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Surface Grinding Parameters Optimization of Austenitic Stainless Steel (AISI 304)

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ABSTRACT

The assembling procedure of surface grinding has been set up in the large scale manufacturing of thin, rotationally even parts. Due to the complex set-up and geometrical, kinematical, dynamical influence parameters, surface grinding is rarely applied within limited-lot production. Surface crushing is a basic procedure for last machining of parts requiring smooth surfaces and exact resiliences.As contrasted and other machining forms, crushing is exorbitant activity that ought to be used under ideal conditions.. Although widely used in industry. The project 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 behaviour and achieve optimal operating processes parameters. A software package is utilized which integrates these various models to simulate what happens during surface grinding processes. Predictions from this simulation will be further analysed by calibration with actual data. The main objective in any machining process is to maximize the Metal Removal Rate (MRR) and to minimize the surface roughness (Ra). In order to optimize these values Taguchi method, ANOVA is used. The surface roughness (Ra) value and Material Removal Rate (MRR), obtained from experimentation and confirmation test, for this the optimum control parameters are analysed.
Keywords : Annova, MRR, Ra

I. INTRODUCTION

Grinding is a material removal and surface generation process used to shape and finish parts made of metals and different materials. The precision and surface finish obtained through grinding can be better than with either turning or milling. Grinding employs an abrasive product, usually a pivoting wheel carried into controlled contact with a work surface. These rough grains go about as cutting instruments, expelling little chips of material from the work. As these abrasive grains wear and become dull, the added resistance leads to fracture of the grains or weakening of their bond. The dull pieces break away, revealing sharp new grains that continue cutting. The requirements for efficient grinding include:

- Abrasive components 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 abrasives used in industry are synthetic. Aluminium oxide is used in three quarters of all grinding operations, and is primarily used to grind ferrous metals. Next is silicon carbide, which is utilized for grinding softer, non-ferrous metals and high density materials, such as cemented carbide or ceramics. Super abrasives, specifically cubic boron nitride or "CBN" and precious stone, are utilized in around five percent of granulating. Hard ferrous materials are ground with "CBN", while non-ferrous materials and non-metals are best ground with precious stone.. The grain size of rough materials is critical to the procedure. Large, coarse grains extract material faster, while smaller grains produce a better finish.

Grinding processes used in industry has many difficulties in various forms. In grinding system the problem of large wheel wear, grinding marks on workpiece, poor chip breaking, wheel glazing, and workpiece tapered. To overcome this problems we have to find out optimum process parameter for grinding of AISI 304 material, for this we used taguchi method which gives minimum number of experiment to find optimum value and ANNOVA is used to find out which parameter most affect surface roughness and material removal rate.
Also, problem of poor chip breaking and machining distortion is observed majorly in case of grinding process. So it is desirable that we have carry out grinding process at optimum levels of those parameters.

Application selected for work i.e. rigid flange used in chemical handling pipelines or equipments, requires surface roughness value generally between 0.5 to 1.6 μm

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 analysed by ANOVA. This study demonstrates that c-BN grinding wheel is preferred for higher MRR and Al2 O3 grinding wheel for better surface finish. The increase in material removal rate surface finish goes down. . Increased rate of material removal result in low time consumption but at the same time surface finish is also important. Machining processes need to be optimized for more material removal and higher surface finish. Surface texture is property of a material which needs to be optimum.

Gaurav upadhyay, Ramprasad, Kamal Hassan (2015) proposed that, metal removal rate and surface finish are the important output responses in the production with respect to quantity and quality respectively. The objective of this paper is to arrive at the optimal grinding conditions that will maximize metal removal rate when grinding IS 319 brass. Empirical models were developed using design of experiments by Taguchi L9 Orthogonal Array and the adequacy of the developed model is tested with ANOVA. The higher the signal to noise ratio, the more favorable is the effect of the input variable on the output. Cylindrical grinding is a metal cutting operation performed by means of abrasive particle rigidly mounted on rotating wheel. Each of the abrasive particle act as single point cutting tool and grinding wheel acts as a multipoint cutting tool. The grinding process is frequently considered as one of the most complex and difficult-to-control manufacturing processes due to its complex, nonlinear, and stochastic nature. Therefore, controlling the grinding process for the improvement of its yield and productivity would often require a highly sophisticated control framework. For Metal Remove Rate (MRR), the depth of cut (μm) was the most influencing factor for IS 319 Brass work material followed by grinding wheel speed and work speed.

Kirankumar Ramakantrao Jagtap, S.B.Ubale (2012) states that metal removal rate and surface finish are the important output responses in the production with respect to quantity and quality. The main objective of this paper is to arrive at the optimal grinding conditions that will minimize surface roughness and maximize metal removal rate when grinding AISI 1040 steel. Empirical models were developed using design of experiments by Taguchi L9 Orthogonal Array and the adequacy of the developed model is tested with ANOVA. The developed model can be used by the different manufacturing firms to select appropriate combination of machining parameters to achieve an optimal metal removal rate (MRR) and surface roughness (Ra). The input parameters considered are: wheel speed, work speed, number of passes and depth of cut and the responses are metal removal rate (MRR) and surface roughness (Ra). The results were further validated by conducting confirmation experiments.

III. Objective and Methodology

A.Objective

The objective of study is to find out the effect of different parameters like spindle speed, feed rate and depth of cut during grinding operation on surface roughness and material removal rate. To study the contribution of process parameters spindle speed, feed rate and depth of cut. Validation of experimental data by experiment and ANOVA.

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 involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at lowest possible cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. Taguchi 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 maturate by Taguchi uses orthogonal arrays (OA) to organize the parameters affecting the process and the levels at which they should be varies. Instead of having to test all possible combinations like 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 product quality with a minimum amount of experimentation thus saving time and resources.

D. Taguchi Method of Orthogonal Arrays

Parameters-3

1. Rotational speed- e.g. A, B, C
2. Feed (Table speed) - e.g. P, Q, R
3. Depth of cut- e.g. L, M, N

Here there are total three levels for each parameter.

Therefore refer Taguchi table of orthogonal arrays L9.

Experiment	Rotational speed	Feed	Depth of cut
1	A	P	L
2	A	Q	M
3	A	R	N
4	B	P	L
5	B	Q	M
6	B	R	N
7	C	P	L
8	C	Q	M
9	C	R	N

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

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

Table 2. Process Parameters with their values at corresponding levels

IV.Result and Discussion

Surface roughness values

Sr. No.	Speed (RPM)	Feed(m/min)	DOC (um)	Surface roughness(Ra) (um)
1	400	3	3	1.107
2	400	9	10.5	1.424
3	400	15	18	1.343
4	750	3	10.5	0.871
5	750	9	18	1.469
6	750	15	3	1.385
7	1100	3	18	1.666
8	1100	9	3	1.770
9	1100	15	10.5	1.586

Table 3. Surface roughness (Ra) value

Source	DF	Seq SS	Adj SS	Adj MS	F	P	Contribution %
Speed	2	13.426	13.426	6.713	5.00	0.167	46.45
Feed rate	2	9.376	9.376	4.688	3.49	0.223	32.57
DOC	2	3.385	3.385	1.692	1.26	0.442	11.60
Error	2	2.684	2.684	1.342			9.38
Total	8	28.870					100.00

Table 5. Analysis of Variance for SN ratios for Ra

Note: DF- Degrees of Freedom,
Seq SS – Sequential Sum of Squares,
Adj SS – Adjusted Sum of Squares,
Adj MS – Adjusted Mean Square,
F test of hypothesis,
P value of hypothesis.

Source	DF	Seq SS	Adj SS	Adj MS	F	P	Contribution %
Speed	2	0.33581	0.33581	0.16791	8.15	0.109	54.36
Feed rate	2	0.17878	0.17878	0.08939	4.34	0.187	29.14
DOC	2	0.06091	0.06091	0.03046	1.48	0.403	9.74
Error	2	0.04119	0.04119	0.02060			6.76
Total	8	0.61670					100

Table 6. Analysis of Variance for Means for Ra

Factor	Level Value	Level
Spindle Speed (S)(RPM)	750	3
Feed rate (F)(m/min)	3	2
Depth of cut (H) (μm)	10.5	3

Table 7. Optimized process parameter obtained from ANOVA – Minitab

The results obtained after grinding on the given workpiece that is austenitic stainless steel sheet 304 using the process parameter with the help of CNC grinding machine. Nine no. of experiments were performed on the workpiece using the combination as given by taguchi orthogonal arrays (OA) and no. of experiment given by MINITAB software. The material removal rate for each experiment was found out using suitable formulas, and then the surface roughness was checked of each experiment using a surface roughness tester and the results were carried out. Here is the comparison of the obtained results and its conclusion.

IV. CONCLUSION

The speed is observed to be most dominant factor followed by feed i.e. table speed and depth of cut on surface roughness within the ranges considered. The higher level of speed, medium level of feed and higher level of depth of cut are identified as optimum levels for achieving the better surface finish.

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