Optimization of Cutting Parameters in Hard Turning of OHNS Steel

Anil Raj, K. Leo Dev Wins, M. Dev Anand

Abstract--- Turning of hardened steel is normally carried out with copious supply of cutting fluid to improve the cutting performance. Most of the cutting fluids in regular use are petroleum based emulsions which create several environmental problems. In this context, pure dry machining is a logical alternative as it is free from the problems associated with the cutting fluid. In this study an effort was made to study the effect of flank wear and cutting temperature during hard turning of OHNS steel under dry condition. A detailed analysis was performed using Taguchi technique to find out the effect of above mentioned parameters. Analysis of Variance (ANOVA) was carried out to find out the influence of individual parameters on flank wear and cutting temperature. Confirmation tests were performed to compare the predicted values with the experimental values and it was found that the results matched well with the experimental results.

Keywords--- Hard Turning, OHNS, Dry Turning.

I. INTRODUCTION

Turning of hardened steel involves application of large quantities of cutting fluid. Procurement, storage and disposal of cutting fluid involve expenses and large scale use of cutting fluid causes serious environmental and health hazards on the shop floor. It may also foul up the machine tool and disposal of cutting fluid has to comply with environmental legislations as well. In this situation, pure dry machining is a logical alternative which is totally free from the problems associated with storage and disposal of cutting fluid [1 and 2].

Less work has been reported in the area of dry machining, especially in the area of hard turning [3-5]. The present work aims at a systematic investigation of flank wear and cutting temperature during dry turning of OHNS steel of hardness 43 HRC. The scheme is environmental friendly and free from the problems associated with the cutting fluid. The input parameters taken for this experiment are cutting speed, feed and depth of cut. Likewise, the output parameters taken for this particular experiment are flank wear and cutting temperature.

II. EXPERIMENT

2.1 Selection of Work Piece

OHNS (Oil Hardened Non Shrinkable) Steel of hardness 43 HRC with 375 mm length and 70 mm diameter was selected as a work material for this investigation which is widely used in die making, casting and allied industries. It is known for its toughness, fatigue strength and tensile strength. The composition of OHNS steel is shown in Table 1.

Table 1: Composition of Work Piece Material

C	Mn	Cr	W	V	Si	Fe
0.95	1.15	0.5	0.5	0.2	0.28	balance

2.2 Selection of Cutting Tool and Tool Holder

The cutting tool inserts and the tool holder were selected as per the recommendations of M/s TaeguTec India (P) Limited who extend their technical/material support for this research work. Accordingly, multicoated hard metal inserts with sculptured rake face with a specification SNMG 120408and tool holder with the specification PSBNR 2525 were used in the investigation.

Figure 1 shows the experimental set up which consists of a medium duty Kirloskar lathe which was modified with DC motors to provide variable speed and feed using variable controllers. Table 2 shows the three input parameters and their levels.

Figure 1: Experimental Set Up

Table 2: Input Parameters and Their Levels

Cutting Speed v(m/min)	75, 95, 115
Feed Rate f(mm/rev)	0.05, 0.075, 0.1
Depth of Cut d(mm)	0.5 , 0.75 , 1

Design of Experiment

A 9 run experiment was designed based on TaguchiL_9 orthogonal array [6] is shown in the Table 3.

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Table 3: Design Matrix for Nine-Run, Three-Level Experiment with Three Factors

Standard Order	Factor Columns		
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

In the experimental phase, preliminary experiments were conducted through trial runs. Trial runs helped in fixing the range of parameters. In the second phase, experiments were carried out using Taguchi L_9 orthogonal array with experimental values and are presented in Table 4.

Table 4: Experimental Data Collected During 9 Run Experiment

Sl. No.	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)	Temperature (◦C)	Flank Wear (mm)
1.	75	0.05	0.5	150.5	0.051
2.	75	0.075	0.75	156.5	0.056
3.	75	0.1	1	178	0.069
4.	95	0.05	0.75	151.5	0.054
5.	95	0.075	1	149.5	0.036
6.	95	0.1	0.5	112	0.028
7.	115	0.05	1	202.3	0.079
8.	115	0.075	0.5	120	0.027
9.	115	0.1	0.75	151	0.056

III. RESULTS AND DISCUSSION

Figure 2 presents the relative significance of the cutting parameters on cutting temperature.

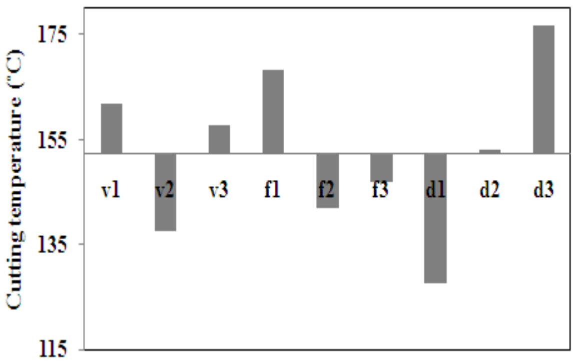

Figure 2: Relative Significance of Dry Machining on Attainable Temperature

(v - Cutting Speed, f - Feed Rate d – Depth of Cut)

ANOVA analysis was also carried out using Qualitek-4 software to find out the percentage influence of individual parameters on cutting temperature and flank wear. It was found that the interaction effects were not significant.

Table 5sum up the results of ANOVA analysis of the data on cutting temperature to identify the level of significance of cutting parameters.

Table 5: ANOVA Summary of the Input Parameters on Temperature

Col#/ Factor	DOF (f)	Sum Of Sqrs. (S)	Variance(V)	F-Ratio (F)	Pure Sum(S')	Percent(%)
Cutting Speed (m/min)	2	995.224	497.612	10.56	900.987	15.378
Feed Rate (mm/rev)	2	1151.409	575.704	12.218	1057.173	18.043
Depth of Cut (mm)	2	3618.009	1809.004	38.392	3523.772	60.144
Error	2	94.236	47.118	-	-	6.435
Total	8	5858.88				100.00%

From the ANOVA results, it was evident that depth of cut forms the most significant parameter influencing the cutting temperature(60.144%).From Figure 2, it is seen that cutting speed at level - 2 (95m/min), feed rate at level - 2 (0.075mm/rev), depth of cut at level - 1 (0.5mm) contributed more on the reduction of cutting temperature.

Figure3 presents the relative significance of cutting parameters on flank wear and Table 6 sum up the results of ANOVA analysis of the data on flank wear to identify the level of significance of cutting parameters.

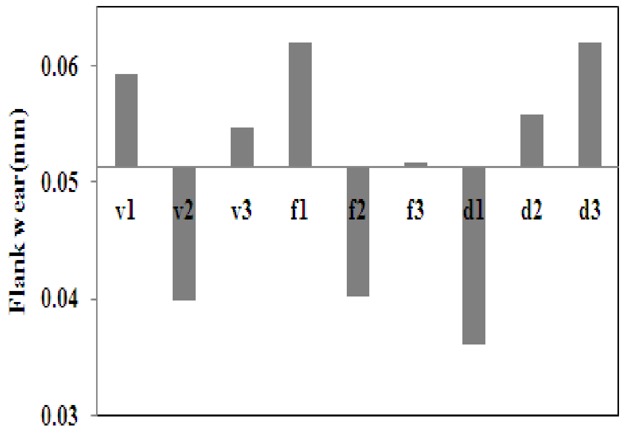

Figure 3: Relative Significance of Dry Machining Parameters on Flank wear

(v – Cutting Speed,f -Feed Rate, d - Depth of cut)

From Figure 3 the cutting speed at level - 2 (95 m/min), feed rate at level - 2 (0.075 mm/rev), depth of cut at level - 1 (0.5mm), contributed more on the reduction of flank wear.

Table 6: ANOVA summary of the input parameters on flank wear

Col#/ Factor	DOF (f)	Sum of Squares. (S)	Variance (V)	F-Ratio (F)	Pure Sum (S')	Percent (%)
Cutting speed(m/min)	2	0	0	6.106	0	20.205
Feed rate(mm/rev)	2	0	0	7.046	0	23.925
Depth of cut(mm)	2	0.001	0	11.119	0.001	40.042
Error	2	-0.001	-0.001	-	-	15.828
Total	8	0.002	-	-	-	100.00%

From the ANOVA results, it is evident that depth of cut forms the most significant parameter influencing the flank wear. The percentage significance of depth of cut on flank wear was 40.042%.

The results of the analysis which lead to a set of levels of cutting parameters to minimize cutting temperature and flank wear are summarized in Table 7.

Table 7: Summary of Cutting Parameters for Optimum performance

Sl. No.	Output Parameters	Objective	Speed (v) m/min	Feed (f) mm/rev	Depth of Cut (mm)	Predicted Result	Experimental Result	Error
1	Cutting Temperature	To Minimize Cutting Temperature	95	0.075	0.5	102.43	120	14.64
2	Flank Wear	To Minimize Flank Wear	95	0.075	0.5	0.025	0.027	7.40

IV. CONCLUSION

1. It was found that the predicted results matched well with the experimental results.
2. In the present investigation revealed that cutting speed of 95 m/min, feed rate of 0.075 mm/rev and depth of cut of 0.5 mm can bring forth better cutting performance.
3. Since no cutting fluid was used in the investigation it promoted green environment in the shop floor, minimized the industrial hazard.

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