Optimization of Cylindrical Grinding Parameters for Minimum Surface Roughness by Taguchi Parametric Optimization Technique

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Abstract- Cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. Surface finish is the important output responses in the production with respect to quantity and quality respectively. The Experiments are conducted on universal tool and cutter grinding machine with L9 Orthogonal array with input machining variables as work speed, grinding wheel grades and hardness of material. The developed model can be used by the different manufacturing firms to select right combination of machining parameters to achieve an optimal surface roughness (Ra).The results reveals surface roughness (Ra).The predicted optimal values for Ra for Cylindrical grinding process is 1.07 Ra respectively. The results are further confirmed by conducting confirmation experiments

Keywords: Grinding, Taguchi, hardness Roughness, S/N ratio, Regression.

1. Introduction

Cylindrical grinding is an essential process for final machining of components requiring smooth surfaces and precise tolerances. As compared with other machining processes, Grindings costly operation that should be utilized under optimal conditions. Although widely used in industry, grinding remains perhaps the least understood of all machining processes.

The present paper takes the following input processes parameters namely material hardness, work piece speed and grinding wheel grains . The main objective of this paper is to show how our knowledge on grinding process can be utilized to predict the grinding behaviour and achieve optimal operating processes parameters. The knowledge is mainly in the form of physical and empirical models which describe various aspects of grinding process. The main objective in any machining process is to minimize the surface roughness (Ra).In order to optimize these values taguchi method, is used.

2. Taguchi Method

Taguchi method is the process of engineering Optimization in a three step approach namely system design, parameter design and tolerance design. In the system design, a basic functional prototype design will be produced by applying scientific and engineering knowledge. In parameter design, independent process parameter values will be optimized and where as in tolerance design, tolerances will be determined and analysed for optimal values set by parameter design. Taguchi method is a powerful design of experiments (DOE) tool for optimization of engineering processes.

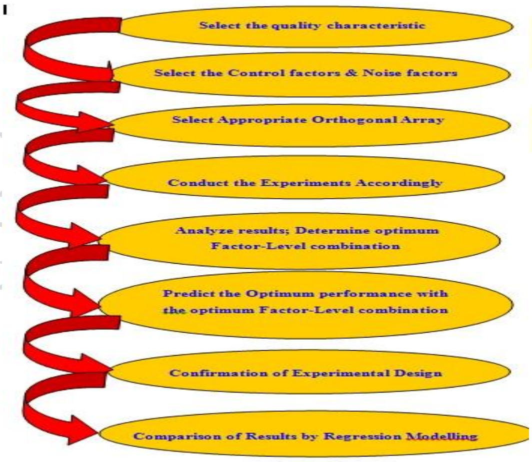

Fig. 1 Steps of Taguchi method

3. Experimental Setup and Cutting Conditions

3.1 Work piece material

The work piece material selected for investigation is EN 24, EN 31 and Die steel. This steel can be hardened and tempered to provide a greater strength.

3.2 Machining Process

The cutting tests were performed on universal tool and cutter grinding machine and Aluminium oxide white grinding wheel. The experiments were conducted as per the orthogonal array and roughness for various combinations of parameters was measured using Deviate DH 5 tester.

3.3 Plan of Experiment

The experiment was planned using Taguchi's orthogonal array in the design of experiments, which help in reducing the number of experiments. The L9 orthogonal array.

Table 3.1 parameters and their levels for experiment hardness test is prepared to have the dimensions (4cm x 2.5cm x 0.5cm).

3.4 Experimental Details

A set of experiments were conducted on tool and cutter grinding machine on different alloy steel of different hardness material to determine effect of parameters namely),Work speed (rpm),material hardness and grinding wheel on surface roughness Ra(µm). Three levels and three factors L9 Orthogonal array used to design the orthogonal array by using design of experiments (DOE) .Grinding wheel used steel. The work piece used for the experiment. for the present work is the aluminium oxide abrasive with verified bond with constant speed of 2850 RPM. The jobs have undergone turning and hardening processes before grinding. Hardening is done for better output response and the HRC is maintained.

Table 3.1 parameters and their levels for experiment

Level	Material hardness (HRC)	Work piece Speed (r.p.m) W	Grinding wheel (grains)
1	50	100	G46
2	55	160	G60
3	60	200	G80

Table 3.2 L9 Orthogonal array

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	3
5	2	2	1
6	2	3	2
7	3	1	2
8	3	2	3
9	3	3	1

Table 3.3 Consolidated design of experiment

Experiment	Combination of input factors	Output Response (Roughness)			
1	$H_1W_1G_1$	2.20			
2	$H_1W_2G_2$	1.65			
3	$H_1W_3G_3$	1.10			
4	H W G	1.59			
5	$H_2W_2G_1$	1.90			
6	$H_2W_3G_2$	1.07			
7	$H_3W_1G_2$	1.31			
8	H W G	1.46			
9	$H_3W_3G_1$	2.11			

Table 3.4 S/N ratio summary sheet

Experiment No.	S/N ratio
1	6.85
2	4.35
3	0.83
4	4.03
5	5.58
6	0.59
7	2.35
8	3.29
9	6.49

Table 3.5 S/N ratio surface roughness

S.No	Parameter	S/N Value for Surface Roughness		
		Low	Medium	High
H	Material Hardness	-4.01	-3.4	-4.04
W	Work piece speed	-4.41	-4.41	-2.64
G	Grinding wheel	-6.31	-2.43	-2.72

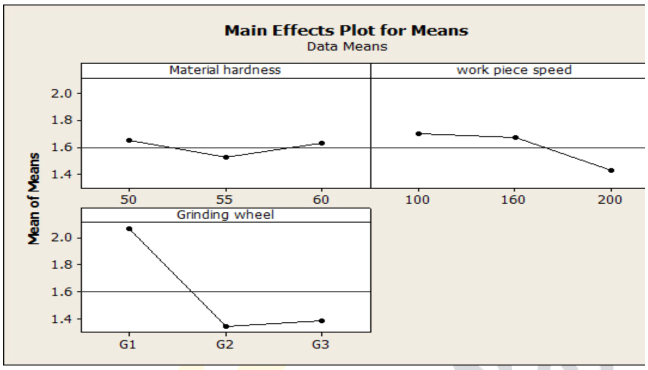

Fig 4.1. Effect of process parameter on Roughness

4.2 Response Graphs for S/N values for Surface Roughness

(a) Level II for Hardness, sH2 = -3.4 dB indicated as the optimum situation in terms of S/N values.

(b) Level III for work piece speed, sW3 = -2.64 dB indicated as the optimum situation in terms of S/N values.

(c) Level II for Grain's, sC2 = -2.43 dB indicated as the optimum situation in terms of S/N values

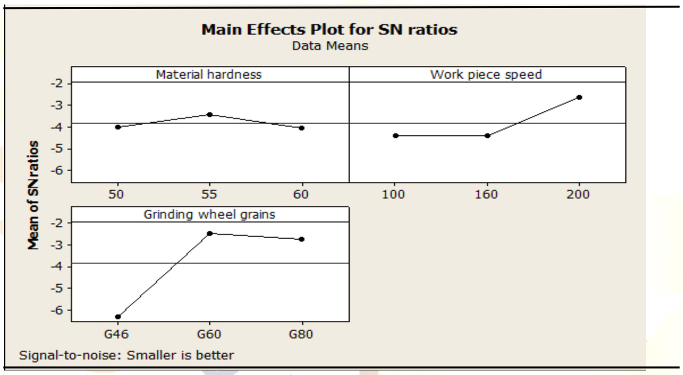

Fig 4.2 Main effect for S/N ratio

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4.3 Effect of Hardness on the Weight Loss And Wear Resistance Of Carburized EN 24, EN 31 & Die Steels:

The variation between hardness and weight loss due to abrasion is represented in figure (4.3). The weight loss due to abrasion is highly affected by the hardness and it varies inversely with the hardness. That is because of the hard material having the greater abrasive wear resistance, so the less wear occurs in the carburized mild steels, and the weight loss decreases.

The wear resistance is affected by the hardness as represented in figures (4.4). The wear resistance increases as the hardness increases

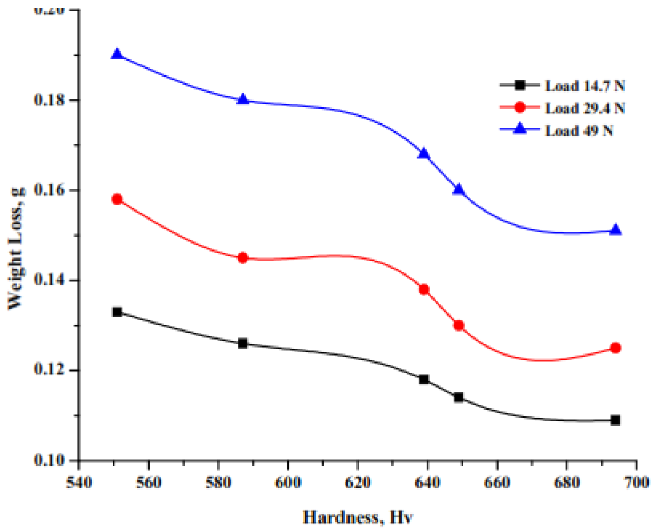


Fig. 4.3: A comparison of weight loss due to abrasion vs. hardness at different loads

5.1 Results

From main effects plotted, it is observed that there is decreases surface roughness as material hardness increased. The roughness decreases when speed is changed from 100 to 160 rpm and again decreases when speed changed to 200 rpm, similarly when grinding wheel grain's change from G46 to G60 surface roughness decreases, but as again change to G80 roughness increase considerably.

(H2), Larger Wok piece speed (W3) and Medium Grain's (G2) , then the Surface Roughness is minimum obtained

Table 5.1 Conformation of experiment

Surface Roughness (Ra)	S/N ratio (dB)
1.07	-0.59

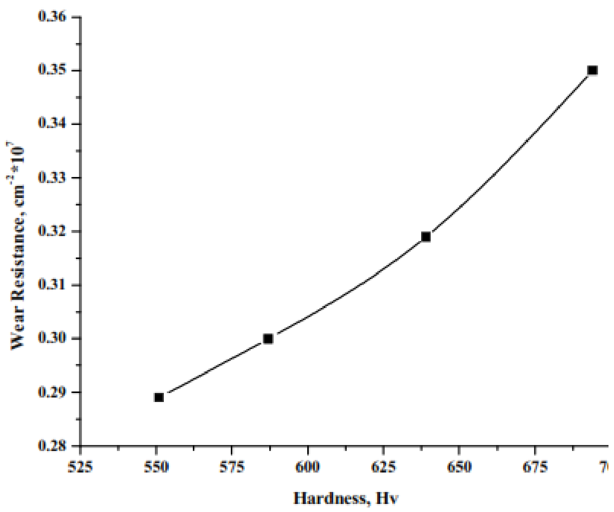
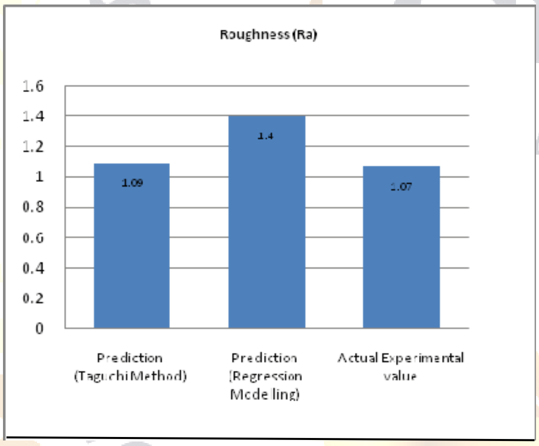


Fig. 4.4 Variation of wear resistance with hardness for the carburization temperature

5.2 Comparison of Result



5.3 Conformation of Experiment

To validate the optimum grinding conditions (H2, W3, G2) the combination of Medium Hardness

Conclusions

From the above discussions so far it can be concluded that:

1. The mechanical and wear properties of EN 24, EN 31 & Die steel were found to be strongly influenced by the process of carburization and carburizing temperature.
2. Hardness and wear resistance increase with an increase in the EN 24, EN 31 & Die steel temperature, while the wear rate decreases.
3. The weight loss due to abrasion, wear volume, and wear rate increases with the increase in the applied load.
4. With an increase in the hardness the wear resistance increases, but there is a decrease in weight loss due to abrasion and wear rate.
5. As comparing for different carburization temperature, the EN 24, EN 31 & Die steel carburized at the temperature of 950 ^{o}C shows the best combination of higher hardness and less wear rate.
6. Finally, the net conclusion is that the EN 24, EN 31 & Die steel carburized under the different temperature range of 850 to 950 ^{o}C in which the SAE1020 steel carburized at the temperature of 950 ^{o}C is giving the best results for

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