© 2017 IJSRSET | Volume 3 | Issue 5 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Surface Grinding Parameters Optimization of Austenitic Stainless Steel Sheet (AISI 304) by Taguchi Method

Tushar Khule*[1], Prof. Mali M.S.[2], Dr.Zope S.B.*[3]
*[1]Department of Mechanical, SPPU PUNE /SVCET, RAJURI, PUNE, Maharashtra, India
Khule.tushar@gmail.com[1]

ABSTRACT

The manufacturing process of surface grinding has been established in the mass production of slim, rotationally symmetrical components. Due to the complex set-up, which results from the large sensitivity of this grinding process to a multiplicity of geometrical, kinematical and dynamical influence parameters, surface grinding is rarely applied within limited-lot production. The substantial characteristics of this grinding process are the simultaneous guidance and machining of the work piece on its periphery. Surface grinding is an essential process for final machining of components requiring smooth surfaces and precise tolerances. As compared with other machining processes, grinding is costly operation that should be utilized under optimal conditions. Although widely used in industry, grinding remains perhaps the least understood of all machining processes. The proposed work takes the following input processes parameters namely Work speed, feed rate and depth of cut. The main objective of this work is to predict the grinding behavior and achieve optimal operating processes parameters. The main objective in any machining process is to maximize the Metal Removal Rate (MRR) and to minimize the surface roughness. In order to optimize these values Taguchi method, regression analysis and ANOVA is used.

Keywords: ANOVA, Depth of Cut, Feed Rate, Surface Grinding, Taguchi Method, Work Speed.

I. INTRODUCTION

Grinding is a material removal Process used to shape and finish components made of metals and other materials. The precision, surface finish obtained through grinding can be up to ten times superior to with either milling or turning. Grinding process uses an abrasive product, usually a rotating wheel brought into controlled contact with a work surface. The grinding wheel is made of abrasive grains which are held together in a binder. These abrasive grains act as cutting tool, removing tiny chips of material from the work. As these abrasive grains wear and become dull, the increased resistance leads to fracture of the grains or weakening of their bond. The dull pieces break away, revealing sharp grains that continue cutting. The requirement for efficient grinding includes:

- Abrasive component which are harder than the work
- Shock and heat resistant abrasive wheels
- Abrasives that is friable.

That is, they are capable of controlled fracturing most abrasive used in industry is synthetic. Aluminum oxide is used in three quarters of any grinding operations, and is primarily used to grind ferrous metals. Next is silicon carbide, which is used for grinding softer, non-ferrous metal and high density material, such as cemented carbide or ceramics. Super abrasives, namely cubic boron nitride and diamond, are used in about five percent of grinding. Hard ferrous materials are ground with the "CBN", while non-ferrous materials and non-metals are best ground with diamond. The grain size of abrasive materials is important to the processes. Large and coarse grains remove material faster and smaller grains produce a finer finish. The binders which hold these abrasive grains together include:

- Vitrified bonds and a glass-like bond formed of fused clay or feldspar
- Organic bonds, synthetic resins and rubber, or shellac.
- Metal, single-layer bond systems for super abrasive.

There are various methods of grinding, but the major industrial grinding processes are:

- Cylindrical grinding
- Internal grinding
- Centerless grinding
- Surface grinding

In surface grinding, the workpiece is fixed and the grinding wheel rotates with high velocity. Surface grinding produces external surfaces that may be straight, tapered, or contoured. The basic components of a surface grinder include a wheel head, which incorporate the spindle & drive motor; a cross-slide, which moves the wheel head to and from the Workpiece; which locates, holds, and drives the Workpiece. The Surface Grinder is mostly used in the finishing process. It is a more precise and accurate method which uses a stationary, abrasive, rotating wheel to shave or finish metallic surfaces which is held in place by a vise. Which is the part of a table, or carriage, is moved back and forth under the abrasive wheel. The table of the grinder may be magnetic, which aids in holding the material still. These things having attraction for iron can be toggled with the help of a lever placed on the front side of the grinder. As compared to other material removal processes, grinding is costly operation which should be utilized under optimal conditions. Although widely used in industry, grinding is the least understood of all the machining processes. The major operating parameters which affects the output response parameters are metal removal rate, surface roughness, surface damage, and tool wear etc., are: (i) wheel parameters: abrasive, grain size, grades, structures, binder, shape and dimension, etc., (ii) Workpiece parameters: fracture mode, mechanical properties and chemical composition, etc., (iii) Process parameters: work speed, depth of cut, feed rate, dressing condition, etc., (iv) machine parameters: static and dynamic Characteristics, spindle system, and table system, etc. The proposed work takes the following input process parameters namely Work speed, feed and depth of cut. Alloy 304 is commonly used to rigid flanges; this application requires precise surface roughness because of use in chemical handling pipelines or equipments. Due to this reason surface grinding for this application requires to be optimum. Hence for this work this application is under consideration. A software package is utilized, which integrates these various models to simulate what happens during surface grinding processes. Predictions from this work will be analysed by calibration with actual data. It involves different variables such as depth of cut, work speed, feed rate, chemical composition of work piece, etc. The main objective this work is to maximize the Metal Removal Rate (MRR) and to minimize the surface roughness. In order to optimize these values Taguchi method is used. For the optimum control parameters which are obtained from Taguchi S/N ratios analysis.

II. LITERATURE REVIEW

Kamaldeep Singh, Dr. Beant Singh, Mandeep Kumar (2015) states that, Grinding is a very important technique in which material is removed at a high rate with high level of surface finish. In their research work Taguchi method is applied to find optimum process parameters for abrasive assisted surface grinding of AISI D3 tool steel. Experiments are conducted on horizontal spindle reciprocating table surface grinding machine with L18 orthogonal array with input machining variables as type of wheel, depth of cut, table speed, grain size and slurry concentration. After conducting the experiments, MRR is calculated and surface roughness is measured using surface roughness tester. Results are optimized by S/N ratio and analyzed by ANOVA. This study demonstrates that c-BN grinding wheel is preferred for higher MRR and Al2 O3 grinding wheel for better surface finish. Depth of cut is the most significant factor for both MRR and surface roughness .**M. Aravind, Dr. S. Periyasamy (2014)** states that, the surface grinding process parameters can be optimized by using Taguchi method and Response Surface Methodology (RSM). The process parameters considered in this study are grinding wheel abrasive grain size, depth of cut and feed. An AISI 1035 steel square rod of 100 mm x 10 mm x 10 mm was considered for grinding. The output response was selected as Surface roughness (Ra and Rz). In Taguchi method, L27 orthogonal array was selected and S/N ratios were analyzed to study the surface roughness characteristics. In response surface methodology, Box-Behnken method was used for optimization. Thirteen experiments were conducted in the surface grinding machine. The surface roughness values were entered in the Design Expert software and the optimal solution was obtained. Both methods showed that wheel grain size and depth of cut influences the surface roughness a lot. Feed of the surface grinding has a very minimal effect on the surface roughness value. This study showed that when the input parameters can be varied within the selected levels, Response surface methodology has an edge over Taguchi method. The confirmation experiments were conducted both for the optimal solution obtained from Taguchi and Response surface methodology. **Pawan Kumar, Anish Kumar, Balinder Singh (2013)** states that, surface quality and metal removal rate are the two important performance characteristics to be considered in the grinding process. The main purpose of this work is to study the effects of abrasive tools on EN24 steel surface by using three parameters (Grinding wheel speed, table speed & Depth of cut). This study was conducted by using surface grinding machine. In this work, empirical models were developed for surface roughness and metal removal rate by considering wheel speed, table speed and depth of cut as control factors using response surface methodology. In this Response surface methodology (RSM) was applied to determine the optimum machining parameters leading to minimum surface roughness and maximum metal removal rate in Surface grinding process. Surface roughness and material removal rate is strongly dependent on wheel speed, table speed and depth of cut**. Mustafa Kemal Kulekcy (2013)** states that, the Taguchi method that is a powerful tool to design optimization for quality can be used to find the optimum surface roughness in grinding operations. An orthogonal array, a signal-to-noise (S/N) ratio, and an analysis of variance (ANOVA) are employed to investigate the surface-roughness characteristics of AISI 1040 steel plates using EKR46K grinding wheels. Through this study, not only the optimum surface roughness for grinding operations is obtained, but the main grinding parameters affecting the performance of grinding operations can also be found. Experimental results are provided to confirm the effectiveness of this approach. The results of this study showed that the depth of cut and the wheel speed have significant effects on the surface roughness, while the rate of feed has a lower effect on it. This study showed that the depth of cut and the wheel speed have significant effects on the surface roughness. The rate of feed has a lower effect on the surface roughness. **Janardhan and Gopala Krishna (2012)** proposed that in surface grinding metal removal rate and surface finish are the important responses. The Experiments were conducted on CNC surface grinding machine using EN8 material (BHN = 30-35) and he found that the feed rate played vital role on responses surface roughness and metal removal rate than other process parameters. Surface grinding is the most common process used in the manufacturing sector to produce smooth finish on flat surfaces. Surface quality and metal removal rate are the two important performance characteristics to be considered in the grinding process. The economics of the machining process is affected by several factors such as abrasive wheel grade, wheel speed, depth of cut, table speed and material properties. In this work, empirical models are developed for surface roughness and metal removal rate by considering wheel speed, table speed and depth of cut as control factors using response surface methodology. In this paper, Response surface methodology (RSM) has been applied to determine the optimum machining parameters leading to minimum surface roughness and maximum metal removal rate in Surface grinding process operation on EN24 steel. The second order mathematical models in terms of machining parameters were developed for metal removal rate (MRR) and Surface roughness on the basis of experimental results. The model selected for optimization has been validated with F-test. The adequacy of the models is tested output responses have been established with analysis of variance (ANNOVA). An attempt has also been made to optimize cutting parameters using multiobjective characteristics for the developed prediction models using Response surface methodology (RSM).

III. OBJECTIVE AND METHODOLOGY

A. Objective

Objective of this work is to study the grinding behaviour and achieve optimal operating processes parameters.Softwares is utilized which integrates these various models to simulate what happens during surface grinding processes. The main purpose in any machining process is to maximize the Metal Removal Rate (MRR) and to minimize the surface roughness (Ra). So to optimize these values Taguchi method is used.

B. Methodology

The goal of experimental work is to investigate the effect of grinding parameters with the process parameters of cutting speed; feed rate and Depth of cut affect the surface roughness (Ra) of Austenite stainless steel AISI 304.

C.Taguchi Method

The Taguchi method helps to reduce the variation in a process through resilient design of experiments. The overall objective of this method is to produce quality product at minimum or low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintains that variation. Taguchi developed a methodology for designing experiments to find out how different parameters affect the mean and variance of a process performance characteristic that defines how the processes are worked. The experimental design proposed by Taguchi involves orthogonal arrays (OA) to organize the parameter which affect the processes and the levels at which they should be varies. Instead of testing all the possible combinations and experiments, the Taguchi method test pairs of combinations or experimental parameters. This allows for the collection of the needful data to determine which parameters mostly affect the product quality with a minimum amount of experimentation, to save time and resources. The Taguchi methodology is mostly used when there is a number of variables in-between (3 to 50), some interactions between variables, and when only some variables gives importantly. The Taguchi arrays can be derived, small arrays can be found out manually; large arrays can be find out by deterministic algorithms. Generally arrays can be derived online. The arrays are selected by the number of parameters and the number of level or states. Analysis of variance on the gathered data from the Taguchi design experiments will be used to select new parameter values to optimize the performance characteristics. The data from the arrays can be examined by plotting the data and performing a visual analysis, ANOVA. It is known that the total economic and technical potential of any producing method are often used only if the method is carried with the optimum parameters. One of the most important optimization techniques is Taguchi method. The Taguchi approach gives a comprehensive understanding of the individual and combined process parameter from a less number of simulation trials. The Taguchi approach is a form of design of experiments with special application principles. This technique or method helps to study or find the effect of many variables on the desired quality characteristics most economically. By learning the effects of person factors on the results, the best factor combination can be derived. Taguchi designs experiments by using specially constructed tables known as "orthogonal array" (OA). Orthogonal array is the matrix of numbers arranged in columns and rows. By using these tables the design of experiments very simple and harmony and it requires minimum number of experimental trials to study the all parameter. As a result, time, cost, and labour saving can be achieved. The Taguchi method makes use of generic signal-to-noise (S/N) ratio to quantify the present variation. These S/N ratios are supposed to be used as measure of the effect of noise factors on performance characteristics. S/N ratios take into account both the amount of variation in the response data and closeness of the average response to target. The experimental results are converted into a signal-to-noise (S/N) ratio. Taguchi recommends the use of the S/N ratio to determine the quality characteristics which deviate from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e. the-Smaller-the-best, the-higher-the best, and the nominal-the-better. The S/N ratio for each level of process parameters is enumerated based on the S/N analysis. The largest S/N ratio corresponds to best quality characteristics. Therefore, the optimum level of the process parameters is the level with the greatest S/N ratio. Taguchi suggest the use of the loss function to determine the deviation of the quality characteristic from the appropriate value. The value of the overall loss function is further converted into a signal-to-noise (S/N) ratio. Normally, there are three categories of the quality characteristic in the analysis of the S/N ratio, i.e. the lower-the-best, the larger-the-best, and the more-nominal-the-best. The S/N ratio for each level of process parameters is enumerated based on the S/N analysis. Regardless of the category of the quality characteristic, a larger S/N ratio corresponds to a superior quality characteristic. Therefore the optimal level of the process parameters is the level with the highest S/N ratio. Moreover, a statistical analysis of variance (ANOVA) is carried out to see which process parameters are statistically important. The optimal combination of the process parameters can then be estimated. Finally, the experiment is done to verify the optimal process parameters obtained from the process parameter design.

D. Taguchi Method of Orthogonal Arrays

PARAMETERS-3

1. Rotational Speed- e.g. H, I, J
2. Feed- e.g. K, L, M
3. Depth of cut- e.g. N, O, P

Here there are total three levels for each parameter.

EXPERIMENT	ROTATIONAL SPEED	FEED	DEPTH OF CUT
1	H	K	N
2	H	L	O
3	H	M	P
4	I	K	O
5	I	L	P
6	I	M	N
7	J	K	P
8	J	L	N
9	J	M	O

Table 1: Taguchi design of experiments according to L9 orthogonal array

Sr. No	Process Parameters	Range	Level 1	Level 2	Level 3
1	Rotational speed	400-1100 m/min	400	750	1100
2	Feed	3-15 m/min	3	9	15
3	Depth of cut	3-18 µm	3	10.5	18

Table 2: Process Parameters with their values at corresponding levels.

IV.RESULT AND DISCUSSION

Experimental values of surface roughness after grinding process and their respective S/N ratio.

Sr. No.	Speed (rpm)	Feed (m/ min)	DOC (µm)	R_a(µm)	SN Ratio
1	400	3	3	1.107	-0.8829
2	400	9	10.5	1.424	-3.0702
3	400	15	18	1.343	-2.5615
4	750	3	10.5	0.871	1.1996
5	750	9	18	1.469	-3.3404
6	750	15	3	1.385	-2.8290
7	1100	3	18	1.666	-4.4335
8	1100	9	3	1.770	-4.9594
9	1100	15	10.5	1.586	-4.0060

Table 3: Result table

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Speed	2	13.426	13.426	6.713	5.00	0.167
Feed	2	9.376	9.376	4.688	3.49	0.223
Depth of cut	2	3.385	3.385	1.692	1.26	0.442
Residual Error	2	2.684	2.684	1.342		
Total	8	28.870				

Table 4: Analysis of Variance for SN ratios of Ra

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Speed	2	0.3358	0.3358	0.1679	8.15	0.109
Feed	2	0.1787	0.1787	0.0893	4.14	0.187
Depth of cut	2	0.0609	0.0609	0.0304	1.48	0.403
Residual Error	2	0.0411	0.0411	0.0206		
Total	8	0.6167				

Table 5: Analysis of Variance for SN ratios of Mean

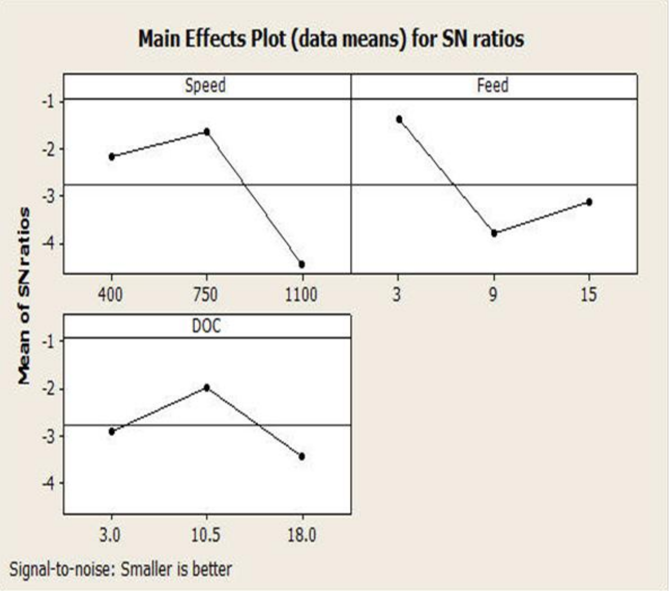

Figure 1. Main Effect Plot for SN Ratio

After conducting the experiment on surface grinding of austenitic stainless (AISI 304) surface finish are given below.

- Speed is a major dominating parameter of surface roughness in surface grinding process.

The optimum parameter for Surface finish for surface grinding of Austenitic stainless steel AISI 304 is 750 m/min of speed, 3 m/min of Feed and 10.5 µm depth of cut are shown in Table 3 and 4, Fig 4.

- However Austenitic stainless steel (AISI 304) is having good machinabilty characteristic and Produce best surface finish.
- Austenitic stainless steel produce good surface finish and get minimum crack tendency.

V. CONCLUSION

After conducting number of experiments on surface grinding, I conclude the following:

- Austenitic stainless steel produces good surface finish during surface grinding process in optimum grinding process parameters.
- Close dimensional tolerance can be achieved during surface grinding.
- Speed play an important role in surface grinding and produce good surface finish in AISI 304 austenitic stainless steel were 750 rpm of cutting speed 3 m/min and 10.5 µm of depth of cut.
- Austenitic stainless (AISI 304) Provide good machinabilty property and the problem of poor chip breaking, wheel loading, and wheel blazing are resolved.
- The influence parameter of surface roughness is speed.
- The optimum parameters of surface grinding overcome problem of poor chip breaking and also machining distortion.

VI. REFERENCES

[1]. Kamaldeep Singh and Dr. Beant Singh. (2015, July).Experimental Investigation of Machining Characteristics of AISI D3 Steel with Abrasive Assisted Surface Grinding.IRJET.Vol:2, Issue: 4.

[2]. M.Arvind and Dr.S.Periyasami.(2014,May). Optimization of Surface Grinding Process Parameters by Taguchi Method and Response Surface Methodology.IJERT. Vol: 3, Issue: 5, pp.1721-1727.

[3]. Pawan Kumar and Anish Kumar.(2013, Oct).Optimization of Process Parameters in Surface Grinding Using Response Surface Methodology.IJRMET. Vol: 3, Issue: 2.pp.245-252.

[4]. Mustafa Kemal Külekcý. (2013). Analysis of Process Parameters for a Surface-Grinding Process Based On the Taguchi Method. Materials and Technology.pp.105-109.

[5]. M.Janardhan and A.Gopal Krishna. (2012, March) .Optimization Of Cutting Parameters for Surface Roughness and Metal Removal Rate in Surface Grinding Using Response Surface Methodology. IJAET.Vol:3, Issue: 1. pp. 270-283.

[6]. Deepak Pal and Ajay Bangar. (2012). Optimization of Grinding Parameters for Minimum Surface Roughness by Taguchi Parametric Optimization Technique.IJMIE.Vo:1, Issue: 3.pp.74-78.

[7]. PV Vinay, Ch Srinivasa Rao. (2015), Experimental analysis and modeling of grinding AISI AISI D3 steel. International Journal of Recent advances in Mechanical Engineering. Vol: 4.

[8]. Deepak Pal, Ajay Bangar., Optimization of Grinding Parameters for Minimum Surface Roughness by Taguchi Parametric Optimization Technique,2012, International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Volume-1, Issue-3.