PARAMETRIC OPTIMIZATION OF CO2 LASER CUTTING PROCESS ON SS -316 USING GRA TECHNIQUES

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ABSTRACT

Laser cutting is mostly a thermal process in which a focused laser beam is used to melt material in a localized area. A co-axial gas jet is used to eject the molten material from the cut and leave a clean edge. A continuous cut is produced by moving the laser beam or work piece and leave a clean edge. A particular characteristic of a laser cut is the formation of striations on the cut edge. These striations play an important part in laser cutting as they effectively control the edge roughness. Laser Beam Machining is widely used manufacturing technique utilized to perform cutting, engraving and welding operations on a wide variety of materials ranging from metals to plastics. In the present work an attempt has been made to study the effect of process parameters such as feed rate, input power and gas pressure of 3 levels of each parameter on the quality of the machined surface using laser beam on stainless steel. Design of experiments is implemented by using a full factorial design. The effect of the process parameters on response have been shown by means of main effect plots developed using ANOVA analysis. After Design of Experiment (DOE) by using full factorial method, the analysis will be carry by the Analysis Of Variance (ANOVA) method and optimization will be carry Response surface methodology.

Keyword : - *SS316 ,ANOVA FULL factorial*

1. *Electrons can transit to other energy levels by absorbing or releasing energy. For example, after an electron has absorbed a photon, it transits from a lower energy level to a higher one as shown in Fig.1.1 (a). By the same sense, an electron at a higher energy level may transit to a lower one if it releases a photon as shown in Fig.1.1 (b). In these processes, the energy of the photon absorbed or released always equals the energy difference between the two levels. [2].*

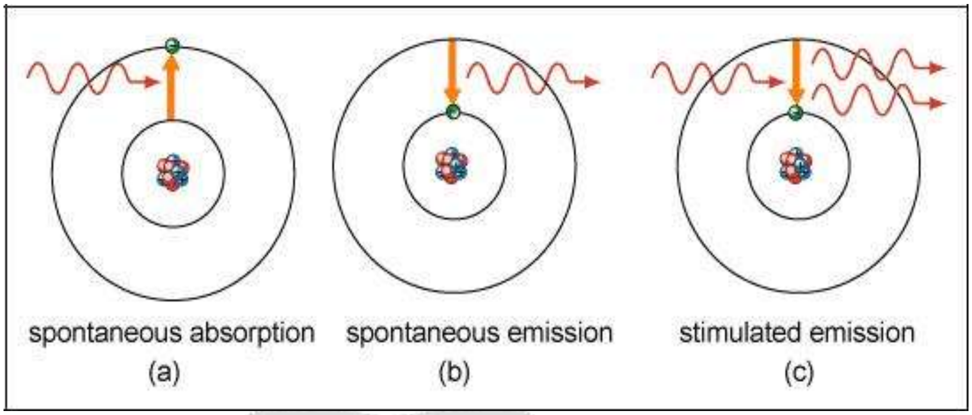

Fig. 1.1 Principle of laser [2]

When all electrons of an atom are at the lowest possible energy levels and thus the atom possesses the lowest energy it has. When one or more electrons are at a higher energy level, we say that the atom is at an excited state. Electrons transit between energy levels by absorbing or emitting light. These transitions are divided into three types:

1. *Spontaneous absorption - an electron transit from a lower energy level to a higher one by absorbing a photon, shown inFig.1.1(a)*
2. *Spontaneous emission - an electron spontaneously emits a photon to transit from a higher energy level to a lower one, shown inFig.1.1(b)*
3. *Stimulated emission - photons incident into the matter to stimulate the electrons to transitfromahigherenergyleveltoaloweroneandtoemitaphoton.Theincidentphoton and their emitted counterparts have the same wavelength and phase; this wavelength corresponds to the energy difference between the two energy levels. A photon stimulates an atom to emit another photon, and hence two identical photons are resulted as shown in Fig.1.1(c) [2].*

In this topic, one has studied that laser beam works on the principle of stimulated emission. This generated laser beam has some properties like mono chromaticity, coherence and collimation which are shown in the next topic.

2.2 Review of research papers

D. J. Kotadiya, et al, [18] from India is investigated onParametric analysis of laserMachining with response method on ss304. Stainless steel is an important engineering material that is difficult to be cut by oxy-fuel methods because of the high meltingpoint and low viscosity of the formed oxides. However, it is suitable to be cut by laser. The objective of this work is to doparametric analysis of process parameters of CO2 laser cutting system on surface characteristics of the cut section in the cuttingof 5mm Stainless Steel (SS) sheet (ASTM 304). In this study, the laser cutting parameters such as laser power, cutting speed andgas pressure are analyzed and optimized with consideration of workpiece surface roughness. Design of experiments (DOE),ANOVA and Response Surface Methodology (RSM) approaches are used to analyze the laser cutting variables and find out theoptimum value for surface roughness. By analyzing, it is observed that the laser power has more effect on responses rather thancutting speed and gas pressure. It is clearly shown that the above performance characteristics in laser cutting process can beoptimized effectively through this approach.

MILOŠ MADIC, et al, [19] has investigated an artificial intelligence approachfor the prediction of surface roughness in co2 laser cutting. In laser cutting, the cut quality is of great importance. Multiple non-linear effects of process parameters and their interactions make very difficult to predict cut quality. In this *paper, artificial intelligence (AI) approach was applied to predict the surface roughness in CO2 laser cutting. To this aim, artificial neural network (ANN) model of surface roughness was developed in terms of cutting speed, laser power and assist gas pressure. The experimental results obtained from Taguchi's L25 orthogonal array were used to develop ANN model. The ANN mathematical model of surfaceroughnesswas expressed as explicit nonlinear function of the selected input parameters. Statistical results indicate that the ANN model can predict the surface roughness with good accuracy. It was showed that ANNs may be used as a good alternative in analyzing the effects of cutting parameters on the*

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Milos madic, et al, [20] investigated on An artificial intelligence approach for the prediction of surface roughness in CO2 laser cutting [June 2012].In laser cutting, the cut quality is of great importance. Multiple non-linear effects of process parameters and their interactions make very difficult to predict cut quality. In this paper, artificial intelligence (AI) approach was applied to predict the surface roughness in CO2 laser cutting. To this aim, artificial neural network (ANN) model of surface roughness was developed in terms of cutting speed, laser power, and assist gas pressure. The experimental results obtained from Taguchi's L25 orthogonal array was used todevelop ANN model. The ANN mathematical model of surface roughness was expressed as explicit nonlinear function of the selected input parameters. Statistical results indicate that the ANN model can predict the surface roughness with good accuracy. It was showed that ANNs may be used as a good alternative in analyzing the effects of cutting parameters on the surface roughness.

Mr.Umang V Patel,et al(21) optimization of process parameter of co2 laser cutting process on ss304[May 2016]. Laser cutting is mostly a thermal process in which a focused laser beam is used to melt material in a localized area. A co-axial gas jet is used to eject the molten material from the cut and leave a clean edge. A continuous cut is produced by moving the laser beam or work piece and leave a clean edge. A particular characteristic of a laser cut is the formation of striations on the cut edge. These striations play an important part in laser cutting as they effectively control the edge roughness. Laser Beam Machining is widely used manufacturing technique utilized to perform cutting, engraving and welding operations on a wide variety of materials ranging from metals to plastics. In the present work an attempt has been made to study the effect of process parameters such as feed rate, input power and gas pressure of 3 levels of each parameter on the quality of the machined surface using laser beam on stainless steel. The quality of cut is assessed in terms of response parameters such as upper kerf width, lower kerfs width, heat affected zone and surface roughness. Design of experiments is implemented by using a full factorial design. The effect of the process parameters on response have been shown by means of main effect plots developed using ANOVA analysis. After Design of Experiment (DOE) by using full factorial method, the analysis will be carry by the Analysis Of Variance (ANOVA) method and optimization will be carry Response surface methodology.

Prof.Dhaval M. Patel2, et al,[22] are investigated on Parametric effect of fiber laser cutting on surface roughness in 5 mm thick mild steel sheet (IS-2062) [2012]. In this paper, Mild Steel are widely used in the fabrication industry and nowadays have become of importance to other industry as well. This paper investigates experimentally the quality of laser cutting for the mild Steel IS-2062 Grade-A, with the use of a pulsed fibar laser 915,930 and 965 Watt laser cutting system. The quality of the cut has been monitored by measuring the edge roughness (Surface Roughness). This work aims at evaluating processing parameters, such as the laser power, the cutting speed and the gas pressure, for the laser cutting of mild Steel. Result revealed that good quality cuts can be produced in mild steel sheets, at a window of laser cutting speed 1450 mm/min and at a heat input of 915 watts under an assisting O2 gas pressure of 0.8 bar.

3.2 METHODS FOR D.O.E:

The design of experiment based on

1. *Factorial design*
2. *Taguchi method*
3. *Response surface method*

3.3 KEY TERMS:

1. ***Factor****:*

 An element of the experimental unit that will be varied. Here in my experiment factors are input power, gas pressure and feed.

2. ***Level****:*

 The possible value of a factor

3. ***Combination****:*

 An instance of the experimental unit with a particular level from each factor applied. We have used factorial design, and used ***full factorial design****. For a full factorial design, if the numbers of levels are same then the possible design N is*

$$N = L^m$$

Where L = number of levels for each factor, and m= number of factors.

Fractional factorial designs are good alternatives to a full factorial design, especially in the initial screening stage of a project. It is used to simplify the experiment. Fractional factorial experiments investigate only a fraction of all the possible combinations. This approach saves considerable time and also money in case of costly materials, but requires rigorous mathematical treatment, both in the design of experiment and in the analysis of the results.

Each experimenter may design a different set of fractional factorial experiments. Taguchi simplified and standardized the fractional factorial designs in such a way to engineers conducting tests thousands of miles apart, will always use similar designs and tends to obtains similar results. Taguchi developed a family of fractional factorial experiments matrices which can be utilizes in various situations. These matrices reduce the experiments numbers but still obtain reasonably rich information. In Taguchi methodology specially design table known as "orthogonal arrays" are used. The use of this table makes the design of experiments vary easy and consistent.

3.4 STEPS TO PERFORM FULL FACTORIAL DOE:

1. ***Identify*** *the importance statistical analysis variables.*
2. *Statistically* ***analyze*** *a dataset.*
3. ***Explain*** *the proper steps in developing a full factorial design of experiments.*
4. ***Design*** *a full factorial experiment.*
5. ***Evaluate*** *the results of experimental data.*
6. ***Organize*** *technical information into a clear and concise formal*

7. *laboratory report.*

FACTORS AND THEIR LEVELS IN LASER CUTTING:

Table: 3.1 Factors and their levels in laser cutting.

Process parameter	Process designation	Level1	Level2	Level3
Input power (watt)	A	1200	1500	1800
Feed (mm/min)	B	1500	1800	2100
Gas pressure (bar)	C	1	2	3

From the above table according to design of experiments with full factorial design total no of experiments to be performed are 27. Table 3.2 shows an experimental design by full factorial method.

4.FUTURE WORK:

- *We will conduct conformation test from GRA result to find out error between optimal value and conformation test value.*
- *We will prepare result and conclusion for thesis.*
- *All LASER cutting operation will be performed on co2 LASER cutting machine MAZAK hyper 510.*
- *For Experiment design we will use full factorial method to find out numbers of reading.*
- *To find out percentage contribution of each input parameter for obtaing optimal condition we will use ANOVA analysis*

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