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PARAMETRIC OPTIMIZATION OF MACHINING PARAMTERS IN THROUGH FEEDCENTERLES GRINDING PROCESS

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Abstract**—** Surface texture is one of the important responses for the machine tool design because poor surface texture causes nucleation, subsurface cracks etc. For this reason, machining process is introduced such as cylindrical grinding, surface grinding, centerless grinding etc. for achieving better surface texture. In that, centerless grinding plays a vital role in getting better surface finish through in-feed, end-feed and through feed methodology. So, the main aim of this work is to investigate the machining parameters such as regulating wheel speed, regulating wheel angle, depth of cut and coolant level on the surface roughness. Simultaneously the productivity and the surfaces roughness are the conflictive objective because the high productivity affects the surface texture properties. So, the selection of the machining parameters is important for process planning engineers in decision making. In this regard, there are cost of mathematical modeling techniques where utilized. In that, Response Surface Methodology (RSM) and regression analysis draws more attention among researchers

Keywords **--** the machine tool , workpiece material , grinding wheel , setup parameters , grinding parameters and grinding fluid

I. INTRODUCTION

Grinding is an abrasive machining process widely used for the final shaping of components that require very smooth surfaces and a high dimensional accuracy. The performance attainable in this process as measured by levels of productivity, cost, and final part quality is determined by the selected combination of (i) the machine tool, (ii) workpiece material (iii) grinding wheel (iv) setup parameters, (v) grinding parameters and (vi) grinding fluid. In many industrial operations, the grinding parameters are still commonly selected according to machining data handbooks or machine operator experience. However, selecting the grinding parameters solely based on prior experience without establishing any guidelines to verify whether or not the selected values are optimum for an operation can be very costly for any high volume manufacturer. In many cases, the selected parameters are too conservative and not adapted to maximize the utility of the machine tool and the grinding wheel. A similar practice is prevalent in the selection of grinding fluid application settings, where different oils are typically used to flood the grinding contact zone without considering more effective alternatives. Although grinding has been used extensively in the production of precision components, these common practices confirm that it still remains one of the least understood and most inefficiently conducted machining process in the manufacturing industry.

In end-feed centerless grinding, the workpiece is fed axially into the machine on one side and comes to rest against an end stop; the grinding operation is performed, and then the workpiece is fed in the opposite direction to exit the machine. End-feed grinding is best for tapered workpieces. In-feed centerless grinding is used to grind workpieces with relatively complex shapes, such as an hourglass shape. Before the process begins, the workpiece is loaded manually into the grinding machine and the regulating wheel is moved into place. The complexity of the part shapes and grinding wheel shapes required to grind them accurately prevent the workpiece from being fed axially through the machine Centerless grinding is a high precision, shallow cut finishing operation used inthe mass production of cylindrical components. Developed in the 1920s, this profilingoperation is able to achieve extremely precise dimensional tolerances for cylindrical parts with outer diameters of 0.003-3 in. (0.0762-76.2 mm). Some of the components typically produced in large quantities by this grinding operation include drill bits, piston pins, rotary shafts, valve stems, needles, fasteners, roller bearings, and bearing rings as shown in Figure 1.1. Centerless grinding holds several advantages over center-type cylindrical grinding in production, including shorter machine setup times, shorter part loading times, and a higher dimensional accuracy.

The basic elements of the centerless grinding system are the grinding wheel, theregulating or control wheel, and the workpiece support blade as shown in Figure 1.2. Incontrast to center-type cylindrical grinding where the part is chucked and rotated by anexternal motor, centerless grinding does not utilize a mechanical fixture to constrain themotion of the part. Instead, the part is supported on its own outer diameter by an inclinedrest blade and its rotational motion is controlled by a lowspeed regulating wheel that serves as a frictional driving and braking element (Figure 1.2).

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Figure 1 Cylindrical components produced by the centerless grinding

Based on the initial shapeof the part, two primary part feeding methods are used to achieve the final desired partgeometry in this operation, including through-feed and infeed or plunge centerless grinding. Through-feed centerless grinding is used to shape straight or tapered cylindrical workpieces and infeed or plunge centerless grinding is used to shape cylindrical workpieces that have projections, multiple diameters, transition radii, or other irregular geometric features. Figure 1.2 Basic elements of the centerless grinding system The levels of productivity and final part quality attainablein the centerless grinding operation are determined by the selected combination of (i) themachine tool, (ii) workpiece material, (iii) grinding wheel, (iv)setup parameters, (v)grinding parameters and (vi) grinding fluid. For a particular workpiece material andgeometry, the selection of grinding parameters and grinding fluid is primarily guided bythe specified part quality levels. In many industrial applications, the productivity of thegrinding process is a secondary objective since it is very difficult to determine the effectof each input parameter on the key process responses without incurring large 5 capitalexpenses for the costly and difficult-to-grind superalloy materials. Consequently, manygrinding operations are still conducted at suboptimum productivity levels without evaluating or implementing solutions that can improve the process performance

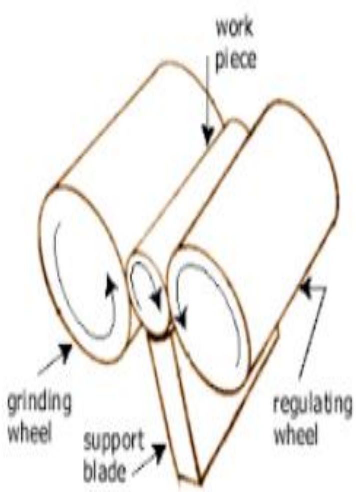
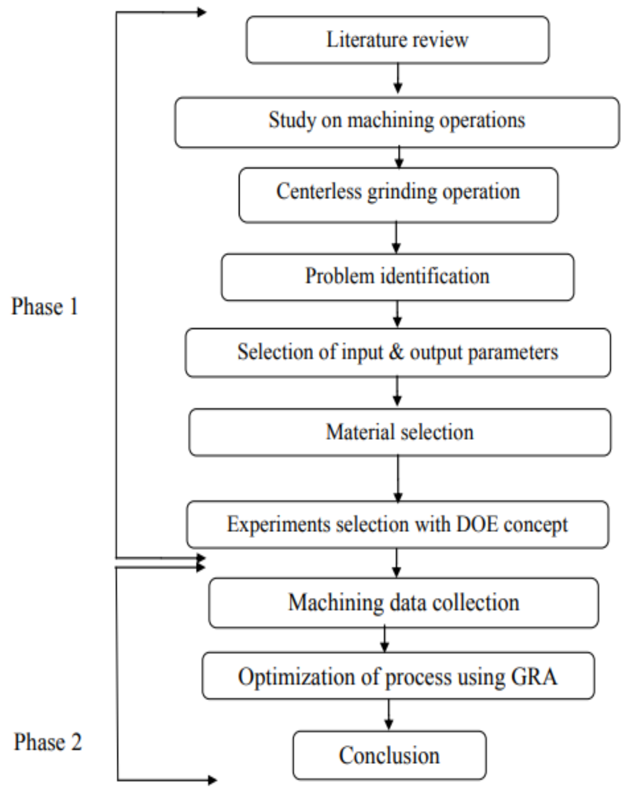


Figure 2 Basic elements of the centerless grinding system

PROPOSED METHEODLOGY



II. EXPERIMENTAL SETUP

Machine used Star make model centerless grinding machine is used for the experimental work. The specification of machine tool is shown table.

TABLE 4.1 TECHNICAL SPECIFICATION OF CENTERLESS GRINDING MACHINE

Abrasive speed	1219 surface m/min (4000 surface ft/min)
Regulating wheel speed	50 rpm
Through – feed rate	3.05 m/min (10 ft/min)
Grinding pressure	0.148 amp/cm (0.375 amp/inch)
Work piece	304 stainless steel round bar 16 mm diameter and 100 mm length.
Coolant	Water based soluble oil

Figure 3 Centreless Grinding Machine

III. MATERIAL USED

Magnesium alloy is selected for experimentation, since it finds a vast application in the field of automobile and aerospace. The properties are listed below.

1. High strength-to-weight ratio.
2. High specific strength.
3. High damping capacity.
4. High recycle ability
5. Excellent formability.
6. Low density

The chemical composition of the magnesium alloy is tabulated below in tablechemical composition of magnesium alloy

TABLE 2

Component	Percentage of component
Aluminium	5.5 to 6.5 %
Manganese	0.25% (minimum)
Silicon	0.10% (maximum)
Zinc	0.22% (maximum)
Iron	0.005% (maximum)
Copper	0.010% (maximum)
Nickel	0.002% (maximum)
Magnesium	Balance

The workpiece used was of 16 mm diameter and 100 mm length.

Figure 4 Experimentation workpiece.

IV. EXPERIMENTAL ANALYSIS

The work aims at analysing the process variables of centerless grinding using GRA. The work analyses the effect of the input parameters (regulating wheel speed, Depth of cut and regulating wheel angle) over the two responses (MRR and SR of work piece after machining). The experiments are designed with the help of DOE method using Minitab software. Full factorial method is used since each parameter has 3 levels resulting 27 in number of experiments. Design expert software is used in analysis by RSM. Here, the response MRR is expected to be maximum whereas the SR is expected to be minimum. The levels and ranges of input parameters used for the experimentation are tabulated in table 1. The workpiece dimension is of 16 mm diameter and 100 mm length

TABLE 3 PROCESS VARIABLES AND THERE LIMITS

Input Parameters	Minimum level	Moderate level	Maximum level
Regulating wheel speed(rpm)	12	25	46
Regulating wheel angle (degree)	2	3	4
Depth of cut (mm)	0.1	0.2	0.3

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V. EXPERIMENTAL DESIGN

Statisticians have developed many types of efficient plans which lay out how to vary the factor levels to explore the systems behaviour. Some DOE plans are more efficient for characterizing certain types of systems while others provide more complete analysis.The major factor in designing experiments is the cost involved and running the experimental trials. In situations where the cost involved is low, running a large number of trials and using an experimental design with high resolutions to explore more factors, its combinations and interactions may be feasible. On the other hand, when the cost of experimentations is high the efficient DOE plans can be used for experimentation. Some of the most popular experimental designs are listed below

1. Full factorial method
2. Fractional factorial method
3. Orthogonal array method
4. One factor at a time

1) FULL FACTORIAL METHOD

This design helps in systematic exploration of each combination of levels of factors. This allows the team to identify all the multi factor interactions and its effects. This also helps in identifying the primary effect of each on the performance. This type of experiment is normally practical only for small number of factors and levels and when experiments are inexpensive.

For an investigation of K factors and N levels each,•

Number of Trials in full factorial methods = N.K•

The major limitation of full factorial method is that, it is not suitable for experiment which involves 4 to 5 factors.

2) FRACTIONAL FACTORIAL METHOD

The design uses only a small fraction of combinations used in full factorial method. In exchange for this efficiency, the ability to compute the magnitudes of all the interaction effects is sacrificed. Instead, the interactions are confounded with other interactions or with some other main factor effects. The major advantage of this method is the layout still maintains the balanced with in the experimental plan. This means that for the several trials at any factor level, each of the other factors is tested at every level for the same valid number of times.

3) ORTHOGONAL ARRAY METHOD

This design is the smallest fractional factorial plan that still allows the team to identify the main effects of each factor. However these main effects are confounded with many interaction effects

4) ONE FACTOR AT A TIME

The unbalanced experimental plan prevails in this method because each trial is conducted with all but one of the factors at nominal levels.

TABLE 4 NUMBER OF TRIALS = 1+K (N-1)

Experiment no.	Regulating Wheel Speed (rpm)	Regulating Wheel Angle (degrees)	Depth of Cut (mm)
1	12	3	0.1
2	12	3	0.2
3	12	3	0.3
4	12	2	0.1
5	12	2	0.2
6	12	2	0.3

TABLE 5 OPTIMIZED PARAMETERS

	Regulating Wheel speed	Regulating wheel angle	Depth of cut
Level 1	4.29344	4.34354	4.17187
Level 2	4.27107	**4.38859**	4.46342
Level 3	**4.55856**	3.95268	**4.48779**

The following graphs indicate the GRG of various input parameters.

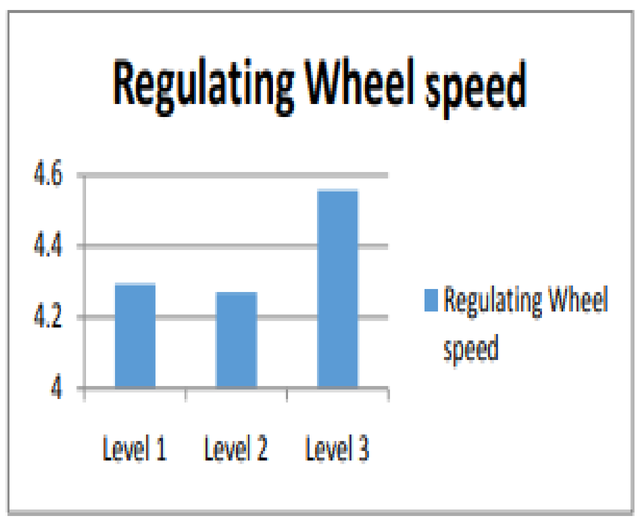

Figure 5 Optimized level of regulating wheel speed.

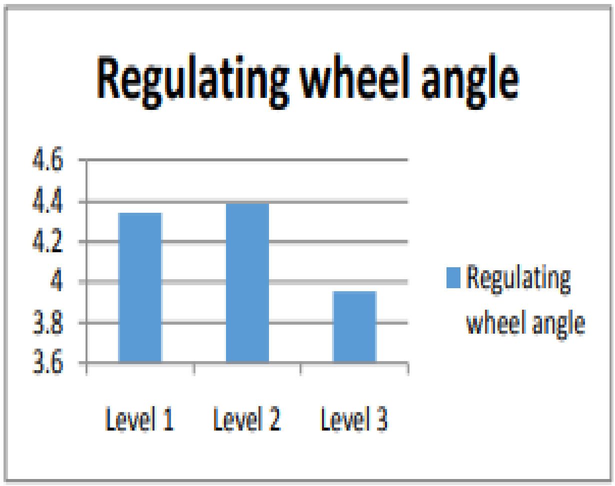

Figure 6 Optimized level of regulating wheel angle.

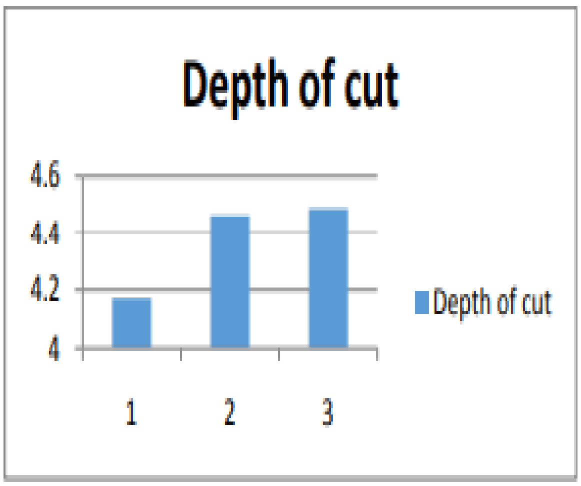

Figure 7 Optimized level of regulating wheel angle

VI. CONCLUSION

The previous works discussed about the domination of various parameters for machining process involving the study of MRR, Surface Roughness and Roundness of machined component. In this work, the experimental examination involves centerless grinding of magnesium alloy using silicon carbide grinding wheel.

- The effect of machining parameters on the responses is studied.
- The input machining parameter combination for obtaining the optimized results is identified using Grey Relation Analysis approach.
- The Wheel speed of 46 rpm, regulating wheel angle of 3 degrees and depth of cut of 0.2 mm can be used to obtain minimum value of Surface Roughness and maximum value of Material Removal Rate.

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