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Hot Machining on OHNS Steel

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***Abstract*- In the modern world, there is a need of materials with very high hardness and shear strength in order to satisfy industrial requirements. So many materials which satisfy the properties are manufactured. Machining of such materials with conventional method of machining was proved to be very costly as these materials greatly affect the tool life. So, to decrease the tool wear, power consumption and better surface finish Hot Machining is preferred. The work piece is heated below its recrystallization temperature, so as to reduce the shear strength of the material. From the past experiments, it was found the power consumed during turning operations is primarily due to shearing of the material and plastic deformation of the metal removed. Since both the shear strength and hardness values of engineering materials decrease with increase in temperature, it was thus postulated that an increase in work piece temperature would reduce the amount of power consumed for machining and eventually increase tool life. For this the Input parameters are Feed and Speed, Depth of Cut and the Output Parameters are Tool wear, surface roughness, Material Removal Rate. Hot machining is carried out on OHNS steel with oxyacetylene flame for heating the work piece. Titanium aluminium nitride coated carbide is employed as the cutting tool. The result indicates significant improvement in surface finish, material removal rate and reduction in tool wear.**

Keywords- Hot machining, OHNS steel, titanium aluminium nitride coated carbide.

I. INTRODUCTION

Hot machining is the process which is used for easy machining and to eliminate the problems of low cutting speed, feeds and heavy loads on the machine bearings. These problems arise when machining process is being done on the new and tough materials. The basic principal behind this process is the surface of the work piece which is to be machined is pre-heated to a temperature below the re-crystallization. By this heating, the shear force gets reduced and machining process becomes easy. During the machining process, instead of increasing the quality of the cutter materials, softening of the work piece is one of an alternate. In hot machining, a part or whole of the work piece is heated. Heating is performed before or during machining. Hot machining prevents cold working hardening by heating the piece below the recrystallization temperature and this reduces the resistance to cutting and consequently favours the machining. Hot machinable materials are classified in four groups according to their composition and properties. These classes are Chilled cast iron. Steel with hardness over 50HRC,steel those surfaces is hardened with cobalt, Steels hardened by cold working

The selection of a heating method for obtaining ideal heating of metals for machining is critical. Faulty heating methods could induce unwanted structural changes in the work piece and increase the cost. In research, many heating methods are utilized. The methods mostly used are electrical resistance and plasma arc heating. Some of the advantages of hot machining process are Easy formation of chip, Lessened shocks to the tools, Good surface finish of the work piece

It is one of the easiest methods of heating. In this process, oxyacetylene gas is employed when high concentration of heat is required. The equipment required for this method is relatively inexpensive and is very effective in milling narrow jobs. But when it is employed for wider jobs problem of localization of heat arises. Another problem which may arise due to this process is oxidation. If this happens post machining is required

II. LITERARY REVIEW

A. Chin-Wei Chang, Chun-Pao Kuo (2007) Conducted an experiment on laser-assisted machining (LAM) as an economical process for manufacturing precision aluminium oxide ceramic parts. Because it is locally heated by an intense laser source prior to material removal, LAM leads to higher material removal rates, as well as improved control of work piece properties and geometry. To assess the feasibility of the LAM process and better understand its governing physical phenomena, experiments were conducted to obtain different measures of surface roughness for Al2O3 work pieces machined by laser-assisted turning using an Nd: YAG laser. The experimental results were analyzed using the Taguchi method, which facilitated identification of optimum machining conditions. The

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findings indicate that rotational speed, with a contribution percentage as high as 42.68%, had the most dominant effect on LAM system performance, followed by feed, depth of cut, and pulsed frequency. LAM's most important advantage is its ability to produce much better work piece surface quality than does conventional machining, together with larger material removal rates (MRR) and moderate tool wear.

B. D.K. pal and S.K. Basu (1969) Hot Machining of austenitic Manganese steel by shaping, in this paper they analysis the effects of various cutting parameters while machining austenitic high manganese steel at an elevated temperature in a Shaping machine. This investigation makes an evaluation of the tool life and studies its dependence on work piece temperature and relative cutting speed. Empirical relationships are also suggested for calculating the values of the cutting forces. For Hot hardness test for high manganese steel was carried out in a Rockwell hardness tester with water-jacketed carbide tipped in dentor. For the measurement of cutting forces, the authors used a three-dimensional strain gauge type dynamometer Tool life does not go on increasing with the increase in the temperature of the work piece. Thus there is an optimum value of cutting speed when the tool life curve, plotted against speeds, gets a sudden break-back. From the measurement of forces, it was found that both cutting and thrust force were independent of speed in hot machining. This, so far as the effect of cutting speed is concerned, is quite similar to the conventional machining process at room temperature.

C. Maity.K.P, Swain.P.K, (2008) Conductedan experimental investigation of Hot-machining to predict tool life an experimental investigation had been carried out for hot-machining operation of high manganese steel using a carbide cutting tool. The heating of the work-piece was carried out by burning a mixture of liquid petroleum gas and oxygen. An expression of tool life as a Function of cutting speed, feed, depth of cut and temperature was developed using regression analysis. The adequacy of the model was tested. The effects of cutting conditions on tool life were also investigated. The functional relationship of the tool life T and variables cutting speed VC, feed s, depth of cut t were assumed the chip-reduction coefficient reduces with increase in temperature. Hence the machinability of the material improves with increase in temperature. The variation of average non-dimensional tangential cutting force FC and effect of cutting parametersthe effects of different cutting parameters on tool life are analyzed andrepresent tool lives corresponding to low and high level of cutting velocity, feed, depth of cut and temperature It is evident from that tool life is greatly influenced by work piece temperature and cutting speed. The significance of feed on tool life is more than thedepth of cut. There is increase in tool life with decrease of cutting speed, feed and depth of cut but tool life increases withincrease in work-piece temperature. The limiting highest temperature will be the recrystallisation temperature of work piece, as higher heating temperature beyond that may induce unwanted structural changes in the work-piece material. A tool life equation is developed for machining hardened high manganese steel for hot-machining operation. The modeladequacy is tested using test. The tool life is influenced by work-piece temperature, cutting speed, feed and depth ofcut in that order. So the effect of temperature of work-piece is found to be the most significant on tool life. However, therecrystallisation temperature of work-piece limits the maximum value of temperature. The chip-reduction coefficient decreases with increase in temperature.

D. Nihat Tosun, Latif Ozler (2002) study of tool life in hot machining using artificial neural networks and regression analysis method, In this study, the high manganese steel specimens heated with liquid petroleum gas flame were machined on a lathe under different cutting conditions of feed rates, depth of cuts, cutting speeds and surface temperatures. A mathematical model for tool life was obtained from the experimental data using a regression analysis method. In addition, the tool life was estimated using artificial neural network (ANN) with back propagation (BP) algorithm. Then, this program was trained and tested. Finally, the experimental data are compared with both the regression analysis results and the estimations the experiments illustrate that the tool life has increased much in hot machining of the manganese steel specimens with respect to that of the room temperature machining. The longest tool life has been obtained at 600ºC machining. The tool life obtained at 600ºC machining is approximately same as the tool life obtained at 400ºC machining. Consequently, 400ºC machining is the optimum heating temperature if we consider the microstructure of the work piece and the cost. The tool life has decreased when the cutting speed Has been increased. And the results indicate that ANNs were giving better result with respect to regression analysis method. In addition, it is shown that ANNs can be used as an effective and an
Alternative method for the experimental studies that's the mathematical model cannot be formed.

E. N. N. S. Chenn and K. C. Lot (1973) Conducted Factors affecting tool life in hot machining ofAlloy steels this paper presents the results of experimental investigation into the factors affecting tool wear in direct current method of hot machining alloy steels. Materials of different hardness's were machined using several grades of carbide tools, over a range of cutting speeds and heating current. Considerable improvement

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in tool life was 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. Proper balance between the thermal conductivity, thermoelectric power and wear resistance properties of the tool material was found to be essential in prolonging tool life from the study indicates a considerable improvement of tool life over conventional machining when hot machining with negative tool polarity. Depending on the tool material used and the heating current applied.

F. G. Madhavulu and Basheer Ahmed (1994)Hot machining process for improved metal removal rate in turning operation, applied a plasma arc to soften a work piece zone just in front of the cutting tool, this paper deals with the Hot Machining Process, for turning operations, which is designed to give improved metal removal rates, particularly on difficult-to machine metals. A high temperature plasma arc is used to provide intense localised heat, softening only the chip material, leaving the work piece relatively cool and metallurgical undamaged. The advantages of plasma arc hot machining are increased metal removal rates, machining hard and tough metals, increase in tool life, suitable for interrupted cuts, This paper discusses the results of productivity studies and economic viabilities of the Hot Machining Process, Finally they concluded that ess spindle power is required, in the hot machining process in comparison with conventional machining process. The reduction in power consumption is an indication of ease of machining at elevated temperatures. From the cost analysis, it was found that the cost of power was much smaller than tooling cost and the increased power of the hot machining process is of no consequence

III. EXPERIMENTAL PROCEDURE

A. DESIGN OF EXPERIMENT

DOE is a systematic approach to investigation of a system or process. A series of structured test are designed in which planned changes are made to the input variables of a process or system. The effects of the changes on a pre-defined output are then assessed.

In general usage, design of experiments (DOE) or experimental design is the design of any information-gathering exercises where variation is present, whether under the full control of the experimenter or not. However, in statistics these terms are usually used for controlled experiments. Another advantage of DOE is that it shows how interconnected factors respond over a wide range of values, without requiring the testing of all possible values directly.

All orthogonal vectors exhibit orthogonally orthogonal vectors exhibit the following properties:

- Each of the vectors conveys information different from that of any other vector in the sequence each vector conveys unique information therefore avoiding redundancy.
- On a linear addition, the signals may be separated easily.
- Each of the vectors is statistically independent of the others, the correlation between them is nil.
- When linearly added, the resultant is the arithmetic sum of the individual components.
- Used DOE to conduct experiments.
- Any of the two DOE methods can be used.
  - Factor at a time approach.
  - Factorial design
  - L9, L18, L27 are orthogonal arrays that can be derived.

The experimental work is carried in the lathe. The work piece material is OHNS (Oil Hardened Non Shrinkage steel). The cutting tool material is titanium aluminium nitride coated carbide tool. The dimensions of the work piece considered are 40 mm diameter & 100 mm length. Machining is carried in a rigid and PSG lathe using Titanium Aluminium Nitride coated carbide Tool. The machining process is carried out by varying the speed, feed, depth of cut. For each condition, separate work piece is used. These work pieces are taken from the same parent raw material as there should not be any deviations in the results obtained in the experiments due to the property change of the material although it is negligible. Similarly, for every combination of speed and feed a new cutting insert in used for machining purpose.

TABLE I. COMPOSITION OF OHNS STEEL

C%	Mn %	Si%	S %	P %
0.919	1.343	0.281	0.140	0.064
V%	Al %	Cu%	Sn %	W%
0.002	0.020	0.060	0.007	0.375
Cr%	Ni %	Mo%	Ti %	B%
0.570	0.127	0.059	0.004	0.00242
Co %	Nb %	Pb %		
0.021	0.004	0.001		

Carbide cutting surface are often used for machining materials such as carbon steel or stainless steel, as well as in situations where other tools would wear away, such as high-quantity production runs. Carbide generally produces a better finish on the part,

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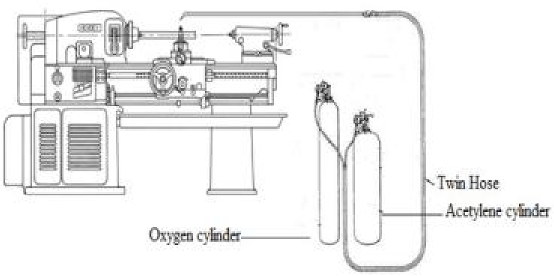
and allows faster machining. Carbide tool can also with stand high temperature than standard high speed tools. TiAlN is a widely-used coating in many applications



where previously TiN was being used. TiAlN coating is used in high temperature cutting operations with minimum use of lubricant. TiAlN has been successfully used to machine titanium, aluminium and nickel alloys, stainless steels, alloy steels, and cast irons. This coating is also used to protect dies and molds that are operated at high temperatures in industries. The colour of TiAlN coating is dependent on the ratio of AlTiN and therefore can range from black to bronze. The thickness of the TiAlN coating ranges between 2 to 4 microns and the Oxidation temperatures between 1652°F/ 900°F. The hardness is typically Hv2800.Properties of TiAlN coated carbide insert are Coating thickness: 0.0025mm - 0.005mm, Hardness: 4000 – 4200 Hv, Deposition Temp: 700 – 800°F, This Coating is known as the "Black" titanium coating

Fig 1. Experimental setup

B. EXPERIMENTAL CONDITION

Work specimen: Oil Hardened Non-Shrinking Steel (θ 40 mm X 100 mm)

Cutting Tool: Carbide tool with Titanium aluminium nitride coating
Process Parameters:
Cutting speed: 140, 200, 250 rpm
(v)**:** 0**.**293,0. 418, 0.523 m/sec
Feed rate: 0.05, 0.1, 0.16 mm/ rev
Depth of cut: 0.5, 1, 1.5mm
Machining Environments: Dry and Hot conditions

C. INPUT PARAMETERS

For all metal-cutting processes speed and feed are important parameters. The colloquial term speed and feed refers to the speed, feed, and depth of cut of a metal-cutting process.
By the assist of L18 orthogonal array several conditions of input parameters are optimized. That optimized as follows

The input parameters for the Dry and hot machining as given below in the table

TABLE II. INPUT PARAMETERS

Speed (rpm)	Feed (mm/rev)	Doc (mm)
140	0.16	1.5
140	0.1	1.5
200	0.05	0.5
250	0.1	0.5
250	0.05	1
250	0.1	1
140	0.16	1
200	0.05	1.5
200	0.16	0.5
250	0.05	1.5
250	0.1	1.5
140	0.1	0.5
140	0.16	0.5
200	0.16	1
200	0.05	1
250	0.16	1
140	0.05	1.5
200	0.1	0.5

D. OUTPUT PARAMETERS

The output parameters are:

1. Material removal rate.
2. Surface roughness.
3. Wear length.

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IV. RESULT

A. MATERIAL REMOVAL RATE

Hot and dry machining is performed for the input parameters and material removal rate is measured, for each work piece

TABLE III. MATERIAL REMOVAL RATE FOR DRY AND HOT MACHINING

Sample	Speed	Feed	Depth of cut	MRR-dry	MRR-Hot
1	140	0.16	1.5	29.20	34.04
2	140	0.1	1.5	24.44	31.02
3	200	0.05	0.5	5.31	8.55
4	250	0.1	0.5	11.03	17.46
5	250	0.05	1	10.58	12.95
6	250	0.1	1	11.91	30.08
7	140	0.16	1	21.94	23.47
8	200	0.05	1.5	11.47	14.03
9	200	0.16	0.5	18.48	25.15
10	250	0.05	1.5	17.37	19.54
11	250	0.1	1.5	22.75	24.89
12	140	0.1	0.5	5.71	10.88
13	140	0.16	0.5	10.63	17.76
14	200	0.16	1	26.70	31.03
15	200	0.05	1	8.67	10.31
16	250	0.16	1	30.65	33.75
17	140	0.05	1.5	8.63	9.98
18	200	0.1	0.5	9.67	13.43

B. SURFACE ROUGHNESSES

After the machining is performed for all input parameters, the surface Roughness (Ra) is measured using TR200 Surface Roughness Tester, for each workpiece, the surface roughness is measured at 5 different places and the average value is taken as a surface roughness of the material.

TABLE IV. SURFACE ROUGHNESS VALUES FOR DRY AND HOT MACHINING

Sample	Speed	Feed	Depth Of Cut	Roughness Dry	Roughness Hot
1	140	0.16	1.5	3.7	1.4
2	140	0.1	1.5	4.3	1.17
3	200	0.05	0.5	2.143	0.874
4	250	0.1	0.5	2.3	0.89
5	250	0.05	1	3.23	1.289
6	250	0.1	1	1.536	1.244
7	140	0.16	1	3.73	1.4
8	200	0.05	1.5	3.266	0.874
9	200	0.16	0.5	3.47	1.202
10	250	0.05	1.5	2.827	1.212
11	250	0.1	1.5	2.82	1.263
12	140	0.1	0.5	4.307	0.898
13	140	0.16	0.5	2.608	1.362
14	200	0.16	1	3.692	1.341
15	200	0.05	1	3.565	0.957
16	250	0.16	1	2.3	1.19
17	140	0.05	1.5	1.602	0.97
18	200	0.1	0.5	3.48	1.047

C. TOOL WEAR

Hot and dry machining is performed for the input parameters the wear rate is measured, for each work piece

TABLE V. TOOL WEAR LENGTH FOR DRY AND HOT MACHINING

Sample	Speed	Feed	Depth Of Cut	Wear length-Dry	Wear length-Hot
1	140	0.16	1.5	0.07	0.035
2	140	0.1	1.5	0.06	0.015
3	200	0.05	0.5	0.04	0.035
4	250	0.1	0.5	0.063	0.015
5	250	0.05	1	0.05	0.067
6	250	0.1	1	0.035	0.02
7	140	0.16	1	0.041	0.026
8	200	0.05	1.5	0.08	0.12
9	200	0.16	0.5	0.067	0.06
10	250	0.05	1.5	0.041	0.052
11	250	0.1	1.5	0.035	0.035
12	140	0.1	0.5	0.031	0.02
13	140	0.16	1	0.043	0.04
14	200	0.16	1	0.041	0.035
15	200	0.05	1	0.03	0.037
16	250	0.16	1.5	0.081	0.073
17	140	0.05	1.5	0.063	0.01
18	200	0.1	0.5	0.06	0.056

V. CONCLUSION

The Hot and dry machining has been done on OHNS steel with Titanium aluminium nitrate coated carbide insert, and observations are noted. From the results plotted from the observation, following conclusions are made.

- For Depth of cut 1mm, speed 250rpm and feed 0.1mm/rev the Material Removal Rate of OHNS steel during dry machining is 11.9mm³/sec and hot machining is 30.8mm³/sec. From the observations Material Removal Rate of hot machining is 61.36% higher when compared to the dry machining, because of heating the work piece the cutting force get reduced due to softening of work piece surface.

- For Depth of cut 1mm, speed 250rpm and feed 0.1mm/rev Surface Roughness of OHNS Steel during dry machining is 1.54µ and hot machining is 1.24µ, From the observations Roughness of dry machining is 19.48 % higher when compared to the hot machining, because of reduction in shear force and due to easy peeling the work piece.

- For Depth of cut 1 mm, speed 250rpm and feed 0.1mm/rev Tool wear of OHNS steel during dry machining is 0.035mm and hot machining is 0.02 mm. From the observations wear length of dry machining is 42.8 % higher when compared to the hot machining, because in hot machining the tool wear is less due to softening of work piece by heating.

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