OPTIMIZATION OF PROCESS PARAMETERS FOR CUTTING TEMPERATURE IN MILLING OF EN-19 ALLOY STEEL

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ABSTRACT: In the present work, by using Taguchi Robust Design methodology the End milling of EN-19 steel alloy is carried out in order to minimize the Cutting temperature and to optimize the milling process parameters. The selected milling process parameters are Cutting Speed, Feed rate, Depth of cut and coolant flow. Taguchi orthogonal array is designed with three levels, four factors and nine experiments using L_9 (3^4) orthogonal array. The nine experiments are performed and cutting temperature is measured. Results obtained by Taguchi Method, shows that the factors affecting the cutting temperature using ANOVA, are found to be significant factors and it is concluded that the effect coolant flow is more followed by depth of cut, feed and cutting speed for cutting temperature.It is found that S/N ratio value of verification test is within the limits of the predicted value and the objective of the work is full filled.

***Index Terms*: Taguchi Robust Design methodology, Milling Process, EN-19 steel alloyl,Signal to Noise Ratioetc.**

1. INTRODUCTION

The growing demand for higher productivity, product quality and overall economy in manufacturing by machining, insists high material removal rate and high stability and long life of the cutting tools. But machining with high cutting velocity, feed rate and depth of cut is inherently associated with generation of large amount of heat and high cutting temperature. Such high cutting temperature not only reduces dimensional accuracy and tool life but also impairs the surface integrity of the product by inducing tensile residual stresses, surface and subsurface micro-cracks in addition to rapid oxidation and corrosion. Machining experiences high temperatures due to friction between the tool and work piece, thus influencing the work piece dimensional accuracy and surface quality. Machining temperatures can be controlled by reducing the friction between tool–work-piece and tool–chip interface with the help of effective lubrication.

Cutting fluids are the conventional choice to act as both lubricants and coolants. But, their application has several adverse effects such as environmental pollution, dermatitis to operators, water pollution and soil contamination during disposal [1, 16-17]. Further, the cutting fluids also incur a major portion of the total manufacturing cost. Milling is the process of removing extra material from the work piece with a rotating multi-point cutting tool, called milling cutter. The machine tool employed for milling is called milling machine. Milling machines are basically classified as vertical or horizontal. These machines are also classified as knee-type, ram-type, manufacturing or bed type, and planer-type. Most milling machines have self-contained electric drive motors, coolant systems, variable spindle speeds, and power-operated and table feeds. The three primary factors in any basic milling operation are speed, feed and depth of cut. Other factors such as kind of material and type of tool materials have a large influence, of course, but these three are the ones the operator can change by adjusting the controls, right at the machine. CNC (Computer Numerical Control) is the general term used for a system which controls the functions of a machine tool using coded instructions processed by a computer. The application of CNC to a manual machine allows its operation to become fully automated.Combining this with the use of a part program enhances the ability of the machine to perform repeat tasks with high degrees of accuracy. [1-2].Literature review bridges the gap between two stages of a project execution i.e. problem definition and evolution of design configuration (Solution). Extensive literature review is carried out to explore the elements of the present project requirements. [1-10]

2. MATERIALS AND METHOD

The objective of this project work is to find out the set of optimum values for the selected control factors in order to minimize cutting temperature using Taguchi's robust design methodology. In the present work, Taguchi method is used to determine the optimum cutting milling parameters more efficiently. Four control factors viz. cutting speed, feed rate, depth of cut and coolant flow are investigated at three different levels. The work piece material used is EN-19 steel alloy. Taguchi method is used to optimize the process parameter i.e. cutting temperature using signal-to-noise ratio for milling process of the work piece materials. Experiments are carried out using L_9 (3^4) orthogonal array.In this work, ANOVA is performed for the selected factors, to be significant or insignificant.

The milling operations are carried out on a CNC milling MTAB. The machining tests are conducted under the different conditions of Cutting speed, Feed rate, Depth of cut and coolant flow. The experiments are conducted at Nalla Narasimha Reddy Educational Society's Group of Institutions, Narapally, Ghatkesar and the machine tool used is MTAB CNC VERTICAL MILLING MACHINE shown in fig. no.1. The work piece material used is EN-19 Steel belongs to steel alloy of 49mm X 49mm X 12mm thickness in the form of plates. The EN-19 defined a number of Emergency Number Steel alloy standards with a numbering scheme for easy reference and are mentioned them in the form of grades shown in fig. no.2.

Fig No:1 CNC Milling Machine

Fig No:2. EN 19 Steel Specimens

The cutting tool used is brass coated carbide inserts with a tool diameter of 16mm. It consists of four teeth. It consists of very high hardness and good toughness and it is principally intended for roughing of super alloys and steel alloys.The specification of tool holder used for machining is BT30-ER16, side lock adapter system shown in fig. no.3.

Table No.1:Control Factors and Levels

Factors /Levels	Speed (A) (rpm)	Feed (B) (mm/min)	Depth Of Cut (C) (mm)	Coolant Flow (D) (lt/min)
1	796	50	0.5	30
2	935	100	1.0	60
3	1094	150	1.5	90

Selection of cutting fluid is important in order to maintain better tool life, less cutting forces, lower power consumption, high machining accuracy and better surface integrity etc. Vegetable Oil (coconut oil) is used as cutting fluid. Coconut oil is an environmentally acceptable vegetables oil based lubricant. In the present work the mixture of vegetable oil (coconut oil), oleic acid and triethanol amine is used as lubricant, out of these three chemicals, coconut oil and oleic acid will improve machining parameters[17]. The solvent triethanol amine is used for proper mixing of coconut oil and oleic acid. It can also control the evaporation rate of water in coolant.

Composition of solution as follows:

1 Coconut Oil is taken 40%

2 Oleic Acid is taken 40% and

3 Triethanol Amine is 20%

40% of coconut oil is taken in a beaker and then 20% of triethanol amine is mixed in coconut oil and this mixture is stirred with mechanical stirrer for half an hour and then 40% of Oleic acid is added in the above solution slowly to dissolve or proper mixing and it is stirred for an half an hour to get a homogeneous mixture which is to be dissolve in water in all conditions.

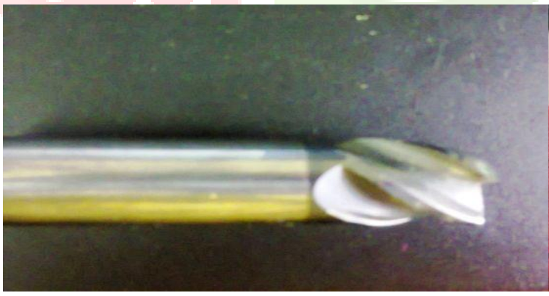

Fig No.4 CVD Brass coated Cutting Tool

Fig No.3Temperature Measuring Device

The four control factors speed (A), feed (B), Depth Of Cut(C)and Coolant flow (D) are selected with three levels and the corresponding orthogonal array L_9 (3^4) is chosen with respect to its degrees of freedom[1] and are tabulated in Table No.2.

3. RESULTS & DISCUSSIONS:

The experiment result obtained by using the Cutting Temperature Measuring Device is shown in fig.no. 3 and are tabulated in Table 2, the performance characteristic is the Cutting temperature which is to be minimized and hence the S/N ratio associated with the response is "Smaller-the-better. For each experiment the corresponding S/N values are tabulated. Optimization of Cutting temperature is carried out using Taguchi methodology. Confirmatory tests have also been conducted to validate the optimal results.

Table No.2:Experimental Design & Experimental Results

EXPERIMENT NUMBER	CONTROL FACTORS				TRAIL1	TRAIL2	MEAN	S/N RATIO
	SPEED (A)	FEED (B)	DEPTH OF CUT (C)	COOLANT FLOW (D)				
1	796	50	0.5	30	28.5	28.7	28.6	29.12732
2	796	100	1.0	60	30.1	30	30.05	29.55689
3	796	150	1.5	90	28.2	29.5	28.85	29.20292
4	935	50	1.0	90	28.9	28.5	28.7	29.15764
5	935	100	1.5	30	31.1	31	31.05	29.84123
6	935	150	0.5	60	29.5	29.3	29.4	29.36695
7	1094	50	1.5	60	30.3	30.1	30.2	29.60014
8	1094	100	0.5	90	28.4	28.7	28.55	29.11212
9	1094	150	1.0	30	30.4	30.7	30.55	29.70022

Table No 3: Summary of S/N Ratios

Factor	Level 1	Level 2	Level 3
Speed(A)	**29.29570885**	29.45527221	29.47082847
Feed(B)	**29.29503249**	29.50341462	29.42336242
Depth of Cut(C)	**29.20212984**	29.47158392	29.54809577
Type of tool(D)	29.55625901	29.50799166	**29.15755885**

The best condition for speed is level 1; for feed is level 1, for depth of cut is level 1 and level 3. Thus, the optimum conditions chosen were: A1-B1-C1-D3. A confirmation test is performed with the obtained optimum cutting parameters, the cutting temperature is measured and the S/N ratio is calculated for this condition. The conformation test results are tabulated in the table no 5.

Table No 4: Optimum Set Of Control Factors

Factors /Levels	Speed (A) (rpm)	Feed (B) (mm/min)	Depth Of Cut (C) (mm)	Coolant Flow (D)
Optimum Value	796	50	0.5	90

Therefore, the predicted average for optimum condition is 28.728.A confirmation test is performed with the obtained optimum cutting parameters. The cutting temperature values are taken for two trials and the S/N ratio is calculated for this condition. The conformation test and the predicted values are tabulated in the table no 5 & 6.

Table No 5. Conformation results

Material removal rate			S/N RATIO
1	2	Average	
27.1	27.8	27.45	28.77085

Table No 6. Comparison of S/N ratios

η predicted	28.728
η conformation	28.77085

Table No. 7: Basic Analysis of Variance

FACTOR	S.S	D.O.F	M.S.S	F-RATIO (DATA)	F-RATIO (TABLE)	RESULT
SPEED	1.33	2	0.665	4.903226	4.26	Significant
FEED	1.563333	2	0.781667	5.763441	4.26	Significant
DEPTH OF CUT	4.623333	2	2.311667	17.04455	4.26	Significant
COOLANT FLOW	6.603333	2	3.301667	24.34409	4.26	Significant
ERROR	1.085	9	0.135625			
S_t	29.55					
MEAN	15717.65	1				
ST	15732.85	18				

Table No. 8: Analysis of Variance

FACTOR	S.S	D.O.F (D_f)	M.S.S (M_{SS})	F-RATIO (DATA)	SS[1]	ρ %
SPEED	1.33	2	0.665	4.903226	1.05875	7.498229
FEED	1.563333	2	0.781667	5.763441	1.292083	9.150732
DEPTH OF CUT	4.623333	2	2.311667	17.04455	4.352083	30.82212
COOLANT FLOW	6.603333	2	3.301667	24.34409	6.332083	44.84478
ERROR	1.085	9	0.135625			7.684136
S_t	29.55					
MEAN	15717.65	1				
ST	15732.85	18				100%

4. CONCLUSIONS:

The objective of the paper is to find out the set of optimum conditions in order to minimize cutting temperature, using Taguchi robust design methodology considering the milling parameters for the EN 19 Steel Alloy material using Vegetable oil. Based on the results of the present experimentation the following conclusions are drawn:

- By using Vegetables oils under flooded conditions the optimum speed obtained using Taguchi Robust Design Methodology is 796 rpm. Similarly the results obtained for feed and depth of cut are 50 mm/min and 0.5 mm respectively. The corresponding coolant flow is 90 lit/min.
- The S/N ratio of predicted value and verification test values are valid when compared with the optimum values individually. It is found that S/N ratio value of verification test is within the limits of the predicted value and the objective of the work is full filled.
- Using ANOVA, the individual factor effects are found to be significant factorsand it is concluded that the effect coolant flow is more followed bydepth of cut, feed and cutting speed for cutting temperature.

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