OPTIMIZATION OF HOT MACHINING USING TAGUCHI METHOD

A thesis submitted in partial fulfillment of the requirement for the degrees of

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In

Mechanical Engineering

By

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of

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Certificate

This is to certify that the thesis entitled "**OPTIMIZATION OF HOT MACHINING USING TAGUCHI METHOD"** submitted by **ARUNESH LENKA (108ME059)** in fulfillment of the requirement for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is a genuine work carried out under my supervision.

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CONTENTS:

Abstract:

The production of exotic and smart materials has become highly in dispensable to satisfy the robust design requirements for aerospace and defense sector. The machining of these materials has posed a great challenge in industries. In this study, work piece is softened by heating and thereby shear strength is reduced. The work piece used in this process is Ni hard material, from this experiment the cutting force and the tool wear is calculated. The work piece was heated at different temperatures, and the power was calculated using an ammeter and voltmeter. The cutting force was eventually developed using the power used and the cutting velocity.

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Chapter -1

INTRODUCTION

1. Introduction:

The production of exotic and smart materials has become highly in dispensable to satisfy the robust design requirements for aerospace and defense sector. The machining of these materials has posed a great challenge in industries. It requires cutting tool of high strength, which is very costly, and sometimes it is even impractible.non-conventional machining process, another viable method, is mostly restricted to small scale removal o material. For bulk removal of materials, the growing interest for hot machining is being developed in industry. In this method work piece is softened by heating and thereby shear strength is reduced. In hot machining, heat is applied to the work piece to reduce its shear strength in the vicinity of the shear zone. The use of hot machining has become very useful in the machining of high strength temperature-resistant (HSTR) alloys. Hot machining has two functions to perform, one, to machine some HSTR alloys which are unmachinable in the conventional machining method. Second, to improve tool life this eventually improves the production rate.

There are various techniques of hot machining which are subjected to requirements. The penetration of heat should be such that the shear zone is appreciably affected. Input rate of heat must be commendably high, so as to temperature sufficiently and quickly. Thermal damage done to work piece through distortion should be minimum. The installation and operation cost should be minimum. The operators in the operation should take safety measures into account. Temperature control should be quickly obtained.

Different Hot-Machining techniques adopted [1]

Furnace heating method

Advantages;

Simple and relatively cheaper

Disadvantages;

Distortion on cooling

Unsuitable for long operation

Safe handling difficult

Flame heating method

Advantages;

With multi-flame fixtures large specific heat inputs are possible.

Disadvantages;

Localization of heat is difficult.

Dangerous to operator.

Arc heating method

Advantages;

High specific heat inputs can be supplied

Disadvantages;

Heating is not very uniform.

Dangerous to operator.

Resistance heating method

Advantages;

It is easy to handle and user-friendly.

No distortion on cooling.

Disadvantages;

Temperature obtainable is limited to that which will not cause damage to the bulk material.

Inductive heating method

Advantages;

Very clean and safe for operation purposes.

High specific heat input and quick temperature rise.

Disadvantages;

High equipment cost

Intricate work piece shapes are difficult to accommodate.

Work piece material must be magnetic

Depth of penetration is limited

Radio-frequency resistance

Advantages;

Heating takes place over a small area.

High specific heat input and quick temperature rise.

Disadvantages;

Work piece material must be magnetic.

High equipment cost.

Electric current heating

Advantages;

Clean and easy to handle.

Readily adaptable and control is easy.

Disadvantages;

Tool material must be conductive therefore cannot be used with ceramics.

Friction heating method

Advantages;

Initial and operating costs low.

Disadvantages;

Cannot be used for intricate work shapes.

Chapter -3

LITERATURE REVIEW

3. Literature review

Study on different techniques of hot-machining and various process involved were analyzed. The review consists of various journals which are also mentioned at adequate places.

KunioUehara, Mitsuru Sakurai, Hideo Takeshita [1], carried out a study on electric hot machining, in which the work piece is heated by electric currents which flows through the cutting point.It was found that the coated carbide tools exhibited a good cutting performance especially on the tool wear, and that the cause of this phenomenon is due to low electric resistance of base metal of the coated tools and high wear resistance of the coated layers.

k.P Maity and P.k swain [2],carried out an experimental investigation of hot machining of hot machining to predict tool life. The work piece used in the process was high manganese steel and a carbide cutting tool was used to machine it. The heating was done to reduce the hardness of the work piece. Since high manganese steel is hard and the tool will break during machining operation, heating is done on the work piece using liquid petroleum gas and oxygen as the flame source. A tool life equation is thus formed using taguchi method

Nihattosun and latifozler,[3] carried a hot machining operation using high manganese steel and liquid petroleum gas flame. A mathematical model was attained for the tool life using regression analysis method. In addition the tool life was also attained using artificial neural network(ANN).At the end both the tool life equation were compared.

KunioUehara, Hideo Takeshita [4], carried out study on acutting technique which enabled the high rate machining of engineering ceramics. They carried out the process through hot machining technique. The cutting force, chip form, surface roughness and tool wear were measured. It was observed that with rise in temperature the ceramics changed from brittle fracture type to plastic deformation type. It was concluded that the surface roughness and tool life were improved by hot machining.

D.K PAL AND S.K BASU, [5],carried out an analysis on the effects of various cutting parameters while machining operation on austenitic manganese steel at high temperatures. Investigations were made on the evaluations of tool life and its dependence on work piece temperature and relative cutting speed were studied empirical relations were also suggested while calculating the tool life.

V.Raghuram and M.K.Muju, [6],presented a paper on the wear results of tungsten carbide tools rubbing against En-24 steel. Tests were performed under hot machining conditions and test results indicated that an external magnetic field can be superimposed in hot machining conditions with the results of reduced tool wear.

N.N.S Chenand K.C Lo, [7], presented a paper on the results of experiment investigation into the factors which affect tool wear in direct current method of hot machining alloy steels. Materials which are of different hardness were machined using several grades of carbide tools. The range of cutting speeds and heating current were also set. Improvements in tool life were recorded.Results also indicate that, for a given machining condition, there exist optimum values of cutting speed and heating current for either maximum or minimum tool life, depending on the polarity of the cutting tool.

T. Akasawaa, H. Takeshitab,K. Ueharab ,[8],carried out an analysis in which the machining steels as the intermediate removing means of the hot forging process will be a significant application of the hot machining. It is predicted that the cooling of the cutting tools is effective for improving the performance of the hot machining of this field. Several problems are examined experimentally. The cermets tools show most suitable nature. The tool life of 8 hours is obtainable in the hot machining of low carbon steels. A cooling method for the cutting tool is contrived and tested. The cooling of the cutting tool is very effective for reducing the tool wear in the hot machining.

Chapter -4

DESIGN OF EXPERIMENT

4. Design of experiment

Tool and Material

In this study, the work piece used was High manganesesteel.The tool used was carbide tool. The work piece was initially centered for easy machining. Due its hardness, it was initially not possible to machine it and fit it in the chuck. Eventually, the work piece was reduced, and its diameter the time of machining of was measured to be 24.5 mm.

Plan of experiment

First, the machine is started using switch button. The chuck to which the work piece is attached to one side and the tailstock on the other side. The chuck is rotated in anti-clock wise direction. The energy meter which gives the power reading and the temperature recorder is set. The four parameters cutting velocity, feed, depth of cut and temperature are adjusted. The tool is then put in contact with the work piece and the readings are calculated. The cutting velocity parameter consisted of readings,19.23 32.31 54.62, feed rate parameter consisted of readings, 0.06 0.07 0.1, the depth of cut consisted of readings,0.5 1 1.5, and the temperature parameter consisted of readings,64 200 35.The results were further analyzed using suitable software.

Chapter -5

EXPERIMENTAL Techniques

5. Experimental Setup and Methodology

Figure-1 (Experimental setup)

The Work piece

Figure-2(The Work piece)

Taguchi method

Taguchi analysis is the most widely used and efficient method for manufacturing design. Taguchi method shows an integration of design of experiments with optimizing of the given parameters to get the desired result.taguchi's signal to noise ratio's which are logarithm functions of the required output serve as functions for optimization. In order to find out optimal solutions in manufacturing design, Taguchi method utilizes signal to noise ratio. The signal to noise ratio is used because it takes both the mean and variance into account. It is defined as the ratio of mean value (signal) to standard deviation (noise).

The main objective in this work is to maximize the S/N ratio.

Chapter -6

EXPERIMENTATION

6. Experimentation

The work piece used was High Manganese steel. The input parameters are cutting velocity, feed rate, depth of cut and temperature. The output parameters were cutting force and tool wear. Thepower consumed was calculated for cold working i.e. in room temperature and for hot working. In hot working different temperatures were used for different input parameters.

Readings for calculation of power consumption (Hot Working)

Current (I)	Voltage(v)	Temperature(T)	Power(kw)	Force (N)
4.7 amp	402 V	Cutting tool	2.6	49.998
4.6 amp	401 V	With cutting tool	2.5	48.075
4.5 amp	401 V	200 c	2.5	48.075
4.45 amp	401 v	250 c	2.4	46.152

Table-1

The work piece diameter was measured to be 2.45 cm.

The feed rate was measured as 0.06 mm/rev

The revolution of the work piece was measured as 420 mm/rev

The power was measured by 1.732*v*i*0.8

Power consumed reading Cold working process

Current (I)	Voltage(V)	Temperature(t)	Power (KW)	Cutting force (N)
4.44	402	25 C	2.4	46.15
4.5	401	25 C	2.5	48.07
4.45	401	25 C	2.6	49.99
4.6	402	25 C	2.59	49.80
4.7	402	25 C	2.6	49.99

Table-2

The power consumption in both hot working and cold working were measured. The difference was noted.

The cutting force was obtained by the Power and the cutting velocity. The power for hot machining was recorded to be 2.5 kw and the power for machining at room temperature was recorded to be 2.6 kw.

Design Of Experiment is based on the use of an orthogonal array for conducting small and highly fractional experiments up to larger and full factorial experiments. The use of orthogonal arrays is just one methodology to design an experiment, the various parameters affecting a work piece during machining can be cutting velocity, feed, depth of cut and temperature of work piece.. Here we use L_9 with 3 levels where the total no of experimental run is nine. In this present work, the number of process parameters are 4, namely, cutting velocity, feed, depth of cut and temperature. All these

Factors	Notations/units	Code	Level of factors	Level of factors	Level of factors
Cutting speed	Vc (mm/min)	A	19.23	32.31	54.62
feed	S (mm/rev)	B	0.06	0.07	0.1
Depth of cut	D (mm)	C	0.5	1	1.5
Temperature	T (degree Celsius)	D	64	200	350

Table 3 (Parameter value)

parameters are controllable.

No of factors=4 and the No of Runs= 9.

Response Table

Run Order	Power (W)
1	750
2	730
3	710
4	800
5	730
6	710
7	990
8	950
9	

Design of experiment using grey based relational Taguchi method.

Cutting speed (Vc)	Feed (s)	Depth of cut (d)	Temperature(T)	S/N Ratio	Mean
19.23	0.06	0.5	64	57.5012	750
19.23	0.07	1	200	57.2665	730
19.23	1	1.5	350	57.0252	710
32.31	0.06	1	350	58.0618	800
32.31	0.07	1.5	64	57.2665	730
32.31	1	0.5	200	57.0252	710
54.62	0.06	1.5	200	59.9127	990
54.62	0.07	0.5	350	59.5545	950
54.62	1	1	64	59.0849	900

Table-4(Experiment using grey based Taguchi method)

Factor levels for Prediction	Predicted S/N value	Predicted Mean value
Feed rate: 0.06, Cutting Speed: 19.23 Temperature: 64 Depth of Cut:0.5	-57.5012	750

ANOVA TABLE FOR S/N RATIO:

Source	Degree of freedom	Seq. SS	Adj. SS	Adj. MS	F	P
cutting velocityVc)	2	9.3804	9.3804	4.69019	0.322	0.455
feed (s)	2	0.9236	0.92359	0.46180	1.23	0.98
depth of cut(d)	2	0.0188	0.01880	0.00940	0.56	0.67
temperature (t)	2	0.1401	0.10413	0.05207	0.78	0.57
Residual Error	*	*	*	*	*	*
Total	8	10.4269	*	*	*	*

Table-5 (anova table for S/N ratio and means)

ANOVA TABLE FOR MEANS:

Source	Degree of freedom	Seq. SS	Adj. SS	Adj. MS	**F**	**P**
cutting velocityVc)	2	8722.2	8722.2	43611.1	0.31	**0.97**
feed (s)	2	8155.6	8155.6	4077.9	0.45	0.56
depth of cut(d)	2	88.9	88.9	44.4	0.67	0.98
temperature (t)	2	1088.9	1088.9	544.4	0.45	0.95
Residual Error	*	*	*	*	*	*
Total	8	96555.6	*	*	*	*

Response Table for Signal to Noise Ratios
Smaller is better

Level	Cutting velocity (Vc)	Feed (S)	Depth of cut (D)	Temperature(T)
1	57.26	58.49	58.03	57.95
2	57.45	58.03	58.14	58.07
3	59.52	57.71	58.07	58.21
Delta	2.25	0.78	0.11	0.26
Rank	1	2	3	4

Table-3(Response Table for S/N ratio)

Response Table for Means:

Level	Cutting velocity (Vc)	Feed (S)	Depth of cut (D)	Temperature(T)
1	730.6	846.7	803.3	793.3
2	746.7	803.3	810.0	810.0
3	946.7	773.3	810.0	820.0
Delta	216.7	73.3	6.7	26.7
Rank	1	2	3	4

Table-3(Response Table for Means)

Chapter -7

GRAPHS

7. Graphs

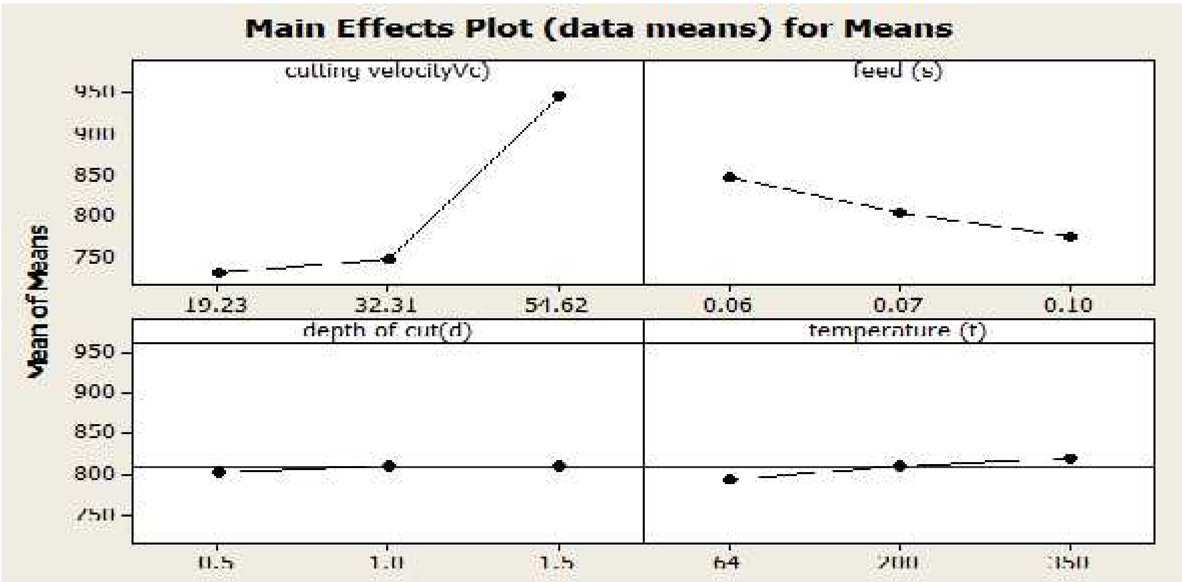

Figure-3

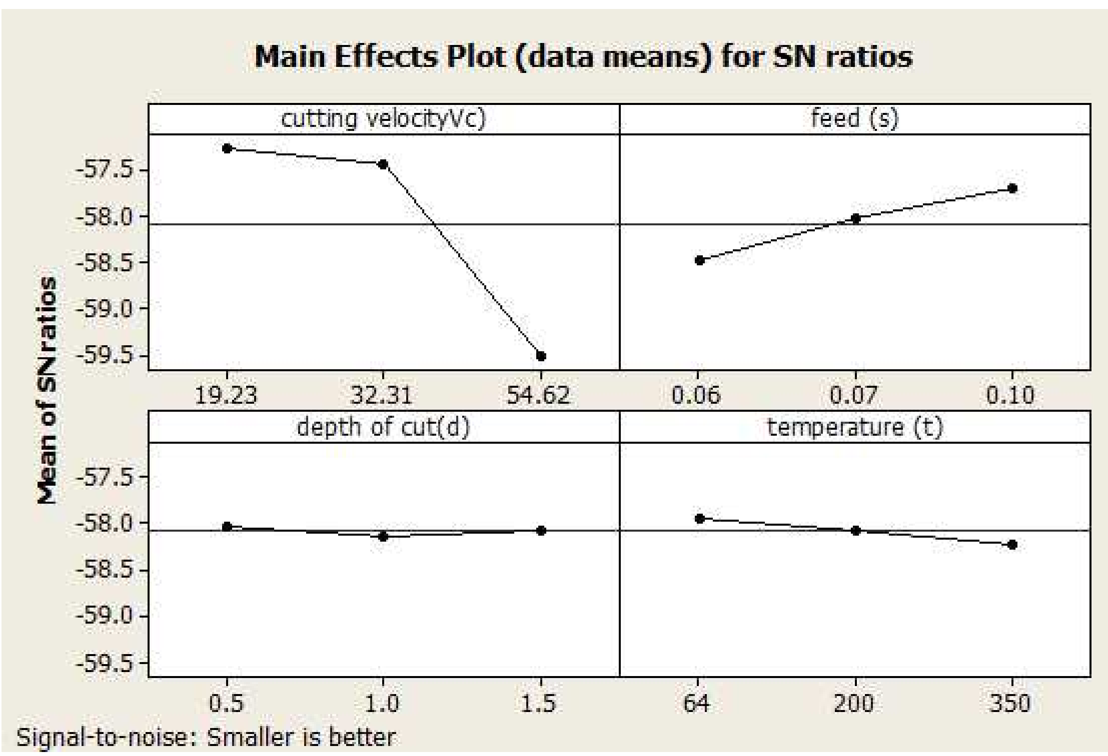

Figure-3

Chapter -8

CONCLUSION

8. Conclusion

1) The requirement of power and cutting force is less than that of machining at room temperature. Reduction in power is measure to be 100 Watt.

2) A Design of experiment using taguchi method had carried out and the optimal value for minimizing power areFeed rate: 0.06, Cutting Speed: 19.23, Temperature: 64, Depth of Cut: 0.5.

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