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Investigation of Hardness Effect of Hardox-400 Cutting Plate by Plasma ARC Cutting System

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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. 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 predictedn this study, 12mm plate thickness Hardox-400 has been cut by high tolerance 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 change the unevenness of plate with cutting speed. The aim is to see how the cutting system and speed affect material structure up to what depth, it was determined that the hardness from the outer surface to the core decreased, while the hardness near to the outer surface ted by the high temperature occurred during cutting increased.

KEYWORDS: *Plasma arc cutting, Unevenness, Hardox-400, hardness*

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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 is considered one of the main non-conventional cutting processes used for cutting electrically conductive hard materials. The process does not provide high quality products, so in order to avoid further processing and to minimize the resulting defects after plasma cutting and to achieve better quality, optimal cutting conditions represented in cutting speed, arc gap thickness and gas pressure should be aimed for. Several researchers worked in this field and in that direction. One of their main conclusions is that higher cut quality during plasma arc cutting can achieved with higher gas flow rate. Modern manufacturing industries emphasize on accurate cutting of materials plate due to high demand in the industrial sector. Previously oxy-fuel cutting process was employed to cut the plate material. But, the production rate was affected due to its poor dimensional accuracy and slower cutting speed. Plasma arc cutting (PAC) process is introduced to overcome this problem. This process also used to cut high strength material which is very difficult to cut in oxy-fuel cutting process 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 pavers 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.

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; 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 con-structions, the "as-received condition of the plates. To clarify, how width of thermal influence area changes depending on carbonic content in unalloyed steel as well as effect of alloyed elements to width of thermal influence area and nature of recession of hardness. The diameter of plasma torch nozzle is 3 mm, diameter of wolfram electrode is 2.5 mm, and for making plasma, air was used. After cutting details were cooled in room temperature A group of specimens was obtained by cutting them with a numerically controlled plasma-cutting Machine 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 can not 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.

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

2.2. Setting and measurement procedure

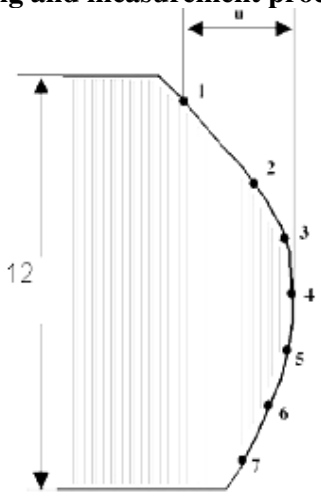

Fig-1 unevenness measurements

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

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

I= Side of plate

m = Side unevenness

M=Mean unevenness

Chemical composition change the ardness values of hardox-400 Hardox is no ordinary wear plate its toughness is very high under most extreme condition, such as high ratio of strain with varying temperature, this makes hardox particularly resistant to impact.

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

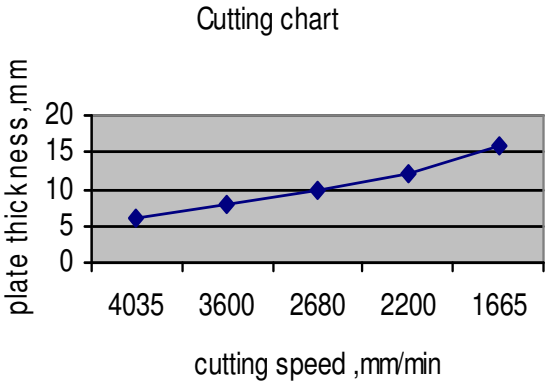

Fig-2: Cutting speed Vs Plate thickness of hardox -400 materials

The Vickers and Knoop Hardness Tests are a modification of the Brinell test and are used to measure the hardness of thin film coatings or the surface hardness of case-hardened parts[21]. With these tests, a small diamond pyramid is pressed into the sample under loads that are much less than those used in the Brinell test. The difference between the Vickers and the Knoop Tests is simply the shape of the diamond pyramid indenter. The Vickers test uses a square pyramidal indenter which is prone to crack brittle materials. Consequently, the Knoop test using a rhombic-based pyramidal indenter has been developed which produces longer but shallower indentations

An applied load ranging from 10g to 1,000g is used. This low amount of load creates a small indent that must be measured under a microscope. The measurements for hard coatings like TiN must be taken at very high magnification, because the indents are so small. The surface usually needs to 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. 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. 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, work table 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. pink line shows experiments values. Hardness measurements were performed using a PMT-3 microhardness tester and a load of 200 g. The measurements were performed in three areas of the specimen and the results were averaged. The measurement results are presented

unevenness

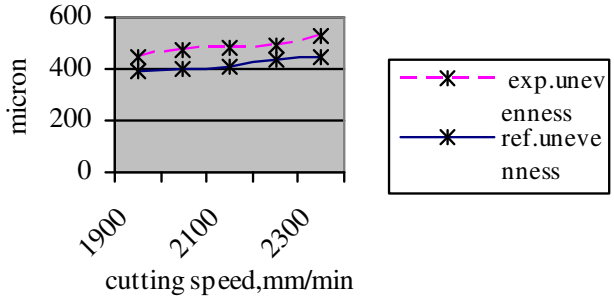

Fig-3: Cutting speed Vs unevenness of 12mm plate thickness Above fig-3 shows unevenness decrease with cutting speed decrease but at this speed some dross are produced at this speed

Hardness

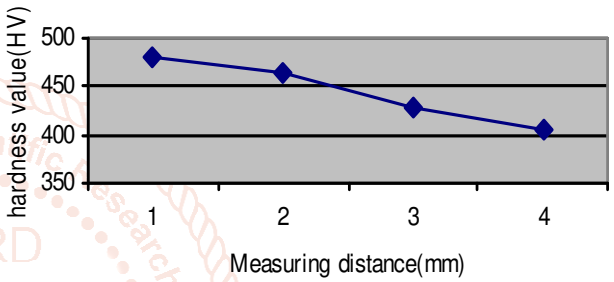

Fig -4 (A) 1900mm/min

Hardness

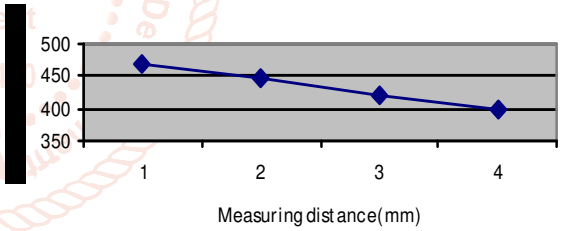

Fig -4 (B) 2100 mm/min

Hardness

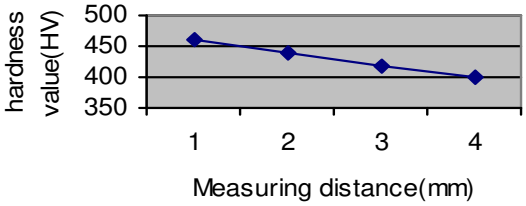

Fig -4 (C) 2300 mm/min

Hardness

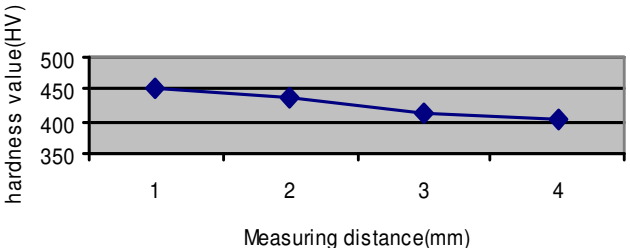

Fig -4 (D) 2400 mm/min

The HAZ is a region around the cut where the material's properties are altered due to the heat input from the plasma arc. Hardness Changes: Increased Hardness: In some cases, particularly with certain steels and higher cutting speeds, the HAZ can exhibit increased hardness due to the formation of harder microstructures like martensite or due to nitriding if air or nitrogen plasma is used. Minimal Change: Other studies have found minimal or no significant change in hardness within the HAZ, especially at lower cutting speeds or with specific materials like copper.

Factors Influencing Hardness: Cutting Speed: Higher cutting speeds generally result in a narrower HAZ and can lead to more significant hardness changes, according to a study published on ScienceDirect.com. Material Type: The material being cut plays a crucial role, with different steels and other metals exhibiting varying responses to the heat input. Plasma Gas: The type of plasma gas used (e.g., air, nitrogen, or other inert gases) can influence the extent of nitriding and its impact on hardness

Fig -4{(A), (B), (C), (D)} Hardness variation of graph of hardox-400 material (plate thickness-12mm) Hardness was measured in the hardness of Vickers at intervals of 1 mm and the upper and lower area of the same area from outer surface to the core of specimens cut with various cutting speeds. Hardness values before cutting specimens were determined to compare Hardness measurements of materials whose micro structures had been investigated were performed on a Vickers hardness measurement device applying 1 kg weight and the results obtained were recorded in graphics, In the same specimens, hardness was measured at intervals of 1 mm in 4 mm region from outer surface to the core and the hardness variation from outer surface to the core was determined. Then, effects of the method were evaluated according to these variations Plasma cutting method is based on cutting materials at near melting temperature. Since the energy applied and cooling conditions vary, different metallurgic specifications and hardness values occur. There by, it can be seen that it causes hardness variations relating effects of metallurgic specifications of the material .High heat occurs in the area where plasma gas becomes effective during cutting. The analysis of arc-related current and voltage waveforms observed during cutting revealed the stability of the aforesaid parameters in relation to given cutting rates. The results revealed that the voltage of plasma arc decreased along with an increase in cutting rates (connected with the reduced length of plasma arc). High cutting rates led to the formation of a large threshold, responsible for the concentration of the anodic area of plasma arc in the upper part of the element subjected to cutting.

Conclusion:

1..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. IAlso side clearance and thermal effect on material and work piece like Heat Affected Zone (HAZ) can also be considered to study the effect on properties of work piece.

2.Cutting speed increase 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. 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, so decrease of speed is very important but the at this speed more dross are produced at bottom of plate. It has been found more value of unevenness is in 16mm plate cutting compare of 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.Cutting speed, amperage, and gas flow rate can also influence the extent of hardening. Higher cutting speeds generally lead to a narrower HAZ and less hardening. The amount of material removed from cutting area is proportional to thickness. The cutting gap becomes small in thin material, bigger in thick material.. 3. An increase in the plasma gas flow rate can facilitate improvement of cut quality for allgases because it increases both energy and momentum density. It was determined that after cutting, in the areas near to outer surface of the part hardness increased,, and it decreased towards to the core of the material.

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