ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology
National Conference on Design, Manufacturing, Energy & Thermal Engineering (NCDMETE-2017)
AGTI's Dr. Daulatrao Aher College Engineering, Vidyanagar Extension, Karad
Vol. 4, Special Issue 1, January 2017

Optimization of Surface Roughness using Taguchi Approach with Minimum Quantity Lubrication for Turning EN-8 Steel

V.N. Gandhe[1], H.K. Shete[2], R. N. Panchal[3], A.P. Kanunje[4], P.S. Gunavant [5]

Assistant Professor, Mechanical Engineering, AGTI's Dr. Daulatrao Aher College of Engineering, Karad, India[1, 2,5]

Associate Professor, Mechanical Engineering, AGTI's Dr. Daulatrao Aher College of Engineering, Karad, India[3]

Assistant Professor, Ashokrao Mane group of Institutions, Vathar, Tarf Vadgaon, India[4]

Abstract: Minimum quantity lubrication (MQL) has increasingly found its way into the area of metal cutting machining and in many areas, has already been established as an alternative to conventional wet processing. In contrast to flood lubrication, minimum quantity lubrication uses only a few drops of lubrication (approx. 5 ml to 100 ml per hour) in machining. This paper deals with a view to optimize the pressure (P) and flow rate (Q) of cutting fluid in MQL system with different type of cutting fluid to obtain improved machining performances in turning EN-8 steel by uncoated carbide insert in respect of tool wear. Fluid selection is important for MQL because it must be a superior fluid such as vegetable oil or synthetic oil. The costs of these superior fluids are higher but eliminate the need for costly fluid recycling and disposal services. MQL may be an ideal option because of the elimination of fluid waste while maintaining the benefits of using oil, but the specific fluid delivery method for individual facilities requires an in depth understanding of the technical aspects of MQL that could make it unfeasible to use this method.

Keywords: EN-8, MQL, Tool wear, Taguchi, S/N ratio.

I. INTRODUCTION

Minimum quantity lubrication is a total-loss lubrication method rather than the circulated lubrication method used with emulsions. This means using new, clean lubricants that are fatty-alcohol or ester based. Additives against pollution e.g. biocides and fungicides, are not necessary at all, since microbial growth is possible only in an aqueous phase. The extreme reduction of lubrication quantities results in nearly dry work pieces and chips. This greatly reduces health hazards caused by emissions of metalworking fluids in breathed-in air and on the skin of employees at their workplaces. Metalworking fluids do not spread throughout the area around the machine, thus making for a cleaner workplace. The extreme reduction in lubricant quantities results in nearly dry work pieces and chips. Losses due to evaporation and wastage, which may be considerable with emulsion lubrication (depending on the work piece being processed), are inconsequential with MQL. This greatly reduces health hazards due to emissions of metalworking fluids on the skin and in the breathed-in air of employees at their workplaces.

EN-8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. EN-8 is suitable for the manufacture of parts such as general-purpose axles, shafts, gears, bolts and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance. In the present investigation, single characteristics optimization model based on Taguchi method employed to determine the best combination of the MQL parameters such as pressure, flow rate and type of cutting fluid to attain minimum tool wear. In order to obtain optimum cutting parameters to achieve minimum tool wear, manufacturing industries have restored to the use of handbook based information and operator's experience.

II. PROCEDURE

To optimize the pressure (P) and flow rate (Q) of MQL system with different types cutting fluid to obtain improved machining performances in turning EN-8 steel by carbide insert in respect of surface roughness this experiment was carried out. The experiment carried out by turning of EN-8 steel rod having initial diameter 40 mm and length 350 mm in a lathe (5 hp) by using carbide insert (SNMG 120408) at constant cutting velocity and feed rate (i.e. optimized value of speed and feed rate obtained from past research) under MQL condition having various pressure and flow rates with different cutting fluids. Depth of cut was kept fixed at 0.4 mm.

a. Design of experimental set-up

Experimental set- up design to optimize the pressure (P) and flow rate (Q) of cutting fluid in MQL system with different type of cutting fluid to obtain improved machining performances in turning EN-8 steel by uncoated carbide insert in respect of surface roughness is shown in Fig.

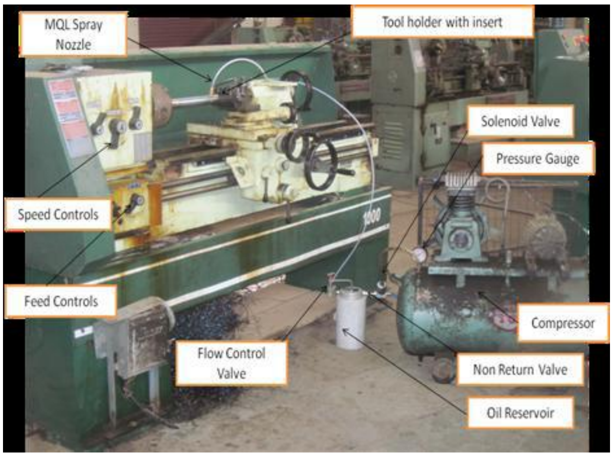

Fig. 1 Experimental set up showing MQL system

b. Experimental conditions –

Table 1: Experimental Conditions

Machine Tool-Lathe Machine	5 H.P.
Work specimen	Material EN-8 steel Size-ϕ 40 $\times$ 350 mm
Cutting insert -	Carbide insert, SNMG 120408
Tool holder -	PCLNR 2525M12 (WIDIA make)
Cutting velocity (V_C)	105, 115, and 125 m/min
Feed rate,(S_O)	0.06, 0.10 and 0.14 mm/rev
Depth of cut, (t)	0.4 mm
Cutting fluid for MQL condition	Vegetable oil, Semi-synthetic oil, Straight cutting oil
Pressure for MQL system	4,5 and 6 bar
Flow rate in MQL	30,60 and 90 ml/hr

Surface Roughness here is measured using Mitutoyo portable surface roughness tester. Readings from the digital heads is noted down and analysis is made thereafter.

III. TAGUCHI APPROACH

The philosophy of Taguchi is widely used. He suggested that engineering optimization of a process or product should be carried out in a three-step approach, i.e., system design, parameter design, and tolerance design. In system design, the engineer applies scientific and engineering knowledge to produce a basic functional prototype design, this design including the product design stage and the process design stage. In the product design stage, the selection of materials, components, tentative product parameter values, etc. are involved. As to the process design stage, the analysis of processing sequences, the selections of production equipment, tentative process parameter values, etc., are involved. Since system design is an initial functional design, it may be far from optimum in terms of quality and cost.

a. Taguchi methods for design of experiments

Taguchi methods of experimental design provide a simple, effective and systematic approach for the optimization of experimental designs for performance quality and for expected economic production. This method is a unique and powerful statistical experimental design technique, which greatly improves the engineering productivity. For present study, identifying the product parameter values under the optimal process parameter values and the objective of the parameter design is to optimize the settings of the process parameter values for improving performance characteristics. the optimal process parameter values obtained from the parameter design are not responding to the variation of environmental conditions ,vibration etc. Therefore, the parameter design is the key step in the Taguchi method to achieving high quality without increasing cost. Nature and the economic consequences of quality engineering in the world of manufacturing.

b. Orthogonal arrays

Taguchi suggested the use of the loss function to measure the performance characteristic deviating from the desired value, further transformed into a signal-to-noise ratio. There are three types of the performance characteristic in the analysis of the signal-to-noise ratio, i.e. the lower-the-better, the higher-the-better, and the nominal- the-better [1,6]. The S/N ratio for each level of process parameters is computed based on the S/N analysis. Regardless of the category of the performance characteristic, the larger S/N ratio corresponds to the better performance characteristic .Hence, the optimal level of the process parameters is the level with the highest S/N ratio. Furthermore, a statistical analysis of variance (ANOVA) is performed to see which process parameters are statistically significant. The optimal combination of the process parameters can be predicted. In this paper, the MQL input parameters design by the Taguchi method is adopted to obtain optimal machining performance in turning.

category-3 : S/NS =-10 log (1/nΣnt= yi2) (1)

Where, S/NS –signal to noise ratio,y2 = Variance of y,
n = Number of observation ly = Observed data

The objective of S/NT is to reduce variability around a specific target, the goal of present work is to produce minimum surface roughness in a turning operation. Smaller VB values represent better or improved surface roughness and tool wear. Therefore, a smaller-the-better quality characteristic was implemented and introduced in this experiment. The use of the parameter design of the Taguchi method to optimize a process with multiple performance characteristics includes the following steps.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

National Conference on Design, Manufacturing, Energy & Thermal Engineering (NCDMETE-2017)

AGTI's Dr. Daulatrao Aher College Engineering, Vidyanagar Extension, Karad

Vol. 4, Special Issue 1, January 2017

1. Identification of the quality characteristics and selection of design parameters to be evaluated.
2. Determination of the number of levels for the design parameters and possible interactions between the design parameters.
3. Selection of the appropriate orthogonal array and assignment of design parameters to the orthogonal array.
4. Conducting of the experiments based on the arrangement of the orthogonal array.
5. Analysis of the experimental results using the S/N ratio and ANOVA.
6. Selection of the optimal levels of design parameters.

c. Selection of the factors and their levels

The experiments were carried out on a 5 hp Lathe by carbide cutting tool for the machining of EN-8 steel bars. The operating conditions such as Pressure, flow rate and type of cutting fluid of MQL system which are generally controllable in any MQL situation were selected as factors for study on the basis of literature. Therefore the initial cutting parameters were as follows: pressure 5 bar, Flow rate 60 ml/hr and depth of cut 0.4 mm kept constant.

The feasible space for the cutting parameters was defined by varying the pressure in the range 4 to 6 bar, flow rate in the range 30 to 90 ml/hr with three different type of cutting fluid. Table 2 shows the control factors and there levels.

Table 2: Control factors and their levels

Factors	Level 1	Level 2	Level 3
Pressure, P (Bar)	4	5	6
Flow rate, (ml/hr)	30	60	90
Cutting Fluid Type	Semi-synthetic oil	Straight cutting Oil	Vegetable Oil

d. Selection of OA and Assignment of factors

For the present study, pressure, flow rate and type of cutting fluid were selected as the machining parameters to analyze their effect on surface roughness. Thus there are total three parameters selected namely pressure, flow rate and type of cutting fluid are varied in three levels. A total of 27 experiments based on Taguchi's L9 orthogonal array were carried out with different combinations of the levels of the input parameters.

The first column of the Table 3 was assigned to the Number of trial; the second to the Pressure (P), the third one to the Flow rate (Q) and the Fourth one were assigned to the Cutting fluid type. It means a total 9 experimental number must be conducted using the combination of levels for each independent factor (pressure, flow rate and type of cutting fluid).Table 3 shows the L9 Orthogonal Array.

Table 3 :L9 Orthogonal Array

Trial no.	Pressure, P (bar)	Flow rate, Q (ml/hr)	Cutting fluid type
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

IV. RESULT AND DISCUSSION

Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. The transformation of the repetition data in a trial into a consolidated single value called the S/N ratio. The term S represents the mean value for the output characteristic while the N represents the undesirable value for the output characteristic. So the S/N ratio represents the amount of variation present in the quality characteristic. With the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Table 4 represent the experimental results.

Table 4: experimental results

Trial no.	Pressure, P (bar)	Flow rate, Q (ml/hr)	Cutting fluid type
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 this paper the analysis was performed in order to determine the effect of pressure and flow rate of cutting fluid in MQL and types of cutting fluid on the magnitude of surface roughness. Statistical analysis was performed using MINITB 15 software.

Table 5: Response Table for Signal to Noise Ratios (For Surface roughness)

Level	Pressure (bar)	Flow Rate (ml/hr)	Cutting Fluid Type
1	-6.612	-7.267	-32.86
2	-6.652	-6.767	-33.39
3	-7.145	-6.376	-31.52
Delta	0.533	0.891	2.317
Rank	3	2	1

Surface roughness is the important parameter in machining of EN-8 steel.S/N ratio analysis and Analysis of variance (ANOVA) was carried out to study the effect of minimum quantity lubrication parameters on the surface finish. The effects of MQL parameters on surface roughness are measured and the trends are shown in fig.2. Here as pressure increases from 4 bar to 6 bar S/N for surface roughness decreases and flow rate increases from 30 ml/hr to 90 ml/hr S/N for surface roughness increases drastically. Whereas when straight cutting oil is used as cutting fluid S/N for surface roughness shows maximum value.

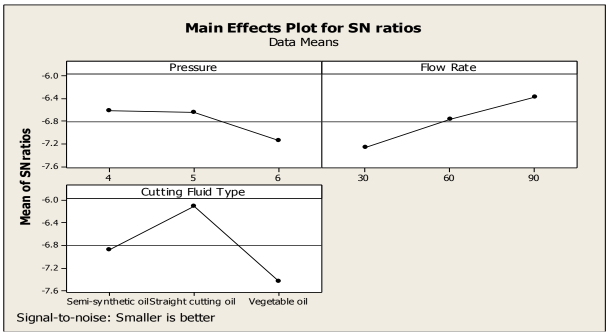

Fig.2: Effects of cutting parameters on Surface roughness

Fig. 2 shows the S/N response graph for tool surface roughness. Based on the S/N ratios analyses, the optimal cutting parameters for surface roughness are Pressure 4 bar, Flow Rate 90 ml/hr, Cutting Fluid type- Straight cutting oil.

Table 6: ANOVA Results for Surface roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Pressure	2	0.5283	0.5283	0.2641	0.40	0.714
Flow Rate	2	1.1971	1.1971	0.5986	0.91	0.524
Cutting Fluid	2	2.6266	2.6266	1.3133	1.99	0.334
Residual Error	2	1.3197	1.3197	0.6599		
Total	8	5.6717				

Table 6 represents the ANOVA results where in the effects of cutting parameters on surface roughness are presented.
It can be observed that cutting fluid type is the most significant factor affecting thesurface roughness contributing 46.31 % to the total effect followed by flow rate and pressure with 21.10 % and 10.73 % contribution respectively.

V. CONCLUSION

I. Anova for surface roughness indicates the cutting fluid type as a most affecting parameter with contribution of 46.31 %.The flow rate and pressure affects on surface roughness with 21.1% and 10.73% respectively.

II. Straight cutting oil or Neat oil with Extreme pressure additives provides better results for tool wear in turning EN-8 steel with MQL.

III. The results indicated that Vegetable oil were superior to Semi synthetic oil. Therefore vegetable oils as viable alternative to petroleum based metalworking cutting fluids. Vegetable oils are nontoxic to the environment and biologically inert and do not produce significant organic disease and toxic effect.

IV. Straight cutting oil or neat oils with extreme pressure additives provide excellent lubrication and anti weld properties over wide range of temperatures.

REFERENCES

1. Vieira J. M., Machado A.R., Ezugwu, "Performance of cutting fluids during face milling of steels", J. material Proc. Technology, Vol.116/2, 2001, pp 244-251.
2. Li Kuan-Ming, Liang S.Y, "Modelling of Cutting Temperature in Near Dry Machining", J. of Man . Sci. and engg., vol. 128/3,2006, pp 416-424.
3. Dhar N. R., Islam S., Kamruzzaman M., " Effect of minimum quantity lubrication on tool wear, surface roughness and dimensional deviation in turning AISI 4340 steel", G.U J. Sci., Vol. 20/2, 2007, pp23-32.
4. Liao Y.S , Lin H.M. , Chen Y.C., "Feasibility study of MQL in high speed end milling of NAK 80 hardened steel by coated carbide tool", Int. J. Machine tool, Vol. 47, 2007, pp 1667-1676.
5. Rahman M.,Senthil K.A.,Salam M.U., "Experimental evaluation on the effect of MQL in milling",Int. J. of Machine tool and Manu.,vol.42(5),2008,pp539-547.
6. Choi S.,Seok P.J.,Byeony H.L., "Effective viscosities and thermal conductivities of aqueous nanofluids containing low volume concentration of Al2O3 nano particles.", Int. J. of Heat and Mass transfer,Vol.51,2008,pp 2651-2656.
7. Sharma V.,Dogra M.,Suri N.M., "Cooling techniques for improved productivity in turning" ,Int.J.of Machine Tools and Manu.,vol.49,2009,pp-435-453.
8. Ramamoorthy B.,Thakur D.G., Vijayaraghavan L.,"Optimization of MQL parameters in high speed turning of superalloy inconel 718 for sustainable development", World Academy of Sci. Engg. And Technology, Vol. 54,2009, pp 224-226
9. Khan M.M.A.,Mithu M.A.H.,Dhar N.R., "Effect of MQL on turning AISI 9310 alloy steel.", J. of Material Proc. Technology, vol. 209, 2009, pp. 5573-5583.
10. McCabe J. and Ostaraff M. A., "Performance Experience with Near-Dry Machining of Alluminum", Lubr. Eng., 57/12, 2001,pp. 22-27.
11. Wakabayashi T.,Sato H.,Inasaki. I., "Turning using extremely small amount of cutting fluid.", JSME Int.J.41 (1),1998,pp.143-148.

BIOGRAPHY

Mr. V.N. Gandhe, M.E. Mech (Production), Faculty, Department of Mechanical Engineering, Dr. Daulatrao Aher College of Engg., Karad, Maharashtra

Mr. H.K. Shete, M.E Mech (Production), Faculty, Department of Mechanical Engineering, Dr. Daulatrao Aher College of Engg, Karad, Maharashtra.