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Surface Roughness Enhancement of Grinding Process Using Compressed air in Case of dry Machining

KEYWORDS

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ABSTRACT *This paper presents the experimental study for surface finish enhancement of grinding process using compressed air. Grinding is a metal removal process that employs an abrasive GW whose cutting elements are grains of abrasive materials of high hardness and high refractoriness. Taguchi method is used to design a robust model which helps to improve the surface finish and eco machining.*

INRODUCTION: [1] Manufacturing is derived from the Latin word manufactus, means made by hand. In modern context it involves making products from raw material by using various processes, by making use of hand tools, machinery or even computers. It is therefore a study of the processes required to make parts and to assemble them in machines. The study of manufacturing reveals those parameters which can be most efficiently being influenced to increase production and raise its accuracy.

[3]Grinding is a metal removal process that employs an abrasive GW whose cutting elements are grains of abrasive materials of high hardness and high refractoriness.

The sharp-edged and hard grains are held together by bonding material. Projecting grains (Figure 1) abrade layers of metal from the work in the form of very minute chips as the wheel rotes at high speeds of up to 60 m/s.

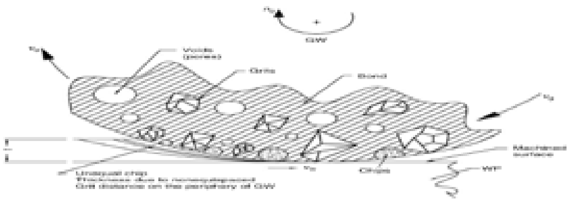

Figure 1. Cutting Principles and Main Variables of a Surface Grinding Process [3]

SYSTEM ELEMENTS - The system elements consist of inputs, disturbances, productive outputs, and non-productive outputs. The elements of a grinding system are illustrated in figure 2.

- **Work piece material:** Shape, hardness, stiffness, thermal properties.
- **Grinding machine:** Type, control system, accuracy, stiffness, temperature stability, vibrations.
- **Kinematics:** The geometry and motions governing the engagement between the grinding wheel and the work **piece.**
- **Grinding wheel:** Abrasive, grain size, bond, structure, hardness, speed, stiffness.
- **Dressing conditions:** Type of tool, speeds and feeds, cooling, lubrication.
- **Grinding fluid:** Flow rate, velocity, pressure, physical, chemical properties.
- **Atmospheric environment:** Temperature, humidity, and effect on environment.
- **Health and safety:** Risks to the machine operators and the public.
- **Waste disposal.**
- **Costs.**

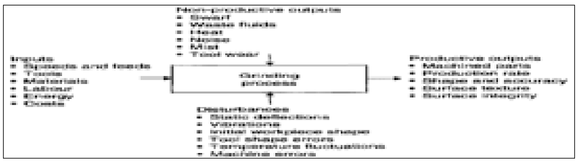

Figure 2. Inputs and Outputs of a Grinding Process [2]

Dry-machining - some Factors for Consideration [7]

- Adopting a 'dry machining' strategy will only make sense, if all the cutting processes in the part's manufacture can be performed without coolant,
- Only by utilizing specialized cutting tool geometries, can 'dry-machining' be possible and effective,
- Tooling typically having special hard multi-layered, or diamond-like coatings, etc., to isolate heat and create minimal thermal conduction across the tool/chip interface,
- Employing cutting tool materials producing sharp edge geometries – to reduce heat,
- For drilling operations, utilize 'soft-glide' coatings –for lubrication, with the necessary and appropriate efficient chip transportation geometries,

THE TAGUCHI SYSTEM OF QUALITY ENGINEERING

The major steps of implementing the Taguchi method are: (1) to identify the factors/interactions, (2) to identify the levels of each factor, (3) to select an appropriate orthogonal array (OA), (4) to assign the factors/interactions to columns of the OA, (5) to conduct the experiments, (6) to analyze the data and determine the optimal levels, and (7) to conduct the confirmation experiment.

SIGNAL-TO-NOISE RATIO

In the field of communication engineering a quantity called the signal-to-noise (SN) ratio has been used as the quality characteristic of choice.

The SN ratio transforms several repetitions into one value which reflects the amount of variation present and the mean response. The discretew case will be explained later.

1) Nominal is Best Characteristics 2) Smaller the Better Characteristics 3) Larger the Better Characteristics

ORTHOGONAL ARRAYS

An orthogonal array is a fractional factorial matrix which assures a balanced comparison of levels of any factor or interaction of factors. It is a matrix of numbers arranged in rows and columns where each row represents the level of the fac-

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tors in each run, and each column represents a specific factor that can be changed from each run. The array is called orthogonal because all columns all columns can be evaluated independently of one another.

Analysis-of-Variance (ANOVA) Models
Analysis-of-variance (ANOVA) procedures separate or partition the variation observable in a response variable into two basic components: variation due to assignable causes and to uncontrolled or random variation.

Analysis-of-variance models for experiments in which all factor effects are fixed adhere to the assumptions listed as follows;

1. The levels of all factors in the experiment represent the only levels of which inferences are desired.
2. The analysis-of-variance model contains parameters (unknown constants) for all main effects and interactions of interest in the experiment.
3. The experimental errors are statistically independent.
4. The experimental errors are satisfactorily modeled by the normal probability distribution with mean zero and (unknown) constant standard deviation.

Table 1: Factor and Level Combinations

Sr. No.	Factor		Level		
			1	2	3
1	A	Cross Feed (stroke / min.)	10	25	35
2	B	Air Velocity (m/sec)	3.5	5	6.5
3	C	Longitudinal Feed (stroke / min.)	35	40	45
4	D	Depth of Cut (μm)	50	100	200

Figure 3. Experimental setup (Surface grinding machine)

Figure 4. Anemometer and Surface roughness tester

From the factor combinations i.e. 3^4 experiments it is found that the L_9 orthogonal array is the best suitable options (refer table 2).

Table 2: Test combinations for L_9

Test	Factor						A_1			A_2			A_3		
	A	B	C	D			B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
T_1	1	1	1	1	C_1	D_1									
T_2	1	2	2	2		D_2									
T_3	1	3	3	3		D_3									
T_4	2	1	2	3	C_2	D_1									
T_5	2	2	3	1		D_2									
T_6	2	3	1	2		D_3									
T_7	3	1	3	2	C_3	D_1									
T_8	3	2	1	3		D_2									
T_9	3	3	2	1		D_3									

Table 3: Results

Test No.	A	B	C	D	Y_1	Y_2	Y_3	Y_4
T_1	1	1	1	1	0.28	0.28	0.29	0.27
T_2	1	2	2	2	0.21	0.21	0.19	0.18
T_3	1	3	3	3	0.17	0.17	0.19	0.18
T_4	2	1	2	3	0.26	0.26	0.23	0.23
T_5	2	2	3	1	0.19	0.18	0.20	0.20
T_6	2	3	1	2	0.27	0.29	0.26	0.28
T_7	3	1	3	2	0.29	0.28	0.23	0.27
T_8	3	2	1	3	0.38	0.31	0.35	0.37
T_9	3	3	2	1	0.32	0.31	0.30	0.29

RESULT ANALYSIS
From the result table 3, two responses are taken for analysis to find out the optimum combination, which can yield into higher peel strength of the adhesively bonded T peel joint. It helps to propose certain recommendations and design changes in the joint geometry, so that joint integrity can maintain under severe operating conditions.

Table 4: Result Table

Test	Response(Repetition)				Test Response Total	Mean	S/N Ratio
	1st	2nd	3rd	4th			
T_1	0.28	0.28	0.29	0.27	1.12	0.28	11.0541
T_2	0.21	0.21	0.19	0.18	0.79	0.1975	14.0699
T_3	0.17	0.17	0.19	0.18	0.71	0.1775	15.0066
T_4	0.26	0.26	0.23	0.23	0.98	0.245	12.2004
T_5	0.19	0.18	0.20	0.20	0.77	0.1925	14.3033
T_6	0.27	0.29	0.26	0.28	1.1	0.275	11.2062
T_7	0.29	0.28	0.23	0.27	1.07	0.2675	11.4222
T_8	0.38	0.31	0.35	0.37	1.41	0.3525	9.03177
T_9	0.32	0.31	0.30	0.29	1.22	0.305	10.3082

Mean Change in sURFACE FINISH
$SA_1 = 1.12 + 0.79 + 0.71 = 2.62$, $SA_2 = 0.98 + 0.77 + 1.1 = 2.85$, $SA_3 = 1.07 + 1.41 + 1.22 = 3.7$

Dividing SA_1, SA_2 and SA_3 by 3×4 (i.e. three factor combination and four repetitions), the mean change in strengths under the conditions A_1, A_2 and A_3 was obtained. Thus;

$A_1 = 2.62/12 = 0.2183$, $A_2 = 2.85/12 = 0.2375$, $A_3 = 3.7/12 = 0.3083$
Similarly calculating the mean change in surface finish under the conditions B_1, B_2, B_3, C_1, C_2, C_3, D_1, D_2, D_3 (Refer Table 5)

Table 5: Mean Change and S/N Ratio for Individual Factors

Factor	Total Result	Mean Change	S/N Ratio
A_1	2.62	0.218333	13.37685
A_2	2.85	0.2375	12.56998
A_3	3.7	0.308333	10.25403
B_1	0.7925	0.264167	11.55888
B_2	0.7425	0.2475	12.46834
B_3	0.7575	0.2525	12.17364
C_1	0.9075	0.3025	10.43067
C_2	0.7475	0.249167	12.19284
C_3	0.6375	0.2125	13.57735
D_1	0.7775	0.259167	11.88853
D_2	0.74	0.246667	12.23275
D_3	0.775	0.258333	12.07959

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From the calculated result of Mean Chang and S/N Ratio Mean effect of individual factor such as A_1, A_2, etc. are plotted and shown in figure 5 and figure 6 respectively.

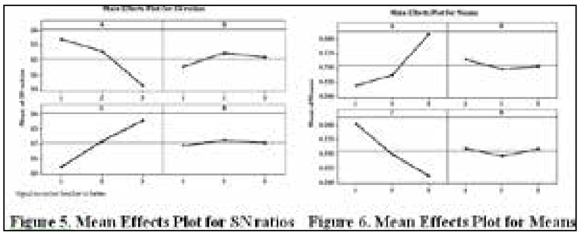
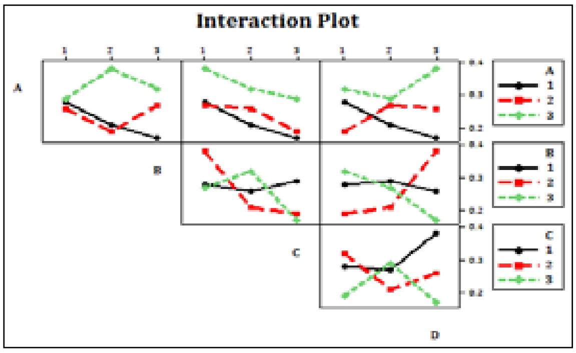


Figure 5. Mean Effects Plot for SN ratios Figure 6. Mean Effects Plot for Means



ANALYSIS OF VARIANCE (ANOVA)

Table 6, ANOVA Table

Source	DoF	SS	V	F	P(%)
A	4	0.053939	0.1348	30.9619	47.19178
B	4	0.001755556	0.000438889	1.007721	1.535956
C	4	0.049155556	0.012288889	28.21618	43.00678
D	4	0.001172222	0.000293056		1.025591
e	19	0.008275			7.239896
Total	36				100

VERIFICATION RUN

As per 95% CI = 0.16 ± 0.01 μm
As per 99% CI = 0.16 ± 0.0127 μm

After conducting the experiment for optimum combination obtained i.e. $A_1B_2C_3D_2$ (Cross Feed 10 strokes/min, Air Velocity 5 m/sec, Longitudinal Feed 45 strokes/min and depth of cut 100 μm) the value of surface roughness is 0.165 μm, which shows close correlation with predicted value.

CONCLUSIONS

From the experimental study it is clearly observed that, the use of air will help to improve the surface finish of machined surface. The optimum combination of factor and level that gives the 0.16 μm surface finish is $A_1B_2C_3D_2$. From ANOVA table factor A and factor C plays vital role in the process. The air can be as used as coolant for moderate depth of cut and feed of grinding operations.

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