International Journal of Research in Advent Technology, Vol.3, No.3, March 2015
E-ISSN: 2321-9637

Application of Taguchi methods and ANOVA in Optimization of Process Parameters for Tool Life in Hot Machining of High Manganese Steel

Rahul D. Rajopadhye[1], Achyut S. Raut[2]
Dept. of Automobile Engg, Rajendra Mane College of Engineering and Technology Ambav, India
Dept. of Mechanical Engg, Rajendra Mane College of Engineering and Technology Ambav, India
autorahul@yahoo.co.in; as_raut@rediffmail.com

Abstract- This paper deals with, effect of Hot Machining process parameters like spindle speed, depth of cut, feed rate and temperature, on tool life of carbide tools while machining High Manganese Steel . Optimization of Tool Life is done with Design of Experiments using Taguchi Method. The experimental results showed that, temperature and depth of cut are most Influencing parameters affecting the tool life. The signal to noise ratio analysis showed that optimized process parameters corresponding to Tool life are Spindle Speed = 140 rpm Depth of Cut = 0.5 mm Feed Rate = 0.05 mm/rev and Temperature = 600^{o}c The results of ANOVA for Tool life show that 48.37% depth of cut is contributing on Tool life than other cutting parameters. The temperature is the **next contributing factor whose contribution is 37.77 %**

Keywords: Hot machining process, Optimization, Taguchi Method, Tool Life.

1. INTRODUCTION

The most widely used machining methods in industries are conventional Machining, Electro Discharge Machining, Lesser Machining and Hot Machining. The Hot Machining process is often preferred because it offers lessened shocks to the tools, easy formation of the chips, less tool wear and low operator skill requirement.

Hot machining is the process where the work piece is preheated to a temperature below the recrystalization temperature. Due to preheating of the work piece, the shear forces decreases and machining becomes easy. For the heating of the work piece there are various methods. Here for experimentation torch flame method is used. Some of the advantages of hot machining process such as easy formation of the chips, reduced shocks to the cutting tool and good surface finish have major contribution in minimizing the tool wear and it leads to increase in tool life which obliviously reduces the machining cost.

2. DESIGN OF EXPERIMENTS

For the experimentation high Manganese steel is machined in all geared lathe machine for the design of experiments, Taguchi methods have been used. Using Taguchi design, L_9 Orthogonal Array has been selected and experiments were performed according to the set of combinations of factors as given in L_9 orthogonal array for finding out levels for final experimentation. The input parameters which can be varied in Hot Machining Process are spindle speed, depth of cut, feed rate and temperature [3]. Experiments are performed on PADMANI-STUDENT Lathe Machine

2.1 Selection of Input and Output Parameters of Hot Machining Process

The working range for all input parameters is decided by conducting trial runs. For determining range of one variable, the other three variables were kept constant during trial runs. In this study levels are selected based upon the results of trial experiments, brainstorming session with production experts, engineers and literature review. The range is selected between low and high levels of various parameters. The selected parameters with their Levels, units and notation are given in Table 1

The set-ups are established according to the Taguchi design and experiments have been conducted.

Table 1: Cutting parameters and their levels

Parameters	Units	Notation	Levels		
			1	2	3
Spindle Speed	[RPM]	V	54	140	315
Depth of Cut	[mm]	t	0.5	1	1.5
Feed Rate	[mm/Rev]	f	0.05	0.1	0.2
Temperature	[Celsius]	T	200	400	600

2.2. Experimental Set Up:

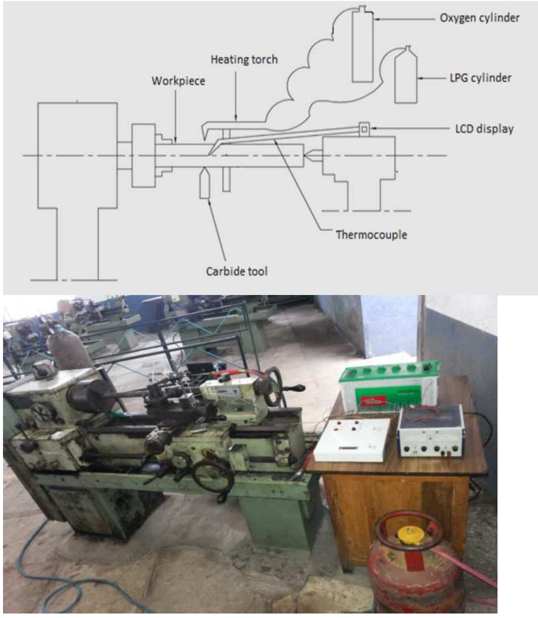

Figure 1: Experimental Set Up

Experimental Runs were carried out on all geared **PADMANI-STUDENT Lathe Machine.** The parameter settings were established according to the Taguchi design. Tool life has been taken as the response and data has been collected from the experimentation. The runs for the experimentation selected randomly, The work piece material which is to be machined is fitted in the lathe, between the lathe head stock and tail stock. Torch is fitted as shown in the figure 1 and it can move with the cutting tool. Torch is connected to a LPG cylinder and an oxygen cylinder. There are valves available to adjust the flow of oxygen and LPG. The distance of the torch nozzle can be adjusted with the handle provided as shown in the figure 1. There is a temperature indicator which can measure the temperature of the work piece. Temperature can be set in the temperature indicator and when the temperature is reached, the torch automatically moves away from the work piece. This is done by using the control system provided.

2.3 Experimental Results Based On Taguchi Parametric Design

Table 2: Average tool life values obtained in all runs

RUN	Spindle Speed RPM	Depth of Cut Mm	Feed mm/rev	Temp ^oC	Tool Life 1min	Tool Life 2 min	Tool Life 3 min	AVERAGE TOOL LIFE min
1	54	0.5	0.05	600	40.781	41.197	40.95	40.976
2	54	1	0.1	400	32.33	32.716	32.322	32.456
3	54	1.5	0.2	200	27.555	27.926	27.997	27.826
4	140	0.5	0.1	200	36.24	36.25	35.882	36.124
5	140	1	0.2	600	37.05	37.107	37.062	37.073
6	140	1.5	0.05	400	32.145	32.371	32.258	32.258
7	315	0.5	0.2	400	34.42	34.542	34.631	34.531
8	315	1	0.05	200	30.245	30.343	30.3	30.296
9	315	1.5	0.1	600	32.485	32.189	33.669	32.781

3. RESULTS

Table 3: Experimental results for Tool Life

EXPT. RUN	Tool Life 1 min	Tool Life 2 min	Tool Life 3 min	AVERAGE TOOL LIFE min	S/N RATIO FOR TOOL LIFE
1	40.781	41.197	40.95	40.976	32.251

2	32.33	32.716	32.322	32.456	30.226
3	27.555	27.926	27.997	27.826	28.889
4	36.24	36.25	35.882	36.124	31.156
5	37.05	37.107	37.062	37.073	31.381
6	32.145	32.371	32.258	32.258	30.173
7	34.42	34.542	34.631	34.531	30.764
8	30.245	30.343	30.3	30.296	29.628
9	32.485	32.189	33.669	32.781	30.312

3.1 Analysis of Experiment

The mean S/N ratio for each level of the machining parameters was calculated and the results are shown in Table 3.Additionally, the total mean S/N ratio is computed by averaging the total S/N ratios. Figure 2 presents' main effects plots of the S/N ratio for the four control parameters speed, feed and depth of cut and Temperature studied at three levels for the tool life.

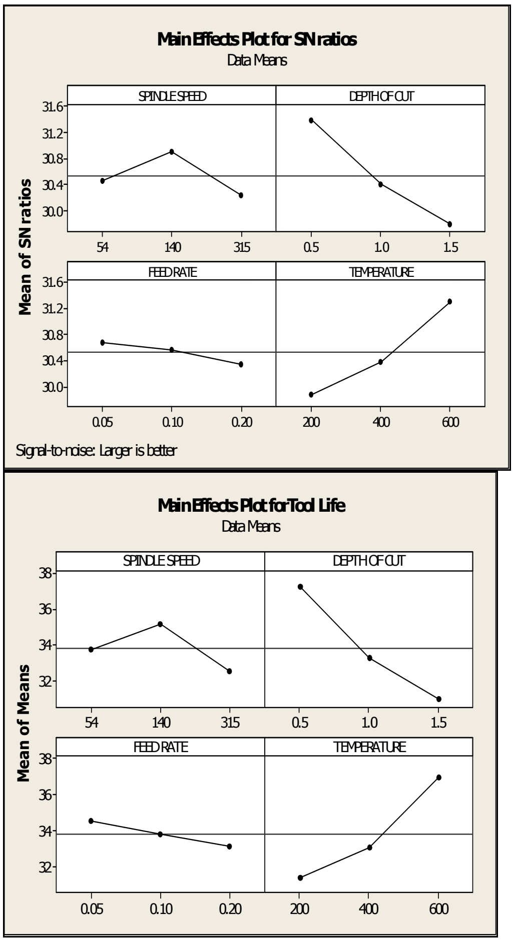

Figure 2: Effect of Cutting speed, Feed, Depth of cut and Temperature on Tool Life

Depth of cut is found to be the most significant parameter and second significant parameter is Temperature which has the significant effect on tool life.. Feed is least significant parameter in all results.

3.2 Significance of Factors Using S/N Ratio Analysis:

Table 4:Response table mean S/N ratio for Tool life factor and significant interaction

	LEVEL	SPINDLE SPEED	DEPTH OF CUT	FEED	TEMPERATURE
Mean S/N ratio	1	33.75	37.21*	34.51*	31.42
	2	35.15*	33.27	33.79	33.08
	3	32.54	30.96	33.14	36.94*
	Delta	2.62	6.26	1.37	5.53
	Rank	**3**	**1**	**4**	**2**

(* indicates optimum level)

After performing the experiment for spindle speed of 54rpm to 315 rpm, depth of cut 0.5 to 1.5mm, feed rate 0.005 to 0.2 mm/rev at low, medium and high temperature. The response values of tool life are obtained from 9 combinations of runs. The signal to noise ratio analysis showed that optimized process parameters corresponding to Tool life are Spindle Speed = 140 rpm Depth Of Cut = 0.5 mm Feed Rate = 0.05 mm/rev and Temperature = 600^{o}c

3.3. Analysis Of Variance (ANOVA)

The ANOVA result for Tool life is illustrated in Table 5. The results of ANOVA for Tool life show that 48.37% depth of cut is contributing on Tool life than other cutting parameters. The temperature is the next contributing factor whose contribution is 37.77 % and it is followed by lower contribution from spindle speed which is 3.33 %. The lowest contribution is of feed rate which is 2.20%

Table 5: Analysis of Variance of SN ratios for Tool Life

Sources Of Variation	Sum of Squares(SS)	Degrees of freedom	Mean Squares(MS)	F Ratio (MS/Error)	P Value	% contribution
SPEED	4.042	2	4.042	1.60	0.274	3.33%
DOC	58.694	2	58.694	23.27	0.008	48.37%
FEED	2.667	2	2.667	1.06	0.362	2.20%
TEMP	45.838	2	45.838	18.17	0.013	37.77%
Residual Error	10.090	0	2.522			
Total	121.330	8				

3.3 Confirmation Experiments

Table 6: Confirmation test for Tool life

Sr. No.	Optimum values of control parameters obtained from Taguchi analysis	Predicted Tool Life Value(Min) from Taguchi method	S/N Ratio obtained from Taguchi result	Average Tool life(Min) obtained from experiments	Error %
1	Spindle Speed = 140 rpm Depth Of Cut = 0.5 mm Feed Rate = 0.05 mm/rev Temperature = 600°c	42.375	32.6987	40.75	3.83 %

Table 6 shows the results of the confirmation experiments using the optimal machining parameters for tool life. By taking initial parameter settings as Spindle Speed = 140 rpm Depth Of Cut = 0.5 mm Feed Rate = 0.05 mm/rev Temperature = 600°c then tool life obtained experimentally is 40.75 minutes,

3. CONCLUSIONS:

It has been noticed that tool life of CNMG Carbide insert was increased as increase in the heating temperature. Significance of machining parameters indicates that depth of cut is significantly contributing towards machining performance Therefore; most influencing parameter on tool life is depth of cut followed by temperature, spindle speed and feed rate. The conclusion can be drawn that with an optimum parameter settings, the Hot Machining Process is useful in minimizing the tool wear which results to increase in tool life and obviously reduces the machining cost for machining of Hard to cut materials

REFERENCES

[1] E.Daniel Kirby. 2006. "A parameter design study in a turning operation using Taguchi method" The technological interface / fall 2006

[2] M.A. Lajis 2009, **"**Hot Machining of Hardened Steels with Coated Carbide Inserts" American Journal of Engineering and Applied Sciences 421-427,

[3] K.P. Maity, P.K. Swain, *2008* "An experimental investigation of hot machining to predict tool life", International Journal of Materials processing technology 344–349.

[4] Ozler, L., Inan, A., Ozel, C., 2000. "Theoretical and experimental determination of tool life in hot machining of austenitic manganese steel" International. Journal of Machine Tool & Manufacturing. 41,163–172.

[5] Mukherjee, P.N., Basu, S.K., 1973. "Statistical evaluation of metal cutting parameters in hot machining". International. Journal of. Production. Vol 2, No-1-21-36.

[6] N.Tosun,L.Ozler, 2002, "A study of tool life in hot-machining using artificial neural networks and regression analysis method", Journal of Material processing technology 124,99-104.

[7 N. Tosun, L. Ozler, 2004, "Optimization for hot turning operations with multiple Performance characteristics" International Journal of Advanced Manufacturing Technology 23, 777– 782.

[8]-Rozzi, J. C., Pfefferkorn, F. E., Shin, Y. C., "Experimental Evaluation of the Laser Assisted Machining of Silicon Nitride Ceramics.", Journal of Manufacturing Science & Engineering, Transactions of the ASME, Vol. 122, Issue. 4