# EXPERIMENTS ON CUTTING PLATE BY PLASMA ARC

*PATEL JITENDRAKUMAR B.,* PATEL MEHULKUMAR K., PATEL KALPESHKUMAR S.*

**Lecturer In Mechanical Engineering, K. D. Polytechnic, Patan,**

*shrey2152006@gmail.com*

***ABSTRACT*:** *In this study, 12mm and 16mm plate thickness EN-9 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 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, Un-Evenness, EN-9.***

## 1 INTRODUCTION

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.

### PHYSICAL MODELING:

Consider a high-power plasma beam striking a small area of metal surface. The plasma beam penetrating through the work piece, the advancing hole and different physical phenomena taking place in the material. The first phenomenon we can observe is the absorption of the energy by the material. The absorption takes place within a thickness usually much less than a millimeter, so we can consider surface heating only. The temperature of the material surface does not rise infinitely. Part of the heat input from the plasma beam melts the metal resulting in solid–liquid phase change in the areas close to the source. When a material melts, latent heats absorbed without any further rise in temperature. The second part of the heat is transferred into the work piece by conduction from hotter to colder metal resulting in rise of the temperature in the material. Next physical process is due to the fact that the plasma beam pierces through the work piece with some constant velocity, while the high velocity gas flow removes the molten material from the bottom of the cut, or the kerf .An interesting phenomenon is the so-called solid–solid phase change. Actually, some parts of the material are heated up to very high temperatures (below the melting temperature though) forcing the formation of one solid phase (austenite, say), which can be later changed to another solid phase (pearlite, martensite, etc.) after we cool down the material to relatively low temperatures.

### MATHEMATICAL MODELING

In this work, we are mainly concerned with the problem of heat transfer and temperature distribution in the work piece during the thermal plasma cutting. The problem is solved, if it is possible at any moment to identify the temperature of every point of the work piece and the geometry of the work piece. Several modeling assumptions have to be made:

(1) The work piece is homogeneous and isotropic.
(2) The material parameters (density, heat capacity, conductivity, etc.) of the work piece are constant.
(3) If the piece is large, then the heat exchange through the surface to surrounding can be neglected in regard to the heat flow in the material itself. This assumption makes sense because the heat conductivity of metals is much greater than the heat transmission through the surface.
(4) The plasma beam has a cylindrical shape, and the heat flux from the plasma beam is emitted only in the normal direction to the surface of the cylinder.
(5) The plasma device moves at a constant velocity with respect to the work piece.
(6) The heat flux density emitted by the plasma beam is constant and given.
(7) The heat lost by radiation is negligible.
(8) The effects of gravity and surface tension are negligible.
(9) We neglect the thermal and mechanical effects caused by solid–solid phase changes.
(10) We do not consider the side effects caused by the smoke of the vaporizing metal. By side effects we mean that, for example, the evaporated material does not interfere with incident plasma beam.

## 2 EXPERIMENTAL

**2.1 BASE MATERIAL:** EN-9 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 con- structions, 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**

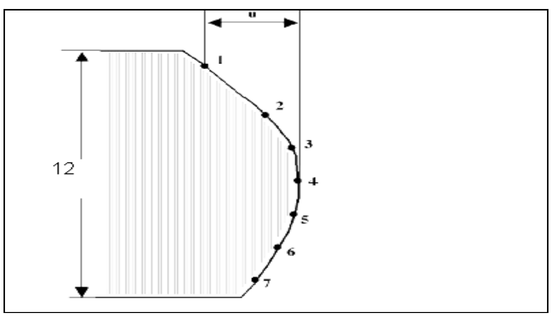


Fig -1 measurements of unevenness

- 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.

$$M = \frac{\sum_{I=4}^{4} MI}{4}$$

I =side of plate
M= mean unevenness

| C | Si | Mn | P | S | B |
|---|---|---|---|---|---|
| 0.5 | 0.25 | 0.6 | 0.012 | 0.002 | 0.002 |

Table -1: Chemical composition of EN-9 -400 Material

Above table shows that cr percentage is increases in EN-9 material in compare of mild steel**.** So EN-9 material become hard compare of mild steel**.**

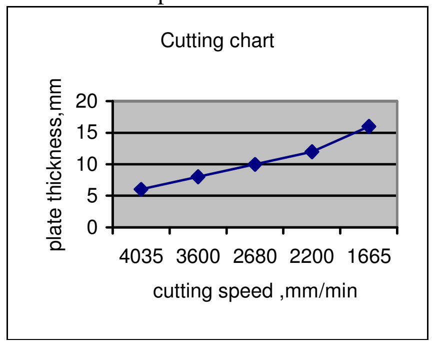


Fig-2: Cutting speed Vs Plate thickness of EN-9 -400 materials

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 Table -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- 3 shows Unevenness of 16 mm Thickness plate measurements. 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 mmplate 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-2 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

Table no. 2 : Cutting speeds selection parameters

| **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 | $O_2$ | 8.5 | 10 | 130 | 133 | 525 | 2300 |
| 12 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 133 | 492 | 2200 |
| 12 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 134 | 479 | 2100 |
| 12 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 134 | 468 | 2000 |
| 12 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 138 | 443 | 1900 |

Table- 3: Unevenness of 16 mm Thickness plate measurements

| **Material thickness (mm)** | **Stand off distance, (mm)** | **Plas-ma gas** | **Air pressure (Kg/cm2)** | **Shielded gas pressure** | **Arc voltage (V)** | **Arc ampere (A)** | **Unevenness (Micron)** | **Cutting speed (mm/min)** |
|---|---|---|---|---|---|---|---|---|
| 16 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 133 | 710 | 1900 |
| 16 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 133 | 659 | 1800 |
| 16 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 134 | 641 | 1665 |
| 16 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 134 | 622 | 1600 |
| 16 | 3.3 | $O_2$ | 8.5 | 10 | 130 | 136 | 598 | 1500 |

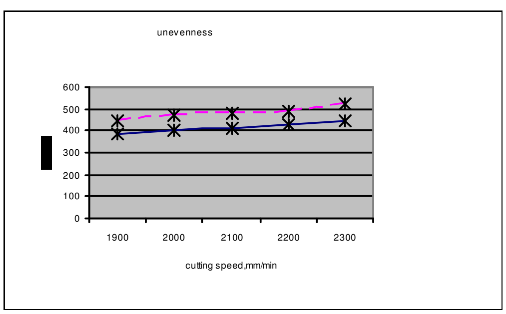


Fig-3: Cutting speed Vs unevenness of 12mm plate thickness

_ _ _ _ _ (Dotted) line shows 12mm plate thickness EN-9 material

_______ Line Value Taken from Ref. [3] 15 mm plate thickness mild steel material

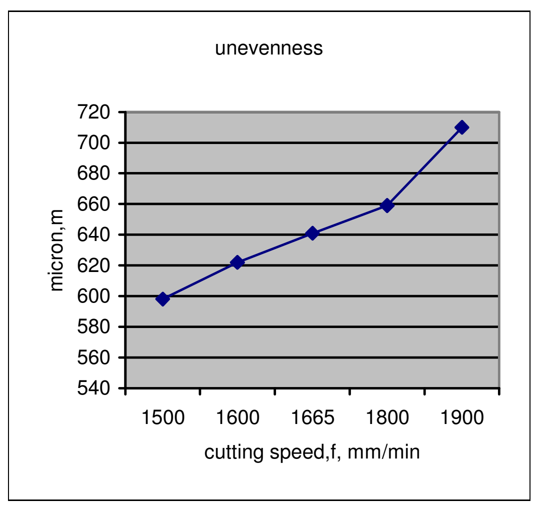


Fig-4: Cutting Speed Vs Unevenness

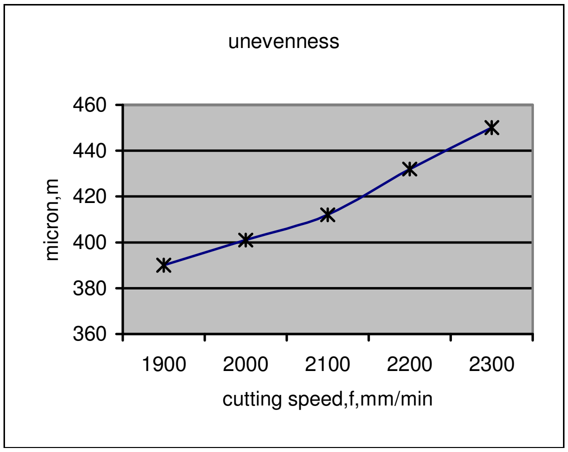


Fig-5 Ref. [3] cutting speed Vs unevenness

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 -4 shows unevenness value of 16 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 EN-9 plates. It has been also found more value of unevenness is in 16mm plate cutting compare to 12mm plate thickness.

**REFERENCES:**

[1] A. Umut Ati, " Investigation of the effects of plasma arc parameters on the structure variation of AISI 304 and St 52 steels", Materials & Design**,** volume27, issue10, 2006, Pages 1157-1162

[2] K. kazuomi, "Effect of torch height on cut surface quality of plasma arc cutting", Volume 2000: pages 213-214

[3] R.Bini, B.M.Colosimo, A.E.Kutluand M.Monno"Experimental study of the features of the kerf generated by a 200 A high tolerance plasma arc cutting system" journal of material procedure, 2007, pages 1-11.

[4] W.JXu, J.C. fang and Y.S Lu, "Study on ceramic cutting by plasma arc, journal of materials processing technology", volume 129, issues 1-3, pages 152-156