PARAMETRIC ANALYSIS OF LASER DIAMOND CUTTING PROCESS

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ABSTRACT

According to current scenario of production industries cutting of diamond is such a difficult, responsible and research field due to cost of diamonds as well as lack fixed methods of diamond cutting. Lack of researches in diamond cutting through LASER can also be included in this field. Due to these reasons, quality result and fixed parameters are necessary for continuous, fast and quality result. But the main problem associated is cost of diamond and lack of diamond cutting industries in localized area. Therefore i am going to study and analysis the number of parameters of Nd:YAG laser for the cutting of diamond and going to set some parameters range which are either negligible or can be use for all types of diamonds. Experiments and results will be based on design of experiment and analysis. Hallmark-4G laser diamond cutting machine is used for the experiment. Input parameters are selected on the basis of literature review and nine numbers of experiments are done by using Taguchi method. Regression and Annova analysis has also done. Pulse duration is the most effective parameter for surface roughness and laser power is the most effective parameter for material removal rate.

Keyword:- *Nd:YAG, Hallmark-4G, Diamond, Surface roughness, Pulse duration.*

INTRODUCATION

A laser is really a device which emits light by using a process of optical amplification in line with the stimulated emission of electromagnetic. The phrase "laser" originated just as one acronym pertaining to "light amplification simply by stimulated emission of radiation". A beam of light differs coming from other sources of light given it emits light-weight coherently. Spatial coherence permits a laser to get focused with a tight spot, enabling apps like beam of light cutting along with lithography. Spatial coherence furthermore allows a laser to stay narrow more than long miles (collimation), enabling applications including laser hints. Lasers may have high temporal coherence allowing them to get a very small spectrum, my spouse and i. e., they just emit an individual color of light. Temporal coherence enables you to produce pulses of light—as short as being a femtosecond. Lasers have got many significant applications. There're used in common consumer devices including optical hard drive drives, beam of light printers, along with barcode readers. Lasers are widely-used for the two fiber-optic along with free-space optical conversation. They are widely-used in medicine for beam of light surgery along with various skin tone treatments, along with in marketplace for chopping and welding resources. They are widely-used in armed forces and police devices pertaining to marking focuses on and testing and rate. Laser light displays utilize laser light just as one entertainment choice.

Nd; YAG (neodymium-doped yttrium lightweight aluminum garnet) can be a crystal that is used to be a lasing medium for solid-state lasers. Oahu is the neodymium ion which provides the lasing activity inside crystal, inside same manner as red chromium ion with ruby lasers. Laser beam operation associated with Nd; YAG was initially demonstrated by means of J. Age. Geusic et al. at Bell Laboratories with 1964.Nd; YAG lasers usually are optically pumped by using a flashtube or even laser diodes. These are probably the most common types of laser, and are also used for many people different programs. Nd; YAG lasers generally emit light with a wavelength associated with

1064 nm, inside infrared. Nonetheless, there are transitions next to 940, 1120, 1320, and also 1440 nm. Nd; YAG lasers work in pulsed and also in continuous function. PulsedNd; YAG lasers are usually operated inside so-called Q-switching function: An optical change is inserted inside laser cavity anticipating a greatest population inversion inside neodymium ions previous to it clears.Nd: YAG lasers are employed in making for engraving, etching, or marking a number of metals and plastics, or perhaps for precious metal surface enhancement processes including laser peening. They're extensively used in manufacturing intended for cutting and welding aluminum, semiconductors and various precious metals. For auto applications (cutting and welding steel) the electricity levels are generally 1–5 kW. Excellent alloy drilling (for gas turbine parts) normally uses pulsed Nd: YAG lasers (millisecond pulses, not Q-switched). Nd: YAG lasers can also be employed to create subsurface tattoos in see-thorough materials such as glass or perhaps acrylic wine glass. Lasers all the way to 400 W are employed for picky laser reducing of metals in chemical layered making. In aerospace programs, they enable you to drill cooling holes intended for enhanced air flow flow/heat harrow efficiency. Nd: YAG lasers can also be used from the non-conventional speedy prototyping course of action laser made net surrounding (LENS). Laser beam peening normally uses substantial energy (10 to help 40 Joule), 10 to help 30 nanosecond and flashed laser systems to build gig w of power at first glance of a part by putting attention the laser down to a few millimeters within diameter. Laser peening can be unlike the other manufacturing processes described in that this neither heats not adds substance; it is often a mechanical course of action cold functioning the metallic component to impart compressive recurring stresses. Laser peening is widely used in gas fired turbine engines within both aerospace and power age group for component damage ceiling improvement and fatigue lifestyle and power increase.

EXPERIMENTAL DETAILS

Doctor.Genichi Taguchi associated with Japan exactly who invented with the methods pertaining to designing associated with experiments to investigate how unique parameters have an impact on the indicate and variance of a process overall performance characteristic which defines the way well the process is performing. His methods target the powerful application associated with engineering strategies in lieu of advanced record techniques. It provides both upstream in addition to shop-floor good quality engineering. Upstream approaches efficiently use small-scale experiments to relieve variability in addition to remain cost-effective and strong designs pertaining to large-scale manufacturing and industry. Shop-floor strategies provide cost-based, real time methods pertaining to monitoring in addition to maintaining good quality in manufacturing. The app of DOE necessary careful arranging, prudent page layout of try and skilled analysis associated with results. He has standardized the strategy for each one of these DOE app steps, hence this become a much more attractive device to practicing engineers in addition to scientist. It provides an opportunity to study not only the individual effects of each factor but also their interactions. Design of experiments is a method used for minimizing the number of experiments to achieve the optimum condition.

Most researchers identified three parameters that greatly affect the machining output;
Laser power (W), Frequency (KHz), Pulse duration (ms) for that factors we choose three level as depicted in Table 3.1, The design of experiments for exploring the influence of various predominant laser cutting process parameters (e.g. laser power, frequency and pulse duration) on the machining characteristics (e.g. the material removal rate and the surface roughness), were modeled. In the present work experiments were designed on the basis of experimental design technique using.taguchi experiments

Experimental variable	Level 1	Level 2	Level 3
Laser power (W)	08	15	22
Frequency (KHz)	07	14	22
Pulse duration (MS)	0.25	0.50	0.75

Table 1.1 Process Parameters with their levels

Experimental run (N)	laser power (W)	Frequency (KHz)	Pulse duration (MS)
1	8	6	0.25
2	8	14	0.50

3	8	22	0.75
4	15	6	0.50
5	15	14	0.75
6	15	22	0.25
7	22	6	0.75
8	22	14	0.25
9	22	22	0.50

Table 1.2 Orthogonal array (L9) for this investigation in coded form

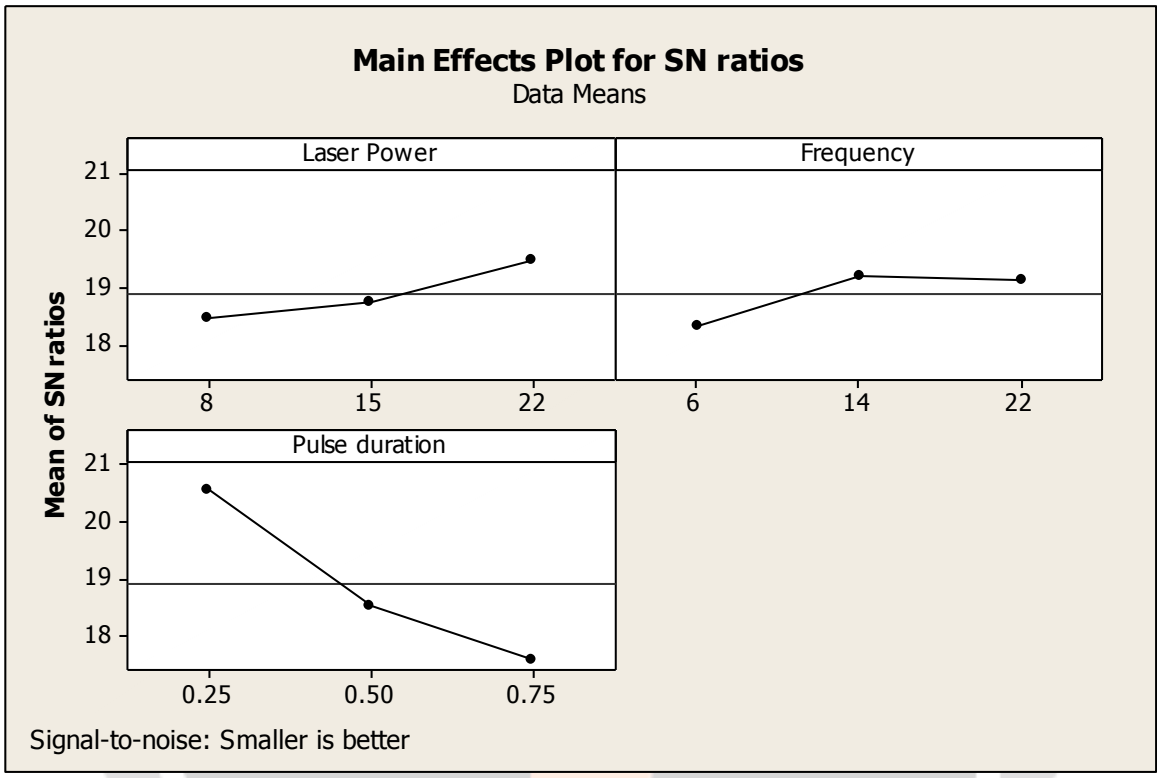
EXPERIMENTAL RESULTS

Sr no (N)	Laser power (W)	Frequency (KHz)	Pulse duration (MS)	Surface roughness (μm)	MRR (cent/min)
1	8	6	0.25	0.101160	0.0009621
2	8	14	0.50	0.124090	0.0009767
3	8	22	0.75	0.134369	0.0016181
4	15	6	0.50	0.128110	0.0048544
5	15	14	0.75	0.124890	0.0033550
6	15	22	0.25	0.096220	0.0027419
7	22	6	0.75	0.136800	0.0059850
8	22	14	0.25	0.084230	0.0046914
9	22	22	0.50	0.103470	0.0022500

The laser diamond cutting experiments were conducted with the process parameter levels set as given in Table 5.1, to study the effect of process parameters over the output parameters. Experiments were conducted according to the test conditions specified by the Taguchi L9 Orthogonal array. Experimental results are given in Table 5.2 to 5.7 for surface roughness and MRR. Experiments are done according to the minitab 16 software. No of experiments are arranged and combine by minitab software itself. 3 level and total number of 9 experiments are conducted.

ANALYSIS AND RESULTS FOR SURFACE ROUGHNESS BY TAGUCHI METHOD

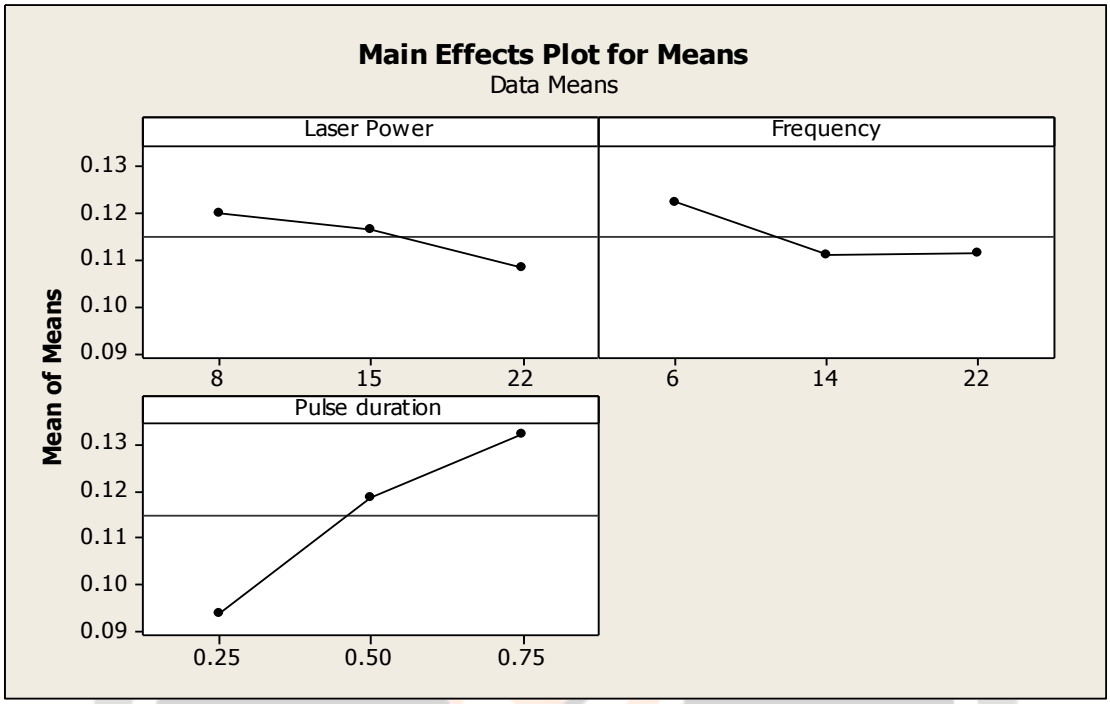
MAIN EFFECTS PLOT FOR SN RATIOS



RESPONSE TABLE FOR MEANS OF SR (SMALLER IS BETTER)

Level	Laser power	Frequency	Pulse duration
1	0.11987	0.12202	0.09387
2	0.11641	0.11107	0.11856
4	0.10817	0.11135	0.13202
Delta	0.01171	0.01095	0.03815
Rank	**2**	**3**	**1**

MAIN EFFECTS PLOT FOR MEANS



ANALYSIS AND RESULTS FOR MATERIAL REMOVAL RATE BY TAGUCHI METHOD

MAIN EFFECTS PLOT FOR SN RATIOS

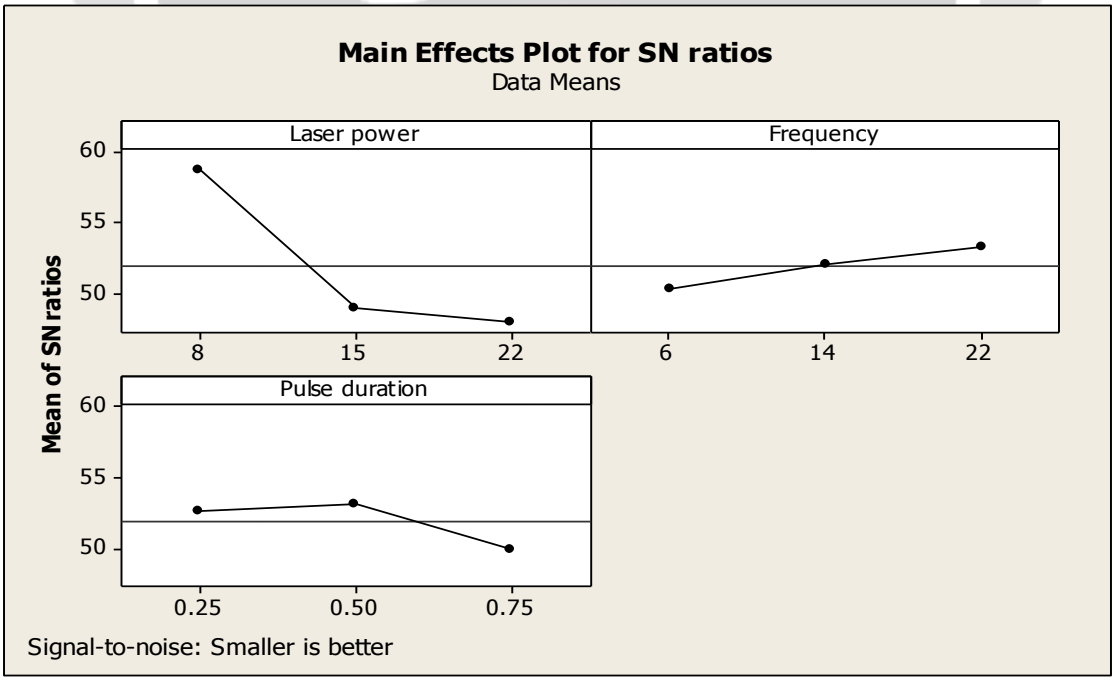


Fig: Main effect plot for SN ratios

RESPONSE TABLE FOR MEANS OF MRR (SMALLER IS BETTER)

Level	Laser power	Frequency	Pulse duration
1	0.001186	0.003934	0.002798
2	0.003650	0.003008	0.002694
4	0.004309	0.002203	0.003653
Delta	0.003123	0.001730	0.000959
Rank	**1**	**2**	**3**

RESUDUAL PLOTS FOR SR AND MRR

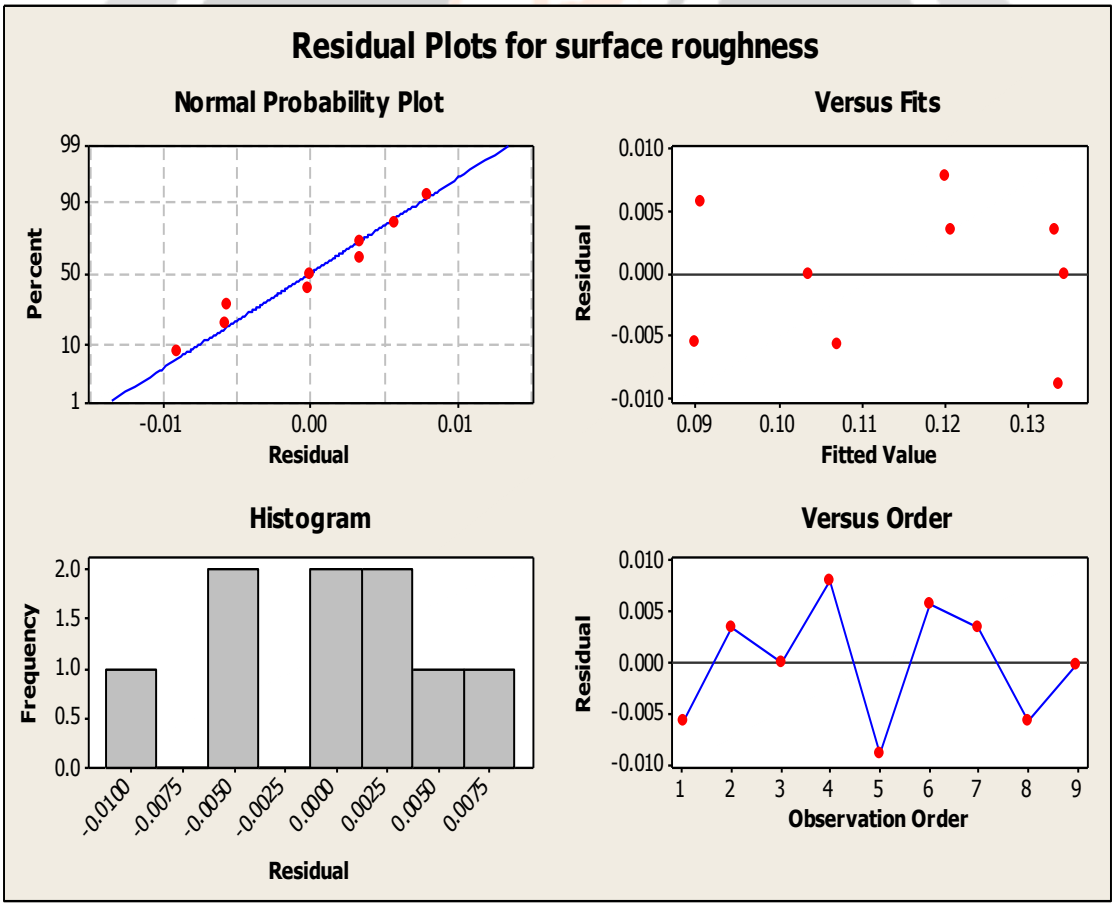


Fig 5.9a Residual plot for surface roughness

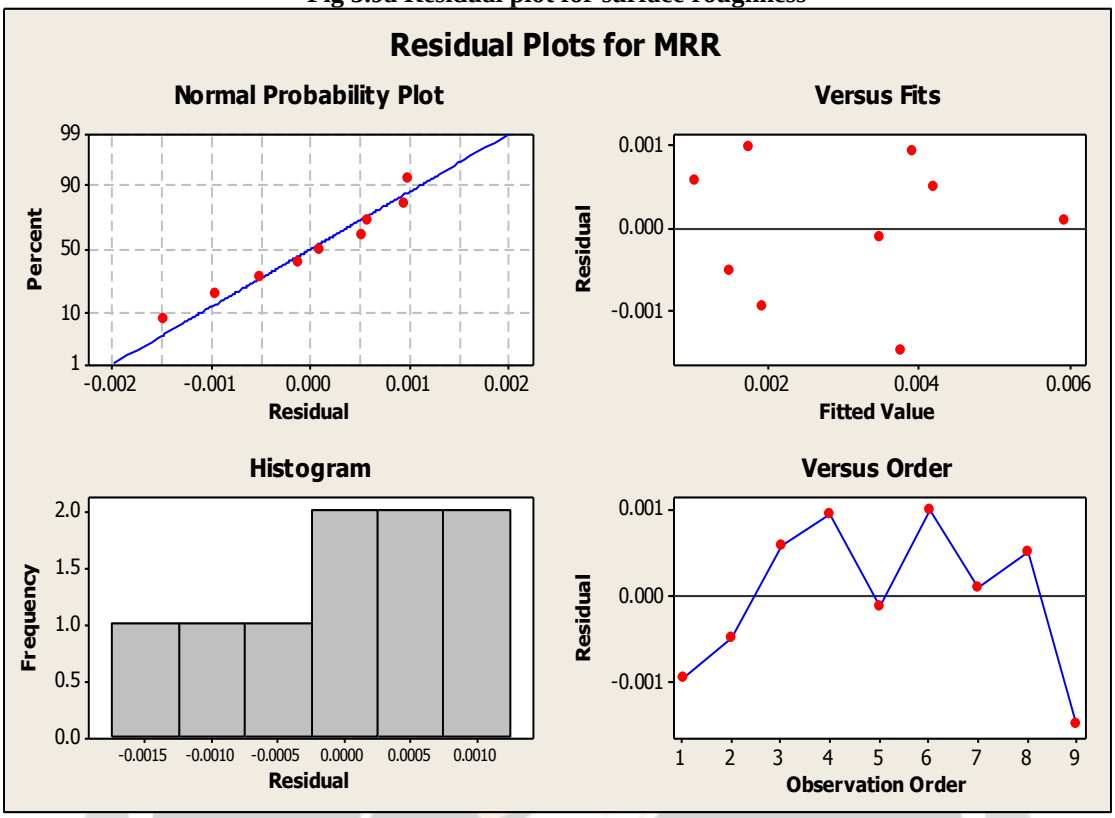


Fig: Residual plot for MRR

COCLUSION

In present study parametric analysis has been carried out for two responses, MRR and Surface roughness. The experiments were conducted under various parameters setting. L9 orthogonal array designed for rough diamond. Minitab 16 software was used for analyze the experimental data. The linear Regression Model also produced for the Responses. Following conclusions drawn after analysis. Process parameters do not have same effect for every response. The most significant parameter for MRR is laser power with first rank given by taguchi analysis. Second rank is given to frequency and third rank to pulse duration.

As laser power increases MRR increases, As frequency increases MRR decreases and for Pulse duration it gives combine result. For 8W laser power it gives minimum MRR, for 22 KHz it gives minimum MRR and for 0.50 MS pulse duration it gives minimum MRR. R^2 value for regression analysis is 77.46% for MRR and it is also checked by Annova analysis

Taguchi analysis for surface roughness gives first rank to pulse duration as most effective parameter. Second rank to laser power and third rank to frequency. As pulse duration increases surface roughness increases. For frequency it gives combine result and as laser power increases surface roughness decreases. R^2 value for surface roughness for regression analysis is 90.56% and it is also checked by Annova analysis.

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