Parameters optimization of surface grinding process for AISI 321 by Using Taguchi Method

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ABSTRACT

Recently stainless-steel AISI-321 finding several applications like Automotive, Aerospace, Nuclear, Chemical plants.
The present work takes the subsequent input processes parameters specifically Work speed, feed rate and depth of cut. The objective of this work is to predict the grinding behavior and come through best in operation processes
parameters. A software system package is also utilized that integrates these numerous models to simulate what happens throughout surface grinding processes. Predictions from this work are additional analyzed by standardization with actual knowledge. It involves several variables like depth of cut, work speed and feed rate The aim of any machining method is to maximize the Metal Removal Rate (MRR).In present work to optimize these values Taguchi methodology, ANOVA is employed.

Keyword: - *surface grinding, Austenitic stainless steel, Optimization Taguchi, S/N ratio, ANOVA.*

1. INTRODUCTION

The manufacturing process of surface grinding has been established in the production of slim and flat symmetrical components. Due to the complicated set-up, which results from the big sensitivity of this grinding method to a multiplicity of geometrical, kinematical and dynamical influence parameters, surface grinding is rarely applied inside limited-lot production. The substantial characteristics of this grinding process square measure the synchronic steering and machining of the work piece on its edge. Surface grinding is an essential method for final machining of elements requiring sleek surfaces and precise tolerances. As compared with other machining processes, grinding is costly operation that ought to be used underneath optimum conditions.
Although wide used in business, grinding remains perhaps the least understood of all machining processes. The major operating input parameters that influence the output responses, metal removal rate, surface roughness, surface damage, and tool wear etc., are: (i) wheel parameters: abrasives, grain size, grade, structure, binder, shape and dimension, etc., (ii) Work piece 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 processes parameters specifically work speed, feed rate and depth of cut. Alloy 321 is commonly wont to rigid flanges; this application needs precise surface roughness thanks
to use in chemical handling pipelines or equipment's. Due to this reason surface grinding for this application require to be Optimum. Hence for this work this application is underneath thought. As of Aware package might be used that integrates these numerous models to simulate what happens throughout surface grinding processes. Predictions from this work will be any analyzed by standardization with actual information. It involves several variables such as depth of cut work speed, feed rate, etc. The main objective in any machining process is to

maximize the Metal Removal Rate (MRR). In order to optimize these values Taguchi method, ANOVA and regression analysis is employed

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2. LITERATURE REVIEW

Rakesh Roy 1, Sourav Kumar Ghosh 2, Tanvir Ibna Kaisar 3, (2022) states that Grinding is widely used as an ultimate machining process in manufacturing of components incorporating excellent geometric accuracy and satisfactory surface finish. Compared with other machining processes, such as turning and milling, grinding process generates a substantial amount of heat at the grinding zone (almost 10–30 times of that in turning) due to the very high energy input per unit volume of material removal raising the temperature of the grinding zone. Excessive temperature may cause thermal damage to the workpiece such as workpiece burn, phase transformations, undesirable residual tensile stresses, cracks, reduced fatigue strength, and thermal distortion and inaccuracies. It may also cause premature failure of the cutting tools, rapid oxidation, and corrosion. The most commonly used dry grinding has the advantages of cost-effectiveness and environment friendly nature with no pollution despite having major drawbacks namely thermal damage, high friction, high residual stress, and high wheel-wear. On the other hand, wet cutting condition removes heat from the cutting zone. However, it does not always seem to be effective as it consumes a large amount (i.e., 8 L/min) of coolant which is not economically feasible and has a significant impact on the ecology and internal environment (workshop). Hence, a trade-off among material removal rate (MRR), cutting zone temperature, and machining cost is needed for effective machining. [1]

DO Duc Trung1, HOANG Xuan Thinh2, LE Dang Ha2 (2022) states that the efficiency improvement of AISI 4140 steel external cylindrical grinding process. Experiments were carried out with two types of grinding wheels, a conventional and the rubber-pasted grinding wheels. With each type of the wheel, nine experiments were performed. Cooling fluid, spindle speed, feed rate and depth of cut are variables in the experiments. Two outcomes used to evaluate grinding efficiency are surface roughness and material removal rate (MRR). Experimental results demonstrate that the surface roughness achieved in the grinding operation using the rubber-pasted grinding wheels is smaller than using the conventional wheel. The Data Envelopment Analysis-based Ranking (DEAR) method was applied to determine the optimal values of the input parameters for the “minimum” surface roughness and “maximum” MRR in the cases of using each grinding wheel. It is found that the optimization of the input parameters in this circumstance are equal. Several grinding experiments for examining the values of the variables were also performed for both the wheels. The results also confirm that the surface roughness in the grinding process with the rubber wheels is about 19.42% smaller than the conventional wheels. [2]

Dung Hoang TIEN1* Do Duc TRUNG1 Nguyen Van THIEN1 Nhu-Tung NGUYEN (2021) states that a study to ensure the minimum values of Ra and Rz, and the maximum value of MRR when external cylindrical grinding by the PSI method. The experiments were performed according to the orthogonal Taguchi L9 matrix with the input parameters including workpiece speed, feed rate, and depth of cut in the conventional grinding machine. Analysis of experimental results by Pareto chart showed that the feed rate and the depth of cut most influence on Ra and Rz, respectively. Feed rate and depth of cut all have a great influence on MRR. Meanwhile, the workpiece speed has a negligible effect on all three output parameters. The research results showed that to obtain the minimum values of Ra and Rz, and maximum of MRR, the workpiece speed, feed rate, and depth of cut were 400 rev/min 37.7 mm/min, 0.09 mm/rev, and 0.02 mm, respectively. [3]

Chuanmin Zhu1, Zhan Tao1, Peng Gu1* and Yiqing Yu1 (2021) states that SiCp/Al is a kind of particle reinforced composites with good material properties, which can be used in the field of lightweight parts and electronic packaging. Ultrasonic assisted grinding process is one of the processes which is suitable for machining hard and brittle materials, the surface quality can be improved by using appropriate ultrasonic-assisted process parameters. In this paper, the ultrasonic-assisted grinding process is used to improve the surface quality of SiCp/Al, meanwhile, the kinematics of abrasive particles in grinding is analysed to explain the effect of ultrasonic vibration. In addition, ultrasonic-assisted grinding experiment of SiCp/Al is conducted, it is found that the axial ultrasonic vibration can improve the surface quality of SiCp/Al in grinding, and the reduction percentage is up to 8.20% compared to the normal grinding. In addition, a regression model is proposed for surface roughness prediction, the result of t-test on the residuals shows that the model is accurate. [4]

K.N. Ronoh a,*, N.W. Karuri a, F.M. Mwema a,b, H.T. Ngetha c, S.A. Akinlabi d, E.T. Akinlabi b (2016) states that the surface roughness of medical grade Ti-6Al-4V alloy was evaluated to understand the effects of cutting fluids, cooling methods, and grinding depths after surface grinding with alumina wheel. Three cutting fluid types namely sunflower oil, sunflower oil-based cutting fluid, and conventional cutting oil were applied to the grinding zone using two cooling methods: minimum quantity lubrication and wet cooling methods. The grinding was undertaken at grinding depths of 0.005, 0.010, and 0.015 mm. The surface roughness of the ground surfaces was determined using a surface profiler. An analysis of variance demonstrated that the individual contributions of cutting fluid types, cooling methods and grinding depths to surface roughness were 42.7 %, 8.46 % and 40.61 % respectively. The design of the experiment was done using Taguchi L9 orthogonal array to determine the collective contributions of the grinding parameters. The analysis of the signal-to-noise ratio shows that the optimal surface roughness of Ti-6Al-4V was obtained with sunflower oil-based cutting fluid, a minimum quantity lubrication of 0.67L/h and a grinding depth of 0.005 mm. This study provides novel evidence of how grinding parameters can be used collectively to optimize Ti-6Al-4V machining. [5]

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 [6].

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. 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. [7].

K Mekala, J Chandradas (2014) sates that the surface grinding parameters on Austenitic stainless steel are conducted using Taguchi design of experiments of L9 orthogonal array was selected with 3 levels with 3 factors and output parameters of Metal removal rate are measured. After conducting experiment optimized by S/N ratio and analyzed by ANOVA and predicts Cutting speed is a dominating parameter of surface grinding. The influence parameter of surface roughness is cutting speed and metal removal rate is influenced by Depth of cut. The optimum parameters of surface grinding overcome problem of poor chip breaking and machining distortion. [8].

3. PROBLEM IDENTIFICATION

Alloy 321 is commonly used to handle sulphur, pulp liquor, acid dyestuffs, acetylating and nitrating mixtures, bleaching solutions, severe oil and coal, and most of the chemical compounds. Some core applications that use alloy 321 include:

- Rigid Flanges
- Pipes
- Butt weld fittings
- Chemical and petrochemical processing equipment
- Textile equipment.
- Fasteners
- Condensers in fossil and nuclear fueled power generation plants
- Food processing equipment

The identification of machining and grinding difficulties for Austenitic stainless steel (AISI 321) which cannot be
tackled using conventional technique because of following problems occur in Grinding.
• Poor Chip Breaking.
• High Work hardened.
• Tendency to sticky.
• Transformation Induced plasticity.
• Passive surface is affected.
• Machining distortion
The above problems are to overcome during surface grinding and achieve good surface finish and close dimensional accuracy.

4. METHODOLOGY

The Taguchi method can be used for this work. Small arrays can be drawn out manually; large arrays can be derived from deterministic algorithms. Arrays can be found online. The arrays are selected by the number of parameters (variables) and the number of levels. This is further explained later in this article. Analysis of variance on the collected information from the Taguchi design of experiments can be used to select new parameter values to optimize the performance characteristic. Data from the arrays can be analyzed by plotting the data and performing a visual analysis, ANOVA.

4.1.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.

Table 1: Layout of experimental design according to L9 array

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 2: Process Parameters with their values at corresponding levels.

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	3	10.5	18

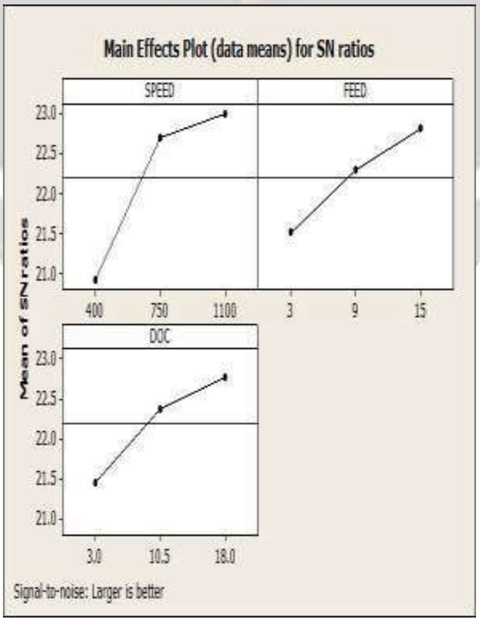
		µm			

5. RESULTS AND DISCUSSION

Table 3: Result table for material removal rate (MRR)

Sr. No.	Speed (rpm)	Feed(m/min)	DOC(µm)	MRR(g/min)	S/N Ratio
1	400	3	3	11.0	20.8279
2	400	9	10.5	13.8	22.7976
3	400	15	18	13.7	22.7344
4	750	3	10.5	9.1	19.1808
5	750	9	18	14.2	23.0458
6	750	15	3	12.9	22.2118
7	1100	3	18	13.4	22.5421
8	1100	9	3	14.1	22.9844
9	1100	15	10.5	14.9	23.4637

Chart 1: Main Effect plot (data means) for SN Ratios



After conducting the experiment on surface grinding of austenitic stainless (AISI 321) for material removal rate are given below.

- Speed is a dominating parameter of Surface grinding for material removal rate.

The optimum parameter for material removal rate for surface grinding of Austenitic stainless steel AISI 321 is 1100 rpm of speed, 15 m/min of Feed and 10.5 µm depth of cut are shown in Table 3.

- However Austenitic stainless steel (AISI 321) is having good machinability characteristic and Produce excellent surface finish.
- Austenitic stainless steel produce good surface finish and get minimum crack tendency.

6. CONCLUSION

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

- Austenitic stainless steel produces good surface finish during surface grinding process in optimum grinding parameters.
- Close tolerance can be achieved during surface grinding.
- Speed play an important role in surface grinding and produce maximum material removal rate in AISI 321 austenitic stainless steel were 1100 rpm of cutting speed 15 m/min and 10.5 µm of depth of cut.
- Austenitic stainless (AISI 321) Provide good machinability property.
- The influence parameter of material removal rate is speed.
- The optimum parameters of surface grinding overcome problem of poor chip breaking and machining distortion

7. REFERENCES

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