time will be better for maximum pressure, current and arc height, medium speed.

III. CONCLUSION

This paper reviews the process of Plasma Arc Welding and plasma arc cutting are as follows, Continuous and extensive experimental studies are going on the field of PAW, in order to optimize the process to extend the range of materials it can weld. PAW has been adopted in the field of aviation and electronics due to its easy setup and comparatively cheaper setup costs to LBW and Electron Beam Welding. The keyhole mode of PAW is widely used in industries due the deep penetration characteristics and also the ability to impart superior quality to the weld joint than the base metal. The Various Process parameters are being constantly studied on, to improve the characteristics of the process. The literature review points that most of the studies done by researchers in the field plasma arc welding the materials on which the studies were conducted were mostly steel, aluminium and tungsten alloys. The various process parameters that were investigated upon included weld width, heat affected zone, Plasma gas flow rate, Shield Gas flow rate, Arc and melting efficiencies, torch height, Welding voltage and current.

- In most of the works welding current, arc voltage, Welding speed, magnitude of ionic gas, torch stand of are considered for predicting and optimizing the Weld bead geometry. However certain other factors Like peak current, background current, pulse, pulse Width, purging gas magnitude are not concentrated Much especially while welding thin sheets using Micro Plasma Arc Welding.
- From the literature review it was understood that many works were carried out on Stainless Steels, Aluminum, Nickel based alloys, Titanium etc. On can try for welding dissimilar materials and new Materials using Plasma Arc Welding and associated Phenomena. Also one can try for grain refinement Techniques such as pulsed current welding, magnetic Arc oscillation etc to obtain better weld quality Characteristics.

Following conclusions for PAC are derived from above literature review.

- 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.
- 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.
- 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 decrease and

cutting speed should be increase for better surface roughness.

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