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A Study to Determine the Effect of M.R.R. on Surface Roughness

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Abstract: In this experimental based approach, turning operation of Aluminium workpiece is done using carbide tipped High speed steel tool. The weight of the materials removed per second (g/s) values and the experimentally acquired Materials removal rate (MRR) in g/s are compared using a graphic technique. The goal of this study is to determine whether the theoretically predicted Weight of materials removed per second (g/s) and the experimentally measured Materials removal rate (g/s) differ from one another. And it has been observed by the authors that theoretically predicted Weight of materials removed per second (g/s) and the experimentally measured Materials removal rate (g/s) do differ from one another.

An approach was taken to find out the reasons for the same. It is observed that the difference, between experimental and theoretical MRR values, is minimum when depth of cut is low and feed rate is high and also, it was seen that, when the feed rate is minimum, Materials Removal Rate, found experimentally is lesser than Weight of materials removed per second (g /s), found theoretically.

Additionally, an analysis was carried out to determine when the experimentally measured and theoretically predicted differences were the smallest in relation to the input cutting parameters. Also, a comparison graph between theoretical and experimental MRR values as well as surface roughness values has been created in this work. Once again, the goal was to determine how the surface may be made smoother. In this study, a carbide tip tool was used on a CNC lathe with three levels of three input parameters, including spindle speed, feed rate, and depth of cut. An L9 orthogonal array was then generated, and the materials removal rates were calculated as well as the surface roughness measured over nine observations.

Keywords: Materials removal rate, Weight of materials removed per second, CNC Lathe, L_9 orthogonal array

I. INTRODUCTION

The material removal rate canbe defined as the amount of material removed from the workpiece per unit time. The rate of material removal can be calculated from the difference in volume or weight of material removed before and after processing. It shows how fast or slow the processing speed is. MRR is highly dependent on process parameters.

Surface roughness, often abbreviated as roughness, is a component of surface texture. It is quantified by the deviation of the direction of the actual surface normal vector from the ideal shape. If these deviations are large, the surface is rough. If small, the surface is smooth. Roughness plays an important role in determining how real-world objects interact with their environment. The surface finish of a part can have a significant impact on friction, wear, fatigue, corrosion, tightness of contact joints, positioning accuracy, etc. Surface finish is an important factor in manufacturing process monitoring and quality control.

In our work, three levels of feed rate—50, 75, and 100 mm/min—as well as three levels of spindle speed—75, 1000, and 1250 RPM—as well as three levels of depth of cut—0.05, 0.075, and 0.1 mm—are used to construct a L9 orthogonal array.

Weight of the workpiece before and after machining, diameters before and after machining, and time taken for machining are all measured for each of the nine observations. Table 1 is a summary of the observations. The MRR found both theoretically and experimentally are tabulated below.

TABLE1: OBSERVATION TABLE

Sl. no.	Spindle speed (RPM)	Depth of cut (mm)	Feed rate (mm/min)	Weight of the job before machining (g)	Weight of the job after machining (g)	Machining time (s)	Materials removal rate (g/s)	Dia. before machining (mm)	Dia. after machining (mm)	Length of machining (mm)	Volume of materials removed (mm3)	Volume of materials removed per second (mm3/s)	Weightof materials removed per second (g/s)	Surface roughness (Micron)
1.	750	0.05	50	73.9	71.9	196	0.0102	18.4	17.5	30	782.1	3.7149	0.01003	1.346
2.	750	0.075	75	71.9	68.9	138	0.0217	17.5	16.1	30	1141.16	8.2692	0.02232	1.396
3.	750	0.1	100	68.9	67.3	80	0.02	16.1	15.43	30	497.654	6.22068	0.01679	1.482
4.	1000	0.05	50	75.7	73.5	182	0.01209	19	18.15	30	743.887	4.08729	0.01103	0.685
5.	1000	0.075	75	73.5	71.5	132	0.01515	18.15	17.25	30	750.541	5.68592	0.01535	1.196
6.	1000	0.1	100	71.5	69.8	109	0.0156	17.25	16.33	30	727.776	6.67684	0.01802	0.762
7.	1250	0.05	50	75.9	74.3	157	0.01019	19	18.35	30	571.917	3.64278	0.00983	1.369
8.	1250	0.075	75	74.3	71.9	152	0.01579	18.35	17.15	30	1003.55	6.6022993	0.0178262	0.973
9.	1250	0.1	100	71.9	69.9	96	0.02083	17.15	16.37	30	615.925	6.41588	0.01732	1.176

II. LITERATURE REVIEW

Bharilya et al. [1] investigated the optimization of machining parameters for turning a given workpiece, such as Carburized Mild Steel (hard material), aluminium alloys and brass (soft material), which were processed by a CNC machine and analyzed through a cutting force dynamometer. Jeyaprakash et al. [2] made a comparison between analytical model and experimental analysis of minimum cutting thickness and surface roughness in CNC micro-turning of aluminium 19000 alloys. Kawin et al. [3] investigated the effect of cutting speed, feed rate and depth of cut on CNC turning of aluminium metal matrix composites. An L9 orthogonal array design was used for the experiments.

Gadekula et al. [4] investigates the parametric optimization of High Carbon High Chromium Steel (HCHCR) material using results after testing on a CNC lathe. Nalbant et al. [5] used the Taguchi method to find optimal cutting parameters for surface roughness in turning. Orthogonal array, signal-to-noise ratio, and analysis of variance are used to investigate the performance characteristics of AISI 1030 steel bars used for turning TiN-coated tools.

III. MATHEMATICAL FORMULATION

As discussed already, three levels of Spindle speed, Feed and Depth of cut was chosen and L_9 orthogonal array has been developed. Weight of the job before and after machining and diameter of the job before and after machining was measured. Also machining length was made fixed as 30mm and time of machining was taken.

Materials removal rate was calculated by the formula, MRR= (Weight of the job before machining (g) - Weight of the job after machining (g)) / Time of machining.

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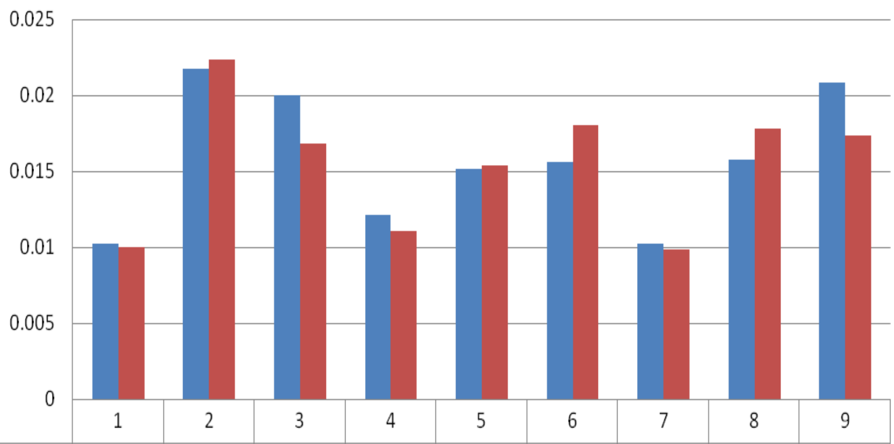
MRR calculated above is the value obtained experimentally. Now to calculate MRR theoretically, diameters of job before and after machining were measured using a Digital Micrometer with least count 0.01mm. Volume of materials removed was calculated by the formula, Volume of materials removed = $\frac{\pi}{4}$ (Diameter before machining^2 – Diameter after machining^2) * Length of machining. Now, the Volume of materials removed per second was determined in mm^3/second. Weight of the materials removed was calculated by taking density of Aluminium as 0.0027 g/mm³ and by using the formula, (Weight of the materials removed) = (Volume of materials removed) x (Density of Aluminium).

IV. RESULT AND DISCUSSION

Firstly, let us draw a comparison between Materials removal rate (g/s) experimental values and Weight of materials removed per second (g /s) theoretical values.



	1	2	3	4	5	6	7	8	9
Materials removal rate (g/s) Experimental values (X)	0.010204	0.021739	0.02	0.012088	0.015152	0.015596	0.010191	0.015789	0.020833
Weight of materials removed per second (g /s) theoretical values (Y)	0.0100303	0.0223271	0.0167958	0.0110357	0.015352	0.0180275	0.0098355	0.0178262	0.0173229

Fig. 1 Comparison between Materials removal rate (g/s) experimentally and Weight of materials removed per second (g /s) theoretically.

It can be easily seen in the graph that Materials removal rate (g/s) experimentally and Weight of materials removed per second (g/s) theoretically differ for all the observations and the difference is shown in the table 2. For observations 2, 5, 6 and 8, weight of materials removed per second (g/s) theoretically is lesser than Materials removal rate (g/s) obtained experimentally. And for the remaining 5 cases weight of materials removed per second (g/s) theoretically is greater than Materials removal rate (g/s) obtained experimentally.

The minimum value of difference between Materials removal rate (g/s) Experimental values and Weight of materials removed per second (g /s) theoretical values, for observations 1,5 and 7. These three observations carry three different spindle speed values, two different depth of cut values (two low and one medium value), two different feed rate values (two high values and one low value). The conclusion can be drawn from these observations that the difference, between theoretical and experimental MRR values, is minimum when depth of cut is low and feed rate is high.

Now, another observation can be drawn from these values that, When the above stated difference is negative, spindle speed value is lower, i.e., 750 RPM for observations 2 and 5, and depth value is medium i.e.,0.075 mm for observations 2 and 5 also feed value is lower for observations 6 and 8. So it can be roughly concluded that in most of the times, weight of materials removed per second (g /s) theoretically is lesser than Materials removal rate (g/s) obtained experimentally when spindle speed and depth of cut values are medium and feed rate value is low.

TABLE 2 TABLE CONTAINING "DIFFERENCE BETWEEN THEORETICAL VALUE OF MRR AND EXPERIMENTAL VALUE OF MRR" AND "SURFACE ROUGHNESS (RA) (NANO METER)".

Sl. No.	Materials removal rate (g/s) Experimental values (X)	Weight of materials removed per second (g /s) theoretical values (Y)	Difference between experimental value of MRR and theoretical value of MRR (X-Y)	Surface roughness (Ra) (Nano-meter)
1	0.010204	0.0100303	0.000174	0.001346
2	0.021739	0.0223271	-0.00059	0.001396
3	0.02	0.0167958	0.003204	0.001482
4	0.012088	0.0110357	0.001052	0.000685
5	0.015152	0.015352	-0.0002	0.001196
6	0.015596	0.0180275	-0.00243	0.000762
7	0.010191	0.0098355	0.000356	0.001369
8	0.015789	0.0178262	-0.00204	0.000973
9	0.020833	0.0173229	0.00351	0.001176

Now, let us compare the difference between experimental values of MRR and theoretical values of MRR with the Surface roughness (Ra) (Nano-meter). From the graph (Fig. 2) between difference of experimental values of MRR and theoretical values of MRR with the Surface roughness (Ra) (Nano-meter). If we take the three minimum values of surface roughness in Nano-meter they are 0.000685 for observation 4, the next minimum value is 0.000762 for observation 6, the next value is 0.000973 for observation 8. For observations 6 and 8, the difference between experimental value of MRR and theoretical value of MRR is negative i.e., theoretical value of MRR is greater than the experimental value. For observations 6 and 8 values of feed rate are minimum. So a rough conclusion can be made that when the feed rate is minimum, Materials Removal Rate, found theoretically, is greater than Weight of materials removed per second (g /s), found experimentally. So, for lower feed rate, by our experiment, the Materials Removal Rate theoretical value is greater. And also for minimum feed rate value, when the Materials removal rate (g/s) theoretical values are greater than the Weight of materials removed per second (g/s) experimental values, the Surface roughness value is smaller, i.e., surface is smooth.

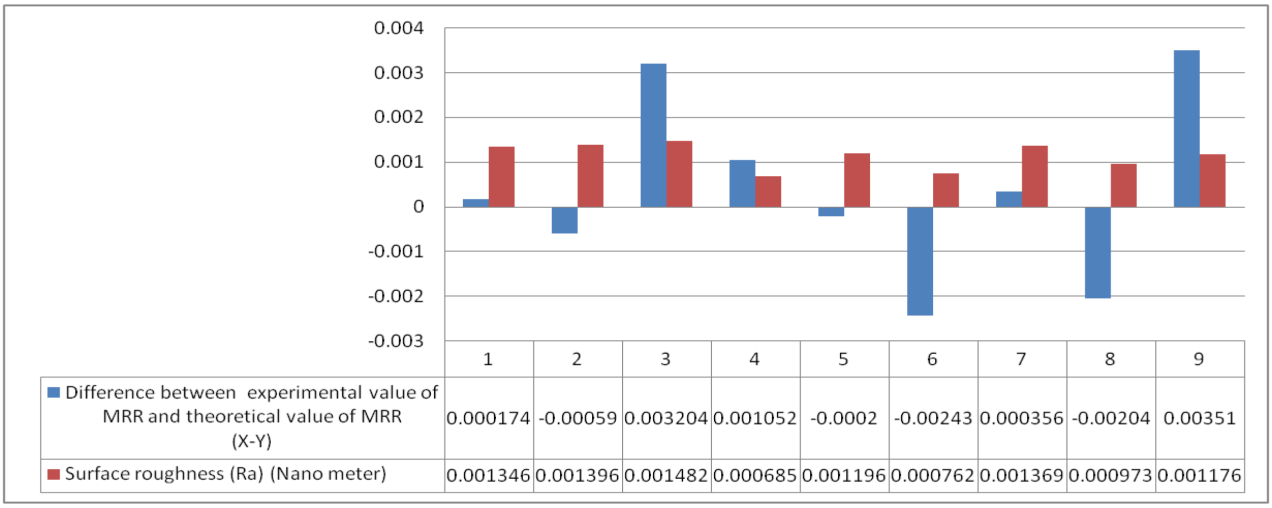


Fig. 2 Graph between difference of experimental values of MRR and theoretical values of MRR with the Surface roughness (Ra) (Nano-meter).

V. CONCLUSION

The conclusions of our experimental analysis are discussed already in Result and Discussion chapter but here they are listed again.

1. The difference, between experimental and theoretical MRR values, is minimum when depth of cut is low and feed rate is high.

2. The Materials removal rate (g/s) obtained experimentally is greater than the weight of materials removed per second (g /s) theoretically, when spindle speed and depth of cut values are medium and feed rate value is low.

3. When the feed rate is minimum, Materials Removal Rate, found theoretically, is greater than Weight of materials removed per second (g /s), found experimentally.

4. When the Materials removal rate (g/s) Experimental values are lesser than the Weight of materials removed per second (g /s) theoretical values, the surface is smooth.

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