
OPTIMIZATION OF UNEVENNESS BY USING ANOVA ANALYSIS ON CUTTING PLATE BY HIGH TOLRENCE PLASMA ARC CUTTING SYSTEM

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Abstract: *In this study, 16mm 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 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

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 to 16 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 16 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

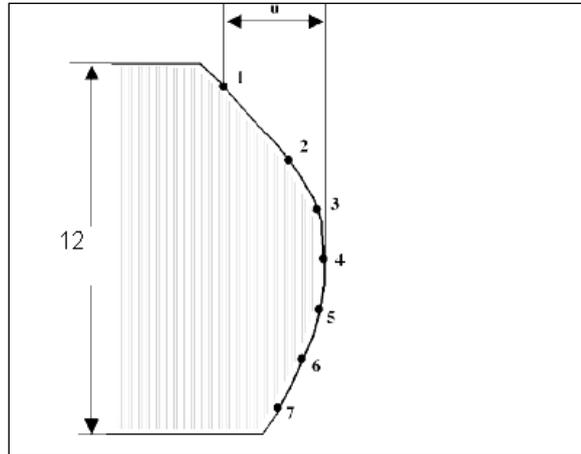


Fig -1 measurements of unevenness

- 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.

$$M = \frac{\sum_{I=1}^4 mI}{4}$$

I =side of plate
 M= mean unevenness

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	.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.

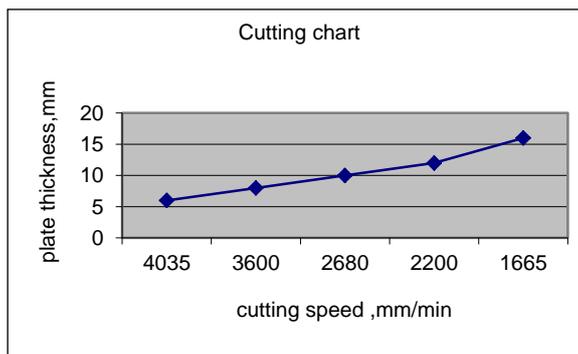


Fig-2: Cutting speed Vs Plate thickness of hardox -400 materials

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-1 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. 1 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, 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-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

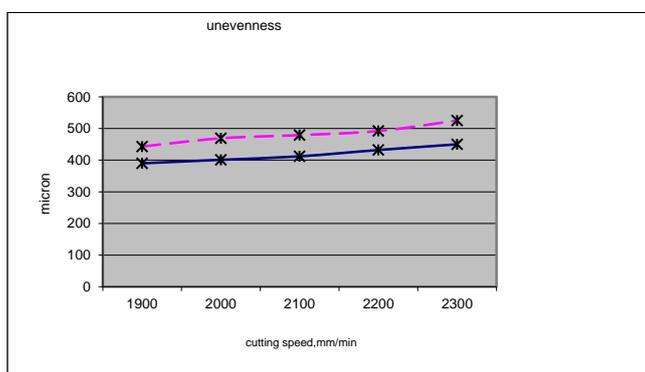


Fig-3: Cutting speed Vs unevenness of 12mm plate thickness

--- (Dotted) line shows 12mm plate thickness hardox-400 material
 _____ Line Value Taken from Ref. [3] 15 mm plate thickness mild steel material

Table- 2: Unevenness of 16 mm Thickness plate measurements

Material thickness (mm)	Stand off distance, (mm)	Plas -ma gas	Air pressure (Kg/cm ²)	Shielded gas pressure	Arc volta ge (V)	Arc ampe re (A)	Unevenness (Micron)	Cuttin g speed (mm/m in)
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

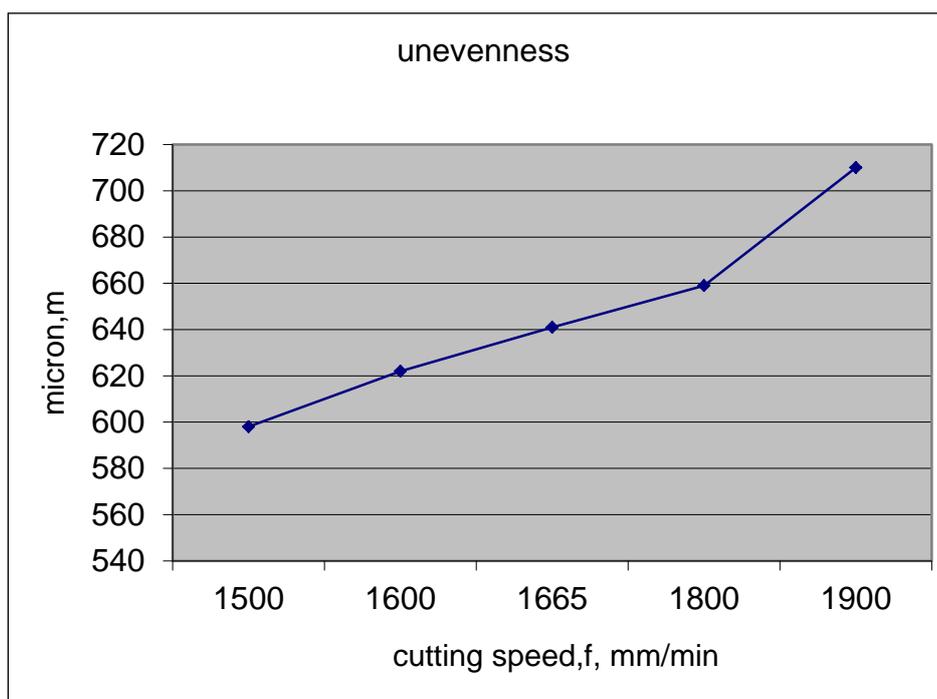


Fig-4] cutting speed Vs unevenness

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 shows unevenness value of 15 mm plate thickness on mild steel at 200A.

A second experimental setup has been designed in order to investigate more thoroughly an effect of cutting speed and voltage. Which were identified as important after the first screening experiment. In order to detect a minimum (if any) in the newly explored. Experimental region. Three levels have been considered for each factor.

In this experimental stage. At least three levels are needed for fitting a quadratic surface response to find an optimum in the response function. Thus, for this set, a balanced two-factor three-level design (nine treatments) has been designed and the low cutting speed-low voltage treatment from the previous design was set as center point Table: 5.1. With respect to

the previous design, the levels span has been reduced since good unevenness values have already achieved with the center point treatment. The levels of the gas factors have kept constant at the values suggested by the system producer. The experimental settings and the measurement procedure remained the same for this second set of experiments.

Table: 3. Factor and level for factorial plan 16mm plate thickness

Factors	Step	Low level	Medium level	High level
Cutting speed (mm/min)	±2.2	1550	1600	1650
Voltage(V)	±3V	127	130	133

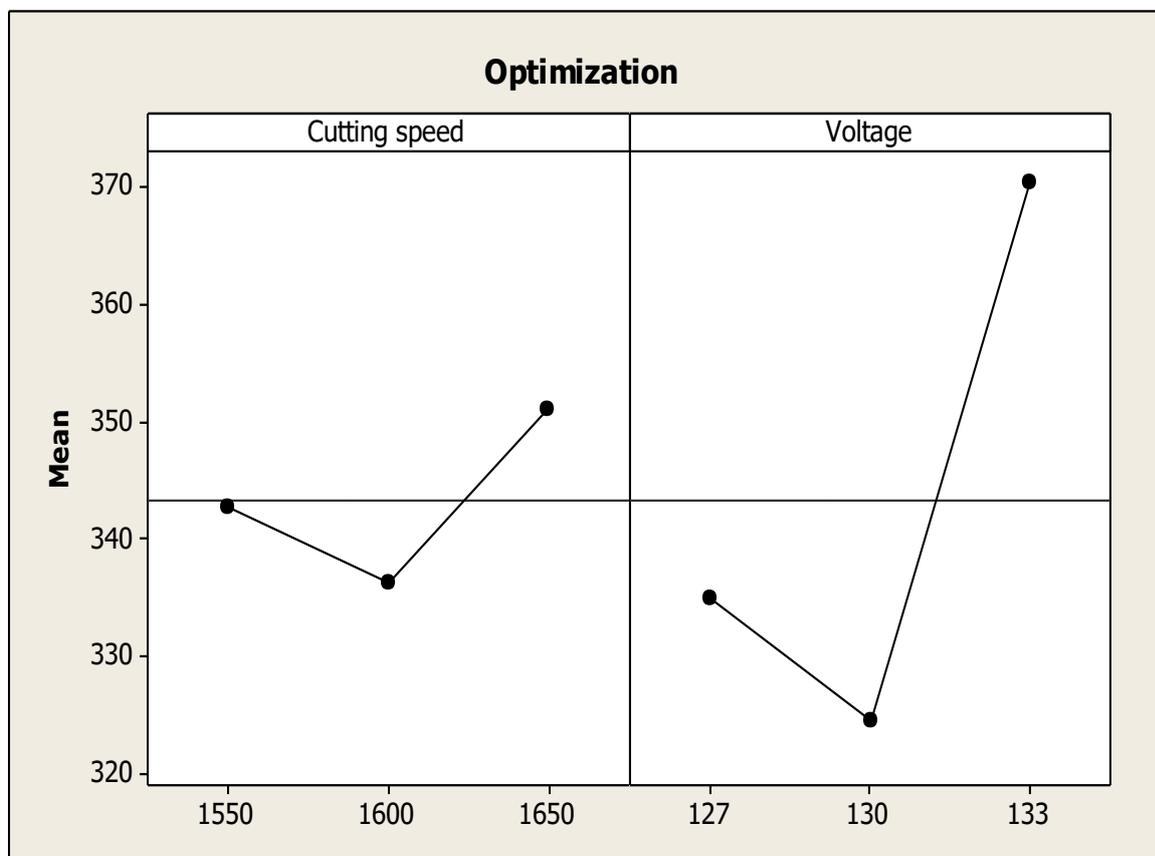


Figure: 5 Cutting speed and Voltage Vs unevenness (optimized)

it was deduced that the whole second factorial design lies in a stable region in the domain of the process parameters. We can see that at (130V, and 1600) .Minimum unevenness which is our optimum value. It is clear that the mean plate unevenness decreased of about 60%.

The improvement of the mean unevenness is well distributed among all the four sides. The stability of each side (described by the standard deviation *within*) is maintained or, in the case of side 1, improved. Eventually, the variability between sides (described by the standard deviation between) is almost halved.

For 16 mm Plate thickness all design and experimental procedure remains same. In this further experimental stage. Here at least three levels are needed for fitting a quadratic surface response to find an optimum in the response function. With respect to the previous design. Unevenness values have been already achieved with the center point treatment. The experimental settings and the measurement procedure remained the same for this second set of experiments.

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. By Optimization unevenness are minimum at the 130 voltage and 1600 mm/min speed unevenness also minimum. The visual investigation of the obtained plates showed an overall good cut quality. We get Minimum unevenness which is our optimum value at 130V, and 1600 cutting speed.

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