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MODELLING AND OPTIMISATION OF WHEEL DRESSING EFFECT OF MACHINING PERFORMANCE IN CYLINDRICAL GRINDING USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

In cylindrical grinding, only a portion of the wheels width is involved in the grinding the workpiece leaving the remainder to trail behind the cutting portion.. This causes the wheel to overlap the previously ground surface and results in the reduction of effective surface roughness. In this paper the effect of wheel dressing in machining parameters on the performance of cylindrical grinding have been focused.

It is found that at lower dressing feed, the finish obtained on the workpiece is good. It is felt that the size and shape of the chips produced in grinding should have some relationship with the finish imparted by the process. As the cutting action of the individual abrasive grains are responsible for the finish produced. It is logical to look for correlation between the finish obtained and the chip size. Hence the chip size analysis is carried out to ascertain the relationship between the chip size and the finish obtained on the workpiece. As lower dressing feed produces finer chip size and thereby workpiece finish is improved.

Keywords: Dressers feed rate, mean chip size, correlation coefficient, particle size distribution, roundness, surface roughness.

1.INTRODUCTION

In grinding, the material is removed by means of a rotating abrasive wheel.It is mainly used to obtain better finish on the surface. During the grinding, due to the wear of cutting edges and due to chip clogging, the grinding efficiency is reduced and wheel loading takes place. Wheel dressing is resorted to bring back the full cutting action of the wheel (Act of improving the cutting action or sharpening operation of wheel).

During dressing, wheel material is removed by dressing tool and reconditioning of wheel is mainly done by dressing. The abrasive grains of the wheel lose their effectiveness. With usage due to their edges becoming blunt. Dressing process affects the topography generated on the grinding wheel surface which in turn strongly influences the wheel performance. Present methods of dressing employ single point or multi point diamond tool, which transfers across the wheel width and generates a uniform helix over the wheel periphery. It has been reported that the type of dresser, its geometry (that is effective cutting profile) its active width and abrasion surface length along with the dressing conditions such as dressing feed and depth of cut influence the surface and results in the reduction of the effective surface roughness(1).The dressing with cone shaped single point diamond dresser has been done for different feed rates in addition to changing the wheel dressing condition their feed and depth of cut are varied to analyze various factors like metal removal rate,G-ratio,mean chip size, workpiece roundness and surface roughness.In machining process like turning and milling where the tool geometry is well defined,theoritical prediction of surface finish in terms of tool geometry and other cutting parameters is possible. Hence in this process, it is believed that the chip size have some relationship with the finish imparted by the process. The experiment conducted on cylindrical grinding with mild steel workpiece to analyze the effect of wheel dressing.

2. EXPERIMENTAL PROCEDURE

2.1. Assumptions made

1. Grinding wheel is considered as a homogeneous structure.
2. The diamond-dressing tool is considered to have geometrically uniform profile.

2.2. Wheel dressing

Specification of Single point diamond dresser

A: Depth of cut given to dresser(μm) -100
N: included angle of the diamond dresser -76deg.
L_e: length of the diamond dresser (mm) -0.78

B_e: breadth of the diamond dresser (mm) -0.46
δ_a: Dressing feed (m/min) -2,3,4,5,6

2.3. Grinding wheel and workpiece

Wheel Specification:-A60K5V10
V_w: Cutting speed of grinding wheel:-πDn/60×1000m/s
N: Rotational speed of grinding wheel:-1600rpm.
N: Rotational speed of workpiece:-80 rpm.
Z: Diameter of grinding wheel:-350mm
D: Diameter of the workpiece (En 8):-31mm
L: Lngth of the workpiece:-170mm
S_l: Traverse rate or feed rate of W/P:-2,3,4,5&6
W: Width of the grinding wheel:-30mm
D_p: Depth of cut while grinding:-0.1mm
Lubricant-water soluble oil:-Trimsol
Analysis software:-Visual c++ "Neural network and fuzzy logic back propagation simulator "(version 1)

3. EFFECT OF WHEEL DRESSING

The grinding wheel was first dressed with the feed rate of 2m/min and depth of cut 0.1mm. Then the cylindrical workpieces of diameter 31mm were ground at the constant dressing feed rate and variable grinding feed rate like 2,3,4,5&6 for one set of value of 2m/min and depth of cut 0.1.
Again the grinding wheel was dressed at the feed rate of 4m/min with the depth of cut 0.1.Then the workpieces were ground at the feed rates of 2,3,4,5&6 and m/min with constant depth of cut of 0.1mm.

Finally the dressing of grinding wheel was carried out at the feed rate of 6m/min and the workpieces were ground for a constant depth of cut of 0.1mm with various grinding feed rates of 2,3,4,5,6 m/min.

For the above mentioned five tests the chips along with abrasive particles were collected. First dust particles were water washed and dried. Using magnetic separator, the abrasive particles were separated out from the metal chips. Both were weighed and G-ratio, Volume of metal removal and volume wheel wear were found and are shown in Table 1

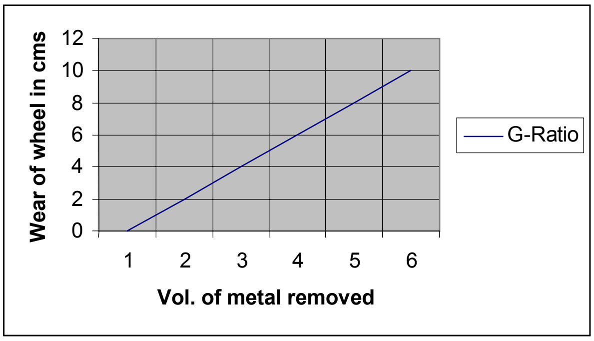

Fig 1. Calculation of G ratio

The roundness of each specimen was measured by a 'Perthen roundness tester'. The various roundness errors for various dressing feed, various depth of cut and grinding feed rate were tabulated .Through the polar graph roundness errors were calculated.

The roughness of the workpiece was measured by 'Perth-o-meter' and the results are tabulated shown in the table 2.

4. CHIP SIZE ANALYSIS

As the cutting action of the individual abrasive grains are responsible for the finish produced, it is logical to look for a correlation between finish produced and the chip sizes. The metallic chips collected for the three tests were to be sieve analysed.The chips were placed on sieve analyzer and vibrated for separation of the various sizes of the chips. The mesh sizes are ranging from 40μm to 600 μm.Then the chips were weighed separately and the results had shown in the table. The mean chip size for each sample was also calculated. The correlation coefficient between mean chip size and surface roughness were found and are shown in table 3.The result is presented in the form of frequency diagram as shown in the figure 1. The vertical axis denotes the percentage of finer particles that fall within a particular mesh size. The cumulative frequency graph is also drawn as in figure 2. It depicts the distribution of particle size with respect to chip sizes under various dressing feeds.

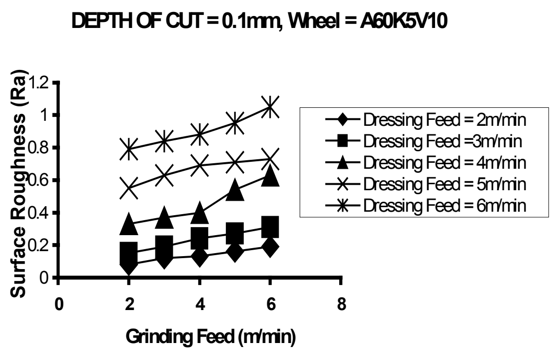

Fig 2. Particle Size Distribution

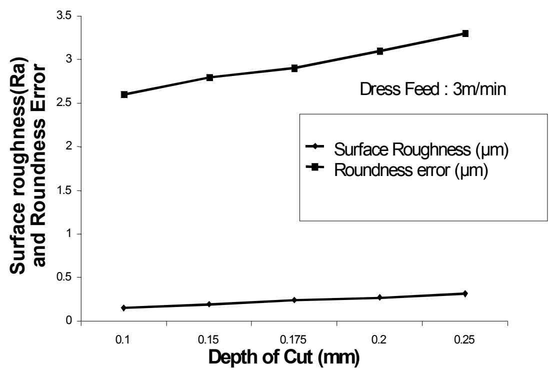

Fig 3.Effect of depth of cut on surface roughness and Roundness error For Dress Feed of 3 m/min

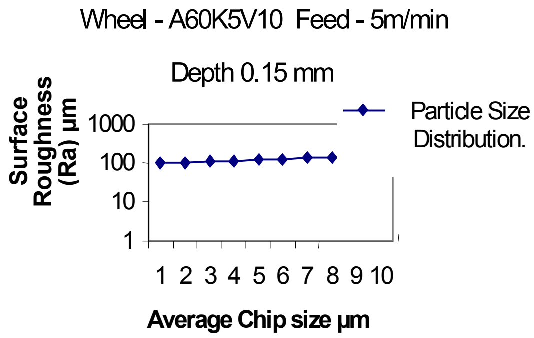

Fig. 4. Influence of dressing feed on particle size distribution

5. RESULT AND DISCUSSION

In the first test, for the dressing feed of 2m/min (depth of cut 0.1mm), the results are shown in fig.2 for the constant grinding feed of 2m/min by varying the depth of cut of grinding as 0.1, 0.175, 0.25 and 0.3mm. From the graph it is clear that the roughness values are increasing from 0.08 to 0.82 µm. It is evident that the increase in depth of cut results in increase in roughness value and roughness error.

In the second test for the dressing feed of 4m/min (depth of cut 0.1mm), the results are shown in fig.2, for the constant depth of cut of 0.1mm with the various grinding feed rates of 2, 4, 6 & 8 m/min. From the graph it is clear that the roughness values are increasing from 0.33 to 0.41 µm and the roundness error is increased from 2.6 to 4.8 µm. It is evident that the increase in grinding feed results in increase in roughness value and roundness error.

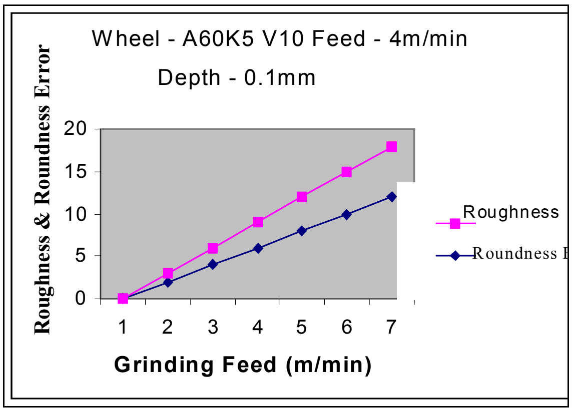

Fig. 5 Influence of grinding feed on surface roughness & roundness

In the third test, for the dressing feed of 4 m/min (depth of cut 0.1mm), the results are shown in fig.5, for the constant depth of cut of 0.1 mm with the various grinding feed rates of the roughness values are increasing from 0.79 to 1.44 µm and the roughness error is increased from 3.3 to 4.8 µm.. It is evident the increase in grinding feed rate results in increase in roughness and roundness error.

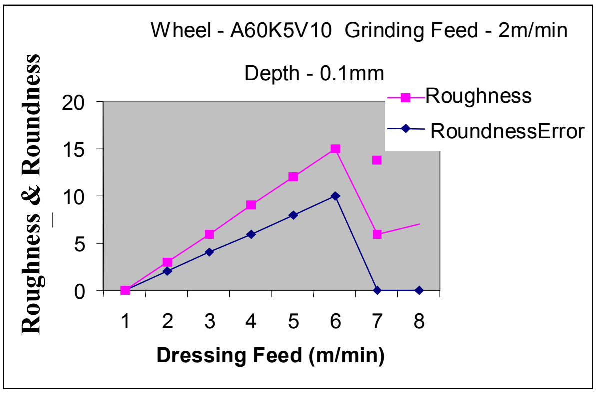

Fig. 6 Influence of dressing feed on surface roughness & roundness

For the same machining parameter (depth of cut 0.1mm and grinding feed rate 2 m/min) by varying the dressing feed of 2,3,4.5 & 6m/min, the surface roughness values are obtained as 0.08, 0.33 and 0.79 µm and roughness errors are 2, 2.6 and 3.3 respectively. It shows that the dressing feed increases the roughness and roundness error also increases. All the second rest roughness values 0.33, 0.34, 0.41 and 0.41 are compared with the third test roughness values 0.79, 0.88, 1.04 and 1.44 µm respectively. It is clearly shows that, with all other conditions are same; the dressing feed affects the surface roughness. Similarly in the second test, roundness errors 2.6, 2.9, 3.2 and 4.8 µm are compared with third test roundness error values 3.3, 3.8, 4.4 & 4.8 µm respectively. It clearly shows that the increase in dressing feed increases the roundness error of the workpiece in fig.6.

In the sieve analysis test, for the same machining parameters (grinding feed rate 2m/min & depth of cut 0.1mm) with various dressing feed of 2, 3, 4, 5 and 6 m/min the chips retained that 60% of finer chips of size (40-75µm) was obtained in lower dressing feed of 2m/min and 28% of finer chips of size40-75µm are obtained in dressing feed of 6m/min.From the particles size distribution graph it is found that the increase in dressing feed from 2 m/min to 6 m/min, the fineness of chip size is reduced. The better correlation coefficient of 0.83 is obtained when the dressing feed increases the correlation coefficient gradually decreases.

6. ARTIFICIAL NEURAL NETWORK

The neural network model stems from the studies on the working of human brain systems and serves as an associative memory between the input and output patterns. These models contain Many densely interconnected elements called **Neurons** or **nodes.**
The neuron has a set of **n** inputs x_j , where the subscript j takes values from 1 to n and indicates the source of the input signal. Each input x_j is weighted before reaching the main body of the processing elements by the connection strength or weight factor w_j (i.e., x_j is multiplied by w_j). In addition, it has a bias term w_o , a threshold value φ that has to be reached or exceeded for the neuron to produce a signal, a non-linearity function F that acts on the produced signal (or activation) R, and

an output O. The basic model of neuron is illustrated in fig. 7

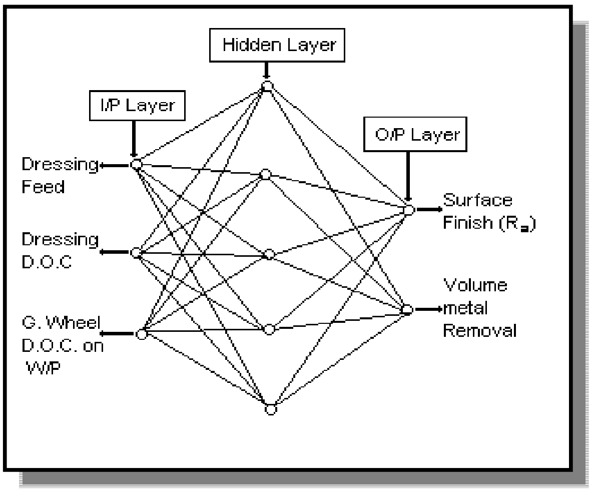

Fig.7 Basic Neuron Model

The non-linearity function used in this work is sigmoid. The sigmoid is very popular because it is monotonic, is bounded, and has a derivative: $f''(s) = kf(s)\,[1- f(s)]$.
The model used in this work is Feed Forward Multilayer perceptron using Back Propagation Algorithm

Table 3. ANN Training Results

S.No.	ANN Training Cycle	ANN Training Output Error
1	10	0.38740
2	100	0.33612
3	1000	0.28390
4	10000	0.16951
5	25000	0.13794
6	50000	0.123181
7	100000	0.0999992

Where **(3 – 6 – 2)**
3 - Input layer
6 - Hidden layer
2 - Output layer

All inputs are analyzed in the experimental validation part with appropriate output results by illustrations of graphs. So the variations of Grinding feed and surface roughness for both ANN and Experiment outputs are shown in the graph

The validation of estimated ANN and Experimental value illustrations is shown in Fig 8 and Fig.9.

7. CONCLUSION

In cylindrical grinding is found that the dressing feed is an important parameter influencing the surface roughness of the workpiece. At lowest dressing feed 2 m/min the finish obtained is better. As the dressing feed increases to 4 m/min the finish imparted on workpiece deteriorates considerably. As the dressing feed increases further, the finish becomes poorer. This is because, at lower dressing feed, the contact between the dresser and wheel is more, i.e the dresser clears the entire wheel and also new grains were obtained by the breaking of grits and thus forms more helical grooves on the wheel surface. This influence more abrasive grits to come out of the wheel and also the abrasive bonds to break. Thus forming many sharp cutting edges by improving the finish.

As the dresser feed increases the contact between the dresser and wheel decreases and very few grooves were formed on the wheel formation of minimum cutting edges.

Table 4. Normalised Training Data for ANN

S.No	INPUT			OUTPUT	
	Feed	Depth of work d.o.c (w/p)	Grinding feed d_w	Surface roughness (Ra) µm	Volume of metal removed cm^3
1	0.3	0.1	0.33	0.08	0.286
2	0.46	0.1	0.66	0.15	0.307
3	0.61	0.1	0.57	0.33	0.294
4	0.76	0.1	0.50	0.55	0.320
5	0.92	0.1	0.40	0.79	0.307
6	0.30	0.1	0.33	0.12	0.444
7	0.46	0.1	0.66	0.19	0.448
8	0.61	0.1	0.57	0.370	0.431
9	0.76	0.1	0.50	0.63	0.405
10	0.92	0.1	0.40	0.84	0.410
11	0.30	0.1	0.33	0.28	0.572
12	0.46	0.1	0.66	0.24	0.628
13	0.61	0.1	0.57	0.40	0.576
14	0.76	0.1	0.50	0.69	0.547
15	0.92	0.1	0.40	0.88	0.534
16	0.30	0.1	0.33	0.45	0.777
17	0.46	0.1	0.66	0.27	0.222
18	0.61	0.1	0.57	0.41	0.747
19	0.76	0.1	0.50	0.71	0.747
20	0.92	0.1	0.40	0.95	0.756
21	0.30	0.1	0.33	0.69	0.962
22	0.46	0.1	0.66	0.31	0.829
23	0.61	0.1	0.57	0.41	0.905
24	0.76	0.1	0.50	0.73	0.888
25	0.92	0.1	0.4	0.95	0.846

The grinding feed also has an effect on workpiece surface finish, at higher feed in grinding, the finish is poorer and at lower, the finish is better. When it is compared with the dressing feed it has less influence over dressing feed. The increase in depth of cut during grinding process decreases the surface finish and increases the roundness error. From the particle size distribution curves it is found that the finer chips are obtained at the minimum dressing feed of 2 m/min. Hence surface finish is directly related to the chip size. It is concluded that the dressing feed affects the roundness and minimum dressing feed improves the surface finish and the mean chip sizes can be suitably correlated with surface roughness values.
The output and results are introduced into neural network processes.

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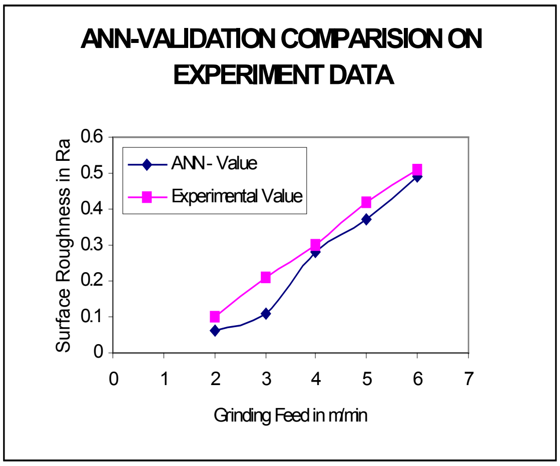

Fig. 8. ANN Validation comparision on Experiment data Surface roughness.

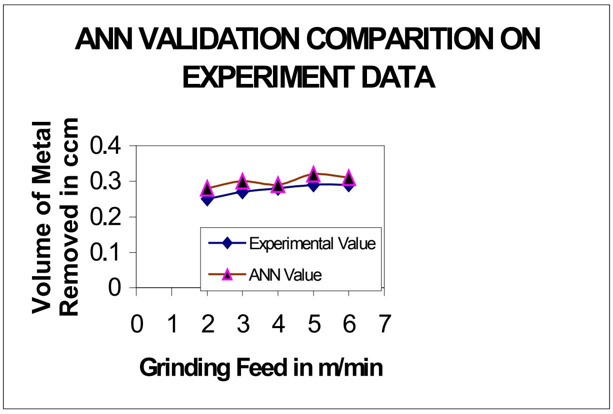

Fig. 9. ANN Validation comparision on Experiment data Volume of metal removal.

Table 1 Volume of Metal Removal And Volume of Wheel Wear

S.No	Dressing condition	Grinding feed m/ min	Depth of cut mm	Wt of iron chips gms.	Wt of abrasive grains gms	Volume of metal removed cm3.	Volume of wheel wear cm3.	g.ratio
1	Dressing feed–2m/min Depth–100µ	2	0.1	6.7	0.25	0.853	0.039	22.0
2		2	0.15	10.4	0.39	1.502	0.053	28.0
3		2	0.175	13.4	0.34	1.707	0.063	27.0
4		2	0.2	15.2	0.42	1.928	0.079	27.0
5		2	0.25	16.8	0.45	0.172	0.086	26.0
1	Dressing feed–3m/min Depth–100µ	3	0.1	7.2	0.23	0.916	0.036	25.0
2		3	0.15	8.5	0.27	1.082	0.042	26.0
3		3	0.175	9.7	0.34	1.298	0.053	24.0
4		3	0.2	13.8	0.43	1.743	0.067	26.0
5		3	0.25	15.4	0.49	1.959	0.077	25.0
1	Dressing feed–4m/min Depth–100µ	2	0.1	7.3	0.26	0.877	0.045	16.0
2		3	0.1	7.9	0.28	1.285	0.047	18.0
3		4	0.1	8.4	0.35	1.718	0.055	19.0
4		5	0.1	8.9	0.42	2.201	0.066	17.0
5		6	0.1	10.3	0.48	2.697	0.75	20.0
1	Dressing feed–5m/min Depth – 100µ	2	0.1	7.5	0.25	0.954	0.039	19.0
2		3	0.1	8.6	0.27	1.298	0.043	20.0
3		4	0.1	9.1	0.35	1.692	0.055	22.0
4		5	0.1	9.7	0.44	2.252	0.069	25.0
5		6	0.1	10.5	0.53	2.735	0.086	25.0
1	Dressing feed–6m/min Depth – 100µ	2	0.1	7.6	0.28	0.916	0.055	20.0
2		3	0.1	8.3	0.35	1.679	0.061	22.0
3		4	0.1	9.2	0.41	2.100	0.066	23.0
4		5	0.1	9.9	0.47	2.279	0.074	25.0
5		6	0.1	10.4	0.51	2.595	0.068	28.0

Table 2. Roughness &Roundness Error Obtained For
Various Grinding Feed and Depth of Cut

S.No.	Dressing conditions	Grinding feed (m/min)	Depth of cut (mm)	Surface roughness (Ra) µm.	Roundness error (µm)
1.	Dressing feed-2m/min Depth -100µ	2	0.10	0.08	2.10
2.		3	0.15	0.12	2.35
3.		4	0.175	0.28	2.65
4.		5	0.20	0.45	2.82
5.		6	0.25	0.69	3.07
1.	Dressing feed-3m/min Depth -100µ	2	0.10	0.15	2.72
2.		3	0.15	0.19	2.60
3.		4	0.175	0.24	2.86
4.		5	0.20	0.27	3.10
5.		6	0.25	0.31	3.34