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Experimental Investigation of Temperature in Drilling under Different Cutting Environment

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Abstract-In the present era of manufacturing most of the applications required drilling process. In the drilling process high temperature is generated due to the friction. To reduce the friction and control the temperature, cutting fluids are used. The use of excessive cutting fluids in machining has significantly improved. In this study, an experimental investigation on the effect of machining parameters and cutting environment on temperature when drilling duplex stainless steel AISI 2205 using high speed steel (HSS) tool with TiAlN coated tool were conducted. The cutting environment is dry, flood and minimum quantity lubrication (MQL). The machining parameters are speed and feed rate. In first experiment speed and feed remains constant and cutting environment varies but in second experiment combination of different cutting speed and feed has been taken for investigation of temperature. The drilling was done on the Vertical Machining Centre (VMC) and temperature is measured by k-type thermocouple. The LAB VIEW software is used for data acquisition system. The analysis of results was done by Taguchi's method which shows that the optimum cutting parameters are cutting speed of 750 rpm, feed rate at.03 mm/rev and flood as cutting environment. Analysis of variance (ANOVA) shows that cutting environment has the highest percentage contribution among all the parameters and their interactions which affect the temperature in drilling of duplex stainless steel.

Keywords— MQL, LAB VIEW, ANOVA, Taguchi, K-Type Thermocouple.

I. INTRODUCTION

Duplex stainless steel have high strength and tough material to machining. High nitrogen present in duplex is responsible for its high strength and hardness. In the machining process, the heat is generated during to the continuous friction between the work piece and the cutting tool. Approximately 98% of the energy is converted into heat. In the drilling process high temperature rise can adversely affect the properties of tool and work piece material, Induce thermal damage of the material. Thermal damage of material caused change in the dimension of drill size in the work piece. Removal of chips is a major problem, High temperature rise during drilling causes weld like action at the tool chip interface which. This welding action increases the tool wear and reduces the tool life. It also reduces the surface quality of drilled holes. It makes necessary to measure the temperature in drilling process. In the drilling process we generally use cutting fluid for reduce the temperature, cutting fluids is used as coolant and lubricant in the machining process, but it also increase the chemical reaction in cutting fluids which leads to harmful effect in human health and environment. The use of cutting fluids also increase the total production cost of the process because it requires a cost associated with its storage, maintenance and disposal

In the recent years, many researchers investigate the temperature in different operation under different cutting environment. Rodrigo et.al (2006) founded that application of MQL is more effective when applied externally [1]. The maximum temperature is observed near the chisel edge[2].Cutting force and flank wear was least in pulsejet mode than flood. In the turning operation Crater wear affected temperature more than flank wear [3].MQL at low velocity more effective than high speed and enabled in reduction of 5% in temperature in the turning process of steel [4].

High temperature in the machining process leads to high heat generation. The heat is lost in the surroundings by three modes of heat transfer conduction, convection and radiation.The use of Nano fluids is also increase the effectiveness of cutting fluids by the increase of heat transfer through conduction [5].MoS_2/ CNT hybrid Nano fluid gives good results than pure Nano fluid due to 'physical synergistic effect' [6].The present work deals with the experimental investigation of temperature in drilling of duplex steel grade 2205 under different cutting environment.

II. Experimental setup

The experiments were carried out by drilling in a duplex stainless steel plate of grade 2205of size 225x150x10 mm on a vertical machining centre (Haas Automation). The experiments were conducted at different cutting speed and feed and dry and minimum quantity lubrication (MQL) as different cutting environment to study the effect of these parameters on temperature. The selection of different cutting speed and feed are taken from the industrial practices and the tool manufacturer's recommendations. The drill bit of high speed steel in 6 mm diameter is used for drilling.

The MQL should be provided at high weight and encroached at fast through the spout at the cutting zone. Considering the conditions required for the display look into work and continuous supply of MQL at steady weight over a sensibly long cut, a MQL conveyance framework has been composed, manufactured and utilized. The schematic perspective of the MQL set up is appeared in Fig.1. The thin however high speed stream of MQL was anticipated along the bleeding edge of the embed, as demonstrated in a casing inside Fig.1, with the goal that the coolant comes to as near the chip-tool and the work-tool interfaces as conceivable.. The MQL has been utilizing for the most part to focus on the rake and flank surface and to secure the helper flank to empower better dimensional precision.

In the MQL cooling system, use of Nano particle improves the effectiveness of the coolant system by increasing the heat transfer by conduction. This experiment consists of Nano particles of alumina Al2O3 of size 80 nm which is dispersed in the Deionised water.This dispersed solution is kept in the bath sonicator at the 40 HZ frequency for 90 minutes so that sound energy can agitated the Nano particles. The Nano fluid solution is transferred to the nozzle where it is mixed with compressed air at the 6.0 bar pressure. The Nano fluid solution supplied to the work piece by the nozzle which is directed at the 45º.

The temperature was measured with the help of K-Type (chromel - alumel) thermocouple. Tip of thermocouple is 0.5mm distance apart from the wall of drill hole. LabVIEW software is used for record and graphical representation of temperature. National Instruments data acquisition system is used to record the data of temperature.

Figure 2: experimental view of MQL drilling System.

Table 1: Experimental set up and conditions

Machine Tool	Vertical Machine Centre (Mini Mill, Haas Automation Ltd)
Work piece Material and Size	Duplex Stainless Steel (C=0.03%, Cr= 22.0%, Ni =4.5- 6.5%, Mo 3.5-4.5%, Mn-2.0%, N=0.14-0.20%. Size- 225x150x10
Cutting Tool	HSS, Guhring co.
Process parameter	Cutting speed= 750,1000 rpm Feed rate= .03,.06 mm/rev Cutting environment= Dry, MQL
MQL Parameter	Pressure= 6 bar Nozzle angle=45º Flow rate= 150 ml/hr Nano fluids= Alumina (Al_2O_3)

III. **Results and discussion**

The experiment had been done based on the Taguchi' L8 orthogonal array. In this experiment there are three factors at the two levels which makes suitable L8 orthogonal array for doing minimum number of experiments for optimum results. In this experiment we had been taken speed, fees and cutting environment as the factors which affects the response.

Table 2: factors of the experiments with their values at different level.

Factor	**Name**	**Level1**	**Level2**
1	Cutting speed (RPM)	1000	750
2	Feed (mm/rev)	.03	.06
3	Cutting environment	Dry	MQL

The experiment has been done at the two different levels with the different cutting environment which includes dry drilling and drilling in the presence of MQL. The response is in this case is temperature which is measured by thermocouple .the temperature reading comes in the unit of degree Celsius (oC). The cutting speed is taken in the revolution per minute and feed rate in mm/ revolution. There are total eight number of experiment with different combination of these three factors which are shown in table 3.

Table 3: reading of temperature with values of different parameters

S No.	**Spindle speed (RPM)**	**Feed Rate (mm/rev)**	**Cutting environment**	**Temperature (^oC)**
1	1000	0.03	Dry	95.93
2	1000	0.03	MQL	65.97
3	1000	0.06	Dry	98.05
4	1000	0.06	MQL	72.46
5	750	0.03	Dry	92.19
6	750	0.03	MQL	53.07
7	750	0.06	Dry	81.34
8	750	0.06	MQL	61.53

Analysis of means (ANOM) diagram of each performance measure is created as shown in figure 6.1. The figure graphically shows the average of each level of the design factors. The level of the factor representing the best values of temperature could be easily evaluated. The Taguchi method is applied and ANOM diagrams are plotted by using Minitab 18.

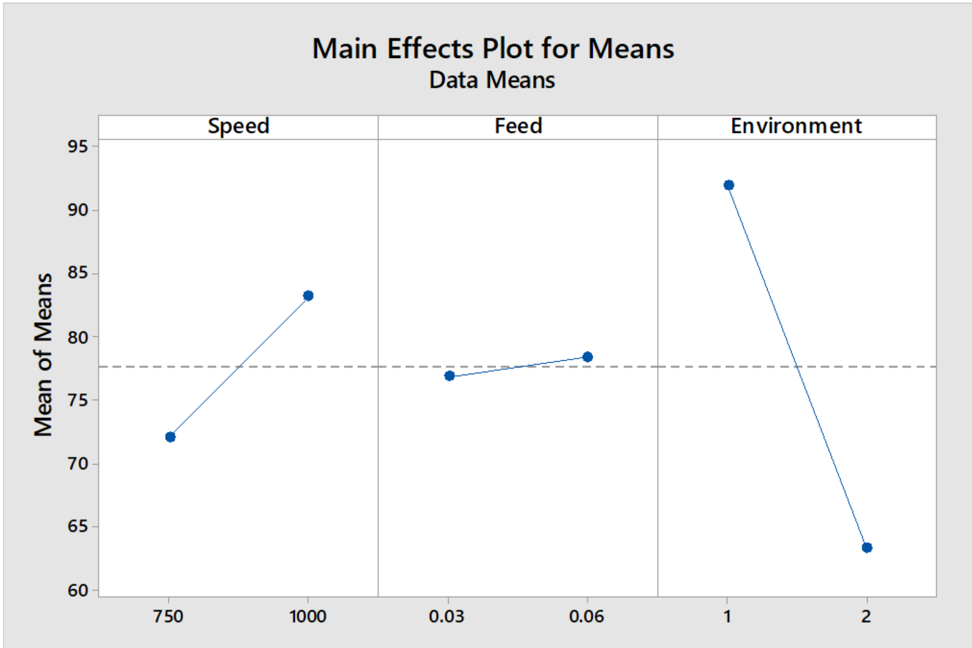

Figure 3: Main effect plot for means

Table 4: Response Table for Means

Level	Speed	Feed	Environment
1	72.03	76.79	91.88
2	83.10	78.34	63.26
Delta	11.07	1.55	28.62
Rank	4	3	1

The range analysis is carried out to determine the effect of each design factor on the performance measure. Table 4 describe the results of range analysis, where range delta= max (I, II, III)-min (I, II, III).Table 4 indicates that the factor significance to temperature is Cutting environment> cutting speed >cutting feed. So the optimum cutting specification is Cutting speed is 750 rpm, feed rate .03 mm/rev and the cutting environment is MQL system.

From this result, it was found that tiny particles flowing at higher velocity will penetrate into the cutting zone more efficiently.

Analysis of variance (ANOVA) for temperature

Apart from the individual factors, their interactions also influence the response. In order to quantify the individual effect as well as the interaction effects, the statistical technique ANOVA is employed. The Analysis of Variances (ANOVA) is one such technique, which is commonly used to establish the relative significance of the individual factors as well as their interaction effect on the behaviour of the response variables. As the value of variance ratio, F-value, gives the relative significance of factors or their interactions, this technique is sometimes referred as 'F-test'.

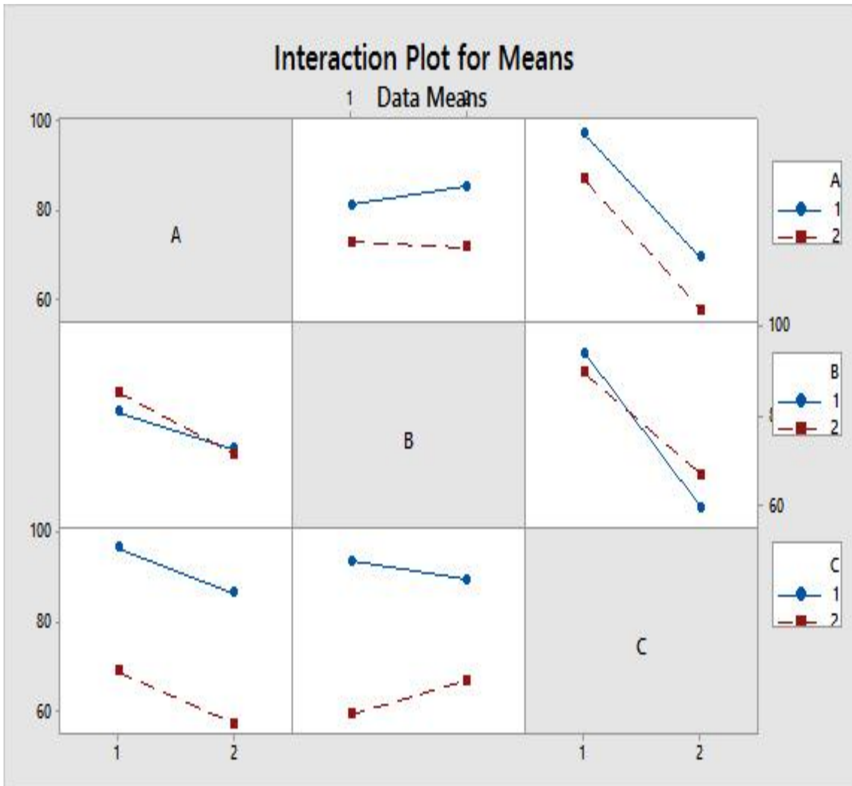

Figure 4: Interaction plot of factor A,B and C

The goal of the analysis of variance is to determine which design parameters meaningfully affect the temperature. The F-ratio test is a statistical tool used to verify which design parameters significantly affect the quality being investigated. This is defined as the ratio of the mean squared deviations to the mean squared error. This analysis was performed with a confidence level of 95%. The importance of the input parameters in ANOVA analysis was identified by comparing the F-values of each input parameters. The F-value determined in the ANOVA table was compared with the value according to standard F-tables for a given statistical level of importance.

Table 5: Results of Analysis of Variance for temperature

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
A	1	245.09	12.24%	245.09	245.09	8.78	0.207
B	1	4.84	0.24%	4.84	4.84	0.17	0.749
C	1	1638.21	81.80%	1638.21	1638.21	58.72	0.083
AXB	1	15.12	0.76%	15.12	15.12	0.54	0.596
AXC	1	1.43	0.07%	1.43	1.43	0.05	0.858
BXC	1	70.09	3.50%	70.09	70.09	2.51	0.358
Error	1	27.90	1.39%	27.90	27.90		
Total	7	2002.68	100.00%				

In the table 5 fourth columns represents the percentage contribution of each factor and their interactions on the variance, indicating their degree of influence on the results. Greater the percentage contribution, greater the influence of the factor on the results. In the table 5. It was found that the factor C which is cutting environment is the most significant parameter affecting temperature with 81.80% for AISI 2205.

IV. Conclusion

In the drilling experiment at the same feed and different cutting speed the temperature increases significantly, varies from 20-25 % for flooded system and 5-10% in dry drilling process. In the experiment of drilling at the same cutting speed and different feed the temperature increases significantly. Taguchi's method of analysis of experiment of drilling at different factors shows that cutting environment have the most significant parameter which affect the cutting conditions, followed by speed and feed. The optimum condition of drilling in duplex stainless steel experiment is at cutting speed of 750rpm and feed 0.03 mm/rev in flood cutting environment. Based on the analysis of variance (ANOVA) results, the most effective parameters on temperature were determined. Namely, the cutting environment is the main factor that has the highest impact on temperature. The percentage contribution of this factor is 81.8%, which is more important than the second ranking factor (cutting speed). The feed rate does not seem to have much influence temperature.

References.

[1]. Zeilmann, R. P. and Weingaertner, W. L. (2006) 'Analysis of temperature during drilling of Ti6Al4V with minimal quantity of lubricant', *Journal of Materials Processing Technology*, 179(1–3), pp. 124–127. doi: 10.1016/j.jmatprotec. 2006.03.077.

[2]. Kuzu, A. T. *et al.* (2017) 'The thermal modeling of deep-hole drilling process under MQL condition', *Journal of Manufacturing Processes*. The Society of Manufacturing Engineers, 29, pp. 194–203. doi: 10.1016/j.jmapro.2017.07.020.

[3]. Leshock, C. E. and Shin, Y. C. (1997) 'Investigation on Cutting Temperature in Turning by a Tool-Work Thermocouple Technique', *Journal of Manufacturing Science and Engineering*, 119(4A), p. 502. doi: 10.1115/1.2831180.

[4]. Dhar, N. R., Islam, S. and Kamruzzaman, M. (2007) 'Effect of Minimum Quantity Lubrication (MQL) on Tool Wear, Surface Roughness and Dimensional Deviation in Turning AISI-4340 Steel', *Journal of Science*, 20(2), pp. 23–32. Available at: www.gujs.org (Accessed: 28 June 2018).

[5]. Zhang, Y. *et al.* (2015) 'Experimental evaluation of the lubrication performance of MoS<inf>2</inf>/CNT nanofluid for minimal quantity lubrication in Ni-based alloy grinding', *International Journal of Machine Tools and Manufacture*. Elsevier, 99, pp. 19–33. doi: 10.1016/j.ijmachtools.2015.09.003.

[6]. Tai, B. L., Stephenson, D. A. and Shih, A. J. (2013) 'Workpiece Temperature During Deep-Hole Drilling of Cast Iron Using High Air Pressure Minimum Quantity Lubrication', *Journal of Manufacturing Science and Engineering*, 135(3), p. 031019. doi: 10.1115/1.4024036.

[7]. Li, R. and Shih, A. J. (2007) 'Tool Temperature in Titanium Drilling', *Journal of Manufacturing Science and Engineering*, 129(4), p. 740. doi: 10.1115/1.2738120.

[8]. Morgan, M. N., Barczak, L. and Batako, A. (2012) 'Temperatures in fine grinding with minimum quantity lubrication (MQL)', *International Journal of Advanced Manufacturing Technology*, 60(9–12), pp. 951–958. doi: 10.1007/s00170-011-3678-7.

[9].O'Sullivan, D. and Cotterell, M. (2002) 'Workpiece temperature measurement in machining', *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 216(1), pp. 135–139. doi: 10.1243/0954405021519645.

[10]. Rahim, E. A. *et al.* (2015) 'Experimental investigation of minimum quantity lubrication (MQL) as a sustainable cooling technique', *Procedia CIRP*, 26, pp. 351–354. doi: 10.1016/j.procir.2014.07.029.

[11]. Seid Ahmed, Y. *et al.* (2018) 'Manufacturing and Materials Processing Prediction and Optimization of Drilling Parameters in Drilling of AISI 304 and AISI 2205 Steels with PVD Monolayer and Multilayer Coated Drills'. doi: 10.3390/jmmp2010016.