International Journal of Latest Trends in Engineering and Technology
Vol.(15)Issue(1), pp.001-003
DOI: http://dx.doi.org/10.21172/1.151.01
e-ISSN:2278-621X

EFFECT OF THERMAL ASSISTED MACHINING PARAMETERS (TAM) ON MATERIAL REMOVAL RATEOF EN 31STEEL

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Abstract.- Now a day with the development of technology there are number of materials having high strength and are hard enough which are difficult to machine. For this researchers had developed many techniques one of them is Thermal Assisted Machining (TAM). This paper reveals the effect of simple step turning operation on EN 31 materialRemoval Rate (MRR) with assistant of heat at a temperature range 380 0C - 430 0C, and effects were recorded accordingly based on the results of the S/N and main effect plot for optimal process parameters.In this paper the focus is given to the directional effect of heating during turning EN31 steel. En-31 steel having hardness value between 60-63 HRC is considered to be hard to machine material. The input parameters feed, spindle speed and depth of cut, at different direction of heating was observed according to the orthogonal array created by Taguchi's method. The effect of these parameters on material removal rate were investigated for the optimum machining conditions at a temperature range 380 0C -430 0C.
Key words- thermal assisted machining, Material Removal Rate, ANOVA.

1. INTRODUCTION

Temperature in the work piece is especially important when thermally enhanced machining is used. A new technique of thermally assisting the work while cutting at higher speeds and feed rates contributed towards the enhancements of efficient machinability of hard to machine materials [1]. In thermal assisted machining consists of heating the work-piece, either by plasma arc, with the help of laser and other heating source.Frank et al (2009)studied the flow of energy in TAM in an attempt to determine how beneficial preheating is [3]. The total thermal energy deposited in the work piece is compared with the theoretical minimum required to heat the removed material in order to determine what percentage of the deposited energy is actually used in assisting the cutting process. Compared to other machinability metrics the thermal energy efficiency is used to evaluate how beneficial preheating is to the machining processes studied. Four sets of data were studied: thermally assisted turning of silicon nitride and partially stabilized zirconia, and micro-end milling of 6061-T6 aluminumand 1018 steel. The specific energy for TAM of silicon nitride is compared with that for grinding of silicon nitride. The temperature rise at the shear zone reduces the yield strength and work hardening of the work piece, which make the plastic deformation of hard-to-machine materials easier during machining. It has been considered as an alternative for hard-to-wear materials such as metallic alloys and ceramics. Sun et al (2010)studied the thermally enhanced machining of hard-to-machine materials. Thermally enhanced machining used external heat sources to heat and soften the work piece locally in front of the cutting tool [4]. The temperature raised at the shear zone reduces the yield strength and work hardening of the work piece, which made the plastic deformation of hard-to-machine materials easier during machining. It incorporated of the external heat source with cutting tools, analysis of temperature distribution around the cutting region, material removal mechanisms, tool wear mechanisms and the improvement in machinability of various engineering materials by the assistance of external heat source.Bermingham et al (2012)studied; thermally assisted machining is an emerging manufacturing process for improving the productivity when machining many difficult-to-cut engineering materials [2]. This work characterizes the tool life and wears mechanism for two uncoated carbide tools when turning Ti-6Al-4V at high speed. It is observed that thermally assisted machining processes reduced the cutting forces in line with increasing work piece temperatures. Reduction in cutting force components of up to 30% was achieved. Thermal assisted machining slightly improved the tool life up to a maximum of 7%; however, this improvement is relatively insignificant com- pared to the over 23.5% improvement that occurs when cool- ants are used under identical experimental conditions.

In the present research the focus is given to the directional effect of heating during turning EN31 steel. En-31 steel having hardness value between 60-63 HRC is considered to be hard to machine material. The input parameters feed, spindle speed and depth of cut, at different direction of heating will be observed according to the orthogonal array created by Taguchi's method. The effect of these parameters on material removal rate were investigated for the optimum machining conditions. The experiments were done on a simple turning operation at a temperature range 380 0C -430 0C to investigate the effects of temperature (380 0C -430 0C) at different directions on material removal rate for thermal assisted turning operation. Although thermal assisted machining has been found as a viable approach to cut hard to machine materials, but the optimization of technique has yet to be confirmed. The thermal assisted machining has produced very good results in terms of surface quality,

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lesser cutting forces and increased tool lives. Optimalprocessparameters for Material removal rate resultsofthemachining (turning) experimentsarestudied byusingthesignal-to-noise ratio. Thesearebasedon theresults of the S/Nandmaineffectplot, optimalprocessparametersforTaguchimethodsuggeststheequationforcalculatingthe S/Nratioforsmaller-the-bettercharacteristics

2. MATERIAL SELECTION

In the present research EN31 steel of 40 mm diameter rod has been used. The rod has been cut into 18 pieces of 55 mm long. The purpose of Selecting Tool Steel is that they are mostly used in the manufacturing industry. The major application of EN-31 steel are manufacturing of Ball and Roller Bearings, Spinning tools, Beading Rolls, Punches and Dies. By its character this type of steel has high resisting nature against wear and can be used for components which are subjected to severe abrasion, wear or high surface loading. Various researchers investigated the effects of TAM at temperature ranges from 370 0 C- 480 0C [1, 5, 6]. Present work has been done at a temperature range 380 0C - 430 0C, and effects were recorded accordingly.

3. EXPERIMENTATION

The Combinations of these parameters are selected as the tool recommendations and optimized by Taguchi’s L9 orthogonal array different combinations of the levels of the input parameters. In this experimental work, the assignment of factors will be carried out using L9 orthogonal array were conducted on Lathe machine for turning operations through MQL technique and flooded machining technique. An infrared thermometer (TB-550) is used to measure the temperature at tool-work interface. The temperature has been measured during the each set of experiment by aiming the laser of infrared thermometer. By pointing the laser towards the surface to be measured, direct readings can be taken. Tungsten carbide insert (CNMG120408) used in present work, by considering the hardness of the EN31 steel and according to the cutting conditions and tool manufacturer’s recommendation. It is characterized by its high strength, toughness and hardness. Cemented carbides (also known as hard metals) are made by 'cementing' grains of tungsten carbide into a binder matrix of cobalt or/and nickel. Cutting operations require cutting tool materials that can withstand the difficult conditions produced during machining. The Hindustan Machine Tool lathe machine used for experimentation consists of tool holder unit, head stoke and tail stoke for machining the work piece. Specifications of the lathe machine are given below. The present experiment is performed on EN31 steel material to investigate the effect of thermal assisted machining processes by the varying different input parameters. In this experiment, the technique used for introducing the heat to cutting zone is by Butane torch, due to its ease of availability as compared to costly laser and plasma techniques. The experimental set up used to perform experiments is assembled at home, by purchasing the different components from the market. Experimental set-up is consists of a butane torch, Pressure gauge, and flow control valve.

Table 2 Response Table for Means

Level	Speed	Feed	Depth of cut
1	1.3377	1.3471	0.9755
2	1.6876	1.6474	1.7322
3	1.9201	1.9510	2.2377
Delta	0.5824	0.6039	1.2622
Rank	3	2	1

4. MATERIAL REMOVAL RATE

After conducting the experiments with different settings of the input factors i.e. direction of heating, cutting speed, feed rate and depth of cut. The value of output variables material removal rate, in longitudinal direction were recorded. Table1showstheexperimentalresults,S/NratioforMRR.Here, inthesignal-to-noiseratio, Taguchiexpressedsignalasdesirablevalueandnoisebeingundesirablevalue.Table 2 shows Response Table for Means.

Table 1 Experimental results of TAM in Longitudinal direction for MRR.

Speedm/min	Feed mm/rev	Depth of cut (mm)	Material removal rate (1)gm	Material removal rate (2)gm	Material removal rate (3)gm	SNRA7	MEAN7
101	0.05	0.5	0.558	0.5576	0.5574	-5.07251	0.557667
101	0.1	0.8	1.3885	1.3888	1.389	2.852585	1.388767
101	0.15	1	1.3997	2.4	2.4006	5.438576	2.066767
145	0.05	0.8	1.3076	1.3076	1.3066	2.327282	1.307267
145	0.1	1	2.5007	2.5	2.4092	7.849813	2.469967
145	0.15	0.5	1.2862	1.2857	1.2848	2.181889	1.285567
182	0.05	1	2.1765	2.1764	2.176	6.754375	2.1763
182	0.1	0.5	1.0837	1.0833	1.083	0.695241	1.083333
182	0.15	0.8	2.5011	2.5	2.5009	7.961116	2.500667

Main effect plot for Means for TAM in Longitudinal direction for MRR is shown in fig.1 Main effect plot for SN ratios for TAM in Longitudinal direction for MRR.is shown in fig.2

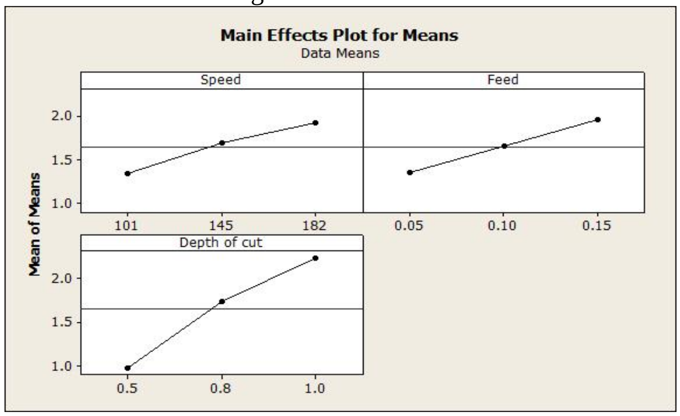

Fig.1 Main effect plot for Means for TAM in Longitudinal direction for MRR

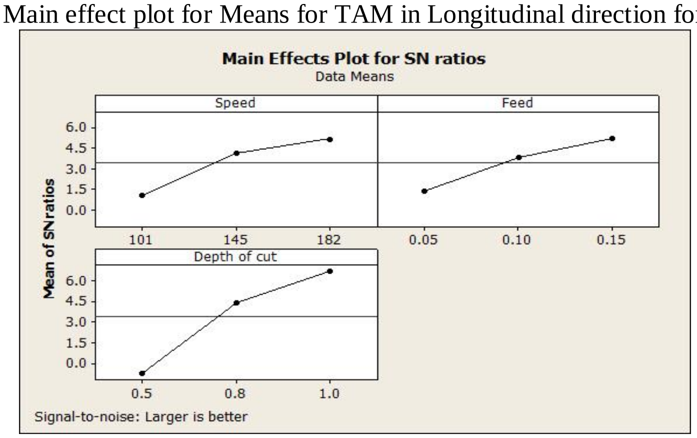

Fig..2 Main effect plot for SN ratios for TAM in Longitudinal direction for MRR.

Table .3Response Table for Signal to Noise Ratios. (Larger is better)

Level	Speed	Feed		Depth of cut	
1		1.0729	1.3364	-0.7318	
2		4.1197	3.7992	4.3803	
3		5.1369	5.1939	6.6809	
Delta		4.0640	3.8575	7.4127	
Rank		2		3	1

5. CONCLUSION

From responseTable 3 for Signal to Noise Ratios ofMRRobtainedin longitudinal direction and fordifferentparameter levels andFromthemaineffectplot(Fig.1and Fig.2)largerobtained for level- 3cuttingspeedandlevel-3forfeedandlevel-3fordepth of cutrespectively.Therefore, theoptimalcombinationofprocessparameter isfoundtobeS3-F3-D3Depth of cut has been found the most affected parameter according to the rank. TAM technique has shown tremendous results over conventional dry machining. Increase in surface quality and high material removal rates were found with the use of TAM.

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