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OPTIMIZATION OF PROCESS PARAMETERS ON CYLINDRICAL GRINDING MACHINE USING TAGUCHI METHOD

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Abstract
Cylindrical grinding is a metal removing process which is used extensively in the finishing operation. Surface finish is an important output parameter in the manufacturing processes with respect to quality. The various process parameters of a cylindrical grinding machine include depth of cut, material hardness, work piece speed, grinding wheel grain size, and grinding wheel speed. The input process parameters considered are material hardness, work piece speed and depth of cut. The main objective is to predict the surface roughness and achieve optimal operating process parameters. In this study, the Taguchi method that is a powerful tool to design optimization for quality is used to find the optimum surface roughness in grinding operations. Investigate the surface-roughness characteristics of mild steel alloys using grinding wheels. Through this study, not only can the optimum surface roughness for grinding operations be 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

Keywords Cylindrical grinding, mechanical characrerisation, Taguchi Optimazation.

I. INTRODUCTION

Machining is a manufacturing process that involves removing materials using cutting tools for getting rid of unwanted materials from workpiece and converting into the shape you desire. A large piece of stock is used for cutting workpiece. The large stock might be in any shape such as a solid bar, flat sheet, beam or even hallow tubes. The process can also be formed on some existing parts like forging or casting. There are many kinds of machining operations, each of which is capable of generating a certain part geometry and surface textureIn Cylindrical grinding, the work piece rotates about a fixed axis and the surfaces machined are concentric to that axis of rotation. Cylindrical grinding produces an external surface that may be straight, tapered, or contoured. The basic components of a cylindrical grinder include a wheel head, which incorporate the spindle and drive motor; a cross-slide that moves the wheel head to and from the work piece; a headstock, which locates, holds, and drives the work piece; and a tailstock, which holds the other end of the work. Internal diameter or "I.D." grinders finish the inside of a previously drilled, reamed, or bored hole, using small grinding wheels at high RPM. The workpiece is usually held between dead centers and rotated by a dog and driver on the face plate. The work rotated about its

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own axis in a chuck. There are four movements in cylindrical grinding. They are (1) the work must revolve, (2) the wheel must revolve (3) the work must pass the wheel and (4) wheel must pass work. Surface finish is the important out put parameter in cylindrical grinding. Many researchers worked in this area, a few are cited here for references. Srinivas Athreyasays (1) that his paper illustrates the application of the parameter design (Taguchi method) in the optimization of facing operation. It is found that the parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for optimizing the process

Model	DEVCO UC-150
Distance between	160mm
Height of center	102mm
Swiveling angle	+/-9^{0}C
Traverse speed	140-260-370-700
In feed of hand wheel	0.01 Division
Grinding wheel size	250*25*76.2 mm
Grinding wheel speed	2300 rpm
Work head single	90-210-360 rpm
Spindle in taper	MT-3
Total power required	3.5HP (MAX)

parameters. Mr. Prasad (2) said that, Bearing failure and high amplitude of vibrations due to lack of contact between inner race and roller shaft is detected. Redesigned the shaft as per bearing selection resulted into stress transfer and stress concentration minimization. Minimization of roller deformation in revised roller design gives added advantage to minimize vibrations. Vibrations and temperature rise are measured on site with the help of standard equipment's. Vibrations and temperature rise reduced to acceptable limit. Mr. Rupesh (3) said that, the paper present that it has use taguchi method to decide the optimal process parameter. The surface roughness depend on hardness of material It is recommended that hardness is 50HRC.The optimum valve for surface roughness is 20mm depth of cut, 0.18mm/rev is the feed rate, 415rpm is the spindle speed , hardness is 50 HRC. Witold F. Habrat (4), the study presents selected results of research in the field of grinding cemented carbide with the use of diamond grinding wheels. The grinding speed, depth of cut and feed rate were considered as input process parameters. Furthermore, the ANOVA (analysis of variance) was employed for checking the developed model results. The results revealed that grinding with the use of resin bond grinding wheel provides significantly lower grinding force components during the process.

Dadaso D. Mohite (5) the ability of a grinding wheel to perform is significantly affected by the way in which the wheel is dressed. The four important parameters of blade type multi point diamond dressing operation are, dressing depth of cut, dressing cross feed rate, drag angle of dresser and number of passes. The effect of these parameters is measured in terms of surface of work piece during subsequent grinding operation. In this work, empirical models are developed for surface roughness by considering selected four parameters of dressing as control factors using Taguchi design methodology. The mathematical models in terms of dressing parameters were developed for surface roughness based on experimental results.

II. EXPERIMENTATION

A. Grinding Machine Specifications

Table 1: Grinding Machine Specifications

B. En Alloy Steels

Mild steel of different compositions are considered for analysis. EN 19, EN 24 and

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EN 31 are the different grades of the mild steels are turned on lathe and then cylindrical grinding operation is performed as per L9 orthogonal array.

EN19 alloy steel

EN19 also known as 709M40 is a high quality alloy steel, renowned for its good ductility and shock resistant and its resistance to wear properties. It is suitable for gears, pinions, shafts, spindles. It is now also widely used in the oil and gas industry.

Table 2: chemical composition of EN19 Or709M40

Carbon	0.36-0.44%
Silicon	0.10-0.40%
Manganese	0.70-1.00%
Sulfur	0.040 Max
Phosphorus	0.035 Max
Chromium	0.90-1.20%
Molybdenum	0.25-0.35%

Table 3: mechanical properties of EN19

Max Stress	850-1000 N/mm2
Yield Stress	700 N/mm2 (Min)
0.2% Proof Stress	680 N/mm2 (Min)
Elongation	9% min
Impact KCV	55 Joules (Min)
Hardness	40 HB

EN24 Alloy Steel

EN24 steel is a readily machinable material, widely used as engineering steel due to its tensile strength. The material provides a combination of high tensile strength with shock resistance, ductility and wear resistance. It is a through-hardening alloy steel which offers excellent machinability. It is used in components such as heavy-duty shafts, gears, studs and bolts.

Table 4: chemical composition of EN19 Or709M40

Carbon	0.36-0.44%
Silicon	0.10-0.35%
Manganese	0.45-0.70%
Sulfur	0.040 Max
Phosphorus	0.035 Max
Chromium	1.00-1.40%
Molybdenum	0.25-0.35%

Table 5: mechanical properties of EN19

Max Stress	850-1000 N/mm2
Yield Stress	680 N/mm2 (Min)
0.2% Proof Stress	635 N/mm2 (Min)
Elongation	13 % min
Impact KCV	50 Joules (Min)
Hardness	47 HB

EN31 Alloy Steel

It is High carbon alloy steel which achieves a high degree of hardness with compressive strength and abrasion resistance. It is suitable for roller bearing components such as brakes. Cylindrical, conical & needle rollers. Chemical composition of EN 31 steel is shown in Table 5. Mechanical properties of EN 31 steel are shown in Table 6.

Table 6: chemical composition of EN19 Or709M40

Carbon	0.90-1.20 %
Silicon	0.10-0.35 %
Manganese	0.30-0.75 %
Sulfur	0.040 %
Phosphorus	0.040 %
Chromium	1.00-1.60%

Table 7: mechanical properties of EN19

Max Stress	750 N/mm2
Yield Stress	450 N/mm2 (Min)
Elongation	30 % min
Density	7.8 kg/m^3
Hardness	55 HB

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III. INPUT PROCESS PARAMETERS AND OUTPUT VARIABLES

The main goals of grinding machine are to achieve a better surface finish and higher productivity. At present we need precise and accurate components in every field, so we use grinding operation to achieve this goal.

Process Parameters

The working ranges of the parameters for subsequent design of experiment, based on Taguchi's L9orthogonal array (OA) design have been selected. In the present experimental study, three levels and three parameters such as work material hardness, work piece speed, and depth of cut have been considered as process variables.

Table 8: Input Parameters and their levels

Factors	Level 1	Level 2	Level 3
Hardness	40	47	55
Speed (rpm)	100	214	340
Depth of cut (microns)	10	20	30

Output Parameters

The response variables for grinding machine process are discussed below. Grinding machine performance is mainly measured by the material removal rate (MRR) and surface roughness of the workpiece that has been machined. These two machining characteristics have been identified by the research as the most significant machining criteria that can influence the grinding machining performance. The process parameters should be chosen properly so as to have minimum MRR, minimum roughness value.

Material Removal Rate(MRR)

The material removal rate of the workpiece is the amount of the material removed per minute. MRR and cutting speed capabilities of grinding have increased enormously over the years. They are influenced by the age and type of machining along with the properties and the characteristics of the workpiece being cut. The machine settings set by the operator and programmer also affect the MRR and cutting speed. MRR is expresse4d in mm3/min. but in case of grinding MRR is defined as the surface being generated per min and expressed as mm3/min.

Surface Roughness (SR)

The roughness of the part surface machined by a given process is referred as surface roughness. No standard has been universally adopted for measuring the surface roughness of the parts. The standard which is utilized in the united states is the roughness average

(RA). This is defined as the arithmetic average of all departures of the roughnessprofile from the centre line of the evaluation length. It is also known as the arithmetic average (AA) and the centre line average (CA).

IV EXPERIMENTAL SETUP

The experimental studies were performed on DEVCO UC-150 Cylindrical grinding machine. Various input parameters varied during the experimentation are depth of cut (D), speed(N), hardness(H). The effects of these input parameters are studied on material removal rate and surface roughness using one TAGUCHI method. Taguchi Method was used to optimize the control parameters. L9 orthogonal array was employed for optimization. Experiments are conducted in the order given by Taguchi method on Cylindrical Grinding Machine as per L9 orthogonal array and the

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corresponding surface roughness values measured using SURFTEST SJ301.In the Taguchi method, the term ‘signal’ represents the desirable value (mean) for the output characteristic and the term ‘noise’ represents the undesirable value for the output characteristic. Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. Smaller is better S/N ratio was used in this study because less surface roughness was desirable.

The formula to calculate s/n ratio is

S/N ratio = -10log (Ra^2 /depth of cut)

In the taguchi method of the smaller is the better method the smallest s/n value which is calculated is the best optimized running in the system. Because the smallest s/n ratio has the highest surface finishing.

Table 9: Surface roughness values as per L9 orthogonal array

S. No	Hardness	Speed (rpm)	Depth of cut (microns)	Roughness (Ra)
1	40	100	10	0.81
2	40	214	20	0.78
3	40	340	30	1.25
4	47	100	20	1.06
5	47	214	30	1.08
6	47	340	10	1.20
7	55	100	30	1.60

From the above Ra values, we obtained using profilometer we calculate the signal to noise ratio using the below formula

S/N ratio = -10log (Ra2 /depth of cut)

Lower S/N ratio, it indicates Better Surface Finish.

Table 10: S/N values for machining the EN 19 work pieces

S.No	Hard-ness	Speed (rpm)	Depth of cut (microns)	Ra	S/N ratio
1	40	100	10	0.81	-18.17
2	40	214	20	0.78	-14.83
3	40	340	30	1.25	-17.20
4	47	100	20	1.06	-17.50
5	47	214	30	1.08	-15.98
6	47	340	10	1.20	-21.65
7	55	100	30	1.60	-19.32
8	55	214	10	1.04	-20.34
9	55	340	20	1.54	-20.75

From the above MRR values, we calculate the signal to noise ratio using the below formula

$$SN = -10x\log\left[\frac{1}{n}\sum_{i}^{n} y_i^2\right]$$

SN=-10xlog [1/nΣy_i^2]

Higher S/N ratio indicates that maximum MRR value

Table 11: Experimental data for MRR

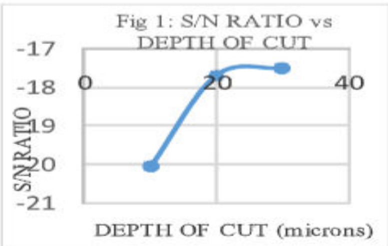
S.No	Depth (microns)	Speed (rpm)	Hardness	Metal Removal Rate (MRR) (mm3/min)
1	10	100	40	152
2	10	214	47	163
3	10	340	55	158
4	20	214	55	169
5	20	340	40	176
6	20	100	47	171
7	30	340	47	246
8	30	100	55	224
9	30	214	40	282

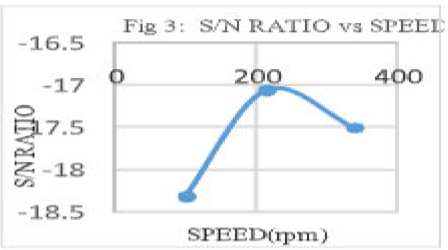
Table 12: S/N values for machining the EN 19, 24, 31 work pieces

S.No	Depth (microns)	Speed (rpm)	Hardness	Metal Removal Rate (MRR) (mm^3/min)	S/N Ratio
1	10	100	40	152	-20.81
2	10	214	47	163	-19.89
3	10	340	55	158	-20.52
4	20	214	55	169	-19.42
5	20	340	40	176	-18.53
6	20	100	47	171	-18.86
7	30	340	47	246	-16.18

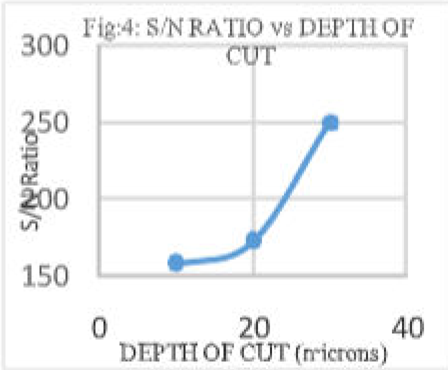
RESULTS AND DISCUSSIONS

Mean Effective Plots for Surface Roughness





Mean Effective Plots for Material Removal Rate



CONCLUSIONS

Based on Taguchi method experiments were conducted using EN alloy steels by varying the process parameters like Depth of cut, Hardness and Speed on cylindrical grinding machine and the following conclusions were drawn.

a) Increase in depth of cut, MRR increases and Surface finish decreases

b) Increase in Hardness, MRR decreases and Surface finish increases
c) increase in Speed, MRR increases and then decreases, Surface finish decreases and then increases

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