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Effects of process parameters on Turning Moment in CNC Milling:

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Abstract: In this paper, the effects of various process parameters of CNC Milling like Spindle Speed (N), table feed rate (FR), depth of cut (DOC), step over (SO) and coolant pressure (CP) have been investigated to reveal their impact on turning moment acting while machining of hot die steel (H-11), using one variable at a time approach.

Keywords: CNC Milling; N; FR; DOC; SO; CP; TM;

I. INTRODUCTION:

To maintain in the global rivalry condition of manufacturing conditions, customer related, fast manufacturing strategies are becoming an unelectable manufacturing philosophy. Larger cutting forces along with turning moment generate poor surface finish as well as extensive surface damage [1].

Milling is a process of producing flat and complex shapes and is one of the most widely used metal removal processes in industry and milled surfaces are largely used to mate with other parts in die, aerospace, automotive and machinery design as well as in manufacturing industries.

II. Experimental Methodology:

The experimental studies were performed on SURYA VF30 CNC VS machine (Figure 1). Various input parameters varied during the experimentation are Spindle speed (N), table feed rate (FR), depth of cut (DOC), step over (SO) and coolant pressure (CP). The effects of these input parameters are studied on turning moment using one factor at a time approach. The units of input parameters are as spindle speed (r.p.m), table feed rate (mm/min), depth of cut (mm), step over (mm) and coolant pressure (lb/inch²).



Figure 1 Vertical CNC Machine Tool

In each experiment one input variable was varied while keeping all other input variables at some mean fixed value and the effect of change of the input variable on the output characteristic i.e. turning moment is studied and reported in this paper. Solid Carbide 4-flute end mill cutter of 10mm diameter was used in the experiments. The work piece material, H-11 hot die steel with 180 mm × 100 mm × 24 mm size was used, because the cuts were made lengthwise. During the experiments, cuts were made of 30mm length and 12mm width, whereas the cutter diameter was 10mm, this is where step over parameter has application. Measurement of turning moment was done by Kistlers Dynamometer & TM in x, y & z directions were displayed and resultant is taken.



Figure 2 Dynamometer beneath workpiece and pressure gauge

III. Observations:

Various experiments were performed to find out how the cutting force varies with the variation in the input parameters. In the first set of experiments spindle speed (N) is varied from 500 r.p.m to 6000 r.p.m in the steps of 500 units. All other input parameters such as table feed rate, depth of cut, step over, coolant pressure were kept constant. The variation in turning moment due to change in spindle speed is shown in Table 1. Fixed input variables in first set of experiments are: FR=910mm/min; DOC = 1mm; SO = 1 mm; CP = 1.2lb/inch²

Table 1 showing turning moment at different spindle speeds:

SR. No	Spindle Speed (rpm)	Turning Moment (Nm)
1.	500	18.02
2.	1000	13.63
3.	1500	14.24
4.	2000	14.61
5.	2500	14.05
6.	3000	13.13
7.	3500	14.03
8.	4000	13.76
9.	4500	15.3
10.	5000	13.87
11.	5500	20.29
12.	6000	16.28

In the second set of experiments table feed rate (FR) is varied from 238mm/min to 1414mm/min in the steps of 168 units. All other input parameters such as spindle speed, depth of cut, step over, coolant pressure were kept constant. The variation in turning moment due to change in table feed rate is shown in Table 2. Fixed input variables in second set of experiments are: N=3500r.p.m; DOC = 1mm; SO = 1 mm; CP = 1.2lb/inch²

Table 2 showing turning moment at different table feed rates:

SR. No	Table Feed Rate (mm/min)	Turning Moment (Nm)
1.	238	11.09
2.	406	12.97
3.	574	12.64
4.	742	11.05
5.	910	12.11
6.	1078	11.92
7.	1246	11.7

8.	1414	12.28
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In the third set of experiments depth of cut (DOC) is varied from 0.2mm to 1.6mm in the steps of 0.2 units. All other input parameters such as spindle speed, table feed rate, step over, coolant pressure were kept constant. The variation in turning moment due to change in depth of cut is shown in Table 3. Fixed input variables in third set of experiments are: N=3500r.p.m; FR = 910mm/min; SO = 1 mm; CP = 1.2lb/inch²

Table 3 showing turning moment at different depth of cuts:

Sr.No	Depth of Cut (mm)	Turning Moment (Nm)
1.	0.2	26.3
2.	0.4	26.17
3.	0.6	23.71
4.	0.8	22.78
5.	1.0	22.42
6.	1.2	23.17
7.	1.4	26.19
8.	1.6	27.21

In the fourth set of experiments step over (SO) is varied from 0.25mm to 2.0mm in the steps of 0.25 units. All other input parameters such as spindle speed, table feed rate, depth of cut, coolant pressure were kept constant. The variation in turning moment due to change in step over is shown in Table 4. Fixed input variables in fourth set of experiments are: N=3500r.p.m; FR = 910mm/min; DOC = 1 mm; CP = 1.2lb/inch².

Table 4 showing turning moment at different step over:

SR. No	Step Over (mm)	Turning Moment (Nm)
1.	0.25	14.02
2.	0.50	16.39
3.	0.75	24.90
4.	1.00	25.68
5.	1.25	24.57
6.	1.50	23.32
7.	1.75	22.61
8.	2.00	23.45

In the fifth set of experiments coolant pressure (CP) is varied from 0.4 to 2.0lb/inch² in the steps of 0.4 units. All other input parameters such as spindle speed, table feed rate, depth of cut, step over were kept constant. The variation in turning moment due to change in coolant pressure is shown in Table 5. Fixed input variables in fifth set of experiments are: N=3500r.p.m; FR = 910mm/min; DOC = 1 mm; SO = 1mm.

Table 5 showing turning moment at different coolant pressure:

SR. No	Coolant Pressure (lb/inch ²)	Turning Moment (Nm)
1.	0.4	23.76
2.	0.8	24.75
3.	1.2	25.76
4.	1.6	26.36
5.	2.0	23.37

IV. Result & Analysis:

The experiments are based on one factor experiment strategy. In this only one input parameter was varied while keeping all others input parameters at constant values. After analyzing the results of the experiments performed, various facts came into light. The effect of spindle speed (N) on the turning moment is shown in Figure 3.

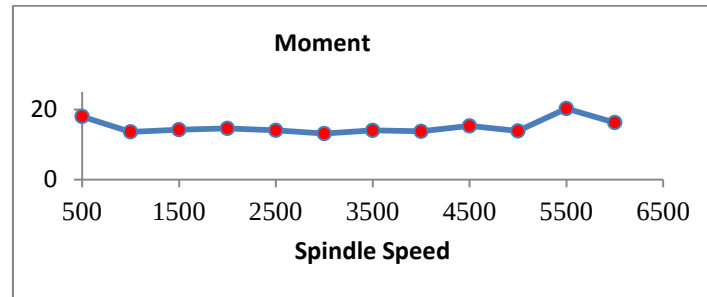


Fig 3 Spindle speed vs. Turning Moment

The graph 3 shows that the turning moment decreases with the increase in the spindle speed. So, the spindle speed can be adjusted to get the desired turning moment.

For the second set of experiments, the effect of table feed rate on turning moment is shown in figure 4.

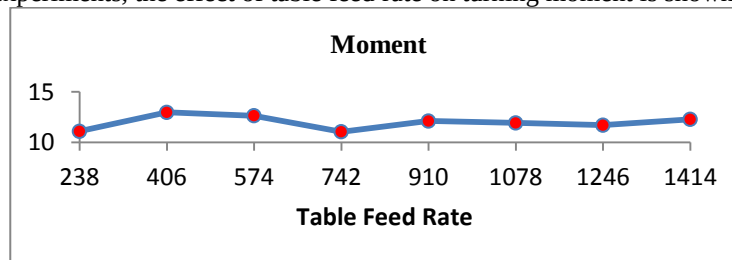


Fig 4 Table Feed Rate vs. Turning Moment

The graph 4 shows that the turning moment increases in a straight line fashion with the table feed rate. So, a mean value of feed rate can be adjusted to get the desired turning moment.

For the third set of experiments, the effect of depth of cut on turning moment is shown in figure 5.

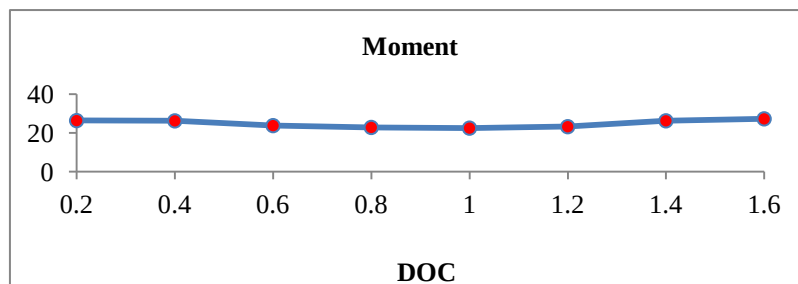


Fig 5 Depth of Cut vs. Turning Moment

The graph 5 shows that the turning moment goes on increasing with the increase in depth of cut. So, an optimum value of depth of cut can be adjusted to get the desired turning moment.

For the fourth set of experiments, the effect of step over on turning moment is shown in figure 6

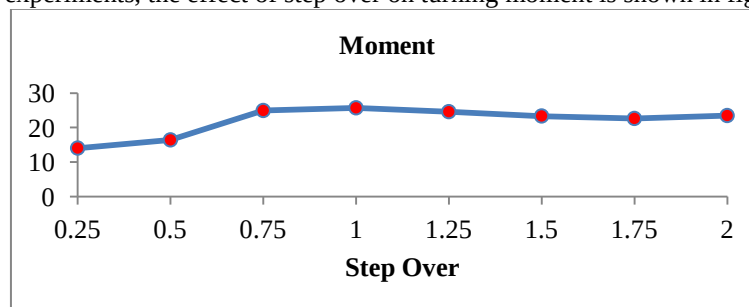


Fig 6 Step Over vs. Turning Moment

The graph 6 shows that the turning moment goes on increasing due to wearing of surface in step over. So, an optimum value of step over can be adjusted to get the desired turning moment.

For the fifth set of experiments, the effect of coolant pressure on turning moment is shown in figure 7.

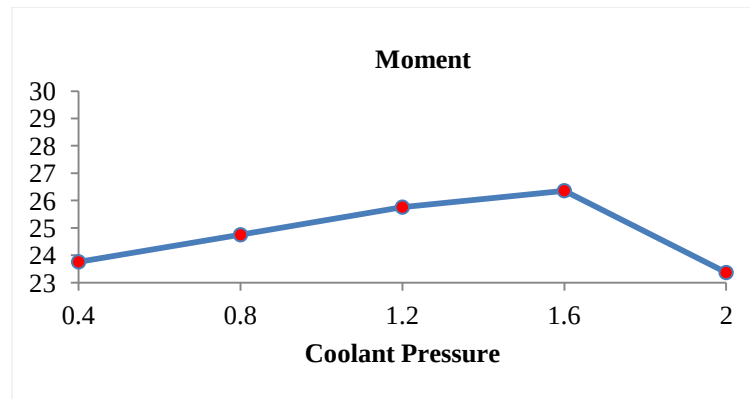


Fig 7 Coolant Pressure vs. Turning Moment

The graph 7 shows that the variation in turning moment is very small with the increase in the values of coolant pressure and the variation follows a zigzag pattern.

V. Conclusions:

The turning moment decreases with the increase in the spindle speed and increases with increase in table feed rate, depth of cut and step over and is not much affected by coolant pressure and the variation is quite small. In the nutshell, we can say that coolant pressure is a neutral parameter, whereas all other parameters affect turning moment significantly, so optimum values of these parameters must be selected for effective machining.

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