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A BRIEF REVIEW ON PLASMA ARC MACHINING

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Abstract:

Technology today in metal cutting process require high quality cut surfaces and good dimensional correctness without further operation. Plasma arc cutting process does high temperature and high velocity contracted arc via a amount of gas between the electrode and the work material to be engrave. There are a variety of process parameters such as arc voltage, arc current, gas pressure, cutting speed, standoff distance and gas flow rate that affect the quality distinctiveness of plasma cut like kerf generated, bevel angle, heat affected zone (HAZ) and surface finish. In this paper, Plasma Arc Cutting (PAC) shows the Cutting Speed (mm/Sec.), Current (A), Pressure (bar) on SS304 Material having the density 8.03 g/cm3. In this Experiment we have done Experiment by using full factorial design methods and regression analysis equation for Surface Roughness by performing cuts of different run sets of L27 orthogonal Array to find out optimal run set of Speed, Current, Pressure which gives the smooth surface. The regression analysis has been used for the development of empirical models able to describe the effect of the process parameters on the quality of cutting.And also evaluated the machining parameters of hot turning of stainless steel by applying ANN and RSM and found that the turned part were incorporated into ANN-based Neurointelligence software package and design expert. Here we determined the grey grade values using Grey Relation Analysis.

*Keywords:*PAM, Parameters, Machining, Quality Characteristic

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1. Introduction:

In plasma arc Machining a plasma gas used as a heat resource. Plasma is a state of a substance which obtained by supply an incredible amount of energy to any gas or when a gas subjected to a high electric field.older stage it was used to pertain for the few materials such as high alloy steel and aluminum but nowadays, it used to cut a number of materials such as Stainless steel, magnesium, titanium alloys, copper, manganese steel, aluminum and its alloys and cast iron including non- alloy and low alloy steels due to its narrow heat affected zone and high cutting speed.Plasma arc cutting process uses a constricted arc formed by plasma gas as a heat source. In this process, an electric arc produced between the electrode and the work piece, where the electrode acts as a cathode and work piece taken as anode.

The plasma gas expands with the high speed through the nozzle simultaneously when an electric current passes through this gas with the assistance of tungsten electrode because of which a high-intensity plasma arc is generated. This plasma arc is then passed on to the surface which is to be cut by turning some of the gas to the plasma. This plasma arc possess energy which will melt or vaporize the surface that is to be cut and travel very fast and flows the molten metal away from the cut. A space is there in plasma arc nozzle between the outer periphery of the electrode and an inner periphery of the nozzle in which the plasma gas gets ionized and heated which makes the plasma to expand in pressure and volume largely. Thus plasma gas flows out of the nozzle with very high temperature and high velocity.

2.Literature Review:

More Reasearch work done in the Area of Plasma Arc Machining. the characteristics of Machining parameters were analysed S.S.Pawar and K. H. Inamdar(2017) The quality cut measured by out responses Kerf width and tapper. Various thickness of the material has been measured and compared. The optimized parameter identified by the help of ANOVA .In this paper concluded arc voltage influencing parameter affects kerf followed by cutting speed, and gas pressure. Aristidis Tsiolikas et.al.(2016) Discusses the Analysis of means and analysis of variances confirms that all parameters change about equal the surface roughness of the operational surface. ANOVA analysis declares that the noise factors root bigger variance than that of the process parameters. B.Venugopal et.al.(2016) A mathematical model has been developed using response surface analysis for surface roughness (Ra) and metal removal rate (MRR) were verified using collected results from the experimental work. Response surface methodology (RSM) & Grey Taguchi (GT) are used to optimize machining parameters while Plasma arc machining of SS420 material. Grey taguchi technique is used for optimal process parameters for obtaining minimum Ra and maximum MRR simultaneously. The optimal setting for obtaining minimum Ra and maximum MRR are 100 Amp cutting current, 1300 mm/min cutting speed and 4 mm torch height.. H.Ravi kumar and S.Thileepan(2015) The Grey based TOPSIS analysis (GTA) method was capable in designing the optimal setting of cutting parameters for 21Cr ferritic stainless steel as - air pressure 5.5 bar, cutting speed 1000 mm/min, arc current: 60 A and stand-off distance 1 mm using Plasma Arc Cutting process. This operating condition had considerably enhanced the S/N ratio, thereby improving the performance characteristics. ANOVA was performed on Grey TOPSIS index GTI to disclose the major cutting parameters affecting the responses as

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cutting speed (46.88%), arc current (27.60%) and air pressure (14.92%).Renangi.Sandeep(2015) The process parameters are cutting current, cutting speed and torch height. The special effects of process parameters on responses, it is denotes Ra increases when increasing cutting current, Ra decreases when increasing cutting speed and torch height. ANOVA concluded that the cutting speed has been more control parameter on Surface roughness and MRR. Gurwinder Singh and Shalom Akhai (2015) CNC plasma arc machining the cutting Speed is the parameter has an important effect on MRR ,Kerf. The cutting speed is inversely proportional to the Taper and kerf is directly proportional to the Taper. Shane Fatima et.al. (2015) The Author optimize the process parameters of plasma arc welding for welding of dissimilar metals like austenitic stainless steel SS-304 L and low carbon steel A-36.Martensitic structure is initiate in the weld zone of directly welded sample and the weld joint joined with filler wire E309L is mixed and consist of austenite, ferrite and martensitic structure. Tensile test discovered that sample broke from CS(carbon Steel) side which established that weld joint is stronger than base metal. S.Siva Teja et.al(2015) He concluded from the analysis, it is established that the most considerable parameters that influence the plasma arc cutting process are plate thickness and current. J.Kechagias et.al(2014) The experimental design concluded that the arc current is the most important parameter that affects the right bevel angle by 58.7%. The torch standoff distances influence the right bevel angle by 15.7% and the cutting speed 19%.K. P. Maity andDilip Kumar Bagal(2014) Response surface method together with grey relational analysis and principal component analysis used to optimize plasma arc cutting processes with multi-objective criteria. Torch height with feed rate is the most influencing parameters in plasma arc cutting machining. R. Adalarasan et.al. (2014) the quality uniqueness of the cut surface were examined by measuring the surface roughness and kerf width though cutting the 304 L stainless steel. The experimental trials were planned by Taguchi's L18 orthogonal array different design used with conventional response surface methodology (RSM), and an included approach of Grey Taguchi-based response surface methodology (GTRSM) was shown for predict the best achievable combination of cutting parameters. A lower value of arc current was found to produce better responses as the increase in thermal content of the arc at higher amperage (60A) was identified to destroy the surface finish and raise the kerf width. Similarly, a lower level of stand-off distance (2 mm) was identified to produce an improved cut surface. Milan Kumar Das et.al(2014) investigation on the optimization and the consequence of machining parameters on MRR and surface roughness uniqueness in plasma arc cutting (PAC) of EN31 steel using Taguchi OA with grey relational analysis.ANOVA Results Shows that, the highly effective parameters is gas pressure, while arc current and torch height are not as much of effective factors. MRR is proportional to gas pressure and surface roughness is proportional to arc current. Yahya Hısman Celik (2013) The current and arc voltage for thin sheets must be low and cutting speed must be high to get the greatest surface roughness, reduce hardness increase. The current increased, and the arc voltage decreased as the thickness of the material to be cut increases. At lesser cutting speed conditions, the surface being cut is showing under high temperature for a longer time. Especially, the results that we obtained surface roughness can decrease by reducing cutting speeds. HAZ increases when cutting speeds decrease. Kulvinder Rana et.al(2013) The current has maximum effect on the process afterward torch moving speed and stand-off distance and air pressure have minimum effect on the process. PAC also be used to cut ceramic which results in high accuracy and less cost. Subbarao Chamarthi et.al(2013) Cutting speed increase or decrease inversely proportional thickness of plate. The cutting speed reduces results in an unnecessary amount of molten metal which cannot be

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entirely removed by the thrust of the plasma jet. the arc voltage is main parameter and it influence all the aspect connected with the cut quality sooner than the outcome on the arc power, further than the arc voltage the cutting speed showed a evident effect. Cebeli Özek et.al(2012) The statistical analysis of variance proved that the majority significant factor on surface roughness was cutting speed, while the plasma arc current was the slightest. Good surfaces were attained by escalating cutting speed and thickness of the cut material. R. Bhuvenesh et.al(2012) the SR values are inversely proportional to the MRR values. The dimensions of the dross decide the quality of plasma arc cutting in terms of surface roughness K. Salonitis and S. Vatousianos (2012)the surface roughness and the conicity are mainly affected by the cutting height.the heat affected zone is mainly prejudiced by the cutting current. M.I.S. Ismail and Z. Taha (2011), The surface roughness in plasma arc surface hardening prove that the arc current is most dominant factor, which confirm a contribution rate of 66.91 %. The second is the carbon content at 20.76 %, and scanning velocity at 11.44 %. Sanda-Maria Ilii et.al(2010), all the factors have an influence on the final results of the cut, less the material thickness which has a lower influence on the Ra parameter. John Kechagias et.al(2010), Accurate predictions of the bevel angle can be attained inside the experimental region, through the trained FFBP-ANN

3.Result and Discussion:

Many researchers studied the Plasma Arc Machining process with different process parameters, different material and different mathematical methods. Some of them are listed below:

Table .1 Parameters and responses

S.No.	Paper title	Year	Parameters	Material	Responses
1.	Experimental Analysis of Plasma Arc Cutting Process for SS 316l Plates	2017	cutting speed, arc voltage and gas pressure	Stainless Steel 316L 4 mm, 8 mm and 12 mm	kerf
2.	Optimization of cut surface quality during CNC Plasma Arc Cutting process	2016	cutting speed, cutting height and arc voltage	St37 carbon steel (mild steel) 16mm thickness sheets	surface roughness

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3.	Experimental Investigation and Optimization of Process Parameters in Plasma Arc Cutting Process	2016	cutting current, cutting speed and torch height	SS420 170x170x10 thickness	surface roughness (Ra) and metal removal rate (MRR)
4.	Analysis in plasma arc cutting of 21Cr ferritic stainless steel	2015	arc current, cutting speed, stand-off distance and gas pressure	21Cr ferritic stainless steel 300 mm x 300 mm x 5 mm	surface roughness and bevel angle
5.	Multi objective optimization of process parameters in plasma arc cutting of SS 420 using Grey-Taguchi analysis	2015	cutting current, cutting speed and Torch height	stainless steel (SS) 420 of 10 mm thickness	Surface roughness (Ra) and Material removal rate (MRR)
6.	Analysis Of Process Parameters And Their Optimization Of CNC Plasma Arc Cutting	2015	Kerfs, cutting speed and standoff distance	10mm mild steel plate	Maximum material removal rate
7.	Optimization of process parameters for plasma arc welding of austenitic stainless steel (304 L) with low carbon steel (A-36)	2015	Current, Speed	stainless steel SS-304 L and low carbon steel A-36 100x50x2mm	Heat Affected Zone

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8.	Experimental Investigations to Study the Impact of Machining Parameters on Mild Steel Using Plasma Arc Cutting	2015	current, voltage, speed, plate thickness	Mild steel	surface roughness, kerf
9.	On the multi – parameter optimization of CNC plasma-arc cutting process quality indicators using Taguchi Design of Experiments	2014	cutting speed, arc ampere, pierce height, and torch standoff distance	St37 mild steel plates	surface roughness
10.	Effect of process parameters on cut quality of stainless steel of plasma arc cutting using hybrid approach	2014	feed rate, current, voltage and torch height	AISI 316 stainless steel 120 mm thickness	kerf, chamfer, dross, surface roughness and material removal rate
11.	Application of Grey Taguchi-based response surface methodology (GT-RSM) for optimizing the plasma arc cutting parameters of 304L stainless steel	2014	Arc current, torch stand-off, cutting speed and gas pressure	304L stainless steel 600 mm×600 mm×5 mm	surface roughness and kerf width

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12.	Optimization of Process Parameters in Plasma Arc Cutting of EN 31 Steel Based on MRR and Multiple Roughness Characteristics Using Grey Relational Analysis	2014	gas pressure, arc current and torch height	10mm thick EN31	material removal rate (MRR) and surface roughness parameters (centre line average roughness: R_a, root mean square: R_{ci}, skewness: R_sk, kurtosis: R_sk and mean line peak spacing: R_{sm})
13.	Investigating the Effects of Cutting Parameters on Materials Cut in CNC Plasma	2013	cutting speeds, amperes, and arc voltage	S235JR sheet materials (4, 6, and 8mm thick),	thickness of heat-affected zone (HAZ), surface roughness, and hardness
14.	Optimization of plasma arc cutting by applying Taguchi Method	2013	current, air pressure, stand-off distance, and torch travelling speed	mild steel sheet with 10 mm thickness	Heat Affected Zone
15.	Investigation Analysis of Plasma arc cutting Parameters on the Unevenness surface of Hardox-400 material	2013	Cutting speed, Plasma Flow rate, Voltage	12mm thick hardox-400	unevenness
16.	A Fuzzy Model for Predicting Surface Roughness in Plasma Arc Cutting of AISI 4140 Steel	2012	arc current, cutting speed, and thickness of cut material	AISI 4140 Thickness 6 ,8 ,10, 12, 15 mm	surface roughness

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17.	Surface Roughness and MRR Effect on Manual Plasma Arc Cutting Machining	2012	Air pressure, Cutting current, Cutting speed, Arc gap.	AISI 1017 Steel of 200 mm x100 mm x 6 mm	surface roughness
18.	Experimental Investigation of the Plasma Arc Cutting Process	2012	cutting power, scanning speed, cutting height and plasma gas pressure.	15mm thick S235 MS sheet	kerf taper angle (conicity), the edge roughness and the size of the heat-affected zone (HAZ).
19.	Experimental Design and Performance Analysis in Plasma Arc Surface Hardening	2011	arc current, scanning velocity and carbon content of steel	ASSAB 618, ASSAB DF3 60 x 40 x 10 mm	surface roughness
20.	Experimental Results Concerning The Variation Of Surface Roughness Parameter (Ra) At Plasma Arc Cutting Of A Stainless Steel Work piece	2010	cutting speed material thickness and current intensity of plasma arc	AISI 304 stainless steel 4, 6	surface roughness
21.	An ANN Approach On The Optimization Of The Cutting Parameters During CNC Plasma-Arc Cutting	2010	Plate thickness, cutting speed, arc ampere, and torch standoff distance	St37 mild steel Two plates of 6.5mm and 10mm thickness	Bevel angle.

From The above table we found that most of Researcher concentrated on surface roughness and kerf .Few authors focused on HAZ effect on the Process.

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4. Conclusion:

Many researches are being carried in the area of plasma arc machining. But still there is scope for improvement seen. It is studied that the output response is influenced by the process parameters. It is observed that the current has maximum effect on the process. Moving speed of torch, air pressure and stand-off distance have minimum effect on the process. PAC can be used to even cut ceramic which results in less cost and high accuracy. Current, cutting speed, arc height and pressure are varied to obtain less roughness and high hardness properties with less machining time. Also it is observed that lower value of arc current produces good responses as the increase in thermal content of the arc at higher amperage (60A) is seen to affect the surface finish and increasese the kerf width.

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