IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. V (Sep. - Oct. 2015), PP 58-62
www.iosrjournals.org

Investigation of Flank wear on Minimal Cutting Fluid Application during turning of OHNS steel

R. Deepak Joel Johnson[1], K. Leo Dev Wins[2], Anil Raj[3], K. Arun Prasath[4]
[1,4](1Department of Mechanical Engineering, M. Kumarasamy College of Engineering,Karur-639113)
[2,3](School of Mechanical Sciences, Karunya University, Coimbatore -641114)

Abstract *: Cutting tools is much selected as the tool life criterion because it decides the adverse accuracy of machining, its resoluteness and reliability. In this present work we are investigating the influence of cutting condition during turning of OHNS steel aided with Minimal cutting fluid application for its tool life. In this study we are going to investigate seven different parameters for the cutting temperature and tool wear using Taguchi and ANOVA. This paper also gives the optimized parameters using Minimal cutting fluid application for the betterment of tool performance and also checks the influence of cutting temperature on the tool wear.*
Keywords - *Tool Wear, Cutting Temperature, Minimal cutting fluid application, Taguchi and ANOVA, OHNS steel.*

I. Introduction

In machining process especially in turning operation performance of the tool plays a significant role, it's the major contributor for the good finish work piece. In our case OHNS steel is the work piece material, OHNS (Oil Hardened Non Shrinkage Steel) will comes under tool steel and it is broadly used in many manufacturing sector. Investigating the tool life during turning of OHNS steel will be a good augmentation to the manufacturing industries.

Thakur, A. Mohanty S. Gangopadhyay K.P. Maity investigates the effect of cutting speed on tool wear and chip characteristics during dry turning of Inconel 825 with inserts and from their research they have concluded that the machining with PVD multilayer coated insert resulted in better tool wear performance.[1]

The work contributed by Adilson José de Oliveira, Anselmo Eduardo Diniz states that the machining of functional die and mold components has complex geometries and is made of high hardness materials, which make them difficult to machine. Their work explains the machining for this type of process and of the wear mechanisms of tools used in semi-finishing operations of hardened steels for dies and molds to a better understanding of this type of process and of the wear mechanisms of tools used in semi-finishing operations of hardened steels for dies and molds[2].

In order to ease the negative effects of cutting fluids, techniques like Minimal Quantity Lubrication (MQL) and Minimal Cutting Fluid Application (MCFA) have been emerged. In minimal cutting fluid application, extremely small quantity of cutting fluid is injected in the mode of ultra fine droplets at very high velocity (about100 m/s) into the cutting zone which is also called as pseudo dry turning. For all practical purposes, it appears like dry turning in achieving improved surface finish, lower tool wear by preserving cutting forces and power at reasonable levels [3].

Experimental investigation of turning process on AISI 304 stainless steel was performed to check influence of cutting parameter on the chip thickness, flank wear and to verify the tool performance and using optimization techniques the optimum condition were obtained by R A MAHDAVINEJAD and S SAEEDY [4]

In the paper "The assessment of cutting tool wear" Viktor P. Astakhov stated the importance of cutting tool performance on the diametric accuracy of machining, its stability and reliability and in this paper it is clearly described the importance the tool selection and comparison is made with different tool material. [5]

Since tool wear affects surface integrity of the final parts and tool life is strictly connected with substitution policy and production costs. In this work A. Attanasio, E. Ceretti, C. Giardini and C. Cappellini performed a comparison between response surface methodology (RSM) and artificial neural networks (ANNs) fitting techniques in tool wear forecasting was performed.[6]

It is clear from the literature survey that the no work has been reported on investigation of tool wear, cutting temperature and chip thickness during turning of OHNS steel with minimal cutting fluid application, till now only optimization of cutting parameters with surface roughness as output parameter[7] and on other machining process have been undergone for OHNS steel. In this present work through investigation on the tool performance is carried out for the turning of OHNS steel with minimal cutting fluid application.

II. Experimentation

2.1 Selection of work material and tool

OHNS (Oil Hardened Non-Shrinkage) Steel with 350 mm length and 65 mm diameter was tabbed as work material for this investigation which is having a broad range of usage in manufacturing sector. It is known for its high resoluteness, reliability and toughness. The tool inserts and the tool holder were tabbed as per the suggestion of M/s Taegu Tec India (P) Ltd. The tool insert used for the investigation was SNMG 120404 and tool holder used was PSBNR 2525 M12.Totally four inserts were taken for the investigation i.e. each insert having eight cutting edges therefore four inserts can be utilized for 27 run experiment and remaining edges were used for rough turning operation.

2.2 Selection of cutting parameters and fluid application parameters

The selection of parameters for this experimentation was done based on the earlier work reported in the area of machining with minimal cutting fluid application [7]. The selected input parameters were varied at three levels. Table 1 shows the parameters and their levels for the experimental investigation.

TABLE 1 Parameters and Levels for the experimentation.

Input parameter	Level 1	Level 2	Level 3
Cutting speed [m/min]	128.64	148.44	168.23
Feed [mm/rev]	0.04	0.06	0.08
Depth of cut [mm]	0.5	0.75	1.0
Pressure at the fluid injector [Bar]	50	75	100
Frequency of pulsing [Pulses/min]	500	700	900
Rate of application of cutting fluid [ml/min]	3	6	9
Composition of cutting fluid [%]	10	20	30

2.3 Experimental setup

Fig. 1 shows the experimental set up which consisted of a medium duty Kirloskar lathe with variable speed and feed drive. The minimal cutting fluid setup facilitated the independent variation of pressure at fluid injector, frequency of pulsing and the quantity (rate) of fluid application. Flank Wear, Cutting temperature and Chip thickness were considered as output parameters and it was measured using Tool Maker's Microscope, Thickness gauge and Pyrometer.

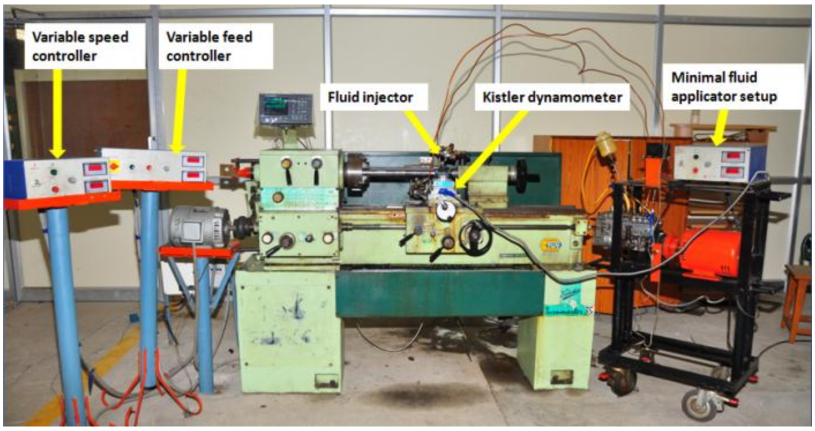

Fig. 1 Experimental setup containing lathe and minimal cutting fluid applicator.

2.4 Design of Experiment:

A Twenty seven run experiment was designed using Taguchi technique. The tabbed seven parameters were assorted at 3 different levels as shown in the TABLE 2.

TABLE 2: Experimental data collected during 27 run experiment

Exp. No.	Cutting speed	Feed (mm/rev)	Depth of cut (mm)	Pressure at the injector (bar)	Frequency of pulsing	Rate of application	Composition of cutting	Tool Wear (mm)	Chip Thickness	Cutting Temperature
1	128.64	0.04	0.50	50	500	3	10	0.265	0.38	123.25
2	128.64	0.04	0.50	50	700	6	20	0.315	0.31	117.75
3	128.64	0.04	0.50	50	900	9	30	0.240	0.39	129.75
4	128.64	0.06	0.75	75	500	3	10	0.340	0.41	180.25
5	128.64	0.06	0.75	75	700	6	20	0.433	0.29	149.50
6	128.64	0.06	0.75	75	900	9	30	0.410	0.30	141.75
7	128.64	0.08	1.00	100	500	3	10	0.255	0.32	174.00
8	128.64	0.08	1.00	100	700	6	20	0.270	0.28	139.00
9	128.64	0.08	1.00	100	900	9	30	0.210	0.36	203.75
10	148.44	0.04	0.75	100	500	6	30	0.385	0.25	170.50
11	148.44	0.04	0.75	100	700	9	10	0.230	0.26	200.00
12	148.44	0.04	0.75	100	900	3	20	0.185	0.22	145.00
13	148.44	0.06	1.00	50	500	6	30	0.345	0.24	149.50
14	148.44	0.06	1.00	50	700	9	10	0.420	0.30	147.00
15	148.44	0.06	1.00	50	900	3	20	0.280	0.33	207.25
16	148.44	0.08	0.50	75	500	6	30	0.325	0.22	149.50
17	148.44	0.08	0.50	75	700	9	10	0.295	0.29	144.50
18	148.44	0.08	0.50	75	900	3	20	0.265	0.28	138.50
19	168.23	0.04	1.00	75	500	9	20	0.325	0.24	147.25
20	168.23	0.04	1.00	75	700	3	30	0.260	0.20	204.25
21	168.23	0.04	1.00	75	900	6	10	0.190	0.19	213.75
22	168.23	0.06	0.50	100	500	9	20	0.195	0.22	151.25
23	168.23	0.06	0.50	100	700	3	30	0.300	0.24	151.25
24	168.23	0.06	0.50	100	900	6	10	0.335	0.23	192.25
25	168.23	0.08	0.75	75	500	9	20	0.265	0.21	212.50
26	168.23	0.08	0.75	75	700	3	30	0.295	0.28	189.75
27	168.23	0.08	0.75	75	900	6	10	0.230	0.23	161.00

III. Results And Discussion

The analysis of the results was made by utilizing MINITAB 14, statistical software for finding the supremacy of each parameter on flank wear, cutting temperature and chip thickness. Taguchi technique uses the S/N ratio to measure the quality characteristic aberrant from the desired value. Table 3 presents the responses for Signal-to-Noise ratio (S/N) on flank wear, cutting temperature and chip thickness.

TABLE 3: Responses for Signal-to-Noise ratio (S/N) – Flank Wear and Cutting temperature.

Level	Cutting speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Pressure at the injector (bar)	Frequency of pulsing (pulses/min)	Rate of application (ml/min)	Composition of cutting fluid, (%)
1	10.572	11.729	11.114	10.745	10.619	11.421	11.152
2	10.605	9.597	10.556	10.242	10.260	10.296	11.269
3	11.661	11.511	11.169	11.852	11.959	11.122	10.417
Delta	1.089	2.132	0.613	1.610	1.699	1.125	0.852
Rank	**5**	**1**	**7**	**3**	**2**	**4**	**6**

The Rank of the Taguchi analysis shows the influence of individual parameters on tool wear, cutting temperature and chip thickness. From the results, it was found that feed rate is having more influence on flank wear, cutting temperature and chip thickness and other input parameters follows according to their ranking in Table 3. The input parameters and their levels are plotted against the Signal to Noise ratio for both flank wear and cutting temperature in which the peak value in the each graph gives the level of parameter which influences more in getting lower value of surface roughness during turning of OHNS steel.

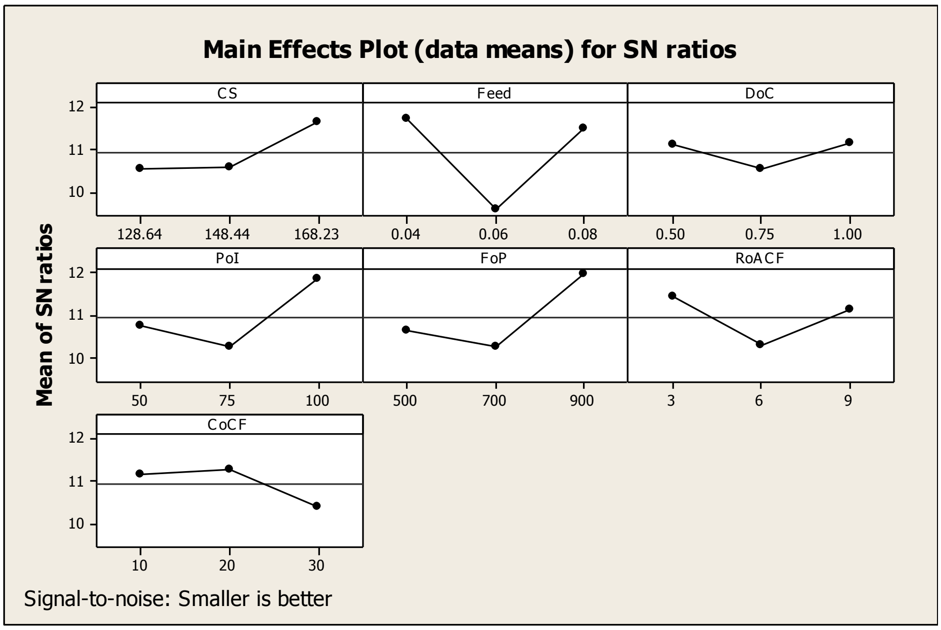

Fig.2: Optimized values (Peak Values) of the experiment.

The ANOVA analysis was carried out to establish the relative significance of individual parameters on flank wear, cutting temperature and chip thickness and the results are shown in Table 4. From the ANOVA results, it was found that all the F values for all the input parameters against flank wear and cutting temperature are more than 2 (F>2) and thus the experiment is valid and effective. It also showed that, feed rate is having more influence on flank wear and cutting temperature. From the ANOVA table the bigger value of F (5.18) was obtained for feed rate which is the dominating parameter in turning of OHNS steel. The results obtained also showed that the model is sufficiently accurate as indicated by the R^2 value which is as high as 96.73% , R-Sq(adj) value of 94.90% and stand error of 9.29059.

TABLE 4: Analysis of Variance on tool wear and cutting temperature

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed (v)	2	8.294	8.294	4.147	4.49	0.125
Feed (f)	2	0.615	0.615	0.308	5.18	0.834
Depth of Cut (d)	2	16.251	16.251	8.126	4.88	0.028
Pressure at the injector (P)	2	1.170	1.170	0.585	3.35	0.711
Frequency of Pulsing (F)	2	1.104	1.104	0.552	2.33	0.724
Rate of fluid application (Q)	2	0.433	0.433	0.216	2.13	0.879
Composition of Cutting fluid (C)	2	3.035	3.035	1.518	3.91	0.428
Error	12	19.988	19.988	1.666		
Total	26	50.891				

S = 9.29059 **R-Sq = 96.73%** R-Sq(adj) = 94.90%

IV. Conclusion

From the present work the following conclusion were made:

1. The most significant parameter for deciding the tool performance is feed rate as the feed rate increases from the ANOVA analysis it shows that the influence of feed significantly decreases the tool performance.
2. As the Cutting temperature increases the flank wear increases again this inturn decreases the tool performance. Optimum Cutting and Fluid application parameters for a decreased flank wear, optimal cutting temperature and minimum chip thickness are as follows,

TABLE 5 Optimized Values for the cutting and fluid application parameter for Flank wear, Chip thickness and cutting temperature

Cutting speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Pressure at the injector (bar)	Frequency of pulsing (pulses/min)	Rate of application (ml/min)	Composition of cutting fluid, (%)
168.23	0.04	1	100	900	3	20

3. From the experimentation it was found that increase in Cutting speed decreases the chip thickness and this in turn improves the tool performance.

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