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Experimental Investigation & Optimization of Cutting Parameters in Plasma Arc Cutting

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Abstract: **Plasma arc cutting (PAC) is a fabrication process which employs superheated, ionized gas funneled through a plasma torch to heat, melt and, ultimately, cut electrically conductive material into custom shapes and designs. And is extensively used to cut high strength materials which are difficult to cut through any other manufacturing process. This process involves highly powered plasma arc to cut any conducting material with good dimensional accuracy in very short time. In this work, by using CNC plasma arc cutting machine, cutting parameters has to be done. In this process, AISI 316 material is used for PAC. It is highly flexible for bending, highly resistive and easily joinable. For this process the input parameters used are Arc current, Gas pressure, Torch height and Cutting speed whereas Material removal rate (MRR) and Kerf width will be taken as output responses. In this analysis to optimize cutting parameters Taguchi approach is used. By using Minitab 17 software Taguchi L_9 orthogonal array (OA) design and analysis experiments was done. In this work by using Taguchi method, Signal to Noise (S/N) ratio is obtained between the input parameters and output responses. To achieve the better efficiency of plasma arc cutting, the confirmation test was carried according to the optimal setting of process parameter. These results play a significant role for a better database to the industries. The outcome of the investigations clearly shows that the specific range of input process parameters achieved the improved machinability.**

Keywords — AISI 316 Stainless steel, Material Removal Rate, Plasma Arc Cutting, Taguchi Method, Kerf Width.

I. INTRODUCTION

The topic for the research work is the Experimental Investigation & Optimization of Cutting Parameters in Plasma Arc Cutting. The main intension on this work is to find out an optimum condition (setting) to obtain MRR as maximum and Kerf Width as minimum. To evaluate the process of Plasma Arc Cutting (PAC) and Gouging process a person need not be a physicist or chemist. The physical matter found in four stages like solid, liquid, gas or plasma. By supplying or subtracting energy in energy or heat form changes occurred from one physical state to another. Best technical properties are exhibited by advanced materials which are high in cost of both raw materials and final produced product. Alternatively, advanced machining such as Plasma Arc Cutting is generally used. In this type of cutting advanced material like nickel-base alloys, titanium alloys and stainless steel can be used as the work piece. Plasma arc cutting is not quite as involved as welding. Depending upon the thickness of material and output of plasma arc cutting machine, the cutting manner of the workpiece is varied.

II. LITERATURE SURVEY

Rana et al. [1] upgraded plasma curve cutting of mellow steel slim plates, both regarding cut quality and exhibitions of the consumables, by applying Taguchi Method. As from the perception it was discovered that it is less expensive than laser cutting for thick plates and from oxy-acetylene for slender plates, PAC has better cut quality. Warmth influenced zone is less or least. Kechagias and Billis [2] displayed a parametric plan of PC mathematical controlled (CNC) plasma bend cutting cycle of St. 37 carbon steel and AISI steel plates by utilizing strong plan of symmetrical exhibit. Bend current is the main factor. The plate thickness is the most un-critical boundary in PAC measure. Yun and Na [3] completed an analysis about the ongoing control of PAC measure utilizing force estimations of shot out plasma gas. They saw that the measure of the joined dross considerably diminished by a straightforward controlled speed. The info boundaries of plasma bend cutting cycle utilizing QstE-380 and Hardox 450 compound steel plate were streamlined by utilizing RSM.

Ferreira et al. [4] saw that there was speed up to 65 % from 35 % with decrease in expense around 28 %. CNC plasma

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cutting cycle by utilizing S235JR sheet materials at various cutting velocities, amperes and circular segment voltages was tested and temperature appropriation, thickness of HAZ, surface harshness (SR) and hardness were estimated from the material at their various qualities [5]. Bober [6] settled the cutting plan of mathematical controlled (NC) plasma cutting machine by utilizing backtracking calculation, hereditary calculation and heuristic calculation individually. He found that the novel hereditary calculation gave prevalent outcomes among all calculations with short time frame in the machining. Lee and Kwon [7] proposed a two-venture hereditary calculation joining worldwide quest for piercing point streamlining and nearby quest for part sequencing. A report on the examination of chose transient wonders occurring in PAC that are pertinent for measure advancement was portrayed and fast imaging diagnostics were misused for the portrayal of various mechanical arrangements to give further experiences into light and cycle plan [8].

Fluffy hypothesis was utilized for the expectation of cutting boundaries in PAC cycle of AISI 4140 steel. The boundaries considered in this investigation were plasma curve current, cutting pace, and thickness of cut material. Fluffy standard based displaying was utilized for forecast of surface unpleasantness. The most advantageous line slicing strategy as per the Fuzzy scientific chain of command measure (AHP) and Fuzzy procedure for request of inclination by closeness to ideal arrangement (TOPSIS) strategies for transport building industry was outlined [9]. Bhuvenesh et al. [10] researched the SR and MRR of AISI 1017 gentle steel utilizing manual plasma bend cutting machining by Taguchi approach. They saw that the connection between normal MRR and normal SR was contrarily relative to one another. Khan and Maity [11-12] utilized MOORA and TOPSIS to tackle distinctive multi target issues for some non-regular machining measures that have different rules issues. Diverse non-conventional machining measures has been examined and analyzed by them including Plasma Arc Cutting. They found that ideal settings of information factors got by utilizing MOORA strategy almost attach with those determined by the prior examiners.

Kumar [13] done boundaries improvement in CNC plasma bend cutting of AISI 206 steel utilizing Taguchi approach. ANOVA results introduced that the pressing factor of gases and speed of spout are critical boundaries for limiting Kerf just as for amplifying Penetration. S. Chamarthia et al. [14] done the analysis of Plasma arc cutting parameters on unevenness surface of Hardox-400 material utilizing Plasma arc cutting machine by ANOVA method. They found that the arc voltage is main parameter and it influences all the aspects related with the cut quality rather than the effect on the arc power, beyond the arc voltage the cutting speed showed a noticeable effect. Results obtained in the experimental stage allowed one to observe that unevenness can be reduced by reducing the cutting speed. Sovan Bhowmick et al. [15] researched the SR and MRR of AISI 304 Stainless Steel utilizing plasma arc cutting machine of setting design of experiments L27. ANOVA results saw that the speed and the thickness are more significant & it is also observed that the pressure is the only significant parameter in case of surface roughness. The gas pressure has a little effect on MRR.

R. Bini et al. [16] done the experimental study of features of Kerf generated by a 200 Amps high tolerance plasma arc cutting system by using design of experiments technique. The analysis confirmed that the HTPAC response is difficult to predict and has a complex behavior and analysed to investigate the effect of the main process parameters on the output unevenness, in a real cutting application. Deepak Kumar Naik et al. [17] researched the analysis of MRR, SR & Kerf of plasma arc cutting of Hardex-400 using Taguchi based desirability analysis. The TDA technique was used and it is very convenient for predicting the parametric design of input process parameter. This process improves the quality characteristics in term of the best output responses. B. Abdulnasser et al. [18] done the plasma arc cutting optimization parameters for Aluminum alloy with two thickness by using Taguchi method. The results indicate that the current and cutting speed is the most significant parameters, followed by the arc gap for both rate of material removal and surface roughness.

Kulvinder Rana et al. [19] researched the optimization of plasma arc cutting of Mild Steel material by applying Taguchi & ANOVA methods. The current has maximum effect on the process after that torch travelling speed and stand-off distance and air pressure have minimum effect on the process. R. Adalarasan et al. [20] applied the Grey Taguchi- based response surface methodology (GT-RSM) for optimization of the plasma arc cutting parameters of 304L Stainless Steel. All the cutting parameters (air pressure, cutting speed, arccurrent and stand-off distance) were found to have a potential effect on the responses (kerf width and surface roughness), and the generated second-order polynomial response surface model for the GRG was found to be significant and adequate. Parthkumar Patel et al. [21] done the optimization of Surface Roughness in Plasma arc cutting of AISID2 Steel using TLBO & GA algorithm. The main objective has been to minimize aforesaid response (process output) characteristics to improve product quality as well as ensuring satisfactory machining performance. The parametric condition obtained from the TLBO showed its effectiveness over GA.

Milan Kumar Das et al. [22] done the optimization of process parameters in plasma arc cutting of EN 31 Steel based on MRR & Multiple Roughness Characteristics Using

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Grey Relational Analysis. Based on ANOVA, the highly effective parameter is gas pressure, whereas arc current & torch height are less effective factors within the specific test range. The grey relational grade from initial to optimal process parameter is improved. K. Ananthakumar et al. [23] researched the measurement & optimization of multi-response characteristics in plasma arc cutting of Monel 400 using RSM and TOPSIS. From ANOVA analysis, stand-off distance and gas pressure are found to be the most influencing parameters on MRR and HAZ, whereas KT primarily affected with cutting speed. Microstructural observation revealed the dross formation, improved HAZ, recast layer, presence of micro striation patterns and micro voids at various cutting conditions. S.Siva Teja et al. [24] researched the investigations to study the impact of machining parameters on Mild Steel using Plasma arc cutting by Taguchi & ANOVA methods. The results saw that the most significant parameters that affect the plasma arc cutting process are plate thickness followed by current. P.Parthkumar et al. [25] done the study of effect of process parameters in plasma arc cutting on Quard-400 material using ANOVA. Material removal rate increases with increase of cutting speed and mean surface roughness decreases with increase of cutting speed.

III. METHODOLOGY

9 test specimens having dimension 150mm x 150mm x 6 mm were prepared for the experimental work. The material for test specimen was Stainless Steel AISI 316. This material is an excellent corrosion resistance nature. It has excellent forming and welding characteristics. This type steel has good Mechanical properties like good weldability, good bendability and high toughness. Mostly AISI 316 Stainless steel is used in manufacturing of various equipment like Pressure Vessels, Tanks, Heat Exchangers, piping systems, flanges, fittings, valves and pumps. The chemical composition of this material is tabulated below.

Table 1. Chemical Composition of AISI 316 Stainless Steel

Elements	Cr	Ni	Mo	C	Mg	P	S	Si	N	Fe
Weight %	16-18	10-14	2-3	0.08	2	0.045	0.03	0.75	0.1	Balance

Equipment for the experiment use is:

1. Plasma arc cutting system CUTMASTER A120 CNC Plasma cutting of Company ESAB CROSSBOW.
2. Digital weight balancer equipment.

Design of Experiments technique has been utilized to obtain the best combination of design factors to achieve optimum performance measures. Plasma Arc Cutting involves several input parameters to be considered during machining process. In this thesis, the combination factors such as Arc Current [A], Gas Pressure [bar], Torch height [mm] and Cutting Speed [mm/min] are considered. These factor are the most important to have the best value for Material Removal Rate (MRR) and Kerf width when cutting material like Stainless Steel or Nickel Base Alloy etc.

A. Arc Current

It is the value of current given during cutting process. The cause of the burn-through was the increase in the cutting current or the decrease in the cutting speed. When the cutting current increases or the cutting speed decreases, the stable state of the key hole changes accordingly. If the cutting current and the flow rate of the plasma gas are increased and/or the cutting speed is decreased, the process will withstand larger variations in the cutting parameters.

B. Gas Pressure

According to Larry Jeffus, "Principle and Application of Welding" Sixth Addition, almost any gas or gas mixture can be used today for the PAC process. Normally Nitrogen or Argon with 0-35% Hydrogen is used for cutting of Steel materials. We used Argon with 0-35% Hydrogen for our experiment purpose. Gas pressure is important to select the correct gas flow rate for the size tip, metal type and thickness. The gas flow is too low will result in a cut having excessive dross and sharply bevelled sides. The gas flow is then it will produce a poor cut because of turbulence in the plasma stream and waste gas. To control the gas flow by Controlling the pressure.

C. Torch Height

Torch height is the gap between the plasma arc cutter torch and welding electrodes with the work piece.

D. Cutting Speed

It is to look at the arc as it exits the bottom of the work piece. Observe the angle of the cutting arc through the proper welding lens. If cutting with air, the arc should be vertical straight down, or zero degrees as it exits the bottom side of the cut. If cutting with nitrogen or argon/hydrogen, then the correct cutting speed will produce a trailing arc (that is, an exit arc that is opposite to the direction of torch travel). The torch speed needs to be adjusted to get a good-quality cut. A cutting speed that is too slow or too fast will cause cut quality problems. In most metals there is a window between these two extremes that will give straight, clean, dross free cuts.

E. Material Removal Rate (MRR):

It can be defined as the volume of material removed divided by the machining time. The material removal rate is metal worn rate from the workpiece.

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F. Kerf Width:

Kerf Width is the width of the cut (or the width of material removed during the cut) and it is measured from the workpiece after cutting through plasma arc process. Kerf is characterized as the width of material that is taken out by a cutting cycle. When discussing CNC shape cutting with commonplace cutting cycles, kerf is the width of material that the cycle eliminates as it slices through the plate.

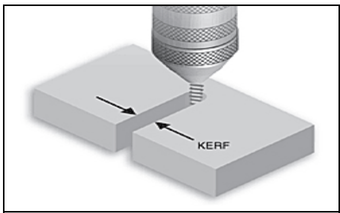

Fig.1 Kerf Indication

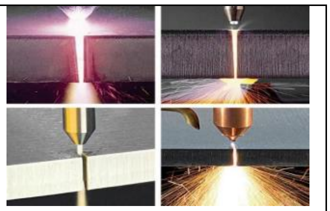

Fig.2 Cutting Tips

For this I consulted to the Fabrication Division of Kakati Karshak Industries Private Limited-Hyderabad, they suggested that Stainless Steel (316) materials are widely used in Plasma Cutting Machine. Taguchi method using design of experiments approach can be used to optimize a process. Here we will to apply D.O.E approach for modelling of MRR in PAC process and the various input parameters will be taken under experimental investigation and then model will be prepared then again experimentation work will be performed. The results obtain will be analyzed and the models will be produced by using MINITAB 17 software. This will help in improving the effective and efficient working of the PAC process.

G. Program Used in Plasma Arc Cutting of SS316:

```
G92 X0.Y0.
G21
G91
G00X45.005Y120.005
M07
G01Y-45.
G03X25.Y-25.I25.J0.
G01X20.
G03X25.Y25.I0.J25.
G01Y45.
M08
G00X50.Y-110.
G41
M07
G01X-10.
G01X-150.
G01Y150.
G01X150.
G01Y-150.
G01Y-5.
M08
G40
M02
```

IV. Experimental Work

In this experiment, there are four parameters at three levels each. The design variables that is the values of input parameters can be summarized as below table 2.

Table 2. Values of Input Parameters

Symbol	Input Parameters	Units	Level 1	Level 2	Level 3
A	Arc Current	Amps	60	80	100
B	Gas Pressure	Bar	4.8	5.2	5.5
C	Torch Height	mm	3.5	4.0	4.5
D	Cutting Speed	mm/min	600	700	800

The degree of freedom (DOF) of a three level parameter is 3 (Number of Levels minus 1), hence total DOF for the experiment is 4. The DOF of the orthogonal array selected should have higher than that of total DOF of the experiment.

Table 3. Experimental Layout in Coded factor levels

S.No.	Run Order	Arc current	Gas pressure	Torch Height	Cutting speed	Arc current	Gas pressure	Torch Height	Cutting speed
		CODED				UNCODED			
1	2	1	1	1	1	60	4.8	3.5	600
2	1	1	2	2	2	60	5.2	4	700
3	4	1	3	3	3	60	5.5	4.5	800
4	7	2	1	2	3	80	4.8	4	800
5	3	2	2	3	1	80	5.2	4.5	600
6	8	2	3	1	2	80	5.5	3.5	700
7	6	3	1	3	2	100	4.8	4.5	700
8	5	3	2	1	3	100	5.2	3.5	800
9	9	3	3	2	1	100	5.5	4	600

The above table 3 displays the L9 (3x4) Taguchi design (orthogonal array). L9 means the experimental runs are 9. 3x4 means 4 factors with 3 levels each. This array is orthogonal; factor levels are weighted equally across the entire design. The table columns represent the control factors, the table rows represent the runs (combination of factor levels), and each cell represents the factor level for that run.

The two most important outputs are Material Removal Rate and Kerf Width the same have been selected as response parameters for this research work and these parameters & experimental data will be analyzed as per Taguchi method to find out the optimum machining condition and percentage contribution of each factor. Each experimental

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runs are conducted as per above table 3 by the following machining parameters were kept constant at each experimental runs.

1. Work piece – AISI 316 Stainless Steel
2. Material Thickness – 6 mm
3. Operating Voltage – 200 V

The bellow fig.3 shows the images of material thickness, CNC Plasma arc cutting machine, specimen arrangement for cutting and final cutting work pieces of each experimental run in L9 orthogonal array.

Fig.3 Images showing the metal thickness, PAC of the SS 316 with 9 specimens

A. Signal to Noise Ratio (S/N Ratio)

Noise factors are those that are either too hard or uneconomical to control even though they may cause unwanted variation in performance. This is noticed that on the target performance is usually satisfies the user best, and the target lies under acceptable range of product quality are often inadequate. If Y is the performance characteristic measured on a continuous scale when ideal or target performance is T then according to Taguchi the loss caused L(Y) can be modeled by a quadratic function as shown in equation (1)

$$L(Y) = K(Y-T^2)\ldots\ldots\ldots\ldots(1)$$

The objective of robust design is specific; robust design seeks optimum settings of parameters to achieve a particular target performance value under the most noise condition. Suppose that in a set of statistical experiment one finds an average quality characteristic to be μ and standard deviation to be o. Let desired performance be μ1. Then one makes adjustment in design to get performance on target by adjusting value of control factor by multiplying it by the factor (μo/μ). Since on target is goal the loss after adjustment is due to variability remaining from the new standard deviation. Loss after adjustment shown in equation (2):

$$k(\mu o/\mu)^2\, \sigma^2\ldots\ldots\ldots\ldots\ldots(2)$$

The factor μ^2/σ^2 reflects the ratio of average performance μ^2 (which is the signal) and σ^2 (the variance of performance) the noise. Maximizing μ^2/σ^2 or S/N ratio therefore become equivalent to minimizing the loss after adjustment. Finding a correct objective function to maximize in an engineering design problem is very important. Depending upon the type of response, the following three types of S/N ratios are employed in practice:

Larger is Better

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the larger-is-better S/N ratio using base 10 log is:

$$S/N = -10*\log(\text{Sum of } (1/Y^2)/n)$$

Where

Y= responses for the given factor level combination &

n= number of responses in the factor level combination.

Smaller is Better

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the smaller-is-better S/N ratio using base 10 log is:

$$S/N = -10*\log(\text{Sum of}(Y^2)/n)$$

Where

Y = responses for the given factor level combination &

n = number of responses in the factor level combination.

- In my thesis work MRR is considered larger is better. Value of MRR is measured by difference between initial and final weight after machining.
- Kerf Width is the width of the cut (or the width of material removed during the cut) and it is measured from the workpiece after cutting through plasma arc process.

B. Experimental Layout

After conducting the 9 experiments runs by using Taguchi method of experimental design and an appropriate orthogonal array then we obtained optimal conditions has been calculated for MRR and Kerf width of specimen by using Minitab 17 software.

The following table shows readings of MRR and Kerf width at each experiment, it also shows S/N ratio for MRR and Kerf width at each experiments.

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Table 4. Experimental Layout & S/N Ratios for MRR & Kerf Width (Actual Factor Levels)

S.No.	Run Order	Arc current (Amps)	Gas pressure (Bar)	Torch Height (mm)	Cutting speed (mm/min)	MRR (g/sec)	S/N ratio for MRR	Kerf Width (mm)	S/N ratio for Kerf Width
1	2	60	4.8	3.5	600	**0.87**	1.209614948	**2.2**	-6.848453616
2	1	60	5.2	4.0	700	**0.95**	0.445527894	**2.0**	-6.020599913
3	4	60	5.5	4.5	800	**0.91**	0.819172154	**2.0**	-6.020599913
4	7	80	4.8	4.0	800	**1.74**	-4.810984966	**2.2**	-6.848453616
5	3	80	5.2	4.5	600	**0.91**	0.819172154	**2.0**	-6.020599913
6	8	80	5.5	3.5	700	**1.05**	-0.423785981	**2.1**	-6.444385895
7	6	100	4.8	4.5	700	**2.00**	-6.020599913	**2.7**	-8.627275283
8	5	100	5.2	3.5	800	**1.67**	-4.454329423	**3.0**	-9.542425094
9	9	100	5.5	4.0	600	**1.00**	0	**2.6**	-8.299466959

By using MINITAB 17 software we obtain some interactions. The below fig.4 shows the effects of various factors on S/N Ratio of MRR and if we look at the same we will observe that with increase in Gas Pressure MRR S/N ratio is decreasing. Material removal rate increases with increase in Arc Current, Torch Height & Cutting Speed.

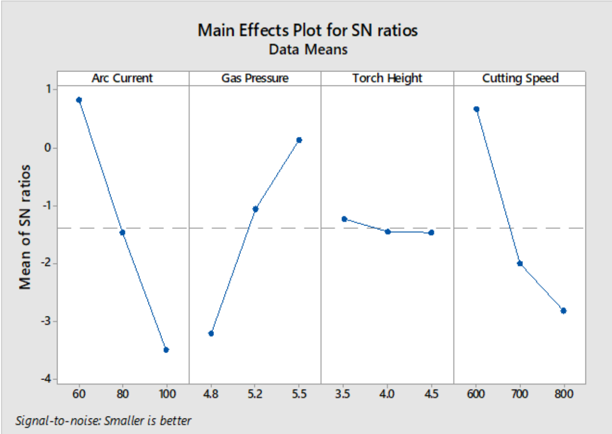

Fig.4 Effects of Various factors on S/N Ratio of MRR

With the below fig.5 of mean of MRR and various factors, we can observe that MRR is decreasing with increase in Gas Pressure and MRR is increasing with increase in Arc Current, Torch Height & Cutting Speed.

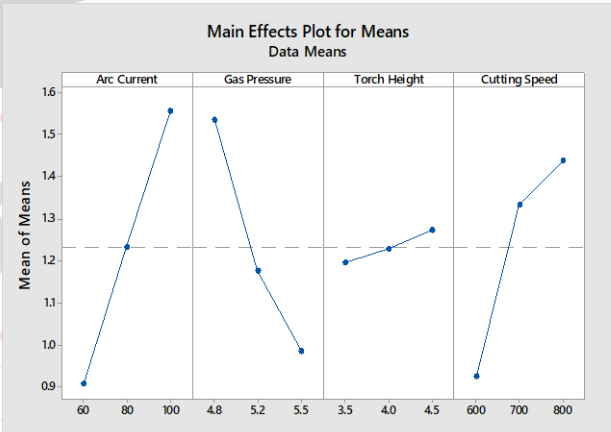

Fig.5 Effects of Various factors on Mean of MRR

Below fig.6 represent the effects of various parameters on S/N ratio of Kerf Width. It can be seen that as value of Arc Current and Cutting Speed increases, S/N ratio of Kerf Width also increases. However, S/N ratio of Kerf Width decreases with increase in the Gas Pressure and Torch Height.

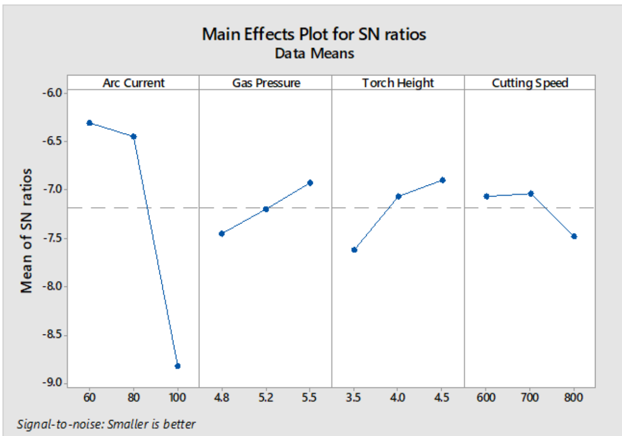

Fig.6 Effects of Various factors on S/N Ratio of Kerf Width

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With the above fig.7 the effects of various factors on mean of Kerf Width, we can observe that Kerf Width is decreasing with increase in Gas Pressure & Torch Height and MRR is increasing with increase in Current & Cutting Speed.

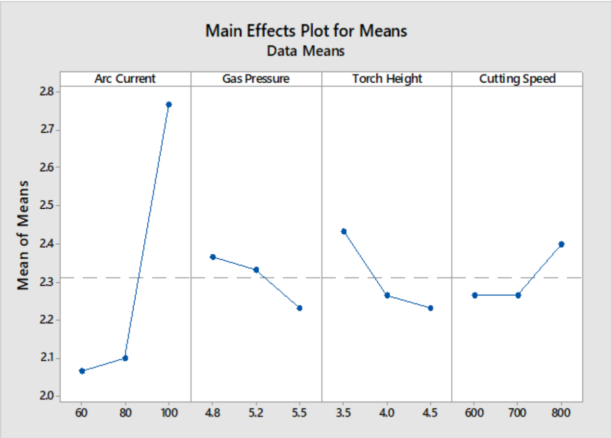

Fig.7 Effects of Various factors on Mean of Kerf Width

C. Confirmation Test

From S/N ratio and mean of each level of every factor we will construct response table for MRR and Surface Roughness which are given below:

Table 5. Responsible Table for S/N Ratio of MRR

Level	Arc Current	Gas Pressure	Torch Height	Cutting Speed
1	0.8248	-3.2073	-1.2228	0.6763
2	-1.4719	-1.0632	-1.4552	-1.9996
3	-3.4916	0.1318	-1.4608	-2.8154
Delta	4.3164	3.3391	0.2379	3.4916
Rank	1	3	4	2

From above response table 5 and main effect plot of MRR we can conclude that the Optimum levels of parameters for maximizing MRR are A3 B1 C3 D2 i.e.,

Arc Current – 100 Amps
Gas Pressure - 4.8 Bar
Torch Height – 4.5 mm
Cutting Speed – 700 mm/min

Similarly, we can create the responsible table for S/N Ratio of Kerf Width

Table 6. Responsible Table for S/N Ratio of Kerf Width

Level	Arc Current	Gas Pressure	Torch Height	Cutting Speed
1	-6.297	-7.441	-7.612	-7.056
2	-6.438	-7.195	-7.056	-7.031
3	-8.823	-6.921	-6.889	-7.470
Delta	2.527	0.520	0.722	0.440
Rank	1	3	2	4

From above response table 6 and main effect plot of MRR we can conclude that the Optimum levels of parameters for minimizing Kerf Width are A3 B2 C1 D3 i.e.,

Arc Current – 100 Amps
Gas Pressure – 5.2 Bar
Torch Height – 3.5 mm
Cutting Speed – 800 mm/min

After evaluating the optimal parameter settings, the next step of the Taguchi approach is to predict and verify the enhancement of quality characteristics using the optimal parametric combination. The estimated Optimum S/N ratio using the optimal level of the design parameters can be calculated:

$$\hat{\eta} = \eta_m + \sum_{i=1}^{q} (\bar{\eta}_i - \eta_m)$$

where, η_m is the total mean of the multi response signal-to-noise ratio,

$\bar{\eta}_i$ is the mean of the multi-response signal-to noise ratio at the optimal level, and

q is the number of the process parameters that significantly affect the multiple quality characteristics.

Based on the above equation the estimated multi response signal to noise ratio can be obtained.

Once the optimal value of MRR and Kerf Width is predicted, the final step is to verify the improvement of the quality characteristic using the optimal level of the process parameters.

After performing experiment as per given optimum levels for MRR and Kerf Width following results obtained:

Table 7. Summary table for Results

MRR (g/sec)	Optimum Value of A3B1C3D2 = 1.6882	Experimental Result of A3B1C3D2 = 1.741	Percentage = 3.12%
Kerf Width (mm)	Optimum Value of A3B2C1D3 = 1.9297	Experimental Result of A3B2C1D3 = 2.033	Percentage = 5.35%

So we can say that there is 3.12% improvement in MRR and also Kerf Width reduce with 5.35%. This finding indicated that the experiments in this study possess excellent repetitiveness and great potential for future reference.

V. Conclusion

This research work has presented an application of the Taguchi method to the optimization of the machining parameters of CNC Plasma Arc Cutting Machine. As shown in this study, the Taguchi method provides a systematic and efficient methodology for determining optimal parameters with far less work than would be required for most optimization techniques. The confirmation experiments were conducted to verify the optimal parameters. These results used to provide a better database to the industries and achieved to improve machinability. It has been shown

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that Material Removal Rate (MRR) and Kerf Width can be significantly improved in the Plasma Arc Cutting process using the optimum level of parameters.

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