INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue2)
Available online at www.ijariit.com

Parameters Optimization of Laser Beam Machine

Tushar V. Jadhav
Dnyanshree Institute Of Engineering & Technology, Satara
tusharjadhav009@gmail.com

Shashank S. Babar
Dnyanshree Institute Of Engineering & Technology, Satara
shashank.babar9561@gmail.com

Sachin R. Mane
Dnyanshree Institute Of Engineering & Technology, Satara
sachinmane90.sm@gmail.com

Amrut K. Chavan
Dnyanshree Institute Of Engineering & Technology, Satara
amrutchavan5@gmail.com

Sagar A. Bile
Dnyanshree Institute Of Engineering & Technology, Satara
sagarbile00@gmail.com

Prof. R. V Salukhe
Dnyanshree Institute Of Engineering & Technology, Satara
rvsalunkhe@gmail.com

Abstract: "LASER is Light Amplified Stimulated Emission of Radiation. A Laser is a device that emits light through a process of optical amplification based on stimulated emission of electromagnetic radiation. Research parameters optimization of "LASER BEAM MACHINE "as laser beam machine, cutting speed power, gas pressure, laser power. For output parameters, surface roughness and kerfs taper are studied. The analysis is done by "TAGUCHI METHODOLOGY" In this research work input parameters are taken as Cutting Speed, Gas pressure, laser powers are studied. Simultaneously their optimum set is analyzed by using TAGUCHI METHOD from Minitab software for Surface Roughness and Kerfs taper as output Parameter.

Keywords: Laser Beam Machining, Cutting Speed, Laser Power, Gas Pressure, Taguchi Methodology, Minitab.

1. INTRODUCTION

Now a day there is many new technologies were incurred in manufacturing field. New derived material having high hardness value. This development leads to many new challenges because of,

- Sometimes very precise and dimensional accuracy is required.
- It is expected to consider a higher reproduction rate and economic factors while machining.
- Also high material removal rate with good surface finish.

Laser beam machining (LBM) is a machining method primarily used for hard metals or those that would be impossible to machine with traditional techniques. The non-contact machining technique has been continuously evolving from a simple tool and dies making the process to a micro-scale application machining alternative attracting a significant amount of research interests. Laser machining has significant applications in the automobile, aerospace and electronics industries for cutting, drilling, and milling. Nowadays, CO2, Nd: YAG and excimer lasers are used for most industrial laser applications. However, the use of these conventional lasers with pulse durations in the range from nanoseconds to microseconds for precise micromachining is limited due to thermal and mechanical damage (melting, the formation of burr and cracks, changes in the morphology etc.). Ultra-short pulsed lasers can overcome these limitations. Using ultra-short pulsed lasers enables an extremely precise processing of nearly all kinds of materials, ranging from metals to semiconductors and dielectrics, with minimal damage. With these advantages over conventional laser processing, a wide variety of applications have opened up for ultra-short pulsed lasers.

Problem statement

- In traditional machining on laser beam machining, the kerf taper is large and surface roughness is not uniform and optimum.

- due to this the quality of workpieces may get affected
- To get minimum kerf taper and surface finish, the input parameter of laser beam machine is optimized by using Taguchi method.

2. TAGUCHI METHODOLOGY

The Taguchi method involves reducing the variation in a process through the robust design of experiments. The overall objective of the method is to produce high-quality product at low cost to the manufacturer. The Taguchi method was developed by Genichi Taguchi. He developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varied. Instead of having to test all possible combinations of the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect the product quality with a minimum amount of experimentation, thus saving time and resources. The Taguchi method is best used when there is an intermediate number of Variables (3 to 50), few interactions between variables, and when only a few variables contribute significantly.

Process parameters

1) Cutting speed (Vc)-It is a travel of a point on the cutting edge relative to the surface of cut in unit time in the process accomplishing the primary cutting motion. It is expressed in mm/min.

2) Gas Pressure (P) - Pressure is the expression of force exerted on a surface per unit area. Symbol of pressure is P and unit are Kg/cm2.

3) Laser power (P) –It is the rate at which energy is emitted from lasers. The unit is Watt.

3. MATERIAL SELECTION

Literature survey reveals that material selection is not mentioned in many papers. Selection of material is a crucial step in the optimization procedure. The material should be selected which has wide applications in industry and also not in focus or in less focus, so it has scope for further optimization. M.S steel is well known and popular material.

3.1 Chemical composition Mild steel

Constituent	C	Si	Mn	P	S
% Composition	0.16-0.18%%	0.40%	0.70%	0.040% Max	0.040% Max

3.2 Physical Properties of MILD STEEL

Sr. No	Properties	Metric
1	Density	7.85 g/cc
2	Melting Point	2600˚c

3.3 Mechanical Properties of MILD STEEL

Max Stress- 400-560 n/mm2

Yield Stress - 300-440 n/mm2 Min 0.2%

Proof Stress- 280-420 n/mm2 Min

Elongation- 10-14% Min

3.4 Response parameters

1) **Surface roughness (Ra)**
   It is a component of surface texture. It is qualified by vertical deviations of the real surface from its ideal form. The unit is micrometer.

2) **Kerf taper (Kf)**
   Kerf taper is special and undesirable geometrical feature inherent to laser beam machine. It is the angle which ranges from 0.1 to 2˚ in normal condition and measured in degree.

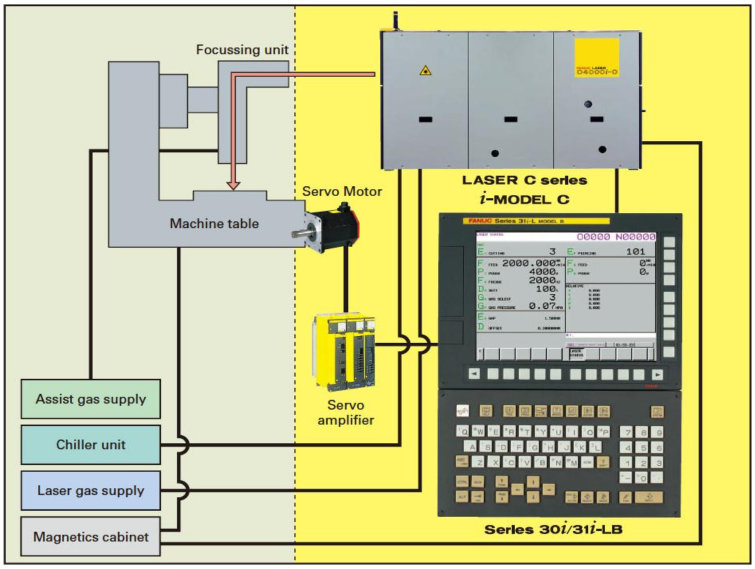


Fig: System Configuration of Laser Beam Machine

3.5 Design of experiment using Taguchi method

Classical experimental design methods are too complex and are not easy to use. A large number of experiments have to be carried out when the 86 number of process parameters increase. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments. Three superplastic forming parameters are considered as controlling factors. They are Pressure, Temperature and Time. Each parameter has three levels – namely low, medium and high, denoted by 1, 2 and 3 respectively. According to the Taguchi method, if three parameters and 3 levels for each parameter L9 orthogonal array should be employed for the experimentation. Orthogonal Arrays (often referred to Taguchi Methods) are often employed in industrial experiments to study the effect of several control factors. Popularized by G. Taguchi. Other Taguchi contributions include

- Model of the Engineering Design Process
- Robust Design Principle
- Efforts to push quality upstream into the engineering design process an orthogonal array is a type of experiment where the columns for the independent variables are “orthogonal” to one another.

Benefits

1. Conclusions valid over the entire region spanned by the control factors and their settings
2. Large saving in the experimental effort
3. Analysis is easy to define an orthogonal array

One must identify

1. Number of factors to be studied
2. Levels of each factor
3. The specific 2-factor interactions to be estimated
4. The special difficulties that would be encountered in running the experiment

When two-level fractional factorial designs are used, it begins to confound our interactions, and often lose the ability to obtain unconfused estimates of main and interaction effects. It was seen that if the generators are chosen carefully then knowledge of lower order Communications can be obtained under that assumption that higher order interactions are negligible. Orthogonal arrays are highly fractionated factorial designs. The information they provide is a function of two things

- The nature of difficult
- Assumptions about the physical system.

Table 3.1 TAGUCHI L9 Runs of Experimental Design

Run	Gas Pressure (N/mm^2)	Laser power (watt)	Cutting Speed (mm/min)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Surface Roughness
A digital Surface Roughness Tester is used for measuring the roughness of the workpieces after machining.

Optical Microscope
An optical micrometer with 10 X magnification is used for measuring the thickness of the workpiece and the diameter of the tool before and after each machining operation.

4. METHODOLOGY FOR ANALYSIS OF CHANGING PARAMETER

Surface Roughness (Ra)
Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if small, the surface is smooth. Surface roughness is denoted by SR in this report.

In this work, the surface roughness was measured by Suyash enterprises. The surface tester is a shop–floor type surface roughness measuring instrument, which traces the surface of various machined parts and calculates the surface roughness based on roughness standards, and displays the results in μm.

4.1 Analysis of Results
Signal to Noise (SN) Ratio

The parameters that influence the output can be categorized into two classes, namely controllable (or design) factors, and uncontrollable (or noise) factors. Controllable factors are those factors whose values can be set and easily adjusted by the designer. Uncontrollable factors are the sources of variation often associated with the operational environment. The best settings of control factors as they influence the output parameters are determined through experiments. From the analysis point of view, there are three possible categories of the response characteristics explained below.

$$\sum_{i=1}^{r} y^2 i = \text{Summation of all response values under each trial}$$

MSD = Mean square deviation

r is the number of tests in a trial (noise of repetitions regardless of noise levels)

y_j = Observed value of the response characteristic

y_o = nominal or target value of the results

The three different response characteristics are given by the following.

1) Higher is better. The SN for higher the better is given by:
$(SN)_{HB}$ = -10 log (MSD_{HB}) (Equation…..3.1)
Where MSD $_{HB}$ =

$$= \frac{1}{r}\sum_{j=1}^{r}\frac{1}{y_j^1} \quad \text{(Equation ... ... 3.2)}$$

MSD_{HB} = Mean Square Deviation for higher-the-better response

2) Nominal is Better. The SN for nominal is better is:
$(SN)_{NB}$ = -10 log (MSD_{NB}) (Equation…..3.1)
Where MSD $_{HB}$ =

$$= \frac{1}{r}\sum_{j=1}^{r}(y_j - y_0)^2 \quad \text{(Equation 3.4)}$$

3) Lower is Better. In this design situation, response is the type of lower is better which is a logarithmic function based on the mean square deviation (MSD), given by

$(SN)_{LB}$ = -log 10 (MSD)

$$= 10\log\left(\frac{1}{r}\sum_{j=1}^{r}(y^2)i\right) \quad \text{(Equation ....3.5)}$$

Where,

$$MSD_{LB} = \frac{1}{r}\sum_{j=1}^{r}(y_j^2)$$

SN Ratio for Response Characteristics

The parameters that influence the output can be categorized in two categories, controllable factors, and uncontrollable factors. The control factors that may contribute to reduced variation can be quickly identified by looking at the amount of variation present in the response. The uncontrollable factors are the sources of variation often associated with the operational environment. For this experimental work, response characteristics are given in the table

Table 4.1: Response Characteristics

Response Name	Response Type
Surface Roughness	Lower is Better
Kerf taper	Lower is Better

4.2 Experimental Result

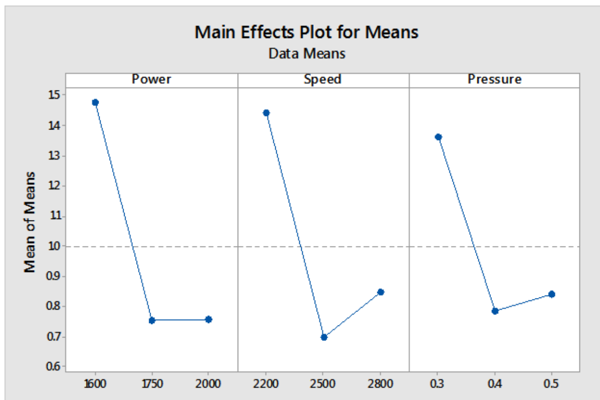
After completion of experimentation, surface roughness and kerf taper of 9 specimens measured. Their results are given in table 4.4.

Table 4.2 Experimental results

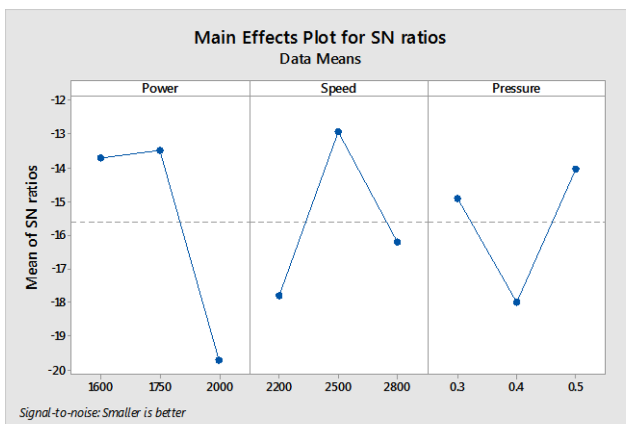
Exp. No.	Laser power	Cutting Speed	Gas pressure	Kerf Taper	Surface roughness
1	1600	2200	0.3	0.80	6.9
2	1600	2500	0.4	1.12	6.6
3	1600	2800	0.5	0.93	7.1

4	1750	2200	0.4	0.74	13.3
5	1750	2500	0.5	0.39	3.3
6	1750	2800	0.3	0.82	6.6
7	2000	2200	0.5	0.77	14.8
8	2000	2500	0.3	0.69	10.9
9	2000	2800	0.4	0.74	15.8

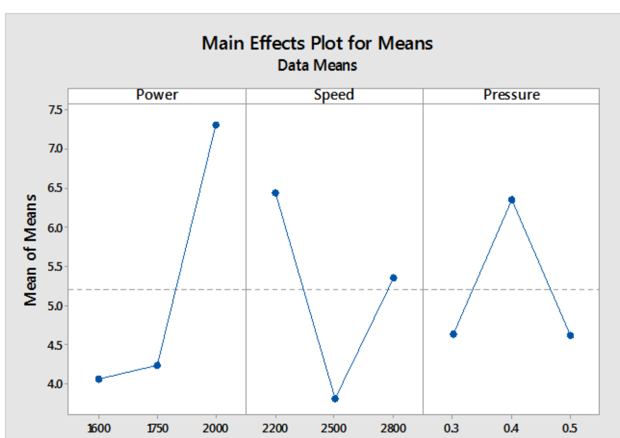
Main effect plot for means (Surface Roughness)



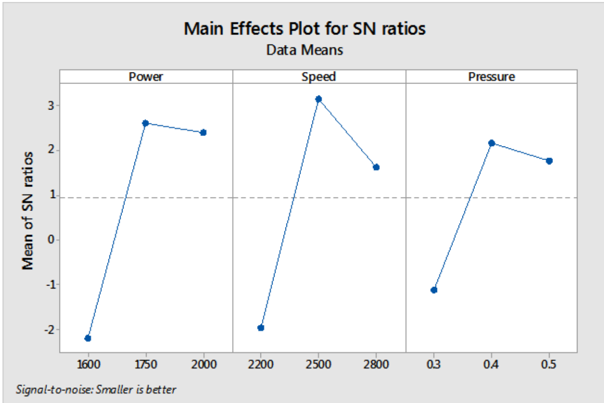
Main effect plot for SN ratios (Surface Roughness)



Main effect plot for means (Kerf taper)



Main effect plot for SN ratios (Kerf taper)



Taguchi Design

Taguchi Orthogonal Array Design

L9(3^3)

Factors: 3
Runs: 9
Columns of L9(3^4)
Array 1 2 3

Taguchi Analysis: Roughness, Kerf width versus Power, Speed, Pressure

Response Table for Signal to Noise Ratios
Smaller is better

Level	Power	Speed	Pressure
1	-13.70	-17.81	-14.91
2	-13.47	-12.90	-17.98
3	-19.73	-16.19	-14.01
Delta	6.26	4.91	3.97
Rank	1	2	3

Response Table for Means

Level	Power	Speed	Pressure
1	4.057	6.438	4.632
2	4.243	3.817	6.360
3	7.313	5.358	4.622
Delta	3.257	2.622	1.738
Rank	1	2	3

Main Effects Plot for Means

Main Effects Plot for SN ratios

Taguchi Analysis: Roughness versus Power, Speed, Pressure
Response Table for Signal to Noise Ratios
Smaller is better
Level Power Speed Pressure

1	-2.200	-1.959	-1.116
2	2.610	3.156	2.156
3	2.406	1.618	1.774
Delta	4.810	5.116	3.272
Rank	2	1	3

Response Table for Means

Level	Power	Speed	Pressure
1	1.4800	1.4433	1.3633
2	0.7533	0.7000	0.7867
3	0.7600	0.8500	0.8433
Delta	0.7267	0.7433	0.5767
Rank	2	1	3

Main Effects Plot for Means

Main Effects Plot for SN ratios

Taguchi Analysis: Kerf width versus Power, Speed, Pressure

Response Table for Signal to Noise Ratios
Smaller is better

Level	Power	Speed	Pressure
1	-16.42	-20.58	-17.66
2	-16.41	-15.84	-20.97
3	-22.73	-19.15	-16.93
Delta	6.31	4.74	4.03
Rank	1	2	3

Response Table for Means

Level	Power	Speed	Pressure
1	6.633	11.433	7.900
2	7.733	6.933	11.933
3	13.867	9.867	8.400
Delta	7.233	4.500	4.033
Rank	1	2	3

CONCLUSION AND FUTURE SCOPE

Conclusion

- It is clear that TAUCHI METHODOLOGY only considers limited search space and searches the optimal solution lies in that space so finally, it comes out with a locally optimal solution. But it is not cased within a sense that it searches the optimal solution in the wide range of search space so that we get the ultimate optimal solution.
- Parameter values for multiple responses using TAUCHI METHODOLOGY gives settings that Gas pressure 0.5, and Cutting speed 2500, laser power 1750
- Surface roughness is 3.3 µ and kerf taper ranges from 0.39

Future scope

- Experimentation can be carried out on different material with different input parameters combinations.
- Mixed optimization can be also done.
- The different methodology of analysis and also for optimization can be used.

REFERENCES

- J. Wang, An experimental analysis, and optimization of CO2 laser cutting process for metallic coated sheet steels (2000). International Journal of Advanced Manufacturing Technology, Vol. 16, pp. 334-340.
- Jun Li and G K Anantha Suresh (2001). A quality study on the exciter laser micromachining of electro-thermal-compliant microdevices, J. Micromesh. MicroEngg, Vol. 11 pp. 38-47.
- Siti India, Binti Rahim, An analysis and optimization of process parameters involved in laser beam machining of stainless steel (6 mm, 8 mm).
- R. Duflou, E. Fallahi Sichani, J. De Keuster, R. Duflou, E. Fallahi Sichani, J. De Keuster has been worked on Development.
- Natasa Naprstkova, Stanislav Dubsky (2012) had worked on Optimization of setting parameters of Laser Cutting Machine.

