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Development of Double Point Cutting Tool for Boring Operation

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ABSTRACT

Machining is the most widely known metal removal process in manufacturing. ***Boring*** *is the process of enlarging a hole that has already been drilled by a single point cutting tool. At present, in machine shops jobs that require high surface finish are realized in two stages. They are (i) boring the internal diameter of the job (ii) finishing the job to its final size within that tolerance range by removing the stock given in the boring operation. The present method practiced will result in draw backs like setting errors, queuing of jobs and schedule delay ("Bottle Neck") and additional finishing operations adds up cost also. To overcome the drawbacks of conventional method practiced, and to enhance the surface quality, a new idea of modifying internal turning tool (single point cutting tool) with an additional cutting edge is proposed, so that finishing operation can be done in lathe itself.*

Keywords: *Single point cutting tool, Surface finish, Taguchi based GRA, Boring operation*

INRODUCTION

Machining operations have been the center of attraction of the manufacturing industry since the revolution of industries. Increasing the productivity and the quality of the machined parts are the main challenges of metal-based industry. In modern industry the goal is to manufacture low cost, high quality products in short time. In applications where surface finish is important to the functioning of a device such as in face seals, ball bearings, gears, cam surfaces, or journals, it is found that performance varies logarithmically. This means that for there to be a twofold improvement in performance, there must be tenfold reduction in surface roughness. Therefore surface must be carefully finished. In aerospace and medical fields, the surface finish of a machined component is of utmost importance. Boring can be viewed as the internal-diameter counterpart to turning, which cuts external diameters and is a very important machining operation. At present, kind of jobs that requires high surface finish are realized in two stages as explained below

1. Boring : Turning the ID of the jobs with allowance in the range of 50 microns for finishing in grinding operation
2. Grinding/Honing/Reaming: Finishing the job to its final size within the tolerance range by removing the stock given in the first step

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Drawbacks of the present method practiced are:

a. Since the jobs are done in two different machines the setting errors may prevail
b. There is only one grinding machine available and queuing of jobs for grinding will result in schedule delay. (Bottle neck)
c. The available grinding machine is 30 years old and having frequent breakdowns which further delays the component realisation.

To overcome the drawbacks of conventional method practiced, the “bottleneck” and to enhance the surface quality, an attempt is made to modify single point cutting tool so that finishing operation can be done in lathe itself.

DOUBLE POINT CUTTING TOOL- THE IDEA

Two simultaneous pass with second pass having zero depth of cut will improve the surface finish. The drawback of this technique is that the time taken for its two passes represents twice the time of regular machining. Another drawback is the difficulty of adjusting the tool in the second pass with the appropriate accuracy. For solving these problems, a tool design is proposed to achieve results of the two-pass in one pass.

In the proposed technique, the single point cutting tool will be modified. The tool will have two cutting edges; the first one will be for cutting operation and next one for finishing operation. So that surface roughness will be reduced in the single operation itself. Boring is started with the first cutting edge with certain cutting conditions and depth of cut. The second cutting edge is for finishing operation, with zero depth of cut

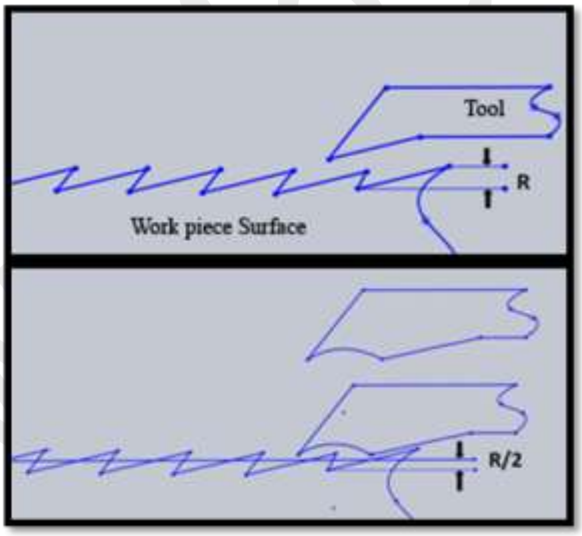

Figure 1: Concept of new technique.

From Fig 1 it is clear that surface roughness will be almost reduced by 50% by the newly proposed technique. It can be achieved in the single operation (i.e. single pass) itself, so it would be the cost and time efficient one

We cannot simply modify a single point cutting tool to a tool with two cutting edges. So first of all we have to finalise the parameters that are going to be changed for the modifying tool. Once parameters are finalised, we have to go for optimisation process in order to finalisethe modified tool.

From the literature survey and observation, we have observed that, 4 factors contribute significantly to the surface finish. They are:

- Distance between the 2 cutting edges (L)
- End cutting edge angle (ECEA)
- Nose radius
- Side Cutting Edge angle (SCEA)

Nose radius is generally taken as 0.2 mm for most of the tool although it can be varied in the range from 0.2 mm to 2.4mm. Since the new tool is developed by grinding, grinding of nose radius to such small value is difficult. So we will keep nose radius for two cutting edges constant.

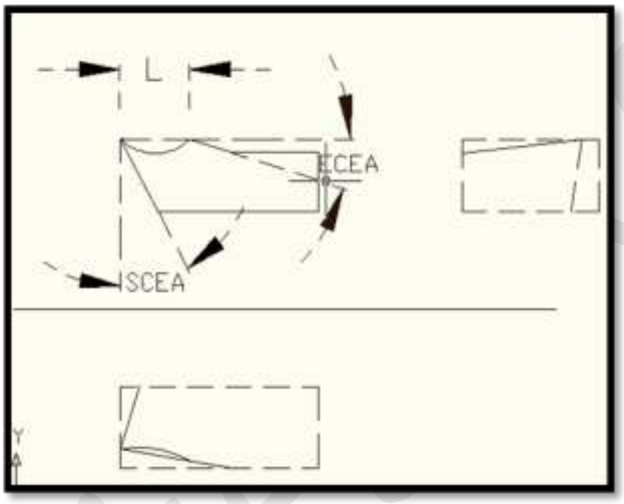

Figure 2: CAD drawing of modified tool

There are 3 parameters whose influence we want to study and the range of these parameters are divided into 3 levels, the range of length is selected based on practical considerations. Various levels for the parameters are given in Table 1.We are following Taguchi L9 orthogonal array for design of experiment, so 9 cutting tool with specification as shown table 3 is to be made

Table 1: Setting of levels

Level	Length (L)	End cutting edge angle (SCEA)	Side Cutting Edge Angle (SCEA)
1	3	5	15
2	6	10	20
3	10	15	25

DEVELOPMENT OF MODIFIED TOOL

The tool material is selected as HSS due to the fact that grinding HSS is possible. HSS blocks of dimension 18 X 18 X 150 are obtained and finally grinded to the required tool dimensions as per table 3.

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Figure 3: Modified cutting tools

Thus after extensive grinding process the tool was developed. The new tools are shown in the figures 3

Signal to noise ratio

There are 3 Signal-to-Noise ratios of common interest for optimization of problems which depend on the objective function

- **Smaller-the-better**

η = -10 Log10 [mean of sum of squares of measured data]

This is usually the chosen S/N ratio for all undesirable characteristics like "defects" etc. for which the ideal value is zero. Also, when an ideal value is finite and its maximum or minimum value is defined (like maximum purity is 100% or maximum Tc is 92K or minimum time for making a telephone connection is 1 sec) then the difference between measured data and ideal value is expected to be as small as possible. The generic form of S/N ratio then becomes,

η = -10 Log10 [mean of sum of squares of {measured - ideal}]

- **Larger-the-better**

η = -10 Log10 [mean of sum squares of reciprocal of measured data]

This case has been converted to SMALLER-THE-BETTER by taking the reciprocals of measured data and then taking the S/N ratio as in the smaller-the-better case.

- **Nominal-the-best**

$$\eta = 10log_{10}\left(\frac{squareofslopeorbeta}{variance}\right)$$

This case arises when a specified value is MOST desired, meaning that neither a smaller nor a larger value is desirable

OPTIMIZATION OF TOOL PARAMETERS OF DOUBLE POINT CUTTING TOOL

The experiment was conducted at RFF machine shop, with the setup specified in table 3.The work pieces were inspected for surface roughness (Ra) along the turned length at two locations 180 degree apart using Taly surf measuring instrument at VSSC QC department.

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Table 2 Experimental Setup for phase 3

Experimental set up	Specifications
Work piece material	15CDV6, Internal diameter -70 mm(approx.), External diameter-94mm ,length-50mm
Machine used	HMT NH 26 (CNC Retrofitted)
Cutting tool	Newly developed tools (9 nos.)
Cutting condition	V=30m/min, f=0.05mm/rev, d= 0.5mm
Coolant used	Water + soluble oil

Table 3: Formation of the experiment

Tool Name	Tool details			Specimen Name
	L (mm)	ECEA (Degree)	SCEA (Degree)	
DPCT1	3	5	15	BT1
DPCT2	3	10	20	BT2
DPCT3	3	15	25	BT3
DPCT4	6	5	20	BT4
DPCT5	6	10	25	BT5
DPCT6	6	15	15	BT6
DPCT7	10	5	25	BT7
DPCT8	10	10	20	BT8
DPCT9	10	15	15	BT9

Figure 4: Conducting Experiment

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S/N ratio for each reading is obtained by using the formula as described above. Since our objective function is surface roughness smaller the better characteristics is used

Table 4: Average Ra values and S/N ratio

Specimen Name	Ra VALUE(microns)		Average Ra Value (microns)	S/N Ratio (η)
	Location 1	Location 2		
BT1	2.90	3.55	3.23	-10.2272642
BT2	2.96	3.33	3.15	-9.9818176
BT3	3.29	3.16	3.23	-10.1857873
BT4	2.7	2.5	2.65	-8.47186064
BT5	2.72	2.83	2.78	-8.88263275
BT6	3.16	3.03	3.1	-9.82897071
BT7	6.25	5.54	5.9	-15.4326468
BT8	3.24	3.51	3.38	-10.5852772
BT9	3.19	3.46	3.33	-10.4558278

Table 5: Average S/N ratio for each parameter at three levels

Symbol	Process Parameter	Roughness value(microns)		
		Low	Medium	High
L	Length	-10.1316	**-9.06115***	-12.1579
ECEA	End cutting edge angle	-11.3773	**-9.81658***	-10.1569
SCEA	Side Cutting Edge angle	-10.2138	**-9.6365***	-11.5004

*Optimized Level

ANALYSIS OF VARIANCE (ANOVA)

The purpose of analysis of variance (ANOVA) is to investigate which of the tool parameters significantly affect the performance characteristics.

Table 6. Results of ANOVA

Source	DOF	SS	MS	F	% C
L	2	14.84171	7.420855	1.9543	46.46882
ECEA	2	4.040886	2.020443	0.53211	12.65186
SCEA	2	5.462395	2.731198	0.71929	17.10255
Error	2	7.594079	3.79704	1	23.77677
Total	8	31.93907			

CONFIRMATION TEST

After evaluating the optimal parameter settings, the next step is to predict and verify enhancement of the quality characteristics using optimal parametric combination. The prediction equation is given by

T′ ′ =Tm+∑ (Ti-Tm)

Where Tm= total mean Ra

Ti=mean Ra at the optimum levels

Table 9.6 Results of confirmation experiment

	Optimal machining parameters		Difference
	Prediction(Ra)	Experiment (Ra)	
Setting level	$L_2ECEA_2SCEA_2$	$L_2ECEA_2SCEA_2$	
Surface roughness	2.15 microns	2.64 microns	0.49 microns

RESULTS AND CONCLUSION

The idea of double point cutting tool for boring operation was proposed and nine tools with varying combination of tool parameters are developed to find out the optimized tool parameters using L9 orthogonal array and the optimized levels are L=6mm,ECEA=20^0 and SCEA=10^0. By Performing ANOVA it has been found out that the most influencing factor in surface finish is Length between two cutting edges. In order to compare the performance of the new optimized tool,a single point cutting tool wasground with all the other parameters (rake angle etc.) same as that of optimized double point tool as shown in figure 5. Now two specimens are bored using the two tools and its surface finish was noted. The surface finish of single point and double point tools are 3.07 and 2.64 microns (Ra value) respectively

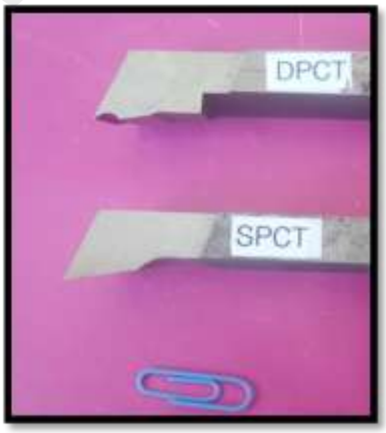

Figure 5: Tools for comparison experiment

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From the readings it has been understood that surface finish have been increased by 14%. The obtained result is very low compared to our expected increase in performance by 50%. The reasons for this difference may be

- Vibration induced due to weakening of tool due to material loss
- Lack of control over tool nose radius
- Incorrect tool setting:
- Tool wear

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