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RESEARCH ARTICLE

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PERFORMANCE OF SEMI SOLID LUBRICANTS ON SURFACE QUALITY IN HARD TURNING OF OHNS STEEL

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ABSTRACT

In the present work, the machinability studies of Semi-solid assisted machining of Oil Hardened Non Shrinking Steel (OHNS Steel) is carried out. The number of experiments are determined according to Taguchi's design of experiments. The input parameters like cutting velocity, feed rate, composition of semi solid lubricant and direction of semi solid application are varied and the corresponding values of surface roughness is measured. The measured values are analyzed using Microsoft excel method and Taguchi's analysis method. The optimal combination of input parameters for obtaining the minimal values of the output responses are found out. The performance of using semi-solid lubricants is compared with the dry machining and wet machining which uses the conventional cutting fluids. The machinability studies on semi solid lubrications in machining of OHNS Steel shows the better performance over the conventional lubrication process

Keywords—OHNS steel, Taguchi's method, semi solid apparatus, semi solid lubrication, wet and dry machining

INTRODUCTION

Some of the mechanical components needed high hardness and conventionally, the such components is turned to the near net shape, then hardened to the required hardness value. This lengthy process can avoid by hard turning process ie, very hard materials directly turned to final dimensions. Recently, hard turning operations accepted in metal cutting operations. Hard turning can reduces process cost, process time, surface quality and wastage. But hard turning operations requires very large amount of cutting fluids, so that the storage and disposal of cutting fluid will be a difficult task and also it involves expenses. Pure dry turning is a solution for the problem. But it requires ultra-hard tool and extremely rigid tools and it is difficult to implement on conventional machine shops.

Semi solid lubricants are a viable alternative to solve these issues. Semi solid lubricant is a blend of grease and graphite. An apparatus known as semi solid injector is required to inject semi solid lubricants to the cutting region. This is very useful to hard turning operations and free from all the problems related to large use of cutting fluids.

The use of semi solid lubricants instead of conventional cutting fluid will enhance the cutting performances in hard turning operations. Application of semi solid lubricant will leads to the improvement in surface. Many investigations shows that semi solid

with minimal fluid application and solid lubricants are better alternative for conventional wet lubrications.

P S Sam and A S Varadharajan [1] investigated the performance of hard turning with AISI4340 steel with minimum fluid application and semi-solid lubrication and they observed that the use of semi-solid lubricants with minimum cutting fluids application reduces cutting temperature, tool vibration, cutting force. S Shaji and V Radhakrishnan[2] studied the effect of graphite in surface grinding and reported improvement in surface finish. N. Suresh Kumar Reddy, P. Venkateswara Rao[3] investigated the performance of solid lubricants on cutting force and surface quality in end milling and their results indicate that there is a considerable improvement in the process performance with solid lubricant assisted machining as compared to that of machining with cutting fluids. P.Vamsi Krishna and D.Nageswara Rao[4] investigated the performance evaluation of solid lubricants in terms of machining parameters in turning and the result shows reduction in tool wear and surface roughness compare to wet and dry machining. S.Shaji and V.Radhakrishnan[5] analysed the process parameters in surface grinding with graphite as lubricant based on Taguchi method. This paper deals with the analysis of the process parameters developed based on Taguchi's experimental design methods. Taguchi's tools such as orthogonal array, signal-to-noise ratio, factor effect analysis, ANOVA, etc. have been used for this purpose and an optimal condition has been found out. Singh Dilbag and P.V. Rao[6] studied about the performance improvement of hard turning with solid lubricants. Results show considerable improvement in the surface finish with the use of solid lubricants Ali jahan, Md Yousaf Ismail and Rasool Noorassana[7] presented a paper on multi response optimization in design of experiments considering capability index in bounded objective methods. This paper explains the methods of optimization of multiple response problems in design of experiments

OBJECTIVE

The major objective of this investigation work is to evaluate the performance of semi solid lubrication on surface finish in hard turning on OHNS steel. In this research work carried out an investigation about the machining parameters, and the influence of input parameters on machining performance especially in surface quality. Input parameters considered in this investigation are cutting velocity, feed rate, composition of semi solid lubricant and direction of application of semi solid lubrication. The objectives include:

- To develop a semi solid apparatus.
- Evaluation of surface finish with respect to input parameters provided in each experiment.
- To find out the combination of input parameters to getting a better surface quality.
- To compare the surface finish on hard turning in the presence of semi solid lubricant with wet and dry turning.

DEVELOPMENT OF SEMI SOLID APPARATUS

Semi-solid lubricant applicator of pneumatic type is used in the present investigation to deliver semi solid lubricant into desired directions. It mainly consists of a cylinder, a piston rod, nylon piston ring and a nozzle. The main body having the piston cylinder arrangement in which grease collected. Vertical piston cylinder arrangement delivers grease into the main piston cylinder. A control valve placed between vertical and horizontal piston cylinder arrangement which used to stop the flow of grease into vertical cylinder from main cylinder during working. The compressed air from the compressor flows through the tubes and it pushes the piston ring to move forward. As the piston ring moves forward, the grease will be delivered through the nozzle at desired direction and location. To control the amount of grease which comes out of the nozzle, the apparatus also consists of a control valve which is used to control the flow of air from the compressor to the cylinder.

EXPERIMENTATION

SELECTION OF WORK MATERIAL

The work material used for this investigation was OHNS steel which was hardened to 48 HRC by heat treatment process. Mainly OHNS steels are used to manufacturing different types of dies and cutting tools like milling cutters, Reamers, Broaches. A bar of OHNS steel of diameter 45mm and length of 380mm were used in this investigation. The chemical

composition of OHNS steel on their weight percentage is available in the Table 1.

Semi solid apparatus

TABLE I. CHEMICAL COMPOSITION OF OHNS STEEL

C(%)	Mn (%)	Cr (%)	W (%)	Cu (%)
0.85	1.35	0.5	0.4	0.3

SELECTION OF TOOL AND TOOL HOLDER

The tool holder used had the specification PSBNR 2525 M12. Multicoated hard metal inserts with sculptured rake face geometry with the specification SNMG 120408 MT TT5100 from TaeguTec were used as cutting tools in this investigation. PSBNR 2525 M12 tool holder is a hardened steel and it can be used in hard turning process. The selection of cutting tool and the tool holder was done based on the information available from literature reviews and the recommendations of the cutting tool manufacturers, M/s TaeguTec India (P) Ltd.

SELECTION OF EXPERIMENTAL PARAMETERS

Surface quality is the measuring parameter or output parameter in this investigation. To evaluate the surface quality, mainly 4 input parameters varied in three different levels. 4 input parameters and its different values are available in table 2. Also 2 parameters kept constant throughout in this investigation which are depth of cut and rate of semi solid application. Depth of cut taken as 0.5mm and rate of semi solid application from the apparatus is limited to 8g/m.

TABLE II. DESIGN MATRIX

Input Parameters	Level 1	Level 2	Level 3
Cutting Velocity(m/min)	80(V_1)	90(V_2)	100(V_3)
Feed Rate (mm/rev)	0.08(F_1)	0.1(F_2)	0.12(F_3)
Composition	Grease +10% Graphite(C_1)	Grease +20% Graphite(C_2)	Grease +30% Graphite(C_3)
Direction of Semi solid Lubrication	Tool – Chip Interface(D_1)	Tool – Work Interface(D_2)	Uncut Portion of Work Piece(D_3)

DESIGN MATRIX

Design matrix is tabular representation of input parameters selected for an experiment and its different values. In this experimental study, four input parameters are selected and each parameter varies in three different levels. Table 2 shows the design matrix selected for this analysis.

SELECTION OF PROPER ORTHOGONAL ARRAY WITH MINITAB SOFTWARE

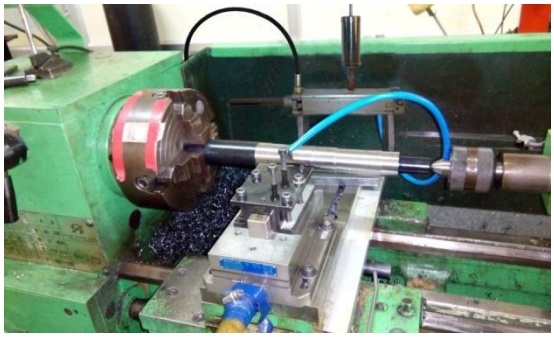
In this investigation have 4 input parameters each one varies in 3 different levels. In Taguchi method, minimum number of optimum combinations is considered. In order to select the proper optimum combinations, in this investigation used Minitab software. The combinations of input parameters for different experiments are shown in the Table 3, which is obtained from Minitab software.

TABLE III. 9 RUN EXPERIMENT

SL NO	VELOCITY	FEED	COMPOSITION	DIRECTION
1	V1	F1	C1	D1
2	V1	F2	C2	D2
3	V1	F3	C3	D3
4	V2	F1	C2	D3
5	V2	F2	C3	D1
6	V2	F3	C1	D2
7	V3	F1	C3	D2
8	V3	F2	C1	D3
9	V3	F3	C2	D1

EXPERIMENTAL SETUP

The experiment were carried out on Kirloskar Turnmaster-35 lathe. Figure 2 shows the experimental setup for this investigation. semi solid apparatus is fixed on this lathe to inject the semi solid lubricant to the cutting region. Surface roughness was measured in this investigation during hard turning. Surface roughness tester was used to measure the surface quality on turning.



Semi solid apparatus

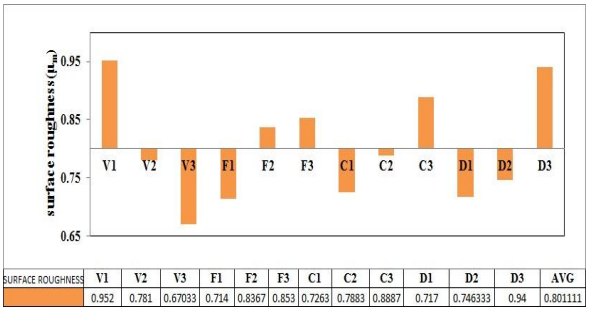
RESULT AND DISCUSSION

Based on the Taguchi's method 9 run experiment was carried out and measured the surface quality in hard turning.the collected data from the 9 run experiment are shown in the Table 4.

TABLE IV. DATA COLLECTED FROM EXPERIMMENTS

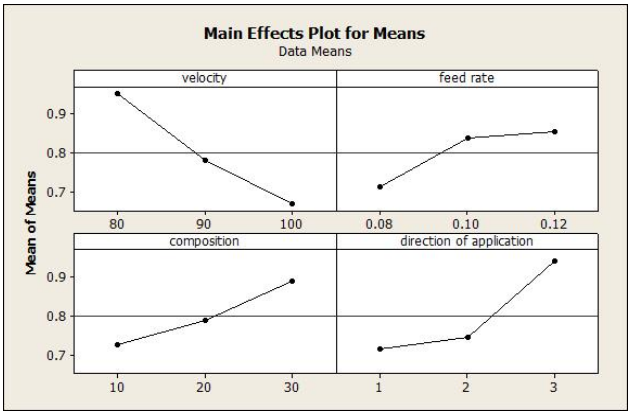
Velocity (m/min)	Feed rate (mm/rev)	Composition	Direction	Surface Finish (μ_m)
V1	F1	C1	D1	0.706
V1	F2	C2	D2	0.920
V1	F3	C3	D3	1.230
V2	F1	C2	D3	0.820
V2	F2	C3	D1	0.820
V2	F3	C1	D2	0.703
V3	F1	C3	D2	0.616
V3	F2	C1	D3	0.770
V3	F3	C2	D1	0.625

The experiment result were analysed using the Microsoft excel sheet as well as Minitab software. Excel sheet and Minitab software is used to find out the optimum combinations of input parameters. The graphs represents the better input parameters are also obtained from the excel sheet and Minitab software. Figures 3 and 4 shows that the relative significant parameters on surface roughness obtained from excel sheet as well as Minitab software. And from the results shows that, high velocity, low feed, low graphite content and direction of semi solid application to tool-chip interface reduces the surface roughness.



SURFACE ROUGHNESS	V1	V2	V3	F1	F2	F3	C1	C2	C3	D1	D2	D3	AVG
	0.952	0.781	0.67033	0.714	0.8367	0.853	0.7263	0.7883	0.8887	0.717	0.746333	0.94	0.801111

Relative Significance of Input Parameters on Surface Roughness from excel sheet



Relative Significance of Input Parameters on Surface Roughness from Minitab software.

TABLE V. LEVELS OF INPUT PARAMETERS TO GETTING OPTIMUM PERFORMANCE

Sl No	Objectives	Cutting Velocity (M/Min)	Feed Rate (Mm/Rev)	Composition	Direction of application
2	improve surface	V3	F1	C1	D1

Table 5 shows the levels of input parameters to obtain better surface finish.The experimental results provides the optimum combinations of input parameters to obtain the better surface finish. Considered the same input combinations and carried with hard turning with wet and dry lubrications. Results show that the quality of surface finish is better with semi solid lubrication and the results of comparison experiments available in Table 6.

TABLE VI. COMAPRISON WITH WET AND DRY LUBRICATION

Parameters	Turning with Semi Solid Lubricant	Turning with Wet Lubrication	Turning with Dry Lubrication
Surface roughness($\mu_{m)}$	0.49	0.93	1.54

CONCLUSION

In this experimental study, an attempt is made to investigate the performance of hard turning in OHNS steel with the presence of semi solid lubrication. Four input parameters like, cutting velocity, feed rate, composition of semi solid lubricant and direction of application of semi solid lubrication are taken for design of experiments. The major performance parameter on machining is surface roughness and it measured during the analysis. Semi solid injecting apparatus developed for experimental purpose. Experiments are designed based on Taguchi's design of experiment. Experimental data analysed and the following conclusions were drawn:

1 Semi solid apparatus developed to deliver the required amount of semi solid lubricator to the desired position of tool work interfaces.

2 The combination of experimental input parameters to reduce surface roughness are, 100 m/min cutting velocity, 0.08 mm/rev feed rate, grease and 10% graphite and semi solid application to tool –chip interface.

3 Hard turning in the presence of semi solid lubrication provides better cutting performance as compared with wet machining and dry machining.

4 This study illustrate the use of semi solid lubricant during hard turning is a viable alternative for hard turning with wet and dry machining. It is also a possible environmental friendly alternative for effective control of heat generated at the machining zone.

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