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Optimizing Plasma Cutting Parameters for Thin Mild Steel Sheets of Various Thicknesses

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Abstract

Plasma machining was investigated for suitability to cut thin sheets and the quality obtained was assessed. The main objective of this investigation is to machine or cut the required mild steel sheet thicknesses and to determine the surface roughness and material removal rate (MRR) values. Traditional cutting techniques have been discovered to be costly in terms of both time and resources. This study may be valuable to car converters, such as firms that make wheelchair-accessible automobiles or other analogous companies where the use of traditional cutting technologies is still common. In turn, a robotic plasma cutter would be a practical solution. In this experiment, mild steel with a thickness range of 3 mm to 5 mm and materials of different compositions were cut using a plasma cutter with a controlled torch height correction. Tests were carried out by varying the plasma parameters like cutting speed, pressure, and intensity.

Keywords: Plasma cutting machine, cutting speed, MRR, material, mild steel

INTRODUCTION

Materials with a substantial amount of hardness and hardness or materials that prove difficult to machine using a traditional machining method. If the part being cut is too flexible or thin can withstand the cutting pressures or if the design of the component is excessively intricate Arc Cut-Away in the PAC (Plasma Arc Cutting) A section or space surrounds the electrode's circumference in the electron arc torch, between the inside radius of the torch tip or nozzle. The heating and disintegration of the plasma gas take place in this chamber. The plasma gas's pressure and volume both significantly increase as the outcome of this heating. Up to 30,000 degrees Fahrenheit (16,000 degrees Celsius) and 6000 meters per second (20,000 feet per second), the plasma gas enters the torch's nozzle or tip at extreme speeds and heat. Arc Cut-Away PAC The area between the circumference of the torch tip or nozzle and the outer diameter of the electrode are separated by a space or region in the plasma arc torch. The plasma vapor is heated and ionized in this chamber. Plasma gas dramatically rises in volume and pressure because of this scorching. Up to 30,000 degrees Fahrenheit (16,000 degrees Celsius) and 6000 m/s (20,000 ft/s), plasma gas comes out from the constricted orifice of the torch’s nozzle or tip at extremely fast speeds and temperatures. However, the suitability of plasma to process thin sheets without altering the material was a concern. The conventional material thickness used when cutting with plasma is medium or thick range. The technique is cost-effective and obtains good quality results when used for thicknesses in the range between 5 and 40 mm [1–5].

Yet an essential issue when using this procedure to cut thin material was surface deformation as the

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outcome of the material's heat transport rate. Therefore, an optimal setting was essential to lessen this problem. Manufacturers do not usually offer the optimal settings needed to get the optimum quality; therefore, analysis and research are often needed. According to several examinations, due to quality concerns, plasma was deemed undesirable for any thickness under 1 mm. Therefore, research into this issue was required to evaluate the technique for handling thin materials under 1 mm and supplanting mechanical tools. This work aimed to show that plasma machining can be used to cut well thin materials under 5 mm (in this example, 3 mm) with no alteration to the surface in addition to looking for ways to maximize the process to reduce the phenomena to their lower level. Automating processing of the underbody vehicle using plasma would be more efficient and rapid than using mechanical tools, so would solve all the issues [6].

PLASMA CUTTING

Electrically conductive components are cut using the procedure known as plasma cutting or plasma arc cutting process, which utilizes a hot plasma jet. Plasma refers to a collection of charged particles that, being concentrated into a jet of ionized gas, can create temperatures above 1000°C necessary to melt the material and run the cutting action. The plasma gets produced during the plasma cutting process through a tiny opening and increases the velocity so it can generate a jet and cut through the metallic substances under concern. Carbon steel, aluminum, stainless steel, copper, brass, Monel, cast iron, titanium, etc. are some of the materials that are frequently cut using the plasma cutting technique [7]. Automotive repair and remediation, industrial construction, fabrication businesses, and salvage and scrapping businesses commonly employ plasma cutting. Plasma cutting has many uses throughout the world because of its highly precise cutting capability and rapid rapidity. The PAC process uses this high-temperature, constricted, high-velocity jet of ionized gas exiting from the constricting orifice of the torch tip to melt a much-localized area and remove the molten material from the metal being cut by the force of the plasma jet. The force of the arc pushes the molten metal through the workpiece and serves the material. PAC offers extremely precise and clean cuts. Furthermore, when cutting thin gauge sheet metal depth, there is relatively restricted warping because of the heat energy's sharp focus [8].

PRINCIPLE OF CNC (COMPUTER NUMERICAL CONTROL) PLASMA ARC CUTTING

This process uses a concentrated electrical arc that melts the material through a high-temperature plasma beam. All conductive materials can be cut. For cutting inert gas plates with depths ranging from 3 to 160 mm, plasma cutting electronics with cutting currents of 20 to 1000 amperes serve the purpose. For piercing light and high alloy steels, copper, magnesium, aluminum, and other metals and alloys, plasma gases included compressed air, oxygen, carbon dioxide, or argon/hydrogen [9].

The plasma arc process has always been seen as an alternative to the oxy-fuel process. In this part of the series, the process fundamentals are described with emphasis being placed on the operating features and the advantages of the many process variants.

A water-cooled nozzle precisely confines the plasma. Densities of energy can be up to 2 × 106 w/cm with this.

It is feasible to get inside the charged particle beam. It expands at elevated temperatures and hurries at supersonic speed to work on the object (anode). According to the plasma beam's enormous kinetic energy and the ability to cut any electrically conducting substance at very rapid cutting speeds dependent on the substrate's thickness, temperatures inside the plasma arch are as high as 30,000°F.

The stability of the arc is another designation for the ideal state of a plasma arc. The arc's stability maintains the plasma jet's supposed shape. It might be produced by one of the following: a) a plasma torch; b) a streaming jet; or c) water.

Temperature, electrical conductivity, plasma jet density, plasma beam diameter, and plasma beam focusing on nozzle output are all variables that need to be monitored.

Prior to beginning the blade-cutting operation, a pilot arc is started by high voltage over the cathode and nozzle. By substantially ionizing the space between the radiant torch and the workpiece, this low-energy pilot arc is prepared. The main arc will start functioning by autonomously increasing power when the pilot arc strikes the workpiece The basic principle is that the arc formed between the electrode and the workpiece is constricted by a fine bore, copper nozzle. This increases the temperature and velocity of the plasma emanating from the nozzle. The temperature of the plasma is more than 20,000°C and the velocity can approach the speed of sound. When used for cutting, the plasma gas flow is increased so that the deeply penetrating plasma jet cuts through the material, and molten material is removed from the efflux plasma.

Contrasting to the oxy-fuel process, which utilizes heat from an exothermic reaction to melt metal, the plasma furnace process uses an arc to melt metal. This is when the two processes vary from their counterparts. As a result, unlike the oxy-fuel process, the plasma approach can be used to cut metals that create refractory oxides, such as stainless steel, aluminum, cast iron, and non-ferrous alloys [10].

The power source needed for the plasma arc process needs to be high voltage and have a drooping characteristic. The open circuit voltage required to start the arc can be as high as 400V DC, even though the operating voltage to maintain the plasma is normally between 100 and 160V. The pilot arc is initially created between the electrode and the nozzle inside the torch's body. For cutting, the arc must be transferred to the workpiece in the so-called 'transferred' arc mode. The electrode has a negative polarity and the workpiece has a positive polarity so that most of the arc energy (approximately two-thirds) is used for cutting.

Plasma is inert and can be produced using either argon, argon-H_2, or nitrogen in the traditional technique utilizing a tungsten electrode. However, oxidizing gases such as air or oxygen can be applied, as described in process variations, but the electrode being utilized must be copper with hafnium. The nozzle bore diameter and current level must be considered while adjusting the plasma gas flow, and both are crucial. The arc will burst and split into two arcs in series, electrode to nozzle and nozzle to the workpiece, if the gas flow is too low for what is currently present, or the current level is too high for the nozzle bore dimension.

'Double arcing' typically has disastrous results, melting the nozzle. The plasma cut-edge quality feels like that attained using the oxy-fuel technique. The larger rate of melting toward the top of the metal, which results in top edge rounding, poor edge squareness, or a bevel on the cut edge, is an unusual feature of the plasma process, which cuts by melting. These restrictions depend on how tightly the arc has been limited, so several torch designs are available to improve arc constriction to produce more uniform heating at the top and bottom of the cut.

The main goals of the process improvements were to increase cutting speed, decrease noise and fumes, and improve cut quality and arc stability. A specific electrode made of hafnium or zirconium placed in a copper holder by shearing is needed to replace the inert or uninspiring plasma-forming gas (argon or nitrogen) with air. Air can also be used to cool the flame over water. The fact that an air electric torch uses air rather than pricey gases is a benefit. It should be noted that even though the only consumables are the electrode and nozzle, hafnium-tipped electrodes may prove more expensive than tungsten conductors.

This relatively new process differs from conventional, dry plasma cutting in that water is injected around the arc. The net result is greatly improved cut quality on virtually all metals, including mild steel. Currently, unheard-of applications, including cutting mild steel with several torches, are becoming normal thanks to developments in equipment design quality cut quality.

ADVANTAGES

Plasma cutting is exceptionally flexible. The cutter device can be made smaller so that it can be easily transported around between job sites as a handheld instrument. Also, new staff can pick up using a plasma chopping torch rapidly.

DISADVANTAGES

normally limited to a 50 mm (air-plasma) plate; noise when cutting thick portions; fume when sawing in the air; arc glare when cutting in the air; and costs associated with commodities (electrode and nozzle).

CNC PLASMA CUTTING MACHINE

A CNC plasma cutter is a machine that is specifically designed to cut through electrically conductive materials by using a computer to control and direct an accelerated jet of hot plasma at the material being cut. Steel, aluminum, brass, and copper are somewhat just a few of the materials that the CNC plasma cutters can cut through. They can also be used in many kinds of different industries, including fabrication and welding shops, auto repair and restoration places of confinement, industrial construction sites, and salvage operation destinations.

WORKING OF CNC PLASMA CUTTING MACHINE

Thermal cutting is an instrument used in the plasma cutting process. This implies that compared to manually cutting the metal, it melts it using heat. The system's primary workings remain constant. Gases like nitrogen or compressed air serve a purpose in plasma cutters. Plasma can be generated by the ionization of these gases. In general, when compressed gases contact an electrode, they ionize and increase pressure. Plasma is forced toward the cutting tool as the pressure increases. A stream of plasma is produced by the cutting tip's confinement of the flow. The workpiece is then exposed to this. Due to the conductive properties of plasma, the workpiece is electrically connected to the support structure via the cutting table. As the plasma arc contacts the metal, its high temperature melts it. At the same time, the high-speed gases blow away the molten metal (Figures 1 to 8).

Figure 1. Plasma machining.

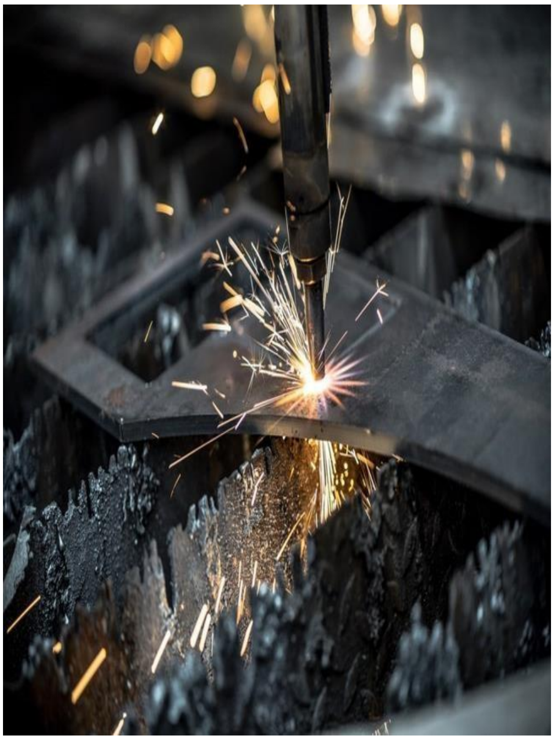

Figure 2. Working principle of plasma machining

Figure 3. Before machining.

Figure 4. After machining.

Figure 5. Machining of mild steel.

Figure 6. Testing of machined specimens.

Figure 7. Surface roughness testing.

Figure 8. Results of surface roughness.

CONCLUSION

- These words give an experimental investigation on the effect of cutting speed, gas pressure, and intensity of plasma machined mild steel grade of like MS E250 and MSE350.
- Material removal rate (MRR) and surface roughness (Ra) can both be improved in the plasma beam machining process utilizing the input parameters, it has been established.
- The study of mild steel panels of two unique grades and varied layers of 3 to 8 mm is evaluated by modifying the values of the parameters that are input.
- Surface Roughness Ra = 0.587 for 3 mm has been chosen to be the ideal combination. 80 Amps 3 mm diameter for 150 mm pitch face at 100% common-mode rejection ratio (CMRR) = 20.526283.
- In comparison to other cutting processes, the PAC process yields fast cutting speeds with reasonable accuracy and surface quality.

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