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EXPERIMENTAL INVESTIGATION OF PROCESS PARAMETERS OF FIBRE LASER ON CUTTING QUALITY OF STAINLESS STEEL 304- A REVIEW

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ABSTRACT

Fibre laser is a newer technology in laser cutting. Also, available at different power levels and very narrow spot size. Stainless Steel is widely used in industries throughout the world. It requires higher power due to the hardness and reflectivity. Therefore fibre laser are used for cutting Stainless Steel(SS-304). The aim of this work is to study the influence of process parameters namely: laser power, cutting speed, assist gas pressure on cutting quality like kerf width using AUTOCAD and surface roughness using profile meter SJ-201 (MITUTOYO). Design of Experiment (DOE) like FULL FACTORIAL method will be used to find the number of experiment runs to perform on the fibre laser machines. A regression analysis will be used to find the relation between process parameters and response. Also the interaction between process parameters and its effect on response will be done by ANOVA analysis.

1. INTRODUCTION

Laser is the acronym of Light Amplification by Stimulated Emission of Radiation. Laser is light of special properties, light is electromagnetic (EM) wave in visible range. Main six processes are doing for Light Emission: Absorption, Spontaneous Emission, Stimulated Emission, Population Inversion, Gain and Loss. A laser device is consisted of: (1) Laser medium like atoms, molecules, ions or semiconductor crystals; (2) Pumping process to excite these atoms into higher quantum mechanical energy levels; and (3) suitable optical feedback that allow the beam of radiation to either pass once through the laser medium or bounce back and forth repeatedly through the laser medium. Lasers have now found applications in almost every field of engineering, medicine, commercially etc.

Laser cutting is a thermal based non-contact process capable of cutting complex contour on material with high degree of precision and accuracy. It involves process of heating, melting and evaporation of material in a small well defined area and capable of cutting almost all materials. The word LASER stands for Light Amplification by Simulated Emission of Radiation). Laser has a wide range of applications, ranging from military weapons to medical instruments. In industries laser is used as an unconventional method for cutting and welding. The main advantage of laser cutting is that, it is a non-contact operative method from which a good precise cutting of complicated shapes can be achieved. Also laser can be used to cut variety of materials like wood, ceramic, rubber, plastic and certain metals. The most commonly used types of laser for laser cutting are CO_2 laser and Nd: YAG laser. Due to low laser absorptivity of aluminium and back reflection, high laser power is required to cut Aluminium. CO_2 laser has a wavelength of about 10.6µm due to this CO_2 laser has high power output when compared to Nd: YAG laser. Thus for cutting aluminium and aluminium based alloys CO_2 laser can be used. The working principle of laser cutting is a thermal, non-contact and highly automated process well suited for various manufacturing industries to produce components in large numbers with high dimensional accuracy and surface finish. They also stated that high power density beam when focused in a spot melts and evaporates material in a fraction of second and the evaporated molten material is removed by a coaxial jet of assist gas from the affected zone as shown in figure. Industrial users of laser technology have demanded laser systems with higher powers. A fibre laser is a type of solid state laser that's been rapidly growing within the metal cutting industry. Unlike CO_2, Fibre technology utilizes a solid gain medium, as opposed to a gas or liquid. The fibre laser produce laser beam and amplified within glass fibre. With a wavelength of only 1.064 micrometers fibre lasers produce an extremely small spot size (up to 100 times smaller compared to the CO_2) making it ideal for cutting reflective metal material. This is one of the main advantages of fibre compared to CO_2.Applications such as cutting, welding, piercing and drilling could be enhanced by the development of more powerful lasers with high beam quality, efficiency and stability. Several solid state laser structures have been developed such as rod, disk and fibre. Fibre/disk lasers are designed to minimise thermal distortion and provide light brightness beam. Both fibre/disk lasers have a 1.06μm wavelength. Likewise several kinds of fibre laser systems in terms of laser source have been developed: single emitter, modular and high power fibre lasers. Regarding optical fibres, single-clad and double-clad fibres have been used.

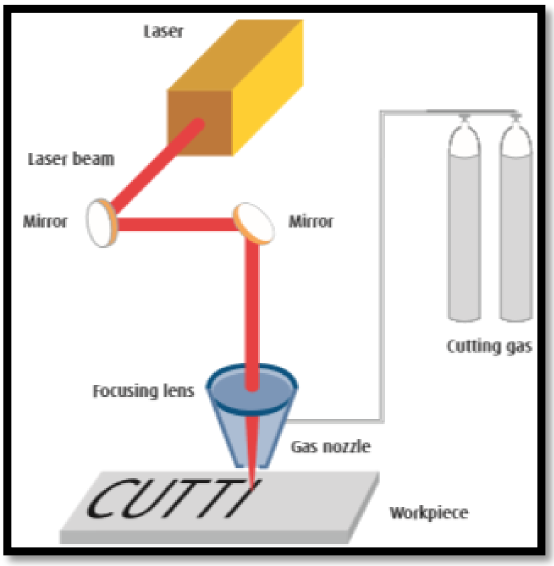

Figure 1.1: Principle of laser cutting system

1.1 TYPES OF LASER

There are three main types of lasers used in laser cutting:

1. CO_2 laser
2. Nd:YAG laser
3. Fibre laser

1.1.1 CO_2 LASER

Because of their ability to produce very high power with relative efficiency, carbon dioxide (CO_2) lasers are used primarily for materials-processing applications. The standard output of these lasers is at 10.6 mm, and output power can range from less than 1W to more than 10 kW. Unlike atomic lasers, CO_2 lasers work with molecular transitions (vibrational and rotational states) which lie at low enough energy levels that they can be populated thermally, and an increase in the gas temperature, caused by the discharge, will cause a decrease in the inversion level, reducing output power. To counter this effect, high-power cw CO_2 lasers use flowing gas technology to remove hot gas from the discharge region and replace it with cooled (or cooler) gas. With pulsed CO_2 lasers that use transverse excitation, the problem is even more severe, because, until the heated gas between the electrodes is cooled, a new discharge pulse cannot form properly. A variety of types of CO_2 lasers are available. High-power pulsed and CW lasers typically use a transverse gas flow with fans which move the gas through a laminar-flow discharge region, into a cooling region, and back again. Low-power lasers most often use waveguide structures, coupled with radio-frequency excitation, to produce small, compact systems. However, the major difference is that the gases in the system are extremely corrosive and great care must be taken in the selection and passivation of materials to minimize their corrosive effects. A system built for CO_2 would fail in minutes, if not seconds. The principal advantage of an CO_2 laser is its very short wavelength. The laser output beam can be focused to a spot diameter that is approximately 40 times smaller than the CO_2 laser beam with the same beam quality. Furthermore, whereas the long CO_2 wavelength removes material thermally via evaporation (boiling off material), the CO_2 lasers with wavelengths near 200 nm remove material via ablation (breaking molecules apart), without any thermal damage to the surrounding material.

1.2 ADVANTAGES OF LASER CUTTING

Advantages of laser cutting over mechanical cutting include easier work holding and reduced contamination of work piece. Precision may be better, since the laser beam does not wear during the process. There is also a reduced chance of warping the material that is being cut, as laser systems have a small heat-affected zone. Some materials are also very difficult or impossible to cut by more traditional methods. Advantage of LBC includes:

- complex figures can easily be cut by incorporating CNC motion equipment

- high cutting speeds
- low distortion
- low dross
- minimal heat affected zones
- very high edge cut quality
- very narrow kerf width
- Efficient processing, as multiple jobs or parts can be nested and cut in a single program
- No secondary cleanup process required for most materials, and is usually ready for immediate shipment
- Reliable

1.3 DISADVANTAGES OF LASER CUTTING

While some disadvantages to laser cutting exist, the benefits far outweigh the downsides.

- High power consumption
- Can be expensive
- Rate of production depends on the material
- Poorly adjust lasers can cause burning
- Difficulty in cutting reflective metals (like copper, brass, and sometimes aluminium)

1.4 APPLICATIONS OF LASER CUTTING

In the industry the users of the laser cutting process stretches far, from big companies down to small shops creating products where the company can utilize the advantages of the laser cutting process. It could be companies that specializes in the laser cutting process but also companies that uses the process as a means of being able to create products without being specialists in the laser cutting process. Laser cutting in metal is today the most used laser processing process in the industry with over 40% of the laser processing market shares.

Other uses of laser cutting are:

- Wood
- Paper
- Leather
- Glass
- Ceramic
- Steel
- Titanium
- Wax
- Plastic
- Fabric
- Medical
- Laser cutting is most often seen in industries that demand a lot of thin metal parts
  - This includes:
    - Automotive
    - Architectural
    - Retail Displays
    - Art and Structural

2. LITERATURE REVIEW

Mirosla Radovanovic and Milos Madic this paper aim is to improving the cutting quality laser cutting. laser cutting is most widely used non-contact type machining process. The experimental investigation on laser cutting of various material and identify most common parameters analyzed cut quality. The review shows that laser power, cutting speed and assist gas and pressure are most affected parameter on cutting quality.

The cut quality includes kerf width, surface roughness, HAZ. The experimental data are optimized using DOE and find optimum combination of process parameters.

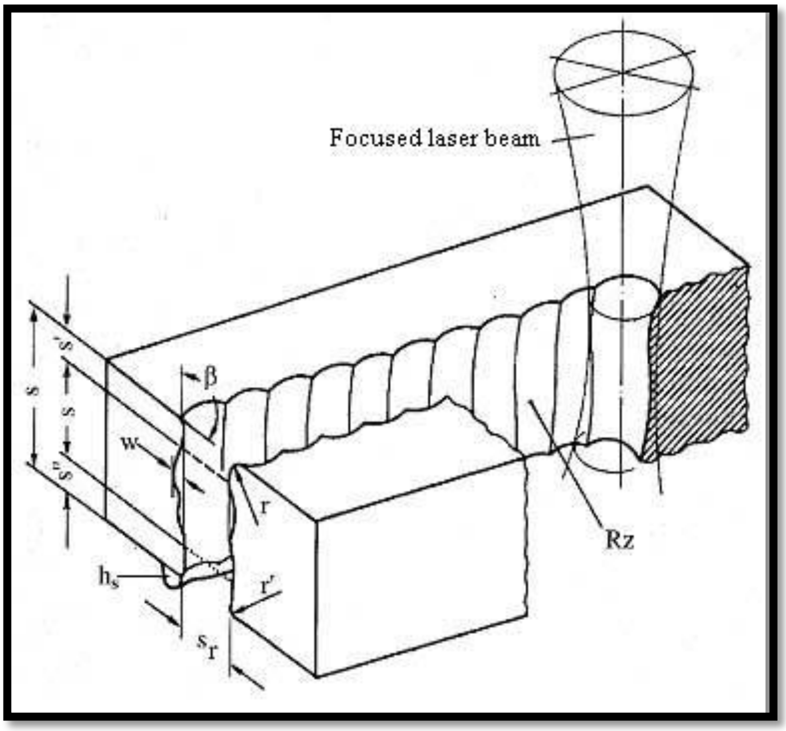

Figure 2.1: Laser cut

A. Riveiro, "The role of the assist gas nature in laser cutting of aluminium alloys" have been studied that the process relies on the removal of the melted material with the aid of a pressurized assist gas. Among the main variables controlling the process, the assist gas type is an essential factor. This gas is normally chosen taking into account the material to be processed and the required cut quality. While the effect of the utilization of different assist gas is perfectly studied in cutting steels, the influence of the assist gas type during laser cutting of aluminium alloys is not well studied. This work presents a study on the influence of different assist gases (argon, nitrogen, oxygen and air) on the edge quality and its surface chemistry during laser cutting of a typical Al-Cu alloy. After investigation the Results indicate a clear influence of the assist gas nature on the finishing characteristics. Formation of oxides and nitrides were observed to modify the cut quality and cutting speed. Oxygen, nitrogen and compressed air react to a greater or lesser extent with the molten material generating a large amount of oxides and/or nitrides. This largely affects the cutting speed and cut quality of the obtained cuts. On the other hand, argon was arisen as the more efficient assist gas to obtain best quality results and with the higher efficiency. Then, from the point of view of quality and efficiency argon is the best choice for processing Al-Cu alloys.

K. Abdel Ghany and M Newishy, "Cutting of 12mm thick austenitic stainless steel sheet using pulsed and CW Nd:YAG laser". In this article the work aims to evaluate the optimum laser cutting parameters for 1.2 mm austenitic stainless steel sheets by using pulsed and CW Nd:YAG laser beam and nitrogen or oxygen as assistant gases, each one separately. For cutting stainless steel by pulsed and CW Nd:YAG laser, it was shown that the laser cutting quality depends mainly on the laser power, pulse frequency, cutting speed and focus position. Increasing the frequency and cutting speed decreased the kerf width and the roughness of cut surface, while increasing the power and gas pressure increased the kerf width and roughness. Comparing with oxygen, nitrogen produced brighter and smoother cut surface with smaller kerf, although it did not prove to be economical. In CW mode, the speed can be increased to more than 8 m/min with equivalent power and gas pressure (limited by the laser system). Pulsed mode was also not economical, especially in limited frequency laser systems, where the pulse overlap should be controlled by both frequency and speed. In CW, the speed can be increased to the maximum system limit.

P.S. Chaudhari *et al*, This paper reviews the research work carried out in the area of laser cutting process and artificial intelligence. In artificial intelligence use for prediction model for given input data of laser cutting operation. There are many factors that effect on performance of cutting process. Our aim is to identify more effective factor which give the significant effect on cutting quality of material. After studying the paper conclude that laser power and cutting speed plays a significant effect on laser cutting.

Artificial Intelligence the branch of computer science that is concerned with the automation of intelligent behaviour. This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way. A more or less flexible or efficient approach can be taken depending on the requirements established, which are use for prediction of result and also save the time and money of experiment work.

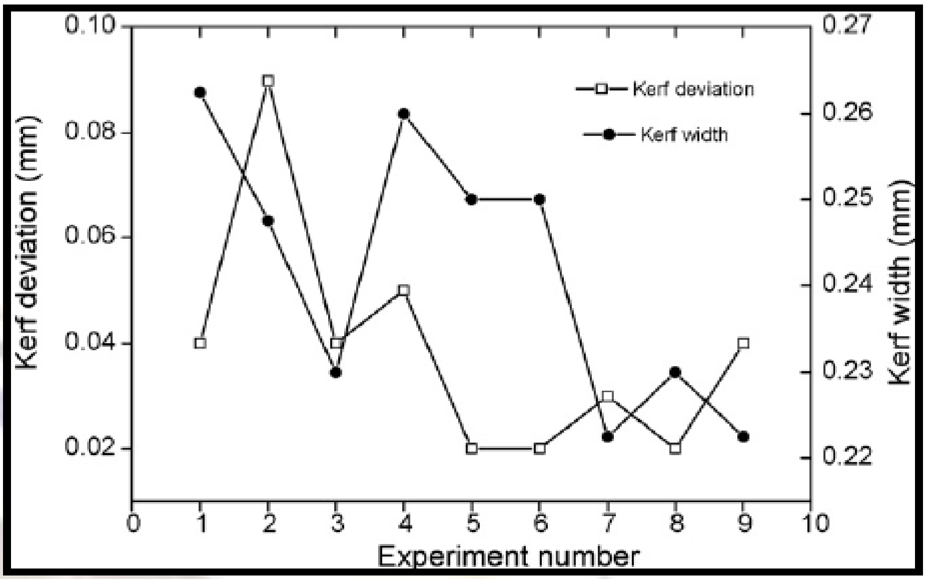

Figure 2.2: Variation of kerf deviation and kerf width with experiment number

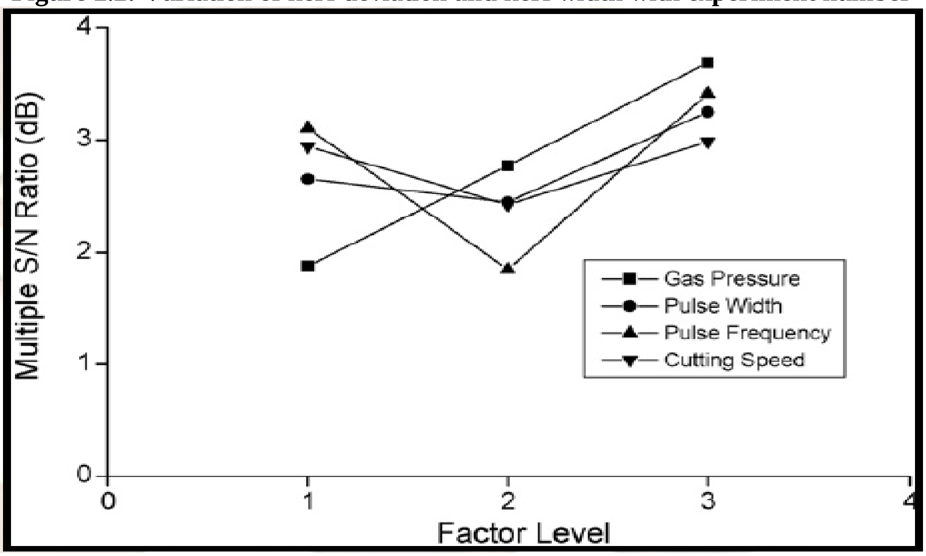

Figure 2.3: Effect of factor levels on multiple S/N ratio (0.9mm Al-Alloy sheet)

Miroslav Radovanovic and Predrag Dasic, mansion that cut quality is a very important characteristic on cutting of contour shape. This paper gives results of the experimental research referring to the determination of surface indicators obtained by laser cutting. In experiment observation carried out on two zones upper and lower one. The surface finish is good whose mutual distance is 0.1...0.2mm while the latter has rougher surface due to deposits of molten metal and slag. R_z increase with sheet thickness and decrease with increase of laser power. By cutting with laser of 800W standard roughness R_z is 10µm for 1mm thickness, 20µm for 3mm and 25µm for 6mm.

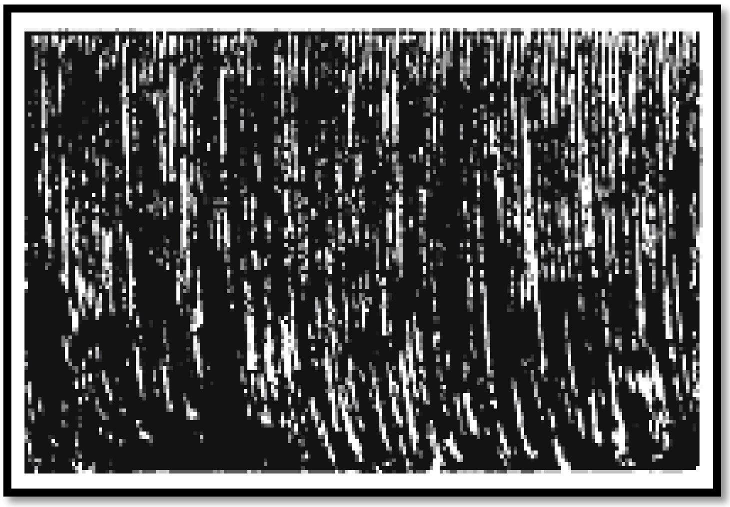

Figure 2.4: Picture of laser cut

3.CONCLUSION

- The present papers indicate that the process parameters like Laser power, cutting speed, assist gas pressure, stand of distance are major influence on cutting quality like kerf width, surface roughness, depth of cut and also vary with type of materials and thickness.
- After studies some research papers based on influence of process parameters on cutting quality, D.O.E (design of experiment) methods like TAGUCHI, ANOVA, ANN, Response Surface Method (RSM) are very effectiveness to optimized process parameters of laser cutting.

REFERENCES

1. V.Senthilkumar*et al*,"Parametric Investigation of Process Parameters for Laser Cutting Process", International Journal of Innovative Research in Science, Engineering and Technology(IJIRSET), Vol. 4, Issue 5, May 2015.
2. Miroslav Radovanovic and Milos Madic,"Experimental Investigations Of Co2 Laser Cut Quality" University of Nis, Faculty of Mechanical Engineering in Nis, Serbia, Nonconventional Technologies Review – no. 4/2011.
3. A.Riveiro, "The Role of the Assist GasNature in Laser Cutting of Aluminium Alloys". Physics Procedia, pages 548–554, 2011.
4. K.A. Ghany, and M.Newishy. "Cutting of 12mm thick austenitic stainless steel sheet using pulsed and CW Nd:YAG laser". JMPT, pages 438–447, 2005.
5. P. S. Chaudhari*et al*, "Artificial Intelligence apply for prediction of Laser Cutting Process", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 4, July-August 2012, pp.1025-1028.