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# A Review Paper on Optimization of Influence Parameter of EN-45A Material using Plasma Arc Cutting Machine

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**Abstract -** *In the previous few decade years, there has been a huge amount of machining research and technological advancement. With the increase in market competition and the need for high accuracy, non-conventional machining is currently becoming the lifeline of any sector. Plasma Arc Machining is one of the most important non-conventional machining processes. Its great accuracy, capacity to finish machining any hard material, and ability to manufacture complicated shapes all contribute to its market demand.*

*The aim of this review paper is to determine the effects of various process variables on the machinability of EN-45A material using the Plasma Arc Cutting Process, as well as the optimum condition (best setting) for achieving maximum Material removal rate (MRR) and minimum Surface roughness (S.R), Kerf width (K.W), and Bevel angle (B.A). Cutting is possible using a plasma arc cutting machine by varying process parameters such as cutting speed, arc current, stand-off-distance, and plasma gas pressure to obtain changes in reaction variables such as surface roughness, bevel angle, Kerf width, and material removal rate.*

***Key Words***: *Plasma Arc Cutting Process and Simple Additive Weighting (*SAW).

## 1. INTRODUCTION

The current work covers experimental research and optimization of Plasma Arc Cutting process parameters for EN-45A material. The emphasis of the research is on the machinability of the EN-45A material in order to find out the influence of various process factors and also the optimal condition (best setting) to get maximum material removal rate and minimal surface roughness (SR), Kerf width (KW) and bevel angle (degree).

Modem industries rely on heavy metal handling using alloys. The machining of raw materials to specified components for the production of infrastructure and machine equipment is done using several cutting processes. Cutting Plasma Arc (PAC) was mainly used to cut stainless steel and aluminium alloys, invented in the mid 1950's. Plasma is the most energized of the four states of matter. Plasma resembles and acts like a high-temperature gas, yet it can carry electricity[1].

The fourth state of affairs, plasma, appears like a high temperature rubber, which has an essential distinction; the electricity is supplied. The plane arc is formed when an electrical arc heats any gas to a very high temperature, causing its atoms to become ionized (an electrically charged gas with an uneven number of protons and electrons) and allowing it to conduct electricity. The main distinction between a neutral gas and plasma is that plasma particles may interact with one another via electromagnetic forces [2].

### *What is Plasma?*

Plasma is sometimes referred to as the "fourth state of matter." Solid, liquid, and gas are the three states of matter that we are most familiar with. Ice, water, and steam are the three states of the most well-known material, water. When you add heat energy to ice, it transforms from a solid to a liquid, and when you add even more heat, it transforms into a gas (steam). If considerable heat is applied to a gas, it becomes the fourth state of matter from gas to plasma.

### *Plasma Arc Cutting*

To begin the cutting operation, a pilot arc is ignited by high voltage between the nozzle and the cathode. The ionization parts prepare a low-energy pilot arc that connects the plasma torch and the work piece. When the pilot arc comes into contact with the work piece (flying cutting, flying piercing), the main arc automatically increases in power. The basic premise is that a fine bore, a copper nozzle, creates the arc between the electrode and the work piece. The temperature and velocity of the plasma ejected from the nozzle are both increased as a result of this system. The plasma's temperature may be boosted to 20,000 degrees Celsius, and its velocity can approach that of sound. The plasma gas flow is raised when cutting so that the deeply penetrating plasma jet cuts through the material and the molten material is removed in the efflux plasma [3].

***Plasma Arc Cutting System***

Cutting plasma arcs can enhance both sheet and metal cutting operations speed and efficiency. High-volume machinery, heavy machinery, aviation components, air handling equipment and many other items manufacturers have found their advantages. Plasma Arc Cutter is made up of eight main components: an air compressor, an AC power supply, a plasma torch, a ground clamp, an electrode, a nozzle, and a work piece.

## 2. LITERATURE REVIEW

There is a lot of Analysis literature available. The literature review presented here in the field of plasma cutting, several researchers worked on this subject and the following aspects were considered:

***Experimental analysis of plasma cutting:***

The effect of a $345 thermal cutting and chemical composition, $390 of material, were researched by **Tinglev A.K. et. al. [4]**. Based on experimental findings, the structural and chemical compositions of the underlying steel brands, most notably the oxy-fuel cutting process, are modified by thermal cutting (in a very limited region of the workpiece adjacent to the cutting area). They also determined that the technique of plasma trimming is the most recommended trimming process in terms of minimized the impact in cutting the quality of work piece edges created from steels S345, 5390.This cutting method practically does not differ in terms of content of the main alloying elements except for the content of Carbon from regulations governing both brands of steel, and the value and equivalent of carbon content does not exceed 0.45 percent, indicating that no limits are placed on its weldability.

The structural variances of AISI 304 and of St. 52 steel plates following plasma-arc cutting were examined by **Gulla A. and Atici U.[5]**. Vickers hardness and digital optical microscope estimated the HAZ and hardness of the materials. It has been found that hardness at the outside surface has been raised and reduced near the inner materials, which is affected by high temperature.

**Akkurt A. [6]** examined the effects of various cutting techniques on pure and Al 6061 Aluminium alloy microstructure and hardness. The Al 6061 material was cut by plasma, saw, milling, oxy-fuel in this investigation of pure aluminium and aluminium alloy. Machines for electronic discharge, submerged plasma, laser, abrasive water jet and wire and then hardness, and microstructures have explored changes in cuts that occurred with different procedures. During cutting the materials, microstructural changes were seen in all cutting methods other than abrasive water jet cutting processes. Oxy-fuel cutting results in the most structural changes after cutting in the size of grain compared to other thermal cutting operations due to extreme heat inputs.

The research and determination of the most essential parameters such as HAZ, conicity and surface roughness, etc., which affect oxygen plasma cutting quality was undertaken by **Salomitis K and Valusianos S. [7]**. 235 mild steel panels, plasma oxygen (primary) gas and air were sliced into protection during this investigation 235 mm thickness (secondary). The key parameters of the analysis are cutting velocity, height cutting, current and plasma gas flow rate and their impact on cutting quality is examined. Cut quality was evaluated with regard to the ruggedness, conicity (edge inclination) and HAZ of the cut-edge surface.

***Optimization of various parameters in plasma cutting process:***

The experiment was carried out by **Thilak M. et al. [8]** to optimize process parameters utilizing the plasma arc processing material Stainless Steel 316L (SS316 L). Different parameters were used in this experiment, such as gas pressure, current, speed and art gap, for achieving a wide variety of reaction rates, kerf width and working time. Optimal findings were acquired by the Gray relation analysis (GRA) approach with the use of ANOVA table and main effects. The parameters such as current and pressure were shown to play a key part in machining.

**I.Y.L. et. al. [9]** performed a roundness experiment using the Taguchi method, to maximize the rounding of the troughs. Thirty-six tests were conducted using the L9 array with 81 (four factors with three caches i.e. 3^4) parameter combinations. The experiment was conducted for the two reaction variables: the first was a smaller diameter deviation from the hole and the other is the smallest. Using the Taguchi approach, they proposed the various combination of optimization parameters, checked with 30 work pieces in a confirmation run.

In order to investigate the impact as well as optimize machining parameters on a plasma cutting mild steel material, **Teja S. S. et. al. [10]** conducted experiments. In order to analyze the breadth and roughness of the fuselage, Taguchi, GRA and ANOVA were used to determine the best combination of cutting speed, voltage, current and plate thickness. The major criteria affecting plasma arc cutting procedure were the thickness of the platform followed by cutting current.

## 3. OPTIMIZATION METHODOLOGY USING PLASMA ARC CUTTING MACHINE

Designed experiments can be used in industry to systematically evaluate the process of product variables that affect product quality. The researcher is interested in the effect of a procedure or investigation when designing experiments. In any firm, increasing productivity and enhancing quality are vital objectives. The methodology for identifying how to improve productivity and quality is changing. The design of experiments (DOE) is a time-saving method for arranging tests and analyzing the results to arrive at valid and objective findings. DOE begins with identifying the experiment's goals and selecting the study's process variables. Experimental Design is the preparation of a precise experimental strategy prior to conducting the experiment.

The term "experiment" is defined as an investigation in which the system under examination is within the investigator's control. This indicates that an experiment is a procedure in which we make deliberate modifications to the input variables of a process or system in order to monitor and discover the causes of changes in the output response. A number of experiments are required to investigate or learn something about any process in order to identify the response of desired output in the presence of enormous input. As a result, the phrase Design of Experiments (DOE) is a widely used strategy all over the world for reducing the number of experiments and obtaining high-quality research. The goal of the paper design is to plan, design, and analyze experimental activity such that objective findings may be drawn quickly and effectively.

**Steps of Design of Experiment**

Designed experiments are usually carried into different stages. For the current study whole work has been divided into following stages as shown below:

Planning

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Screening

↓

Experimental analysis

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Optimization using Numerical Techniques

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Validation of results

***Selection of Material*** The material EN-45A, a medium alloy carbon steel with good hardness, fatigue strength, and compressive strength, was chosen for this study. It is widely utilised in the automobile industry, particularly in the manufacture of leaf springs, as well as in machine construction. Table 3.1 shows the chemical make-up of this substance.

Table 3.1 EN-45A material chemical composition

| S. No. | Element | Volume % |
|---|---|---|
| 1 | P | 0.0482 |
| 2 | Si | 1.911 |
| 3 | Mn | 0.861 |
| 4 | C | 0.577 |
| 5 | S | 0.0494 |
| 6 | Cr | 0.141 |
| 7 | Mo | 0.0112 |
| 8 | W | 0.0150 |
| 9 | Co | 0.0074 |

EN-45A material is known as Manganese-Silicon steel and its also known as Spring steel. EN-45A is widely utilized in the automotive sector and a variety of other engineering applications.

***Planning*** Before beginning the process of testing and data gathering, it is critical to properly outline the path of the experiment. A detailed and precise aim outlining the necessity to undertake the inquiry, assessment of time and resources available to fulfill the objective, and integration of existing knowledge connected to the experimentation technique are just a few of the things to bear in mind at this stage. Identifying possible elements to study and the most relevant response(s) to measure should be done by a team comprised of professionals from several disciplines related to the product or process. The team approach fosters synergy, resulting in a more diverse set of factors to investigate and, as a result, a more comprehensive experiment. A well-thought-out perimeter always results in a better understanding of the product or process. Experiments that are well-planned are simple to carry out and analyze. Experiments gone wrong, on the other hand, might provide data sets that are inconclusive and difficult to evaluate, even with the best statistical methods available.

***Screening*** Out of a broad pool of potential components, screening studies are performed to find the relevant factors that affect the process under investigation. . These experiments are carried out in conjunction with prior process information in order to minimize insignificant aspects and focus attention on the crucial factors that require more extensive analysis. Screening trials are usually quick and easy to run, with the goal of discovering the most important few components rather than interactions.

***Experimental Analysis*** After planning and screening, the experimental analysis comes next. The effect of various factors on process response variables is investigated using experimental analysis. Surface roughness, bevel angle, kerf breadth, and material removal rate are four response variables that are dependent on four input parameters: cutting speed, cutting current, stand-off-distance, and plasma gas pressure in the current investigation.

***Optimization Technique*** Once the essential elements affecting the process have been identified, the following step is to find the optimum values for these factors in order to achieve the intended outcome. This goal may be to enhance yield or decrease variability, or to attain values that achieve both at the same time, depending on the product or process under consideration.

***Simple Additive Weighting (SAW)*** The current study used the Simple Additive Weighting (SAW) method to determine the best values for various input process parameters.

The most well-known and extensively utilized Multi Attribute Decision Making (MADM) approach is the Simple Additive Weighting (SAW) method. The SAW approach, also known as the Scoring Method, is one of the best and most straightforward methods for making multiple attribute decisions. . The SAW approach works by calculating a weighted sum of each alternative's performance ratings across all criteria. The weighted average is used in this procedure.

***Validation of Results*** After experimental analysis work and optimization, the next step in design of experiment is to check the validation of these results. This can be done by following ways: either by carrying out same experiments for a number of times and then comparing the results obtained by different experiments or by using numerical techniques.

## 4. RESULTS AND DISCUSSION

The objectives of this publication is to look at the impact of various input process parameters on various response variables, as well as to determine the optimum condition (best setup) of the Plasma Are Cutting Machine for minimizing Surface Roughness (Ra), Bevel angle, and Kerf while optimizing MRR.

Cutting Speed, Current Flow Rate, Stand-off-distance, and Plasma Gas Pressure have all been identified as critical characteristics in a literature review. Surface Roughness experiment findings and numerous reaction graphs (Ra). Bevel angle, Kerf width and MRR have been obtained and there optimum values have been analyzed

The major goal of this publication is to look at the effects of various process parameters on the response variables, such as Surface Roughness, Bevel Angle, Kerf width, and Material Removal Rate, as well as to determine the best parameter values for maximizing M.R.R while reducing the other three. This study took into account four input process parameters: cutting speed, current, stand-off distance, and plasma gas pressure.

## 5. CONCLUSION AND FUTURE SCOPE

The current research looked at how the Simple Additive Weighting (SAW) approach could be used to optimize the machining parameters of a Plasma Arc Cutting Machine. The SAW method, as demonstrated in this study, provides a systematic and effective process for discovering optimal parameters with significantly less effort than conventional optimization strategies.

Using a Plasma Arc Cutting system, add parameters like Kerf, Voltage, Angle, Material Dimension, and different advanced materials like brass and bronze, and compare the results.

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