OPTIMIZATION OF HOT MACHINING IN EN19 ALLOY STEEL BY USING TAGUCHI METHOD

Kathiravan.C[1], Dr.R.Jamuna[2], Singaravel.M[3], Surendhar C[4]

[1,3,4]*PG Scholar, Government College of Engineering, Salem, India*
[2]*Assistant professor, Government College of Engineering, Salem, India*

Abstract - In this work experiments are going to conduct on EN 19 alloy steel using K20 carbide tool based on Taguchi L9 orthogonal array design. The work-piece materials are heated using oxy acetylene gas flame which is the cost effective method compare to other heating technique used in hot machining process. The Analyses Of Variance (ANOVA) is going to performed to get the contribution of each parameter on the performance characteristics are going to investigated. The optimal set of process parameters were found to be cutting speed (31.41 m/rev), depth of cut (0.75 mm), Work piece temperature (300°c) and feed rate(0.3mm)to maximize the material removal rate and minimize the surface roughness.

Key Words: Taguchi, Oxy acetylene, ANOVA, Surface Roughness, Material Removal Rate (MRR).

1. INTRODUCTION

Machining is one of the major manufacturing processes to produce component with higher dimensional accuracy and surface. There are also variety of part geometries that can be produced. However, new materials have been introduced to aerospace, nuclear, medical and automotive industries, and some of them are called difficult-to cut materials such as heat resistant materials, super alloys, composites, titanium, nickel, tool steels, stainless steels, hardened steels, etc. They have higher hardness and higher strength comparing to other Engineering materials.

1.1 MACHINING PROCESS

Machining is the broad term used to describe removal of material from a work piece. Includes Cutting, Abrasive Processes (grinding), Advanced Machining Processes (electrical, chemical, thermal, hydrodynamic, lasers). Machining processes, which include cutting, grinding, and various non- mechanical chip less processes, are desirable or even necessary for the following basic reasons: (1) Closer dimensional tolerances, surface roughness, or surface- finish characteristics may be required than are available by casting, forming, powder metallurgy, and other shaping processes; and (2) part geometries may be too complex or too expensive to be manufactured by other processes. However, machining processes inevitably waste material in the form of chips, production rates may be low, and unless carried out properly, the processes can have detrimental effects on the surface properties and performance of parts.

2. MATERIAL SELECTION En 19 steel has a carbon content of 0.38% and the commonest form of steel as it provides material properties that are acceptable for several automobile applications such as significant duty gear, shaft, pinion, camshafts and gudgeon pins. It's neither outwardly brittle nor ductile due to its lower carbon content and lower hardness. Because the carbon content will increase, the metal becomes more durable and stronger.

2.1 Properties of EN 19 alloy steel

S.NO	PROPERTIES NAME	VALUE
1.	Elastic limit	190 Gpa
2.	Yield Strength	600 Mpa
3.	Ultimate strength	580 Mpa
4.	Tensile strength	950 Mpa
5.	Thermal Conductivity	13.3 W/Mk(350°C)
6.	Hardness	Max 200HB

2.2 Chemical composition

C	Mn	Cr	Si	S	Fe
0.30-0.45%	0.6-1.0%	0.70 %	0.19 %	0.19%	BALANCE

3. EXPERIMENT PROCEDURE

The experiments were performed on the lathe with different feeds, speeds, depth of cut and work piece temperature is summarized in table K20 carbide as a tool and EN19 alloy steel with 20mm diameter as work piece used in these experiments. The chemical composition of these material is shown in table4.1.experiments are conducted by using the oxy acetylene heating setup for heat the work piece. oxy acetylene heating is one of the best choice of hot machining because it requires low equipment cost the heat transfer of work piece is very low. Metallurgical damage of the work piece is very low. Hot machining setup is shown in fig the temperature of the work piece is measured by using Infrared thermometer. The surface roughness's of the work piece are measured by mitutoyo surf test. Material removal rate was calculated by using the formula for given below.

MRR = VxDxF

Where,

V – cutting speed, f – feed rate, d – depth of cut.

3.1 CUTTING PARAMETERS

CUTTING PARAMETERS	LEVELS			UNITS
	1	2	3	
CUTTING SPEED	25.13	31.41	37.69	m/min
FEED RATE	0.2	0.3	0.4	Mm/rev
DEPTH OF CUT	0.5	0.75	1.0	cm
TEMPERATURE	200	300	400	˚C

3.2 EXPERIMENTAL SETUP

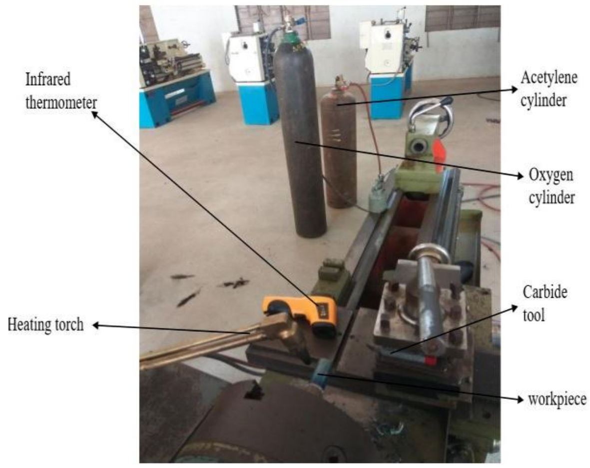
The substrate material we are going use is an EN 19 alloy steel. The experimental setup mainly includes a turning center (lathe machine), and it is consists of the Experimental Setup which we have implemented. Work piece is mounted between lathe headstock and tail stock, and in front of tool carriage the fixture is mounted. This experimental setup mainly consists of seven important components and they are as follows:

Heating Torch and Infrared Thermometer

Oxy-Acetylene Cylinder

Chip Formation of Normal Machining

Chip Formation of Hot Machining



Experimental Setup

4. CHARACTERISTICS

4.1. Surface Roughness

If you look at machined parts, you will notice that their surfaces embody a complex shape made of a series of peaks and troughs of varying heights, depths, and spacing. Surface roughness is defined as the shorter frequency of real surfaces relative to the troughs. A product's exterior cover, a vehicle's dashboard, a machined panel---the differences in appearance, specifically whether something is shiny and smooth or rough and matte, are due to the difference in surface roughness.

Surface roughness test machine

4.2. Material Removal Rate

Finishing -Achieves final dimensions, tolerances, and finish, Low feeds and depths, high cutting speeds.

Material removal rate was calculated by using the formula

MRR = Vxdxf

Where

V– cutting speed, f – feed rate, d – depth of cut

4.2. Micro Hardness Test

Micro Hardness Tester/Vickers Hardness Tester is a key piece of equipment that is in dispensable to metallographic research, product quality control and the development of product certification materials. Standard specifies making indentation with arrange of loads using a diamond indenter which is then measured and converted to a hardness value. For this purpose as long as test samples are carefully and properly prepared, the Vickers/Micro hardness method is considered to be very Useful for testing on a wide type of materials, including metals, composites, ceramics, or applications such as testing foils, measuring surface of a part, testing individual microstructures, or measuring the depth of case hardening by sectioning a parts and making a series of indentations.

Micro Vickers Hardness Tester

4.4. L9 Orthogonal Array

S.NO	CUTTING SPEED	FEED RATE	DEPTH OF CUT	TEMP ˚C
1.	25.13	0.2	0.5	200
2.	31.41	0.3	0.7	300
3.	37.69	0.4	1.0	400
4.	31.41	0.3	0.7	300
5.	37.69	0.4	1.0	400
6.	25.13	0.2	0.5	200
7.	37.69	0.4	1.0	400
8.	31.41	0.3	0.7	300
9.	25.13	0.2	05	200

5. RESULTS & DISCUSSION

Actual machining has to be done. The material removal rate was found out by using the formula. The surface roughness was to be found out by using Surface roughness testing equipment. By feeding the different cutting parameters like (Cutting Speed, feed, depth of cut & temperature) value into this Minitab18 software. By using this software we have to found out Signal to Noise ratio, Mean & Standard deviation with related surface roughness (The larger is better).

5.1. Experimental Results

S.NO	Speed m/min	Feed Rate m/rev	Depth Of Cut Cm	Temp ˚C	Ra µm	MRR Cm^3/min
1.	25.13	0.2	0.5	200	1.32	2.513
2.	25.13	0.3	0.75	300	2.28	5.654
3.	25.13	0.4	1.0	400	1.51	10.052
4.	31.41	0.2	0.5	200	1.77	3.141
5.	31.41	0.3	0.75	300	2.22	7.067
6.	31.41	0.4	1.0	400	1.67	12.564
7.	37.69	0.2	0.5	200	1.89	3.769

8.	37.69	0.3	0.75	300	3.18	8.417
9.	37.69	0.4	1.0	400	2.69	15.076

Experiment result

5.2. Material Removal Rate(MRR)

Material removal rate was calculated by using the formula

MRR = V×f×d

Where

V – cutting speed ,f – feed rate ,d – depth of cut.

1. job 1 (MRR)

MRR = 25.13×0.2×0.5

= 2.513 Cm^3/min

2. Job 2 (MRR)

MRR = 25.13×0.2×0.75

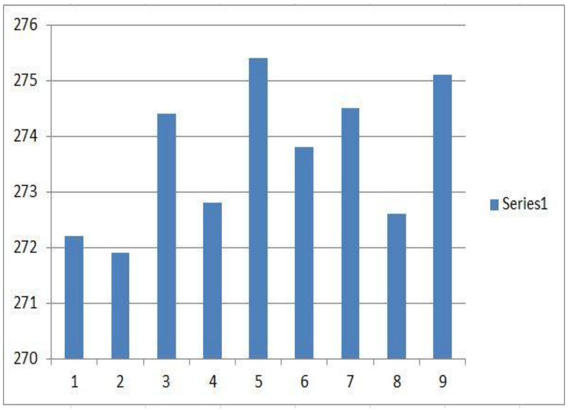
= 3.769 Cm^3/min

5.3. Micro Vickers Hardness Testing Result

S.NO	LOAD (Kg)	Hardness Value	Average
1.	10	272.2	274.5
2.		271.9	
3.		274.4	
4.	20	272.8	
5.		275.4	
6.		273.8	
7.	30	274.5	
8.		272.6	
9.		275.1	

Micro Hardness Testing Results

The micro hardness are to check the Vickers harness testing machine and three different level is used to find the value. The levels are hot machining for 200°C, 300°Cand 400°C and also less amount of hardness values are change in original hardness value for 277HV.



Graph for micro hardness results

5.4. ANOVA analysis for EN 19 alloy steel using hot machining

The calculation of the SN for the first experiment in the array above is shown below for the case of a specific target value of the performance characteristic. In the equations below, yi is the mean value and si is the variance. yi is the value of the performance characteristic for a given experiment.

$$SN_i = 10 \log \frac{\bar{y_i}^2}{s_i^2}$$

Where

$$\bar{y}_i = \frac{1}{N_i} \sum_{u=1}^{N_i} y_{i,u}$$

$$s_i^2 = \frac{1}{N_i - 1} \sum_{u=1}^{N_i} (y_{i,u} - \bar{y}_i)$$

Where,

i=experiment number,

u=Trail number,

Ni =number of trails for experiment

For the case of minimizing the performance characteristic, the following definition of the SN ratio should be calculated:

$$SN_i = -10 \log \left(\sum_{u=1}^{N_i} \frac{y_u^2}{N_i} \right)$$

For the case of maximizing the performance characteristic, the following definition of the SN ratio should be calculated:

$$SN_i = -10 \log \left[\frac{1}{N_i} \sum_{u=1}^{N_i} \frac{1}{y_u^2} \right]$$

Signal To Noise Ratio	Mean	Standard Deviation
4.1527	0.87186	1.8965
8.7016	1.08117	3.0045
6.4733	2.45083	3.2930
6.8993	1.44886	2.7445
9.5416	2.38578	3.9670
6.9062	4.27022	4.6195
8.2406	2.16799	3.4930
12.2068	3.12470	5.3295
11.3948	5.18451	6.3860

5.5 Minitab Outputs

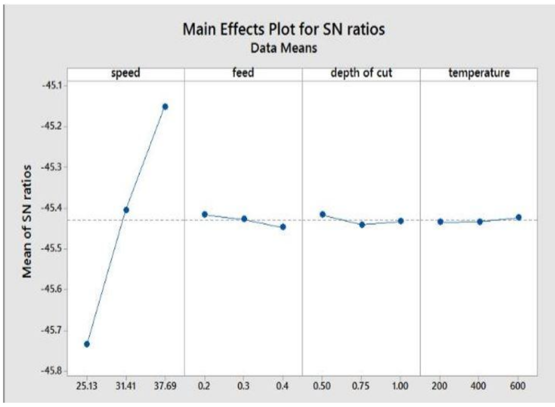
Design Summary

Taguchi Array L9 (3^4)

Factors: 4

Runs: 9

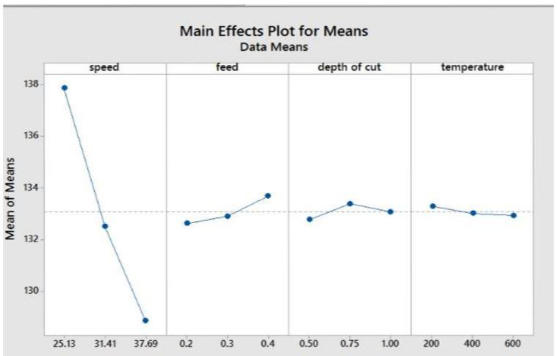
Level	Cutting speed	Feed	Depth Of Cut	Temp˚C
1	4.337	4.233	5.370	5.998
2	5.317	8.016	6.802	5.644
3	8.140	5.545	5.622	6.152
Delta R	3.803	3.782	1.432	0.508
Rank	1	2	3	4



Main Effects Plot for Signal to Noise Ratio

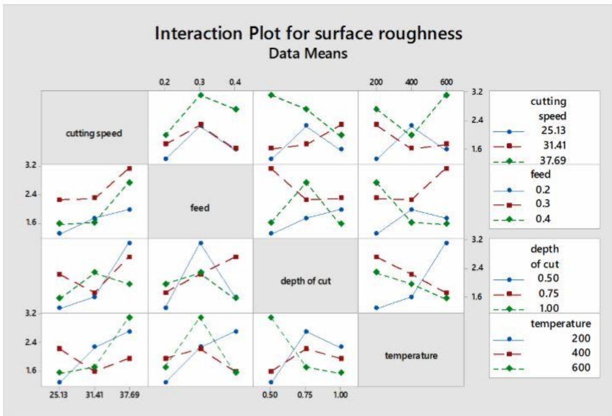
Level	Cutting speed	Feed	Depth Of Cut	Temp˚C
1	1.693	1.653	2.000	2.093
2	1.867	2.547	2.227	1.933
3	2.600	1.960	1.933	2.133
Delta R	0.907	0.893	0.293	0.200
Rank	1	2	3	4

Average Means and Rank



Main effect plot for means

This gives the complete interactions among all the process parameters at all the parametric levels in surface roughness



Interaction Plot for Surface Roughness

6. CONCLUSION

The hot machining experiment is carried out on EN 19 alloy steel successfully and the characterization and optimization of the work pieces successfully.

Hence the following conclusion have been evaluated by applying taguchi analysis on hot machining of EN 19 alloy steel.

1.The experimental results shows that cutting speed (31.41 m/rev), depth of cut (0.75 mm), Work piece temperature (400°c) and feed rate(0.3mm) will give the

optimal results for hot machining of steel by using optimization using taguchi method.
2. From the optimization shows the cutting speed has most significant factor 46.42% in contribution ratio, while feed rate has 30.23%and depth of cut 12.19%influencing on the surface roughness and metal removal rate in hot machining of EN 19 alloy steel.
3. The hot machining process is the optimal and cost effective method for machining hard alloy like to super alloys comparing to unconventional machining process.

7. REFERENCES

[1.] Chakradhar.D, Multi objective optimization of hot machining of 15-5PH stainless steel using grey relation analysis , Procedia Materials Science 5 (2014) 1810 – 1818.

[2.] Dadapeer.B, Machining Studies of EN-353 Steel Using Taguchi Technique by Turning Operation , Journal of Multidisciplinary Engineering Science Studies (JMESS) Vol. 1 Issue 1, November – 2015.

[3.] M. R. Jadhav, Experimental study of surface integrity of Al/SiC particulate metal–matrix composites in hot machining, 48th CIRP conference on manufacturing system-2015, PP.914-919.

[4.] kalipada maity, Effect of nose radius on force, and process parameter in hot machining of Inconel 718 using finite element analysis, engineering science and technology, an international journal 20 (2017), PP. 687-693.

[5.] Mehmet Alper, Effects of Cutting Tool Parameters on Surface Roughness, International Refereed Journal of Engineering and Science Volume 4, Issue 8 (August 2015), PP.15-22.

[6.] R. D. Rajopadhye, Experimental Setup for Hot Machining Process to Increase Tool Life with Torch Flame, IOSR Journal of Mechanical and Civil Engineering, PP: 58-62.

[7.] R. D. Rajopadhye, Experimental Setup for Hot Machining Process to Increase Tool Life with Torch Flame, IOSR Journal of Mechanical and Civil Engineering, PP: 58-62.

[8.] Shalom akhai Comparison of Surface Hardening Techniques for En 353 Steel Grade by, et al.,International journal conference, PP 194-203.

[9.] P. Tamil arasu, Effect of Hardness and Microstructure on En 353 Steel by Heat Treatment, International Journal Of Engineering And Science, Vol.2, Issue 11 (April 2013), PP 01-05.

[10.] Vincent wagner, An Experimental Investigation of Hot Machining with Induction to Improve Ti-5553 Machinability, (2011) applied mechanics and materials, vol. 62. PP. 67-76.