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Review Article

Parameters Effectuating Machining Characteristics of Plasma Arc Cutting: A Brief Review

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A B S T R A C T

The selection and management of input process parameters is a frequent problem for Plasma Arc Cutting (PAC) during the cutting of mild steel, which affects the material removal rate. In various industrial sectors, PAC is widely applicable for carbon steel, aluminum, and stainless steel, etc. In the current paper, a comprehensive review was carried out on developments in this process in context to the selection of the most effective input parameters which affect the production rate and MRR. Herein, the experimental studies reviewed have exhibited that the most effective parameter for optimization in PAC is cutting speed, kerf width, and stand-off distance.

Keywords: Plasma Arc Cutting, Material Removal Rate, Process parameters, Kerf width

Introduction

Plasma Arc Cutting (PAC) is a non-conventional process developed for cutting difficult-to-cut materials such as mild steel, copper, tin, magnesium, etc. The study aims to gather different studies from the published papers and to highlight significant factors that affect the material removal rate while using water jet Plasma Arc Cutting.

Plasma Arc Cutting (PAC) is a non-conventional process which can perform several electrically conducting materials, stainless steel, aluminum, and its alloys, magnesium, titanium alloys, manganese steel, and cast iron. Plasma cutting process is invented about 30 years ago for processing hard and difficult to machine materials. The principle of the PAC is shown in Figure 1.

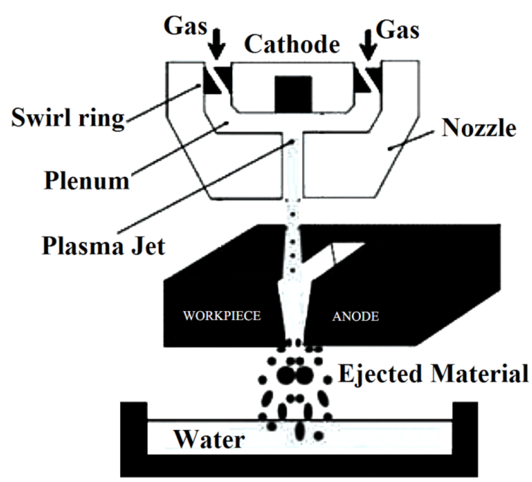

Figure 1.Principle of PAC (Cinar et al. 2000)

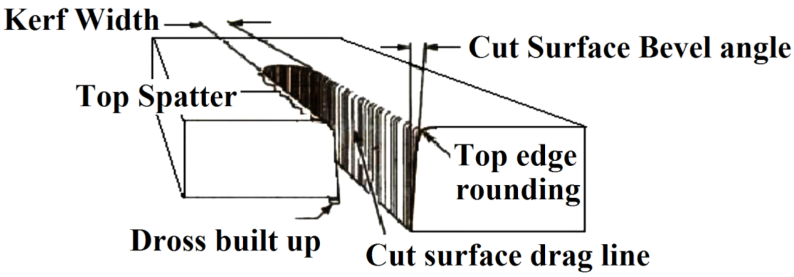

Figure 2.Quality Characteristics of Plasma Arc Cutting Process

Table I

Sr. No.	Author	Problem Statement/ Title	Material/ Steel Grade	Method	Findings
1	R. Bini et al. in 2008 [1]	Experimental study of the features of the kerf generated by a 200 A high tolerance plasma arc cutting system	15 mm thick mild steel sheets metal	A high tolerance plasma arc cutting (HTPAC) system of 200 A was utilized to cut the plates	The results showed that the cutting impact depended on the thickness of the sheet also
2	E. Gariboldi et al in 2005 [2]	High tolerance plasma arc cutting of commercially pure titanium	5 mm thick titanium	High tolerance plasma arc cutting (HTPAC) process	The feed rate was altered in different experiments and it was found that kerf width was at the optimum best at most occasion because of the oxidation reactions of the plasma gas
3	Joseph C. Chen et al in 2015 [3]	Deposition of large area high-quality diamond wafers with high growth rate by DC arc plasma jet	Diamond wafers	Used Taguchi parameter design and conducted 36 experiments to determine the significant factors	The results showed that cutting speed has the most impact followed by the other parameters based on the equipment and the workpiece
4	Hardik Dholakiya et al. in 2015 [4]	Parametric study on plasma arc cutting of Al – 6063	Al – 6063	Process performance data for various parameters was analyzed using ANOVA	The results showed that the arc length increases with the increase of export pressure
5	Narimanyan, A et al. in 2009 [5]	Unilateral conditions modelling the cut front during Plasma cutting	Thin films of TiAlSiN	Used Taguchi methods for optimizing the plasma arc cutting process	The results indicate that cutting speed and kerf width are both interlinked and should be considered to be significant parameters

6	G. Cantoro aet al. in 2008 [7]	Plasma arc cutting technology: simulation and experiments	Mild steel thin plates (thickness in the range 1-3mm)	Transferred plasma arc torches	The result showed good level of optimization in the initial piercing and cutting phases
7	Janish A. et al. in 2019 [8]	Experimental Investigation on Effect of Plasma Arc Cutting Parameters on SS304 by Full Factorial Design	SS 304 Material having the density 8.03 g/cm3	Regression analysis has been used to develop empirical models	The results showed that Material removal rate should always be maximum, i.e. the value as high as possible
8	Abdul H. et al. in 2014[9]	Optimization of process parameters and quality results using plasma arc cutting in aluminum alloy	Al-Mg (seri5000)	Taguchi method and Gray Relational Analysis with the orthogonal array L9 design selection	The result showed that cutting current dominated all the process parameters
9	Sovan B et al. in 2017 [10]	Experimental study of plasma arc cutting of AISI 304 stainless steel	AISI 304 stainless steel	Analysis of variance has been used to obtain these results	The results proved that seed and thickness are significant parameters
10	Rotundo F. et al. in 2012 [11]	Plasma arc cutting: Microstructural modifications of hafnium cathodes during first cycles	Hafnium cathodes	The erosion of the cathodes was studied through scanning electron microscopy (SEM)	The deposition of the oxide layer was observed to be increasing as the number of cutting cycles increased

Literature Survey

A literature review was made of all the literature available, and the following were the findings related to them:

The material removal rate, MRR, can be defined as the volume of material removed divided by the machining time. Material Removal Rate (MRR) is defined by:

MRR = WRW/T [g/min]

The dominant parameters affecting MRR in the cutting process based on PAC as observed from Table 1 are following.

Cutting Speed: It is one of the important input parameters. The Cutting 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. The cutting quality is also depending upon the workpiece thickness and hardness. Every material has its properties and compositions, so the cutting speed depends on it.

Stand of distance: It is the gap between the plasma arc cutter torches with the workpiece.

Kerf width: The width of the material removed by the cutting process.

Conclusion

From the above literature, it is very clear that the 3 most significant parameters for Plasma Arc Cutting are cutting speed, kerf width, and stand-off distance. Cutting speed has the greatest effect on MRR and is followed by Stand of distance and Kerf.

Over the years, many techniques are applied to analyze PAC and its key parameters and their effects. Most researchers have applied Taguchi as the most common technique from 2000 to 2017; however, there is still room for the application of other DOE methods. Application of DOE can sufficiently help in estimating the main effects of the key parameters, addressing the influence of noise variables, generating Response surface models for optimization, and last but not the least, in reducing the number of experiments, thereby reducing the cost of experimentation.

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