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Original Research Paper

Optimization of Boring Process Parameter for Dimensional ConformanceUsing Taguchi Method

Engineering

KEYWORDS : Boring, Taguchi, Optimization, Process Capability, Deviation

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ABSTRACT

Boring is a unit processin manufacturing as a mass reduction step, used for enlarging and accurately sized existing hole by means of asingle point of a cutting tool with multiple cutting edges.Achieving a desired level of dimensional accuracy for CNC boring parts requires practical knowledge and skill to properlyset up this type of operation with the given specifications andconditions. In this present work, the effect of process variables such as cutting allowance, cutting speed and spindle speed, on response of boring operation in the form of dimensional conformance has been investigated using Taguchi robust design methodology. Analysis of variance (ANOVA) and F-test were performed to determine the significant parameters at a 95% confidence interval

1. INTRODUCTION

Machining industries continuously demanding for higher production rate and improved machine ability as quality and productivity play significant role in today's manufacturing market. The extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during the usage of the procured goods. Therefore, every manufacturing or production unit should concern about the quality of the product. Apart from the quality, there exists another criterion, called productivity which is directly related to the profit level and also goodwill of the organization. Metal based industry is focused to increase productivity and quality of the machined parts. For these purpose all aspects of every process need to be monitored. Certain desired parameter of machined parts are chosen and checked against desired degree of a quality. The technology of boring has shown some important advances in recent years, from advanced chip-breaking control tooling.

2. Boring Process

Boring operations involving rotating tools are applied to machine holes that have been made through methods such as premachining, casting, forging, extrusion, flame-cutting, etc. For internal machining, Boring is a precision operation. It increases whole diameter and also it gives desired degree of a surface roughness and dimensional accuracy provided that parameters affecting are maintained under control conditions as observed in experimental analysis. This process used after drilling or cast. Boring is a unit process in manufacturing as a mass reduction step, used for enlarging and accurately sized existing hole by means of a single point of a cutting tool with multiple cutting edges Boring is used to achieve greater accuracy of the diameter of the hole and can be used to a cut tapered hole. Boring is done with the conjunction with turning, facing or other machined operation. Because of the limitation on tooling design imposed by the fact the work piece mostly surrounded the tool, boring is inherently somewhat more challenging than turning. Boring can be viewed as the internal diameter counterpart to turning, which cuts external diameter.

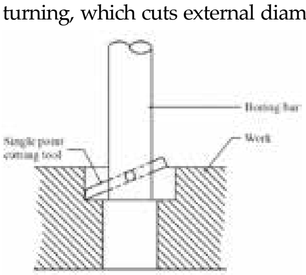

Figure 1 Boring operation

3. RESEARCH PROBLEM

Roughing operations are performed to open up the existing hole to within large tolerances and usually to prepare for finishing, which makes the hole to within tolerance and surface finish limits. Achieving a desired level of dimensional accuracy for CNC boring parts requires practical knowledge and skill to properly set up this type of operation with the given specifications and conditions. A manufacturing engineer or CNC machine setup technician is often expected to utilize experience and published shop guidelines for determining the proper machining parameters to achieve a specified level of dimensional accuracy. This must be done in a timely manner to avoid production delays, effectively to avoid defects, and the produced parts monitored for quality. Therefore, in this situation, it is prudent for the engineer or technician to use past experience to select parameters which will likely yield a surface roughness below that of the specified level, and perhaps make some parameter adjustments as time allows or quality control requires.

The objective is to optimize the process parameters viz., Cutting Allowence, Cutting Speed, Spindle Speed to achieve the closer dimensional accuracy of the bored hole of small end of connecting rod. Also to see the influencing contribution of each process parameter for achieving the same. After finalizing the the optimized process parameters it is imperative to establish the redundant manufacturing system, so that to imrove the process capability.

4. EXPERIMENTAL SETUP

Figure 2 Boring Bar With Insert

Figure 2 shows an insert used for machining. The insert is having designation as;

CCGT0602005-F1, CP500 made by SECO.

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Figure 3 Insert

Figure 5 shows the experimental arrangement for workpiece and cutting tool.

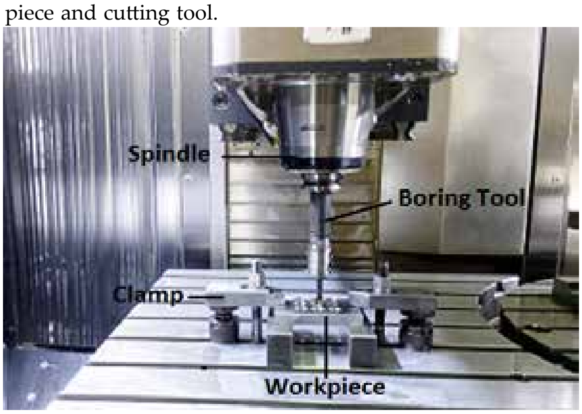

Figure 5Workpiece and Boring Tool Arrangement

Following steps has been followed for carrying out the experiments:

1. Firmly clamp the workpiece in the fixtures.
2. Put the chosen boring bar installed with appropriate insert, in the spindle.
3. Call the CNC program written for performing desired machining operation.
4. Edit the program for necessary Cutting Allowance, Cutting Speed and Spindle Speed mentioned in the L9 orthogonal array.
5. Start the machine and run the program, so that the given test will carry.
6. Repeat the program twice to get three repetitions of the same test.
7. Carry out the experiments for remaining eight tests. Each test to be carried out three times.

5. PLANNING OF EXPERIMENTS

Design of Experiment involves these seven steps:

- Set the objectives (responses)
- Select various input process variables (factors)
- Select proper experimental design
- Execute the experimentation as design plan
- Measure output responses. (Data should be consistent with the experimental assumptions)
- Analyse data and interpret the result obtained from experimentation
- Implement the result.

Experiments were carried out as per the experimental design determined by applying Taguchi method using MINITAB software. Through this method, parameters affecting experiments can be investigated as controlling and non controlling (noise factors). Secondly, this method can be used to investigate the parameters for three levels.

The use of parameter design in the Taguchi method to optimize a process with multiple performance characteristics includes the following steps:

- to identify the performance characteristics and select process parameters to be evaluated;
- to determine the number of parameter levels for the process and possible interaction between the process parameters;
- to select the appropriate orthogonal array (OA) and assignment of the process parameters to the OA
- to conduct the experiments based on the arrangement of OA
- to calculate the performance characteristics and ANOVA;
- to select the optimal levels of process parameters

Based on the discussion with the persons from industry and academia the influencing factors and its levels for boring operation has been finalized and is given in Table 1.

Table 1 Factor and Level Combinations

Factors	Levels		
	1	2	3
A - Cutting allowance (mm)	0.4	0.5	0.6
B - Cutting speed (mm/min)	30	35	40
C - Spindle speed (rev/min)	400	500	600

Table 2 shows the orthogonal array (L_9) for 33 factor level combination in coded form.

Table 2 L Orthogonal Array (Coded Values)

Test No.	Factors		
	Cutting Allowance (A)	Cutting Speed (B)	Spindle Speed (C)
T_1	1	1	1
T_2	1	2	2
T_3	1	3	3
T_4	2	1	2
T_5	2	2	3
T_6	2	3	1
T_7	3	1	3
T_8	3	2	1
T_9	3	3	2

Table 3 shows the orthogonal array (L_9) for 33 factor level combination in natural form.

Table 3 L9 Orthogonal Array (Actual Values)

Test No.	Factors		
	Cutting Allowance (A)	Cutting Speed (B)	Spindle Speed (C)
T_1	0.4	30	400
T_2	0.4	35	500
T_3	0.4	40	600
T_4	0.5	30	400
T_5	0.5	35	500
T_6	0.5	40	600
T_7	0.6	30	400
T_8	0.6	35	500
T_9	0.6	40	600

Figure 6 below shows the machined plate with nine holes.

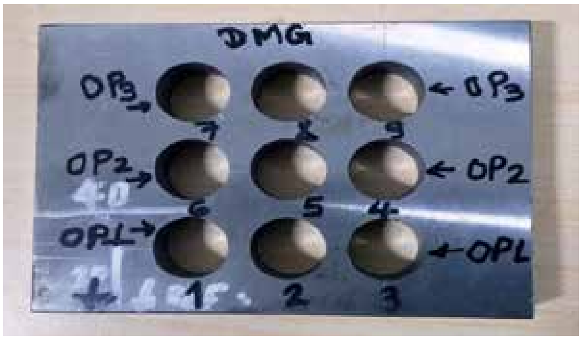

Figure 6 Machined Component (L9 Experiments)

Figure 7 shows the measurement process of hole diameter using dial bore gage.

Figure 7 Measurement of Bored Hole Diameter

The measured results has been given in Table 4.
Table 4. Observation Table

Test No.	Factors			Response (Bore Size mm)			Bore Size Deviation mm		
	A	B	C	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
T_1	1	1	1	19.010	19.012	19.009	0.01	0.012	0.009
T_2	1	2	2	18.997	19.00	18.998	0.003	0	0.002
T_3	1	3	3	19.014	19.015	19.017	0.014	0.015	0.017
T_4	2	1	2	19.015	19.016	19.016	0.015	0.016	0.016
T_5	2	2	3	18.995	18.998	18.999	0.005	0.002	0.001
T_6	2	3	1	18.996	18.992	18.993	0.004	0.008	0.007
T_7	3	1	3	19.011	19.010	19.009	0.011	0.01	0.009
T_8	3	2	1	19.019	19.017	19.017	0.019	0.017	0.017
T_9	3	3	2	19.012	19.017	19.010	0.012	0.017	0.01

Bore Size Deviation = |(Actual Size – Basic Size)|
(1)Bore Size Deviation = |(19.010 - 19.000)|
Bore Size Deviation = 0.01 mm
Similarly the other values have been calculated and is given in Table 4.7.

6 STATISTICAL ANALYSIS

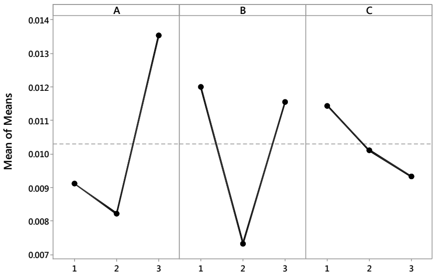

Figure 8 Main Effects Plot for Means

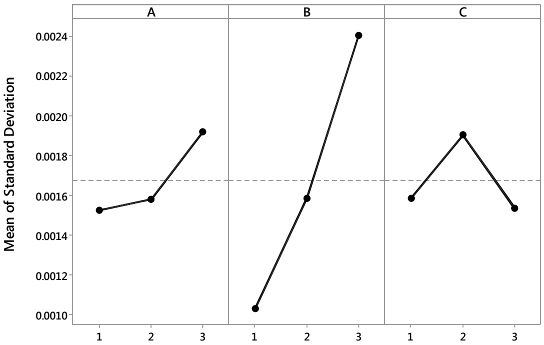

Figure 9 Main Effects Plot for Standard Deviation

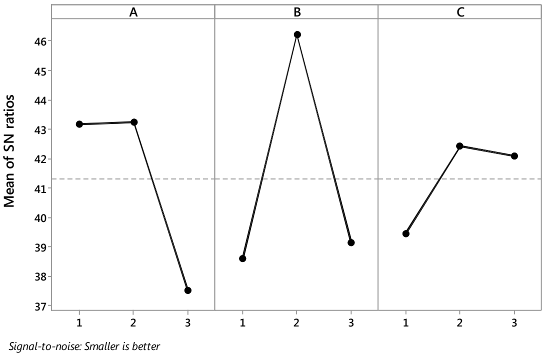

Figure 10 Main Effects Plot for SN ratios

From the S/N ratio plot the optimized process parameter combination obtained as $A_2B_2C_2$

Where,
A2 = Cutting Allowance = 0.5 mm
B2 = Cutting Speed = 35 mm/min
C3 = Spindle Speed = 500 rpm

6.1 Interaction Plot

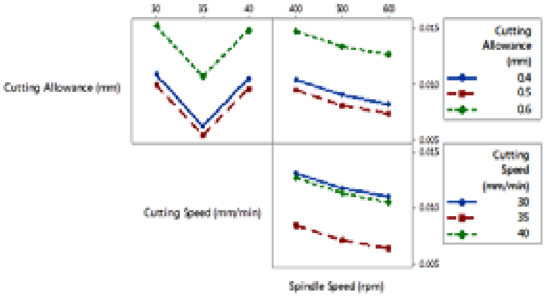

Figure 11 Interaction Plot

From the interaction plot shown in figure 11 it is seen that there is no significant interactions observed between Cutting Allowance-Cutting Speed, Cutting Allowance-Spindle Speed and Cutting Speed-Spindle Speed as the lines go parallel to each other.

6.2 Analysis of Variance (ANOVA):

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.

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Table 5 ANOVA Table for Bore Diameter Deviation

Factor	DOF (f)	SS	MS	V	F	%p
A	1	0.000149	0.000149	0.000149	0.00978	0.054275
B	1	0.000122	0.000122	0.000122	0.00797	0.04430
C	1	0.0000228	0.0000228	0.0000228	0.00149	0.00831
e	18	0.27484				
Total	26	0.27514				

6.3 Confirmation Test

Based on the data obtained through L9 orthogonal array experiments, the full factorial data has been predicted using MINITAB 17 software.

The predicted result for optimize process parameter combination gives the bore diameter deviation as 0.0050741 mm (i.e. approximately 5 µm).

The same combination test has been carried out for validation and the result satisfies the predicted value with closeness.

7 Contour Plots

In a contour plot the values for two variables are represented on the X and Y axes, while the values for a third variable are represented by shaded regions called contours. A contour plot is like a topographical map in which X, Y and Z values are plotted instead of longitude, latitude and altitude. In simple, it is a three dimensional plot shown on two dimension.

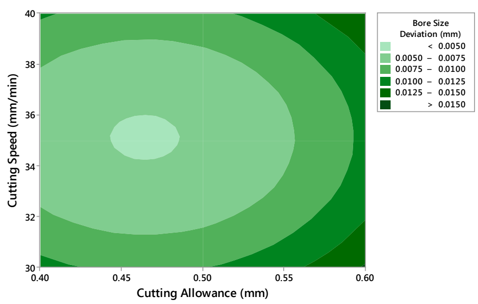

Figure 12 Contour Plot of Bore Size Deviation vs Cutting Speed, Cutting Allowance

From above contour plot it is clear that the minimum bore size deviation is observed at level 2 of Cutting Allowance and Cutting Speed.

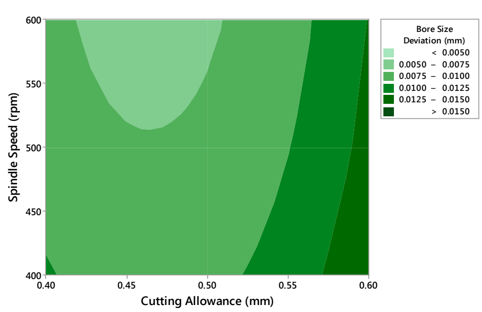

Figure 13 Contour Plot of Bore Size Deviation vs Spindle Speed, Cutting Allowance

From above contour plot it is clear that the minimum bore size deviation is observed at level 2 of Cutting Allowance and Spindle Speed.

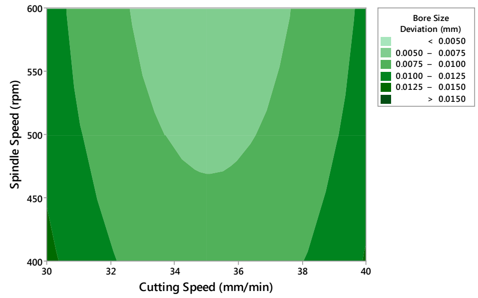

Figure 14 Contour Plot of Bore Size Deviation vs Spindle Speed, Cutting Speed

From above contour plot it is clear that the minimum bore size deviation is observed at level 2 of Cutting Speed and Spindle Speed.

8 ConCLUSIONS

Based on Taguchi Analysis

Total 27 tests were conducted (i.e. L9 Orthogonal Array with 3 repetitions). The results obtained are used for calculation S/N ratio and the criterion used is smaller-the-better. From the S/N ratio plot the optimum combination obtained is A2B2C2.

Where,
A2 = Cutting Allowance = 0.5 mm
B2 = Cutting Speed = 35 mm/min
C3 = Spindle Speed = 500 rpm

Based on Analysis of Variance (ANOVA)

From ANOVA the hierarchy wise influencing factors are; (1) Cutting Allowance (2) Cutting Speed and (3) Spindle Speed for obtaining closer values to the basic size.

Based on Contour Plot

All the contour plot confirms the outcomes of the S/N ratio.

9 REFERENCES

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