Research Paper Engineering

Effect of Plasma Arc Cutting Speed-voltage On the Unevenness of Hardox-400 Material

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ABSTRACT

plasma arc cutting (PAC) is a thermal cutting process that makes use of a constricted jet of high-temperature plasma gas to melt and separate(cut) metal, In this study, 12mm and 16mm plate thickness Hardox-400 has been cut by high tolerance. Arc voltage and cutting speed, plasma gas flow rate are included as main parameters in the analysis and their effect on unevenness of cut surface is evaluated. plasma arc cutting machine and the unevenness of cutting has been investigated. According to the experimental results, it has been seen that burning of particulars and distribution amount were increased when the cutting was performed measured the speeds. Moreover, it has been noticed that the change the speed which affects the cutting width of plate also changes the unevenness of plate with cutting speed. In this study is that quality of the cut can be improved by means of a proper selection of cutting speed.

Keywords : Plasma arc cutting, Unevenness, Hardox-400

1. Introduction

Plasma arc cutting is arc cutting process which cut the metal by melting localized area with constricted arc and removing molten material with high velocity and hot ionized gas called plasma jet. Plasma cutting system is most economical and cut a verity of shape accurately. This is new technology is commonly called high tolerance plasma arc cutting system. HTPAC system share the key ability of generating very constricted and arcs, in other words high energy density along the torch axis which produces narrow and nearly square kerfs. The challenge of today research in HTPAC is to increase the energy density generated by the system to achieve higher cutting thickness without losing the overall quality of cut. Steel typically used for the construction of paver's vehicles and in carpentry, thanks to its excellent quality in welding. Different options exist to profile a sheet or a plate; laser, plasma, oxy-fuel, water-jet and mechanical profiling are those most frequently used. Limiting our attention to railway constructions and railway trucks in particular, they are typically welded structures built by starting from plates with a thickness in the range of 6 to12 mm. Plasma cutting in this case is cheaper and faster than laser or water jet cutting, and it provides better edge finish than oxy fuel.

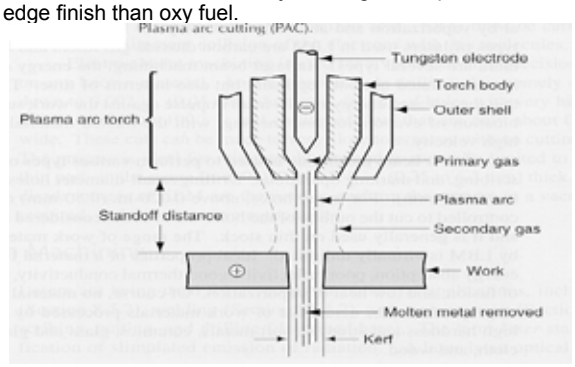


Figure.1 Schematic Diagram of plasma arc cutting

2. Experimental

2.1 Base Material:

Hardox-400 in standard plate supply has a ferrite structure; the chemical composition of this material is given in Table-1.specimens, 50 mm wide, were machined from plates with thickness of 12 mm; and 16mm plates of this thickness are typically used in the construction of pavers & plants. The external surfaces of the specimens were not machined, so as to maintain, as in real constructions, the "as-received" condition of the plates.

2.2 Plasma Cut Specimens.

A group of specimens was obtained by cutting them with a numerically controlled plasma-cutting machine. The torch was water-cooled and had a nozzle with an outlet diameter of 2.5mm the plasma gas was oxygen, 0.05m3/s, at a pressure of 10.bar.a current setting of 130 amps at 135volts was used. The distance between the torch and the plate was 3.3 mm; the cutting speed was varies given in table. The plasma cut specimens was also obtained in the longitudinal direction of the plates. The plasma cut surfaces did not look as regular as the milled surfaces. The plasma cut edges were not straight and the width of the plate on the reverse side was about 0.8 mm smaller than that on the torch side, 50.05 mm, while the nominal dimension was 50 mm. These differences are generally meaningless in large structures, but can be important in small structures, so that it can be concluded that close tolerances cannot be obtained by standard plasma cutting. Besides, small scratches were present on the cut surfaces. The loads to be applied in the tests on Plasma cut specimens were evaluated by taking into account their actual dimensions.

2.3 Setting and measurement procedure

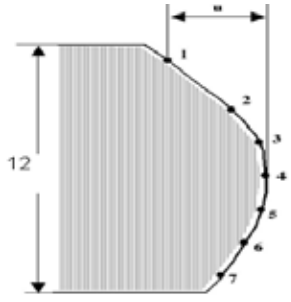


Fig.2 Unevenness measurement profile

The unevenness is measured by using Plunger dial Depth meter which is Mittu Toyo Company and have Range and accuracy are 0-30 mm and 0.01mm respectively. The unevenness is average measured all four side.

$$M=\frac{\sum_{i=4}^{4} mI}{4}$$

M = Mean unevenness

m = unevenness of one side

I =side of plate

On each side of the plate, three profiles were inspected. The location of these points was selected according to the ISO 9013 standard. The middle profile was positioned at the centre of the side and the other two 15 mm apart from it. For each profile the unevenness value was calculated as the maximum difference between the horizontal coordinates of seven measured points Figure 3. is cutting by plasma gas cutting machine 50X50 cutting plate of hardox-400 material

Figure 3 cutting plate of hardox-400 material.

Table -1: Chemical composition of Hardox -400 Material

Hardox-400							
C	Si	Mn	P	S	Cr	Mo	B
0.13	0.53	1.24	0.012	0.002	0.65	0.019	0.002

Above table shows that cr percentage is increases in hardox-400 material in compare of mild steel. So hardox-400 material become hard compare of mild steel.

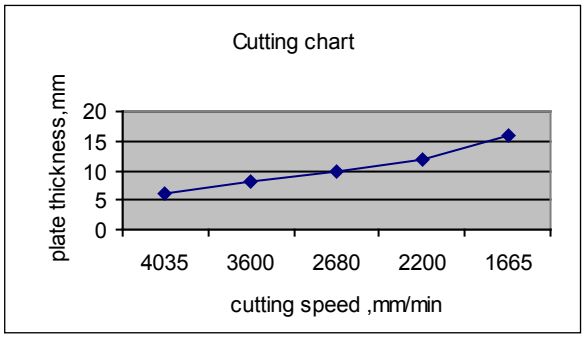


Fig-4: Cutting speed Vs Plate thickness of hardox - 400 materials

Cutting speeds to be selected according to the thickness of material suggested by machine tool manufacturing company, the tip diameter of the head to be used, blowing rate of cutting gas voltage and ampere amount necessary for the machine tool are listed in fig-2 According to the cutting speed entered the machine tool during cutting the program written in the machine tool memory and feed rate appeared automatically. Above fig.2 shows that plate thickness increase inversely proportional to cutting speed

Table -2: Unevenness of 12 mm Thickness plate measurements

Material thickness (mm)	Stand off distance	Plasma gas	Air pressure	Shielded gas pressure	Arc voltage (V)	Arc ampere (A)	Unevenness Micron	Cutting speed (mm/min)
12	3.3	O2	8.5	10	130	133	525	2300
12	3.3	O2	8.5	10	130	133	492	2200
12	3.3	O2	8.5	10	130	134	479	2100
12	3.3	O2	8.5	10	130	134	468	2000
12	3.3	O2	8.5	10	130	138	443	1900

The high tolerance plasma arc cutting system used during the experimental study consists of a plasma torch installed on a CNC flexible automatic machining centre for sheet metal processing. With this system, all the processing can be mounted on to a Y-axis, worktable moves perpendicularly (x-axis) during processing. The axis which controls the plasma torch standoff (z-axis) is servo assisted to provide a constant arc length. All the process parameters can be directly set through the CNC interface. In this experiment 50mmX50mm square plates were cut with 3.3mm, air pressure taken as 8.5 kg/cm2, 133A, on 12 mm plate thickness, The cutting speed 2200 mm/min is machined tool manufacturing company in this experiment variance of cutting speed 10% above and below. Below fig-4 shows unevenness decrease with cutting speed decrease but at this speed some dross are produced at this speed. Also compare with mild steel 15 mm plate thickness which indicate reduce speed with unevenness decrease.

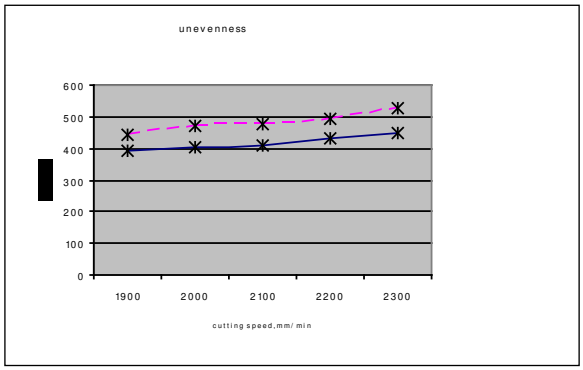
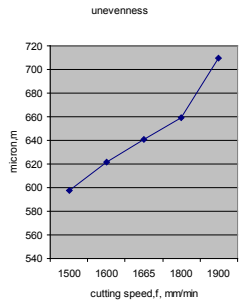


Fig-5: Cutting speed Vs unevenness of 12mm plate thickness

_ _ _ Line shows 12mm plate thickness hardox-400 material
_____ Line Value Taken from Ref. [5] 15 mm plate thickness mild steel material

Table- 3: Unevenness of 16 mm Thickness plate measurements

Material thickness (mm)	Stand off distance, (mm)	Plasma gas	Air pressure (Kg/cm2)	Shielded gas pressure	Arc voltage (V)	Arc ampere (A)	Unevenness (Micron)	Cutting speed (mm/min)
16	3.3	O2	8.5	10	130	133	710	1900
16	3.3	O2	8.5	10	130	133	659	1800
16	3.3	O2	8.5	10	130	134	641	1665
16	3.3	O2	8.5	10	130	134	622	1600
16	3.3	O2	8.5	10	130	136	598	1500



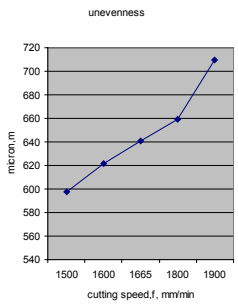


Fig-6: Cutting Speed Vs Unevenness Fig-7 Ref. [5] cutting speed Vs unevenness

Experiment on 16mm plate at 135A cutting speed decrease with unevenness decrease in 16 mm plate. More value of unevenness is in 16mm plate cutting compare of 12mm plate thickness. Fig - 6 shows unevenness value of 15 mm plate thickness on mild steel at 200A.

3. Conclusion:

Cutting speed increases or decreases inversely proportional to the 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. Further, at low cutting speeds the shape of the cut front changes resulting in a change in the direction of ejection of molten metal. The unevenness of plate increase with increase of cutting speed due to hardness of Hardox-400 plates. It has been also found more value of unevenness is in 16mm plate cutting compare to 12mm plate thickness. It was determined that after cutting, in the areas near to outer surface of the part hardness increased, around 390-480 HV, and it decreased towards to the core of the material.

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