A Review Paper on Parametric Analysis of Laser Cutting Machining Process for MS

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Abstract— Laser cutting is widely used thermal energy based non-contact type, non- convectional machining process. In the present research, the effect of laser machine processing parameters such as laser power, gas pressure, cutting speed and thickness effect on measured response such as surface roughness. The experiment is designed according to Taguchi L9 orthogonal array with three different level of each input parameter. For result interpretation, analysis of variance (ANOVA) was conducted and optimum parameters selected on the basis of the signal to noise ratio, which confirms the experimental result. Find out most important role of input parameter on output parameter.

Keywords: Laser Cutting, Anova, Taguchi Method, Minitab, Mild Steel

I. Introduction

In 1960, the first working laser was described as "a solution looking for a problem." It was in short order, and with some creative thinking, the laser's distinctive qualities were being found to have numerous applications. The laser's power to produce an intense, very narrow beam of light from a single orientation was being captured for science, technology, and medicine. Today, lasers are everywhere--from research laboratories at the cutting edge of quantum physics to medical clinics, supermarket checkouts and even the telephone network. The term laser is a short form of Light Amplification Stimulation Emission of Radiation (LASER) and the Laser Beam Cutting (LBC) is a method of cutting metal utilizing a high intensity laser for melting and vaporizing material and related tolaser beam machining. A medium, either gaseous or solid, is excited to emit a monochromatic (single wavelength) coherent source of light. This light can be focused to a point source, called spot size, resulting in very high power, densities, capable of vaporizing various materials.

II. Literature review

In 2019, Kedong Zhang, Xuhong Guo, Lining Sun, Xiangfeng Meng, Youqiang Xing [1] In this work, the TiAlN coated tool with a fem to second laser pretreated substrate was fabricated, and the wear properties of this developed tool during dry cutting SLM-produced AISI 316 L stainless steel was investigated. A periodic nano-ripples structure (nanotexture) is successfully induced on the WC/Co substrate by a fem to second laser. In this experiment, the nanotexture fabricated by pulse energy of 2.5 μJ and scanning speed of 500 μm/s is of high quality. In the experiment of dry milling SLM-produced AISI 316 L stainless steel, the main wear mechanism for TiAlN coated tools is adhesive wear, and the cutting performance of the nanotextured TiAlN coated tool is dramatically enhanced compared with that of the conventional one. The presence of periodic nano-ripples structures on the tool substrate leads to the reduction in the cutting forces, cutting temperatures, surface roughness and tool wear, which can be ascribed to the enhanced coatings adhesiveness and the formation of stable protective and lubricating layer.

In 2021, M. Boujelbene , B. El Aoud , E. Bayraktar , I. Elbadawi , I. Chaudhry , A. Khaliq , A. Ayyaz , Z. Elleuch [2] The laser cutting process has been used in several engineering applications. This research focused on the CO2 laser cutting of pure grade 2 Ti sheet. Results show significant influence of cutting speed(V), laser power beam (Pu), and the gas pressure (p) on the surface quality of machined parts. The quality and the surface topography of the cut pieces were influenced by the main input parameters such as the power of the laser beam and the speed of movement of the nozzle. Cutting speed has a dominant effect on surface quality and topography. A cutting speed of 2400 mm/min resulted in high quality surfaces after cutting process. The values of roughness parameters grow with the increase in distance from upper cut edge. For the smallest value of the arithmetic roughness Ra, a maximum value of the S/N ratio is -18.04. The optimal values of the parameters are; V: 2400 mm/min, Pu: 2 kW and the gas pressure p: 14 bars. For the smallest value of the total roughness Rt, a maximum value of the S/N ratio is –32.94. However, the optimal values of the parameters are; Pu: 2 kW, V: 2400 mm/min and the gas pressure p: 2 bars.

In 2014, Venkatesh Kannan M.,Kuppan P, Senthil KumarA., Ramesh Kumar K., John Rozario Jegaraj J. [3] study the potential of LAM for alumina ceramics. The surface temperature of the ceramic material increases with the increase in laser power and decrease in laser scan speed. The optimal temperature (around 1250°C) is obtained at laser power of 350 W and laser scan speed between 35 and 55 mm/min. The minimum cutting force is observed during LAM at laser power of 350 W and laser scan speed of 45 mm/min.The maximum cutting force and specific cutting energy reduction of about 80% was observed for LAM at identical machining conditions when compared to conventional machining. The cutting force and specific cutting energy is reduced from 2 to 3 folds while increasing the laser/tool traverse speed between 15-45 mm/min. Tool wear shows significant improvement while increasing the laser scan speed from 15 to 45 mm/min, which is low at laser traverse speed of 45 mm/min. The surface temperature plays major role on cutting forces, and tool wear in LAM.

In 2020, K. Muralidharan , S. Shalini Packiam Kamala, D. Alankrutha , K. Bhanu Prakash , Ram Subbiah , S. Marichamy [4] The strenx steel plate was cut by CNC laser cutting machine. The cutting quality and surface roughness were measured. The laser cutting parameters have been optimized through Taguchi method. The optimal SR was attained at laser power of 600 W, cutting speed of 900 mm/min and gas pressure of 6 bar. Laser power was produced 54.66% of effect on SR followed by cutting speed.

In 2018, A Parthiban, M Chandrasekaran, V Muthuraman, S Sathish [5] This work provides with detailed study on the Kerf quality of the AISI 304 stainless steel sheet. The optimization procedure has been made to study the effect of while CO2 laser cutting which would help in real practice. The CO2 laser cutting parameters levels was analyzed and then the experimentation was carried out according to the optimization approaches. From the Response Surface Methodology the selected CO2 laser cutting parameters Laser power, Cutting speed and gas pressure plays a dominant role in the turning conditions of AISI 304 stainless steel sheet. This indicates that the significantly affect the responses for kerf quality. The Best ranges obtained by using the genetic algorithm approach are Laser power 2571 watts, Cutting speed 5498 mm/min and Gas pressure 0.899 Mpa. To achieve optimal Kerf quality of Genetic Algorithm is Top kerf width 0.4033mm and Bottom kerf width is 0.3246mm.

In 2021, Yadvinder Singh , Jujhar Singh , Shubham Sharma , Abhinav Sharma, Jasgurpreet Singh Chohan [6] The Taguchi approach is used in laser cutting to find a ‘‘robust” solution, i.e., identifying laser cutting conditions unaffected by parameter changes and noise.Also, the Taguchi approach has only been used to improve metallurgical characteristics (HAZ, Burr inclusion) and productivity efficiency characteristics (MRR). Other essential performance variables, for instance, precise cutting speed, efficiency, processing time, and costs, should be considered using the Taguchi method. The Taguchi approach does not perform any further interpolation or extrapolation because it is a model-free optimization technique. To address this shortcoming, the Taguchi method and response surface methodology are combined to combine the benefits of both at the same time. There is currently no literature that demonstrates a hybrid approach, i.e., combining the Taguchi method and artificial neural networks for process variable optimization, and further research is needed in this field. Some research concluded that there were numerous input variables in the laser cutting process that had a significant effect on the material’s qualities, while other parameters had no considerable impact on the response variables; therefore, process variables had to be selected and fixed ideally.

In 2021, Yaowen Wu , Guangyi Zhang , Jianxin Wang , Yang Chao , Wenwu Zhang [7] In terms of process optimization, when other parameters remain unchanged, the cutting depth gradually increases with laser power increasing while the slit width has no obvious change; with increase of feed speed, the equivalent cutting speed gradually increases while the cutting depth of single grooving gradually decreases and the slit width has no obvious change, but the cutting quality is gradually getting worse; and with increasing water jet speed, the cutting depth of single grooving decreases while the slit width has no obvious change, the slit width gradually decreases, and the cutting quality has no obvious change. The efficient cutting of 10 mm CFRP is realized by adopting different cutting paths. Because the laser and water jet are coaxial, the erosion of high-speed water jet makes the melt discharge faster, the cooling effect makes the heat affected zone smaller. Thus, the inner wall of the channel is clean and the carbon fiber section is neat without thermal expansion phenomenon.

In 2021, I. Sakaev , A.A. Ishaaya [8] In this work we investigated the LASOX cutting using high power diode lasers with a laser beam delivered off-axis to the cutting oxygen jet formed by standard 7 bar supersonic nozzles available from the oxyfuel cutting industry. The experimental results show that, a fiber-coupled diode laser system with a power as low as 400 W is capable of cutting thick mild steel sections of up to 40 mm. 20 mm thick workpieces can be cut with a speed of 200 mm/min and an edge quality potentially acceptable for industrial applications. Modern water-cooled diode bar stacks systems can easily reach 1 kW optical power output, allowing previously demonstrated high quality cutting of steel sections up to 50 mm thickness (and possibly above with increasing the size of the nozzle). More compact and lightweight air-cooled systems with a lower optical power (as in this work) can be used as portable cutters with high quality cutting limited to ~20 mm thickness and lower quality separation capability of up to ~40 mm thick steel sections.

In 2021, Amit Patel, Sanket N. Bhavsar [9] Cutting of die steel EN-31 by CO2 Laser source has been analyzed experimentally and statistically. The main research aim was to achieve a minimum taper angle, minimum HAZ and better surface finish for thick and hard die steel material. Second order Mathematical models have been generated using DoE and found good agreement between the results of experiments and mathematical models. Through the optimized model, the minimum taper angle obtained was 0.02_. HAZ observed after optimized conditions were 0.44 and 1.04 for top and bottom edge respectively. Surface roughness achieved to 0.37 mm which is quite good results for the hard and 10 mm thick material for the die industry. Surface damages and waviness of the cutting edges have been studied using SEM. Along with HAZ, a dark zone was observed in microns. The regression analysis and Optimization process show a significant advantage over the other machining process to obtain a required cut quality for a hard and thick plate. This experimental work shows a significant advantage of laser cutting over another nonconventional machining for hard and thick material.

In 2019, K. Rajesh , V.V. Murali Krishnam Raju, S. Rajesh, N. Sudheer Kumar Varma [10] The complete analysis of influence process parameters was performed by laser cutting on SS-304 Stainless steel. The cutting parameters preferred during experimentation are laser power (P), gas pressure (p) and cutting speed (V) and while the response parameters taken is Ra and Kw. Multiple regression model is generated by using MINTAB 18 from experimental data to predict the Ra and Kw. From the ANOVA table it is established that laser power is the major influence factor followed by cutting speed and gas pressure. Based upon the experimental results, through Regression model, it is found surface roughness increase with cutting speed and laser power. _ From the main effect plots it is found that the minimum surface roughness is obtained at Laser power 600 W, cutting speed 2000 mm/min and gas pressure 0.4 bar. Regression analysis was successfully applied to prediction accuracy of surface roughness is 82.07%. From the main effect plots it is found that the minimum kerf width is obtained at Laser power 600 W, cutting speed 2000 mm/min and gas pressure 0.5 bar. Regression analysis was successfully applied to prediction accuracy of kerf width is 71.67%. Based upon the experimental results, through Regression model, it is found Kerf width increase with cutting speed and laser power.

In 2019, R. Karthikeyana, V.Senthilkumar, Dr. M. Thilak, A.Nagadeepan [11] In the present study, the selection of optimum parameters using grey relation analysis for minimization of kerf quality like kerf width and kerf taper during CO_2 laser cutting of mild steel was considered. The application of grey relational analysis integrates the multiple kerf quality characteristics like kerf width and kerf taper into single performance characteristic called grey relational grade. The obtained grey grade reflected the actual results in terms of kerf width and kerf taper. The experimental results shown that the optimal cutting parameters were high power 1 kW, lower speed 4.3m/min and moderate gas pressure 0.15 bar.

In 2016, D. J. Kotadiya, D. H. Pandya [12] In this paper, the complete analysis of the influence process parameters on the laser cutting process has performed with CNC laser cutting machine hyper gear 510, MAZAK make. After DOE analysis total 17 run have identified for experiment with sheet metal operation (5 mm thick) SS 304 as workpiece material. The optimal values of these parameters have defined with the aim of achieving the required surface roughness. It has found that the laser power is most significant compare to cutting speed and gas pressure. Laser power and gas pressure has identified most significant interactive parameter with highest F value of 0.64. By using regression analysis method, the optimized value of parameters found as power 1.46 kW, gas pressure 0.70 bar and cutting speed 2.00 m/min for the minimum value of surface roughness 2.18179 µm. Based on these results, the optimal cutting condition, at which the surface roughness is minimized and both the delayed cutting phenomenon is estimated to improve both the quality of the cut section and the cutting efficiency

In 2016, M. Balajia, B.S.N. Murthyb, N. Mohan Raoc [13] In this work, eight experiments (trials) were conducted with two levels of cutting parameters on AISI 304 steel. A noncontact monitoring system was used with laser Doppler vibrometer to observe vibration of drill bit during machining. Tool life was evaluated by analyzing surface roughness and acceleration drill bit vibration velocity with the help of Taguchi and ANOVA analysis. The following points can be concluded from this work. Vibration of drill bit is found to be increased along with the progression of the tool wear. Helix angle is found to be significant on surface roughness followed by acceleration of drill vibration velocity with contribution of 78.22% and 50.02% respectively. Optimum levels of cutting parameters for surface roughness are obtained as 25 degrees of helix angle, 12mm/min of feed rate and 800rpm spindle speed. Optimum levels of cutting parameters for acceleration of vibration are obtained as 25 degrees of helix angle, 10mm/min of feed rate and 600rpm spindle speed.

In 2016, Hsueh-Liang Huang, Wen-Yuh Jywe, Ming-Chen Cho [14]This study developed a novel 2D contouring accuracy compensation system for the laser cutting machine. This system breaks through the bottleneck of high-speed contouring test systems with a small-working-range by enabling the measurement of the laser cutting machine, particularly for the processing of small work pieces. This study also established an error compensation method suitable for the 2D command contouring tests. The results of a high-speed contouring error compensation experiment verify that the proposed system is capable of significantly decreasing error in contouring tests.

III. OBJECTIVES

- I have selected MS sheet material With Thickness
- 3mm for carried out the experiment.
- Selected Taguchi Method With L9 Orthogonal Array
- Prepare L9 Based Laser Cutting Job
- Find Out Surface roughness
- Analyze effect of welding process parameter

IV. CONCLUSION

From This Literature Review find the gap that, many research paper works on different parameters and welding. So, tried to derive objective by executing work with laser cutting machine. From the review of few research paper we have observed the effect of laser power, gas pressure and cutting speed on different material. but still the same effect not observed in Mild steel so we have selected M.S material for our research. And I have selected MS material with plate thickness is 5mm and selected process parameters such as laser power (watt), gas pressure (bar), cutting speed (mm/min) and analyse the effect on Surface roughness (µm). I have tried to optimize the process parameters and with this work.

ACKNOWLEDGEMENT

Simply to acknowledge the help verbally is not the complete way of expressing the feelings. Even though the words, if brought from bottom of the heart, can serve the purpose to a considerable extent .this is also a small effort for the same. First of all, I am humbly expressing thanks to my respected guide Prof.C.V.Patel (Assistant Professor, Department of Mechanical Engineering, SPCE, Visnagar) for his valuable time and constant help given to me. He encourages me to express my ideas freely and gave valuable suggestion during the implementation of project work. It was a great learning experience right from searching for the topic for my dissertation phase-1.

I would like to express my deeply thanks to Dr.D.J.Shah (Principal, SPCE,Visnagar), Dr.D.S.Patel (Head of the Department Mechanical Engineering Department, SPCE,Visnagar) for their kind support in all the way.

Finally, I am indebted to my parents, who encouraged me and provided the moral support and all my friends who have directly or indirectly helped me during this work.

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