Effect of Process Parameters on Surface Roughness of Cylindrical Grinding Process on Ohns (Aisi 0-1) Steel Rounds using ANOVA

* M.Melwin Jagadeesh Sridhar[1], P.Sathish Kumar[2]

[1]Assistant professor, Department of mechanical Engineering, P.R.Engineering College, Thanjavur-613 403, India, [2] Assistant professor, Department of mechanical Engineering, St.Joseph's College of Engineering and Technology, Thanjavur-613 403, India,

Abstract: *Surface finish is the most important output responses in the production with respect to quantity and quality respectively cylindrical grinding is the important metal cutting process used widely in the finishing operations. OHNS steel is the most preferable material for manufacturing of fasteners, automotive components, die blocks and cutting tools. Surface quality is the important performance factor which to be considered in grinding process. The experimental work and statistical analysis in Research activities help in improving quality standards of manufactured components. In this work, the Surface quality of OHNS steel after cylindrical grinding process is proposed to be studied using L9 orthogonal array having three levels and three input parameters. Work speed, depth of cut and number of pass are considered as the input parameters for this study and the response parameters are minimum surface roughness and minimum tool wear. Lower surface roughness is the main objectives of every machining process. After conducting experiment, S / N ratio is used for optimization and ANOVA is used for analysis. It is predicted that work speed is a dominating parameter for lower surface roughness of cylindrical grinding.*

Key words: *Cylindrical Grinding, OHNS, Surface Roughness, S/N ratio, optimization, ANOVA*

I-.INTRODUCTION

The high quality and contentious of products makes them crucial for the processes adopted to manufacture a work piece as impressive as possible. In order to achieve such a goal the study of machining processes, grinding process in particular should focus on the constant improvement of manufacturing parameters and methods. One of the most important factors to assess the quality of every product is surface roughness. Cylindrical grinding is the essential process of super finishing operation of circular components required for smooth surfaces and precise tolerances because it can meet the strict requirements for surface roughness and precise tolerances. The main operating input parameters which influence the output responses, metal removal rate, surface roughness, heat generation, surface damage, tool wear and machining time etc. are (i) wheel parameters: abrasives, structure, grain size, shape and dimension, grade, binder, etc. (ii) Work piece parameters: fracture mode, chemical composition and mechanical properties, etc. (iii) Process parameters: work speed, depth of cut, Number of pass etc. (iv) machine parameters: spindle system, static and dynamic Characteristics and table system, etc. in this paper the following input processes parameters namely Work speed, depth of cut and number of pass. The main objective of this research is to show how our knowledge on grinding process can be utilized to predict the behaviour of grinding process and to optimize the operating processes parameters. Physical and pragmatic models that describe various aspects of grinding process is used to achieve this objective. The proper combination of machining parameters is an important work because the optimal values of surface roughness are determined by that. In order to predicate the influence of the operating conditions it is important to develop mathematical models. Pallavi et al. [01] proposed that Taguchi's design of experiment and ANOVA to optimize the turning parameters for surface roughness in lathe when machining mild steel with coated carbide tool under dry cutting condition. Turning is the process of removing the material from a workpiece to obtain specific dimension and tolerances. It is observed that value of surface roughness (Ra) gets reduced as signal to noise ratio increases due to the various levels of machining parameters. It is found that by increasing the signal to noise ratio, the optimal design condition was achieved. The design of experiments L9 orthogonal array was employed with input parameters of cutting speed, feed rate and depth of cut and assess minimum value of surface roughness was found as 2.2 μm. In this study, Interaction Severity Index has been found between the speed and depth of cut was 18.04 %. Signal to noise ratio

based on the Taguchi's design of present study was -13.78. [02] Surinder kumar et al. developed a surface roughness prediction model for the machining of unidirectional glass fiber reinforced plastics (UD-GFRP) composite with polycrystalline diamond tool of different tool rake angle and tool nose radius using genetic algorithm approach and multiple regression methodology to forecast and optimize the parameters of tool rake angle, tool nose radius, cutting speed, feed rate, cutting environment Dry, Wet and Cooled and depth of cut on surface roughness. It was found that Taguchi's mixed level design of L18 orthogonal array employed for the experimentation work. Application of this material is in advanced structural application due to their light weight, high modulus and specific strength. It was found that the minimum value of surface roughness was 1.1653 µm. Qiyong Zeng et al. [03] propsed that the cutting parameters affect the workpiece surface quality. Process Failure Mode and Effect Analysis (PFMEA) was conducted and found that cutting force, cutting temperature and mechanical vibrations are the main factors that affect the workpiece surface roughness. The cutting temperature, cutting force and vibration can be controlled by controlling feed rate, cutting speed and cutting depth. Surface roughness of the workpiece was measured by surface roughness tested. The three-dimensional piezo electric dynamometer and thin film thermocouple sensor were used to measure the system for cutting force and cutting temperature. The piezo electric dynamometer work fast with high sensitivity is convenient for real time measuring on line. In this work, Polycrystalline Cubic Boron Nitride (PCBN) was used as the cutter material. Surface roughness of workpiece is good under the condition of low cutting speed and low cutting depth. The thin film thermocouple is an advanced sensor used to measure the changes in temperature. It is concluded that feed rate and cutting depth affect the workpiece surface roughness than cutting speed.Janardhan. M et al. [04] explains the optimization of surface quality and metal removal rate using the Response Surface Methodology [RSM]. In this work, depth of cut, table speed and wheel speed as the control factors. The surface grinding machine with aluminium oxide abrasive wheel is used for this investigation. For this research work, L27 orthogonal array is selected. MRR is calculated using the ratio of volume of metal removed from the workpiece to the machining time. Surface roughness was measured using the surface roughness tester. The material used for this investigation is EN 24. The Design Expert (MINITAB) software is used for finding the output responses. Bhattacharya et al. [05] examined the improvement of surface properties measured in terms of improved finish and increased micro hardness of die steel materials with Si, W and graphite powders mixed in dielectric in PMEDM

process using Taguchi design. Ali Zahedi, Taghi T et al [6] proposed that the Grinding is a small scale material removal surface finishing process operation in which the cutting tool is an individual abrasive grain of an irregular geometry and is spaced randomly along the periphery of the wheel. The average rake angle of the grains is highly negative, typically -60 degree or lower, consequently the shear angle are very low. The cutting speeds of grinding wheels at very high, typically on the order of 30 m/s. Grinding are the machining processes which improve surface quality and dimensional accuracy of work piece. Naresh kumar et al [7] examined that the Surface roughness is one of the most important requirements in machining process, as it is considered an index of product quality. It measures the finer irregularities of the surface texture. Achieving the desired surface quality is critical for the functional behavior of a part. Surface roughness influences the performance of mechanical parts and their production costs because it affects factors such as friction, ease of holding lubricant, electrical and thermal conductivity, geometric tolerances and more. The ability of a manufacturing operation to produce a desired surface roughness depends on various parameters. The factors that influence surface roughness are machining parameters, tool and work piece material properties and cutting conditions. For example, in grinding operation the surface roughness depends on depth of cut, material hardness, work piece speed, grinding wheel grain size, no. of pass, material removal rate and grinding wheel speed and on the mechanical and other properties of the material being machined. Even small changes in any of the mentioned factors may have a significant effect on the produced surface.

Oil Hardening Non Shrinking Die Steel (OHNS)

OHNS steel refers to a collection of carbon and alloy steels that are particularly well-suited to be made into tools such as stamping and blanking dies, Punches, Thread cutting tools, Milling cutters, Gauging tools, Reamers, Wood working tools, Rotary shear blades, Measuring tools, Broaches and Chisels. Their suitability comes from their resistance to abrasion, their ability to hold a cutting edge, distinctive hardness and/or their resistance to deformation at elevated temperatures.

Table 1 Chemical composition of OHNS steel

C	Mn	Cr	W	V
0.95	1.15	0.5	0.5	0.2

Table 2 Mechanical properties of OHNS Steel

Maximum Stress (N/mm^2)	Yield stress (N/mm^2)	Elong ation	Impact strength (joule)	Hardnes s value (BHN)
950	465	10%	25	288

PROBLEM IDENTIFICATION

The identification of cylindrical grinding problem for OHNS Steel rounds which cannot be tackled using conventional technique because of following problems occurs in cylindrical grinding process.

• Need more cutting pressure for machining.

• Difficult to achieve Close tolerance

• Poor Chip Breaking.

• High surface roughness.

• Need high hardness grinding wheel for machining.

II-EXPERIMENTAL SETUP

The aim of this experimental work is to examine the effect grinding parameters with the process parameters like work speed, Number of pass and Depth of cut influencing the machining time of OHNS Die steel. The work material OHNS Die steel in the form of round with 25 mm diameter and length 70 mm. There are 9 experiments are conducted with different machining parameters for determine optimal solution of cylindrical grinding process.

Fig 1. Cylindrical grinding Machine

Fig 2 OHNS steel rounds

Fig 3. Surface Roughness Testing Machine

METHODOLOGY

➢ State the problem

➢ State the objectives of experiments

➢ Select the factors that may influence the selected quality characteristics

➢ Identify quality and noise factors

➢ Select levels for the factors

➢ Select appropriate orthogonal array

➢ Select interactions that may influence the selected quality characteristics

➢ Conduct the tests described by trails in orthogonal array

➢ Analyze and interpret results of the experimental trails

➢ Conduct confirmation experiment

Taguchi Design of Experiments

Taguchi method is a effective tool in quality Optimization makes use of a special design of orthogonal array (OA) to examine. Number of experiments used to design the orthogonal array for 3 parameters and 3 levels of grinding parameters

Minimum experiments $= (L-1)X\ p]+1$
$= [(3-1)X\ 3]+1 = 7$
$\approx L9$

Based on the Design of Experiments concept L_9 Orthogonal Array (OA) is selected for cylindrical grinding parameters of OHNS steel rounds

Table 3 Cylindrical Grinding parameters of surface roughness

Test No.	work speed (rpm)	Depth of cut(mm)	No of pass	Ra (µm)
1	150	0.02	1	1.18
2	150	0.04	2	1.251
3	150	0.06	3	1.379
4	250	0.02	2	1.457
5	250	0.04	3	1.673
6	250	0.06	1	1.55
7	350	0.02	3	1.663
8	350	0.04	1	1.593
9	350	0.06	2	1.711

Table 4 Response Table for Signal to Noise Ratios (Smaller is better)

Level	work speed (rpm)	Depth of cut(mm)	No of pass
1	-2.058	-3.042	-3.096
2	-3.849	-3.486	-3.293
3	-4.376	-3.754	-3.893
Delta	2.318	0.713	0.797
Rank	1	3	2

The table 4 represent the work speed is a influencing parameter (Rank 1)of surface roughness on OHNS steel rounds while cylindrical grinding process calculated from signal to noise ratio.

III-RESULT AND DISCUSSION

After conducting the experiment of cylindrical grinding on OHNS Steel cylindrical rounds the following results were obtained.

1. Work speed is a dominating parameter of surface roughness in cylindrical grinding process of OHNS steel rounds.
2. The primee parameter for surface roughness of cylindrical grinding process of OHNS steel cylindrical rounds were 150 rpm of work speed, 0.02mm of depth of cut 1 number of pass from conducted experiments.
3. It is found that the surface roughness of OHNS steel rounds greatly depend on the work speed on cylindrical grinding process.
4. OHNS steel provides good machinability characteristic and Produce extraordinary surface finish.
5. The work speed, Depth of cut and Number of pass are dependable parameters of getting lower surface roughness on cylindrical grinding process of OHNS steel rounds.
6. Cylindrical grinding is an essential process for final machining of OHNS steel rounds provides smooth surface and precise tolerance.
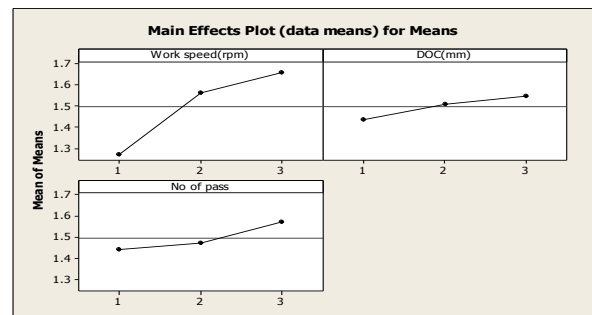

Fig 4. Main effect plot for surface roughness on cylindrical grinding parameters
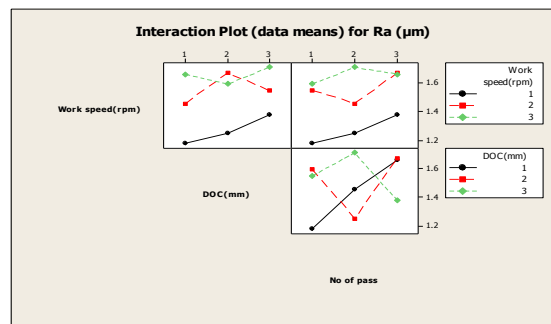

Fig 5 Interaction plot for surface roughness values

The figure 5 shows the interaction plot between all parameters such as Work speed, depth of cut and No of pass of cylindrical grinding OHNS steel rounds and also indicate the dependable parameters of achieving minimum surface roughness.

Table 5 ANOVA values of cylindrical grinding Parameters

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Work Speed (rpm)	2	0.241991	0.241991	0.120995	73.95	0.013
DOC (mm)	2	0.019758	0.019758	0.009879	6.04	0.142
No of pass	2	0.027833	0.027833	0.013916	8.51	0.105
Error	2	0.003272	0.003272	0.001636	--	---
Total	8	0.292854	----	---	----	---

The table 5 shows ANOVA values of cylindrical grinding process and higher value of F-test represents work speed is a dominating parameter while achieving minimum surface roughness.
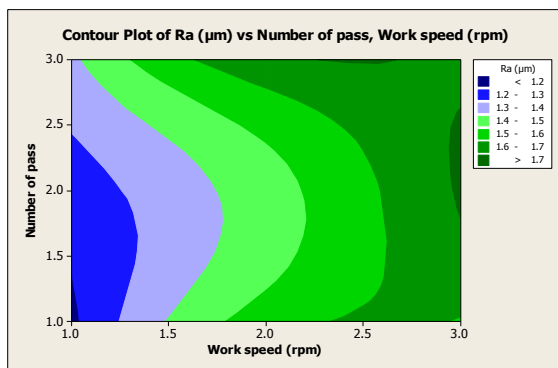

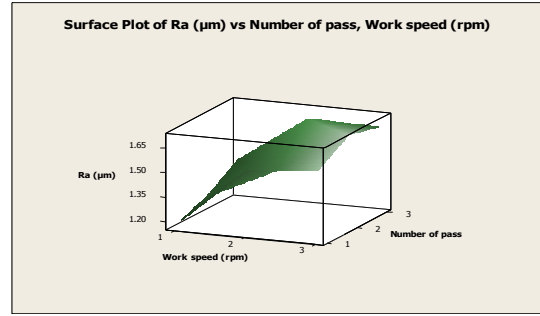**Fig 6 Contour plot for surface roughness**

Fig7 Surface plot for surface roughness

The figure 6 and 7 denotes the graphical representation of optimal parameters of surface roughness during cylindrical grinding process. It is also mentioned that surface roughness is increased by work speed in cylindrical grinding process.

The F-test

The F-test is used for comparisons of the components of the total deviation. For example, in one-way or single-factor ANOVA, statistical significance is tested for by comparing the F test statistic

$$F = \frac{\text{variance between treatments}}{\text{variance within treatments}}$$

IV-CONCLUSION

In this study, the Taguchi method was used to obtain optimal parameters in cylindrical grinding of OHNS 01 steel. Experimental results were examined using ANOVA. The results can be drawn as follows:

- OHNS steel produces excellent surface finish during cylindrical grinding process with most favorable grinding parameters.
- Precise tolerance can be achieved on OHNS steel rounds during cylindrical grinding.
- Work speed of grinding process play an important role for achieving minimum surface roughness for machining in cylindrical grinding process.
- The optimal parameter of OHNS steel rounds in cylindrical grinding process are 150 rpm of work peed ,0.02 mm of depth of cut and 1 number of pass.

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