Experiment Investigation by using Hot Turning for Die Steel

Varun Shekhar[1]
School of mechanical and building science,
VIT University
Vellore- 632014 Tamil Nadu

Aditya Kulshestra[2]
VIT University
School of mechanical and building science,
Vellore- 632014 Tamil Nadu

***Abstract*-A significant amount work has been conducted for determine the effect of hot machining on hard materials by changing different parameters during machining. Numerous attempts have been made to approach this problem with experimental analysis. Here the work piece heated with oxyacetylene flame that reduce the hardness of material as material become soft and then machined under different parameters that is cutting speed, feed rate, depth of cut, and work piece temperature on a conventional lathe. The effect of cutting speed, feed rate, depth of cut, and the work piece temperature on surface roughness, tool life and cutting force have been optimized by conducting experiments. From experiments the optimum level of cutting parameters has been identified. Experiment results revel that feed rate and cutting speed are dominant variable on the performance and can further improve the hot turning process. Here statistics analysis is done by using Taguchi methods. As Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over variety of condition. The primary aim is to find factor settings that minimize response variation while adjusting the process on target. A process is designed with the aim of produce more consistent output. A process designed with this aim will produce more consistent performance regardless of the environment in which it is used. Taguchi method advocates the use of orthogonal array designs to assign the factors chosen for the experiment. The most commonly used orthogonal array designs are L8, L16, L9 (That means eight experimental trials), L16 and L18. But we are using L9 for our experiment purpose. The power of Taguchi method is that it integrates statistical methods into engineering process.**
Finally this paper is going to give graphical relationship of different parameters of machining such as feed rate, cutting speed and depth of cut with respect to force and surface roughness. Effect of temperature which is playing important role for machining is also discussed in this paper.

Keyword- Hot turning, Surface roughness, Die steel, Acetylene gas.

I INTRODUCTION:

With the development in the technology and science in the world there is requirement of such type of material which have very high strength and hardness. So different type of material which fulfill such properties are manufactured. Machining such type of materials with conventional method of machining was proved to be very costly as it affects the surface finish and the tool life. Hot turning comes into existence for increasing tool life, to improve the surface finish, to reduce cutting power required and for improving the machinability. Here we raise the temperature of the work piece which can be raised to several hundred or even thousand degree Celsius above ambient by using oxy-acetylene flame heating at tool-work interface. As we know the energy require or consumed during turning operation is due to shearing of the material and plastic deformation of metal removed. As with increase in temperature there is decrease in both the shear strength and hardness value of engineering materials so this means that increase in temperature result in increase in tool life and improvement in surface finish and reduction in amount of power consumed for machining. In hot machining of die steel using oxy-acetylene flame the tool life can also be increased by the selection of the proper cutting speed and feed rate and depth of cut.

In the present work the high carbon high chromium steel(Die steel) was heated with the flame produced by the mixture of oxygen and acetylene and was machined under different cutting parameters such as cutting speed, feed rate, depth of cut, work piece temperature on all geared lathe to determine tool life, surface roughness, cutting force and flank wear. Here taguchi method is used for optimization of machining parameters in hot turning of die steel using the tungsten carbide insert (WC). The tungsten carbide insert has been chosen for this work because of abundant availability and economical reason. Here we have taken three sample of die steel for performing our experiment

Table 1.1: Mechanical properties

Mechanical Properties	Specification
Hardness HBN(Typical)	Less than 235
Tensile Strength	680MPa

Table 1.2: Chemical Composition (Weight %)

C : 0.32-0.45%	S: 0.030 max
Mn: 0.20-0.50%	Mo::1.10-1.75
Si:0.80-1.20%	V: 0.80-1.20%
Cr: 4.75-5.50%	P: <0.30%
Fe: Remaining	

II CUTTING CONDITION OR CONTROL FORMAT

The below table represent the control factors for hot machining of die steel. As we have four control factors and three levels per factor according to taguchi method we choose L9 taguchi design we use orthogonal arrays instead of standard factorial design. This design reduces the number of experiments from 24 to a designed set of 9 experiments

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 03, March-2016

The machining is done by a tungsten carbide insert

Table 1.3: Control Factors with three levels

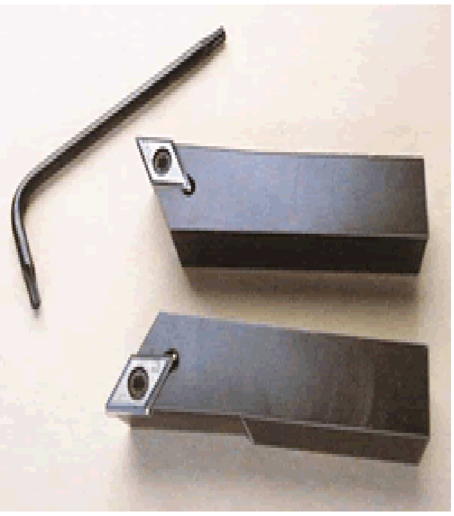
CONTROL FACTOR	LEVEL-1	LEVEL-2	LEVEL-3
Cutting speed	28.92 m/min	43.98 m/min	62.8 m/min
Feed	0.05 mm/rev	0.1 mm/rev	0.16 mm/rev
Depth Of Cut	0.25 mm	0.5mm	0.75 mm
Temperature	150 C	200 C	250

III LITERATURE REVIEW:

Earlier research has shown that the selection of a proper heating eliminates the undesirable structural changes in the work piece and reduces the machining cost. Chen and Lo presents results of an experimental investigation into the factor effecting tool wears in a flame heating of hot machining alloy steel. According to M.J Bermingham and S. Palanisamy present result that by heating the work piece result in improvement in the machinability and also reduction in the cutting forces especially for hard material like titanium alloys

IV EXPERIMENTAL SET UP AND PRINCIPLE OF WORKING:

As the work piece material which has to be machined is set in the lathe head stock and tail stock. Nozzle or torch is fitted but it is also movable with respect to cutting tool. Torch is connected with the oxygen cylinder and acetylene cylinder. As the valves also present for controlling the rate of oxygen and acetylene flow. The distance or nozzle position can be varied or controlled by the clamped system provided. Pyrometer is used for measuring the temperature of the work piece. Temperature is checked by pyrometer and when they require temperature reach than the nozzle is manually removed or taken away from the work piece. Generally pyrometer consists of optical system and a detector. As the optically system focused the thermal radiation on the detector. As the output signal of detector is related to the thermal radiation or irradiance of target object through Stefan Boltzmann law. The output show by the pyrometer is temperature of work piece as it is not necessary to touch the pyrometer with the work piece.



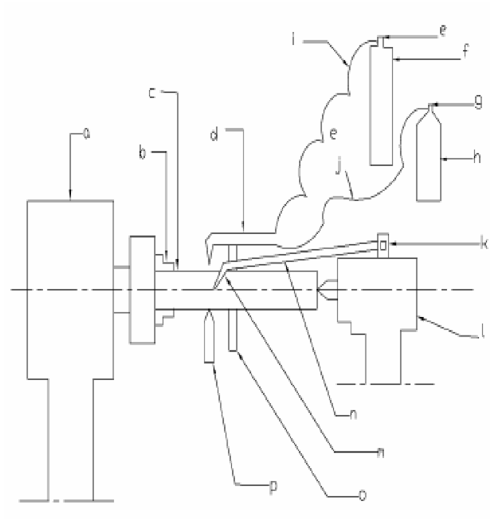


Figure1: Tungsten carbide inserts
Figure2: Experimental setup

Experimental setup details

(a) Lathe head stock

(b) Chuck

(c) Work piece

(d) Torch

(e) Oxygen

(f) Oxygen cylinder flow valve

(g) Acetylene flow pipe

(h) Acetylene cylinder

(i) Oxygen pipe

(j) Acetylene pipe

(k) Temperature indicator

(l) Tail stock

(m) Wire

(n) Wire Tip

(o) Distance adjustment

(p) Cutting tool handle

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 03, March-2016

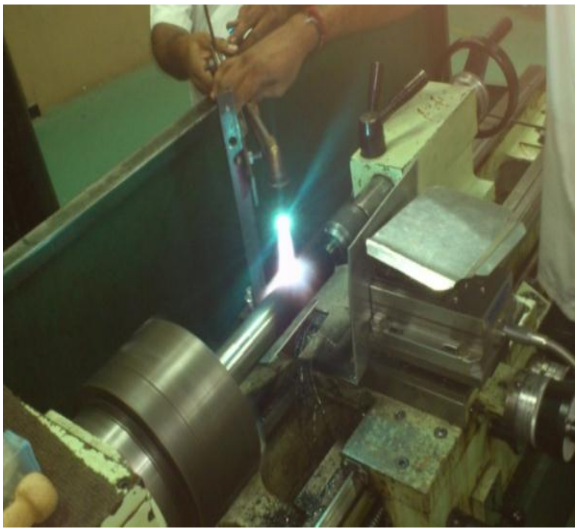


Figure3: Heating of the Die steel using oxy-acetylene flame

V METHOD:

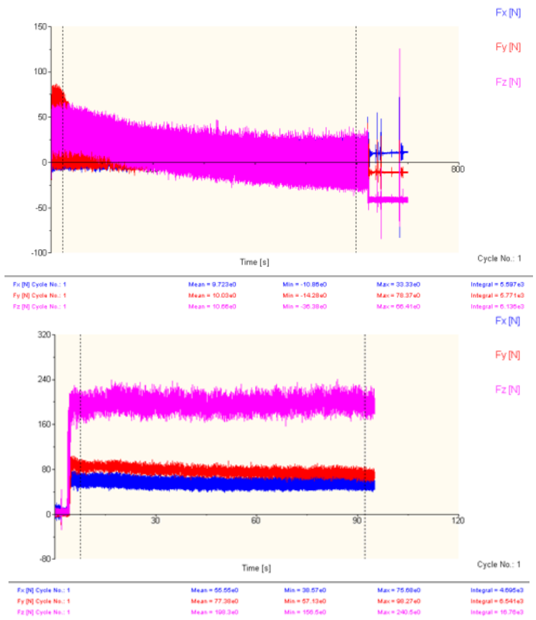
In this experiment we have conduct 9 experiments which is defined as L9 experiment and with the help of heating by oxyacetylene flame we have reduced the hardness of material now after heating we start the first experiment and t give depth and feed of cut for machining of work piece than after completing the experiment we get the cutting force from Kistler 8 channel dynamometer after completing of the first run we keep the work piece for cooling and after some time when work piece become cool we measure its surface roughness .

Between the cooling time of first experiment work piece we start the second experiment by taking second sample and heat the sample and after reaching the temperature we required we removed the nozzle or torch and then start machining on the sample by giving certain feed rate and depth of cut and after completing of machining we keep the sample for cooling and we take the third sample and again start experiment.

So we proceed up to the extend when we complete the 9 experiments

TRAIL NUMBER(RUNS)	Control Factors			
	Cutting Speed	Feed (mm/rev)	Depth of cut (mm)	Temperature
1	180 rpm	0.05	0.25	150
2	180 rpm	0.1	0.5	200
3	180 rpm	0.16	0.75	250
4	280 rpm	0.05	0.5	250
5	280 rpm	0.1	0.75	150
6	280 rpm	0.16	0.25	200
7	400 rpm	0.05	0.75	200
8	400 rpm	0.1	0.25	250
9	400 rpm	0.16	0.5	150

Table 3.1: EXPERIMENTAL OBSERVATIONS



Cutting speed= 29m/min, feed= 0.05mm/rev, Depth of cut = 0.25mm, Temperature= 150

Cutting Speed= 63, feed= 0.10mm/rev, Depth of cut= 0.5mm, Temperature= 150

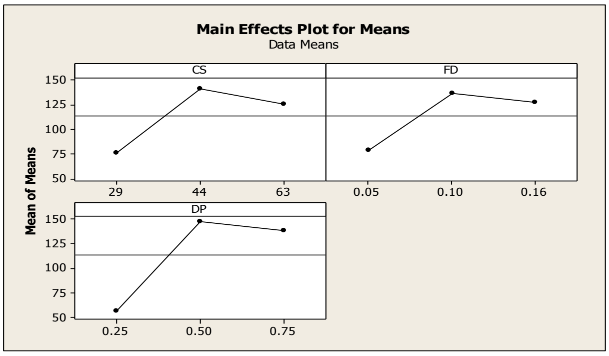
VI RESULTS:

A Cutting force:

All the forces are taken by using Kistler the 8-channel Dynamometer attached to lathe machine. Using the dynamometer we got 9 graph images for all the nine readings.

B Surface Roughness:

As during Taguchi L9 experiment we are measuring the surface roughness for each experiment with the help of surface roughness tester manufactured by Mitutoyo Company.



International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 03, March-2016

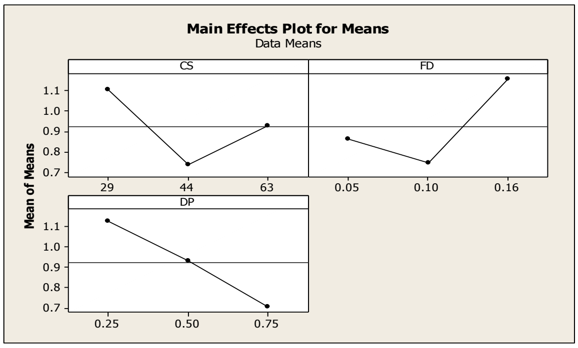


Figure 3(a): cutting speed vs. Cutting force
Figure 4(a): Cutting speed vs. surface roughness
Figure 3(b): feed rate vs. cutting force
Figure 4(b): Feed rate vs. surface roughness
Figure 3(c): Depth of cut vs. cutting force
Figure 4(c): depth of cut vs. surface roughness

Runs	Cutting Speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Temperature (c)	Cutting force (N)	Surface roughness(microns)
1	29	.05	0.25	150	11	1.54
2	29	.1	0.5	200	128	0.87
3	29	.16	0.75	250	89	0.89
4	44	.05	0.5	250	114	0.45
5	44	.1	0.75	150	215	0.63
6	44	.16	0.25	200	93	1.12
7	63	.05	0.75	200	110	0.59
8	63	.1	0.25	250	66	0.72
9	63	.16	0.5	150	199	1.46

Fig 3(a) shows that we get that as cutting speed is increased to 44m/sec the cutting force is increasing simultaneously in a linear manner but cutting force decreases with increase in cutting speed. Fig 3(b) similarly indicates that when the feed rate is increased to 0.10 mm/min then the cutting force is increased and then there is decrease in the force beyond that point. Fig3(c) Whereas indicates that when the depth of cut is increased to 0.50mm the slope obtained is much steeper and after that point cutting force starts decreasing. This shows that a little variation in the depth of cut significantly affects the cutting force.

Fig 4(a) indicates that when cutting speed is increased then surface roughness decreases but when cutting speed reaches 44mm/sec then the surface roughness increases. Fig 4(b) shows that when feed rate is increased till point 0.10mm then surface roughness decreases but after that it increased. Fig 4(c) indicates that when depth of cut is increased then the surface roughness will decrease all the way.

VII CONCLUSION

As by Tungsten Carbide insert tool for turning operation by hot machining and design of experiment using taguchi statistical analysis, we observed that there is very high improvement in the surface quality and tool life is also increased. As the flank wear is very much in conventional machining, it is very negligible in hot turning. As the work piece is heated, it then becomes soft. It results in less cutting power requirements which were highly required in conventional machining

We also concluded that the best machining parameters to obtain higher cutting force and surface roughness is
Cutting Speed = 63m/min
Feed = 0.1mm
Depth of cut = 0.25mm
Temperature = 250 C

REFERENCES

[1] Kitagaea T, Maekawa K (1990) Plasma hot machining for new engineering materials. Wear 139:251–267
[2] Chen NNS, Lo KC (1974) Factors affecting tool life in hot machining of alloy steels. Int J Mach Tool Des 14:161–173
[3] Wang MY, Lan TS (2008) Parametric optimization of multiobjective precision turning using grey relational analysis. Inf Technol J 7(7):1072–1076
[4] “Hot machining process for improved metal removal” J.Mater.Techno.44 (1994)199-206.
[5] EJ Krabacher, M.E.Merchent “Basic factor of hot machining of metals” Trans ASME, Vol.73, 1951.
[6] ”Hot machining of alloy steels” Ho Chung Fi, BSc(Engg),HK university of Hong Kong.
[7] Teaching of Taguchi method to industrial engineers” Fiju Antony & Frenie Fiju Antony.
[8] Nptel.iitm.ac.in/courses/IIT...Steel...I/1.../3 properties of steel.pdf
[9] http://mdmetric.com/tech/chempropi.htm
[10] http://wiki.answers.com/Q/What is tensile strength of hot die steel
[11] http://www.efunda.com/materials/alloys/alloy home/steels properties.cfm