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Research Paper

Experimental Study and Optimisation of the Taper by CNC Plasma ARC Cutting

Engineering

KEYWORDS : CNC, Plasma Arc, Taper, Kerfs, Cutting Speed, Standoff Distance.

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ABSTRACT

Automated CNC plasma cutting is an effective process for building complex two dimensional metallic parts in a short period of time. The research and development in the precise and accurate machining technology of hard metals (Ferrous and non-ferrous etc) is gaining much importance in the industry since last many years. Due to the tremendous competition and cost factor, the non-conventional machining technology is becoming the first choice of the engineers and technicians. In this era of advanced technological processes the CNC plasma arc machining is gaining tremendous ground in the industry. The main objective and targets of this practical experiment is based to achieve the best possible setting and parameters of operation on a CNC plasma arc machine to minimize the TAPER.

INTRODUCTION

Automated equipment and good shop layout normally improves speed, precision and quality regardless of which type of fabrication is performed. Plasma arc cutting (PAC) is a non-conventional machining process. This is most suitable for machining quite a number of metals like Mild steel, stainless steel etc. This technique is also employed for machining, field steel as well as non ferrous metals and alloys i.e. (Copper, Aluminum, Tin, magnesium and there alloys). Plasma arc machining or plasma arc cutting is a process that is used to cut precision profiles patterns, sheets of different metals by the help of a plasma torch or Plasma gun.

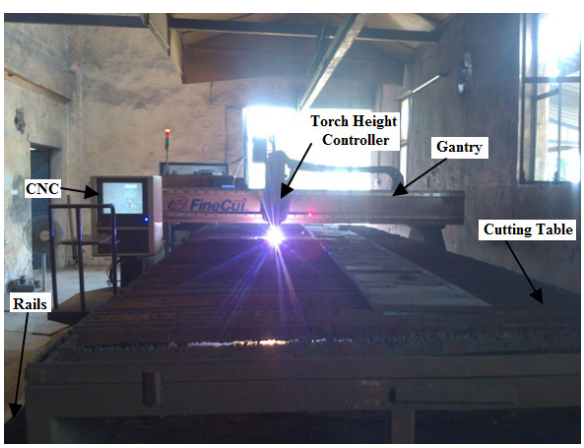

Figure 1.1 Plasma arc cutting gun

An inert gas as a mixture is blown through a nozzle at a very high speed along with an electric arc formed between the electrode and workpiece. A very high temperature is produced by the arc which is used to cut the metal by melting it and by removing away the molten metal efficiently by gas pressure. This Process is also used for plasma arc cutting, machining, welding and some other specialized applications.

OBJECTIVE

According to Taguchi philosophy the product should be designed so that it is immune to uncontrollable environmental factors. In other words, the signal (product quality) to noise (uncontrollable factors) ratio should be high. Based upon this the work was developed to study about the plasma arc cutting parameter in smooth cutting using straight polarity process. Thus the main purposes of this work are listed below:

(a) To study about the influence of Plasma Arc Cutting Parameters on Mild Steel material.
(b) To design a series of experiment using the help of Design of Experiments (DOE) layout in order to study about Plasma Arc Cutting (PAC).
(c) To study about the best combination of solution for minimize the TAPER.

EXPERIMENTATION

In this project of plasma machining, the plasma is usually initiated by a high voltage pulse which creates a conductive path for a continuous electric arc to form between the hot tungsten cathode and anode. The working gas flows around the tungsten cathode and through a constricting tube or nozzle. The temperature, in the narrow orifice around the cathode, reaches 28,000°C which is enough to produce a high-temperature plasma arc. Under these conditions, the metal being machined is very rapidly melted and vaporized. The stream of ionized gases flushes away the machining debris as a fine spray creating flow lines on the machined surface. The removal rates by this method are substantially higher than those of conventional single-point turning operation.

The effects and parametric optimization of process parameters for plasma arc cutting (PAC) of 10mm mild steel work piece. Three process parameters viz. Kerfs, cutting speed and standoff distance are considered and experiments are conducted based on L_9 orthogonal array (OA).Process response TAPER Parameters of the machined surface are measured for every experimental runs. For minimum TAPER Characteristics process parameters are optimized based on Taguchi method. Analysis of variation (ANOVA) is performed to get the contribution of each process parameter on the performance characteristics and it observed that cutting speed and kerfs are significant process parameter that affects the response i.e. TAPER.

RESULTS & DISCUSSION

Experimental design strategy, using Taguchi orthogonal arrays concept as used. The following L-9 orthogonal array was applied:

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Table 1.1 L-9 Orthogonal array with actual values

Width1	Width 2	Taper Width (W1-W2)
30.90	29.58	1.32
30.78	29.60	1.18
30.80	29.76	1.04
30.92	29.34	1.58
30.88	29.40	1.48
30.76	29.62	1.14
30.82	28.99	1.83
30.56	29.04	1.52
30.68	29.28	1.40

Observations in Taguchi Analysis: TAPER versus kerfs, cutting speed, standoff distance

The above Means graph was made using 3 variables i.e. kerfs, cutting speed and standoff distance. As observed from graph, it is clear that at 1.92 mm of kerfs, 1600 mm/min cutting speed and 5mm standoff distance gives the best output in terms of minimize the TAPER.

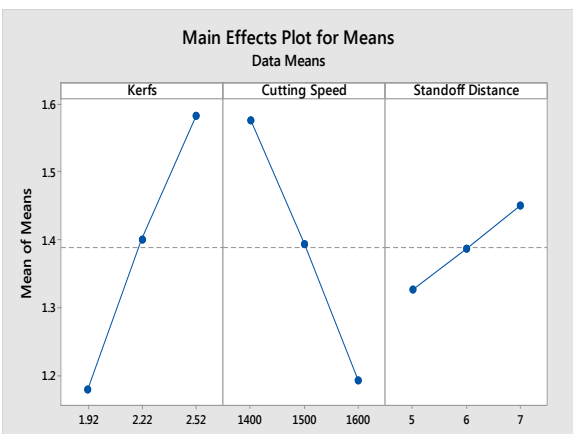

Figure 1.2 Main effects plot for Means (TAPER)

ANOVA Test results for TAPER.

Table 1.2 General linear Model (ANOVA) for Taper

Source	DF	SS	MS	F	P	Contribution %
Kerfs	2	0.2446	0.1223	355.19	0.003	50.06
Cutting speed	2	0.2205	0.1102	320.16	0.003	45.12
Standoff distance	2	0.02282	0.01141	33.13	0.029	4.66
Residual Error	2	0.00068	0.00034			
Total	8	0.48875				

From the ANOVA model for the above experimentation, the calculations are done at 95% confidence level. In an analysis of variance table, the P value determines the most significant factor. The factor whose P value is less than 0.05 will be most effective factor. The ANOVA table clearly indicates that Stand of distance parameter is not significant parameter for defining the Taper. Cutting speed and kerfs parameters are significant, means that these terms influence the model to a great extent. Kerf has the greatest effect on TAPER and is followed by cutting speed and Standoff distance.

General Regression equation for TAPER versus Kerfs, Cutting speed and Standoff distance

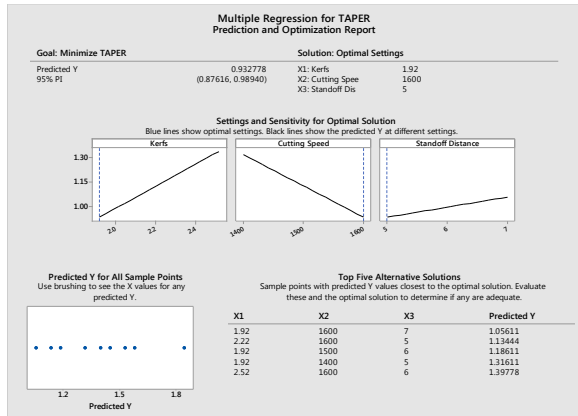

Figure 1.3 Multiple Regressions for TAPER (Prediction and optimization report)

The above figure 1.3 indicate that the optimal settings for minimize the TAPER.

The equation has been formed with the help of software MINITAB version 17, the equation is given below.

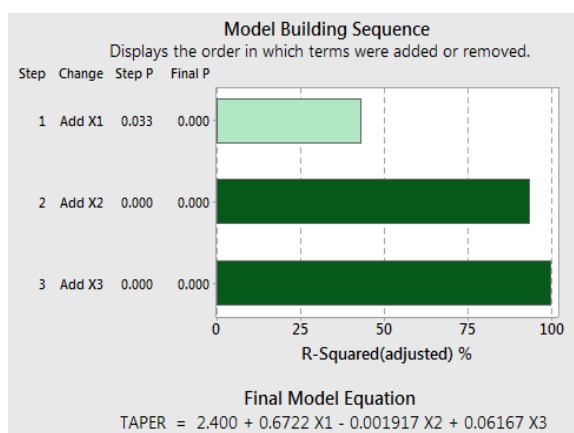

Figure 1.4: Model Equation

Model Adequacy Check: The P- value of Regression equation (0.050) indicates that the regression model is significant. The coefficient of determination (R2) which indicates the goodness of fit for the model so the value of R2 =**99.69**% which indicate the high significance of the model.

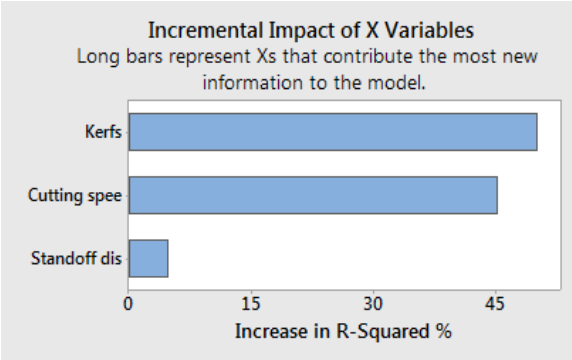

Figure 1.5: Impact of variables

OPTIMIZED PARAMETERS COMBINATION

As Taper is the "Smaller is better" type quality type characteristic, from the figure1.2 it can be seen that the first level of kerfs(A1), third level of Cutting speed (B3) and first level of Standoff distance (C1) results in minimum value of Taper.

Table 1.3 Optimal value of TAPER.

Sr. no.	kerfs	Cutting speed	Standoff distance	TAPER
1	1.92	1600	5	0.931774

CONTOUR PLOTS FOR TAPER

Contours along with three dimensional surfaces are shown in figure 1.6, 1.7 and 1.8 with the help of these contours the value of response can be calculated at any point in the designed region. The figure 1.6 shows the response Taper between kerfs and cutting speed. In this the other parameter Stand of distance kept constant to the smaller value. Figure 1.7 shows response Taper between the Cutting speed and Standoff distance. In this the other parameter applied Kerfs constant to the smaller value. Figure 1.8 shows response Taper between the kerfs and Standoff distance. In this the other parameter applied cutting speed constant to the smaller value.

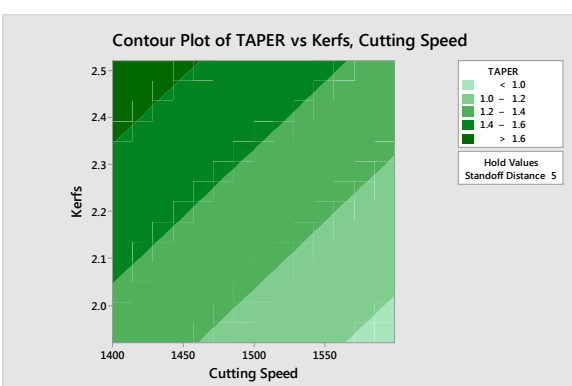

Figure 1.6 Contour plot of TAPER for Kerfs and Cutting speed

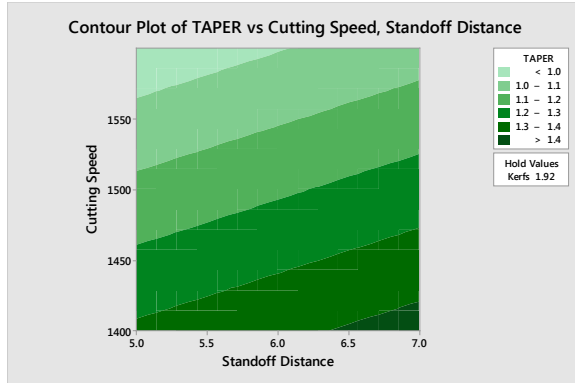

Fig1.7 Contour plot of Taper for Cutting speed and Standoff distance

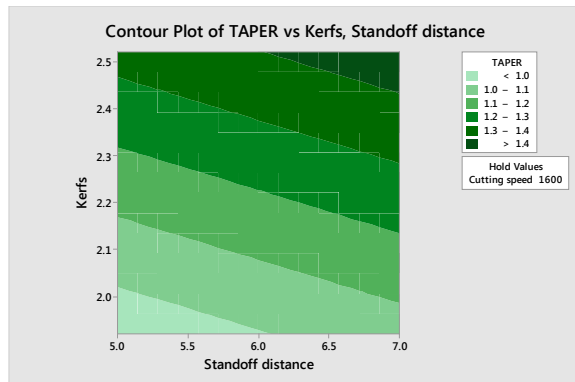

Figure 1.8 Contour plot of Taper for Kerfs and Standoff distance

CONCLUSION

This work presents an application of the Taguchi method to the optimization of the machining parameters of CNC Plasma Arc Cutting Machine. Taguchi method lays emphasis on fact that quality is best achieved by minimizing the deviation from a target. It has been shown that TAPER can be significantly improved in the CNC Plasma Arc Cutting process using the optimum level of parameters. From experimental analysis done on MILD STEEL, it was concluded that:

[1] In CNC plasma arc machining the cutting Speed and kerfs is the parameter has a significant effect whereas the other parameters viz. standoff distance is less effective.

[2] The steam as the plasma gas will generate more energy than other gases for the same current value and the plasma jet generated is much narrowed when Oxygen and air is used as plasma gases.

[3] For Minimize TAPER the cutting speed and kerfs play a very important role. Smaller the value kerfs and higher the value of cutting speed, smaller is the TAPER.

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