[Singh*, 5(3): March, 2016] ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# ANALYSIS OF SURFACE ROUGHNESS AND MATERIAL REMOVAL RATE IN DRY AND THERMAL ASSISTED MACHINING OF EN8 STEEL

**Harpreet Singh [*], Er.Sandeep Sharma, Er. Mohit Gaba**

[*] Mechanical Engineering, Asra College of Engineering and Technology PTU Jalandhar, India

**DOI**: 10.5281/zenodo.48350

## ABSTRACT

It is widely understood that aerospace materials such as titanium, nickel based alloys and high strength steels are difficult to machine owing to their favorable material properties. An alternative pathway to achieving greater tool life is thermally assisted machining (TAM). This approach is seemingly contradictory to the traditional method and instead relies on introducing heat from an external source to reduce the work piece material's strength and hardness, thereby reducing cutting forces and making the material easer to machine. In present research to investigate experimentally the role of thermal assisted machining on various parameters at recommended speed, feed and depth of cut, and to compare the effectiveness of dry machining with thermal assisted machining on EN-8 steel. The objective of present work is concluded and recorded that is Surface roughness has been decreased in thermal assisted machining significantly, due to the ease in machining by application of heat. Heat softens the material and helps in easy removal of the material resulting material removal rates increase significantly

**KEYWORDS**: Thermal assisted machining, Hard to machine materials.

## INTRODUCTION

Metal cutting is one of the most important methods of removing unwanted material in the production of mechanical components. In metal cutting process in which a wedge shaped, sharp edged tool is set to a certain depth of cut and moves relative to the work piece. Under the action of force, pressure is exerted on the work piece metal causing its compression near the tip of the tool. The metal undergoes shear type deformation and a piece or layer of metal gets repeated in the form of a chip. If the tool is continued to move relative to work piece, there is continuous shearing of the metal ahead of the tool.

Over US$ 100 billion is spent annually worldwide on metal part finishing processes such as turning, milling, boring and other cutting operations. It is envisaged that up to 20% savings should be possible by using the correct choice of tooling and machining conditions [1].The metal working is used is used in machining which help to increases tool life due to decrease in friction and heat generation at the machining zone. Cutting fluid may be significantly affecting the cutting temperature at interface of tool and work material.

***Metal Working Fluid (MWF)***

Metal Cutting fluids/ Metal working fluids are usually classified into four main categories: straight oils, water soluble oils, synthetics, and semi-synthetics. The base oil used for straight and water soluble cutting fluids is usually petroleum based, whereas synthetics are water based solutions of complex organics and contain no mineral oil. Semi-synthetics are a combination of both synthetic and mineral oils. Straight oils are applied undiluted, while water soluble, synthetic, and semi-synthetic fluids are usually diluted in water. In general, dilutions are between 1% and 20% cutting fluid concentrate in water, with 5% being the most common.

As cutting fluids are complex in their composition, they may be irritant or allergic. Even microbial toxins are generated by bacteria and fungi present, particularly in water-soluble cutting fluids, which are more harmful to the operators. To overcome these challenges, various alternatives to petroleum-based MWFs are currently being explored by scientists and tribologists. The major negative effect is particularly linked to their inappropriate use, which results in surface water and groundwater contamination, air pollution, soil contamination, and consequently, agricultural product and food contamination. So, to eliminate the use of metal working fluids several new techniques are being investigated. The techniques like Dry Machining, Minimum Quantity Lubrication and Thermal assisted Machining.

**Thermal Assisted Machining**

Workpiece temperature plays an important role in the chip formation during the metal cutting process as it affects the material deformation. The large amount of energy generated due to the bulk deformation and friction is almost exclusively converted to thermal energy, leading to high chip and tool cutting temperatures. Temperature in the workpiece is especially important when thermally enhanced machining is used. The effects of externally applied heat sources on the temperature distribution of the workpiece must be known. Peak temperatures must be known so that thermal damage is prevented or minimized in the workpiece surface, and the temperature must be known at the cutting point to control the process. TAM improves the machinability of titanium alloys though a reduction in cutting forces, typically reported between 15% to 50% [3]. TAM shows that 80% of the flank wear and 60% of the crater wear have been reduced [4]. Laser Assisted Machining (*LAM*) of Inconel 718 reported a reduction of tool wear by 40%, cutting force by 18% and increase in metal removal rate by 33% [5].

Figure 1 shows the schematic diagram of thermal assisted machining. A heat source is normally used in thermal assisted machining, as the assistance of thermal energy helps to soften the material, and thus easy removal of metal. A heat source is normally introduced near the cutting tool while machining, at a constant temperature, and softens the material while cutting. This process is normally used in hard to machine materials, as conventional process would lead to premature tool failure, and causes irregularities in surface morpography, which is obviously unwanted. For precision works a good surface finish is highly required, and ease of machining could cause a lesser tool wear. Thermal assisted machining helps in ease of machining, and increase machinability.

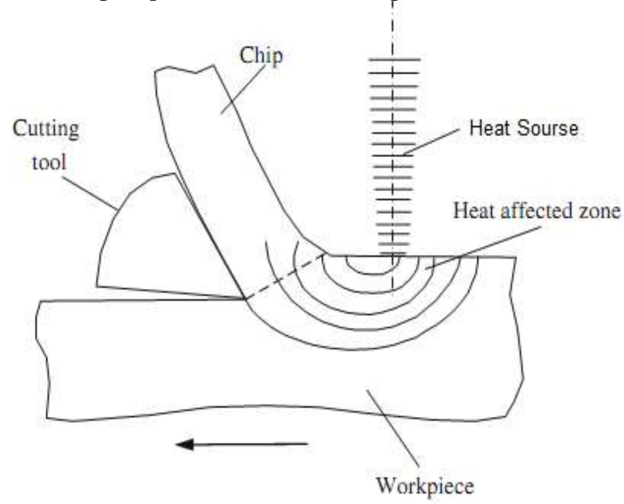


**Figure 1** Schematic Diagram of Thermal Assisted Machining[6].

### 1.2.1 Advantages of TAM

- Decreased tool wear
- Surface Integrity and Part quality
- Environmentally-friendly green manufacturing
- No More Hazardous Coolants
- Low Overhead Charges

Sustainable Manufacturing

## EXPERIMENTATION

 ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

For the present experimental studies, EN 8 steel were plain turned in a rigid and powerful HMT lathe by carbide inserts CNMG12408 at industrial speed–feed combinations under both dry and thermal assisted machining condition.

**Figure 2** Thermal Assisted Machining

Since there was not any mechanism to control the temperature, a temperature range has been selected $380^0$ C to $430^0$ C. the temperature was continuously measured using an infrared thermometer. The experimental conditions are given in Table 1.

**Table 1** Experimental Conditions

| | | |
|---|---|---|
| 1 | Tool | CNMG 12408 |
| 2 | Material | EN8 steel |
| 3 | Input parameters | Speed, 91 m/min., 135 m/min., 172 m/min.<br>Feed, 0.05 mm/rev, 0.10 mm/rev., 0.15 mm/rev.<br>Depth of cut, 0.5 mm, 0.8 mm , 1.00 mm |
| 4 | Output parameters | Material removal rate, Surface roughness |
| 5 | Machining operation | Fine turning |
| 6 | Machining environment | Dry machining, Thermal assisted machining |

The ranges of the cutting velocity, depth of cut and feed rate were selected based on the tool manufacturer's recommendation and industrial practices.

### *2.1. Experimentation Setup*

The present experiment is performed on EN8 steel material to investigate the effect of thermal assisted machining processes by the varying different input parameters. In this experiment, the technique used for introducing the heat to cutting zone is by Butane torch. The experimental set up consists of a butane torch, Pressure gauge, and flow control valve. The construction of an experimental set up is given below.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

**Figure 3** Thermal Assisted Machining Setup

**2.2. Design of Experimentation**

A total of 18 experiments based on Taguchi's L9 orthogonal array were carried out with different combinations of the levels of the input parameters. In this experimental work, the assignment of factors will be carried out using L9 orthogonal array were conducted on Lathe machine for turning operations through TAM technique and dry machining technique.

## RESULTS AND DISCUSSION

After all the experiments were completed the results were analyzed. The input factors cutting environment i.e Thermal assisted and dry machining, cutting speed, feed rate and depth of cut were varied at different levels, the value of output variables (surface roughness and material removal rate) were recorded and plotted graphically. This study is made to investigate the effects of thermal assisted machining and dry machining techniques on EN8 steel. According to the design of experiment, different values of output parameters were measured by precisely relevant instruments. The observations are detailed as per experimental results given below: From the results of experimentation, the effect of dry and thermal assisted machining at different cutting speed and feed combinations on output parameter like surface roughness and material removal rate are observed, explained and plotted in graphs.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

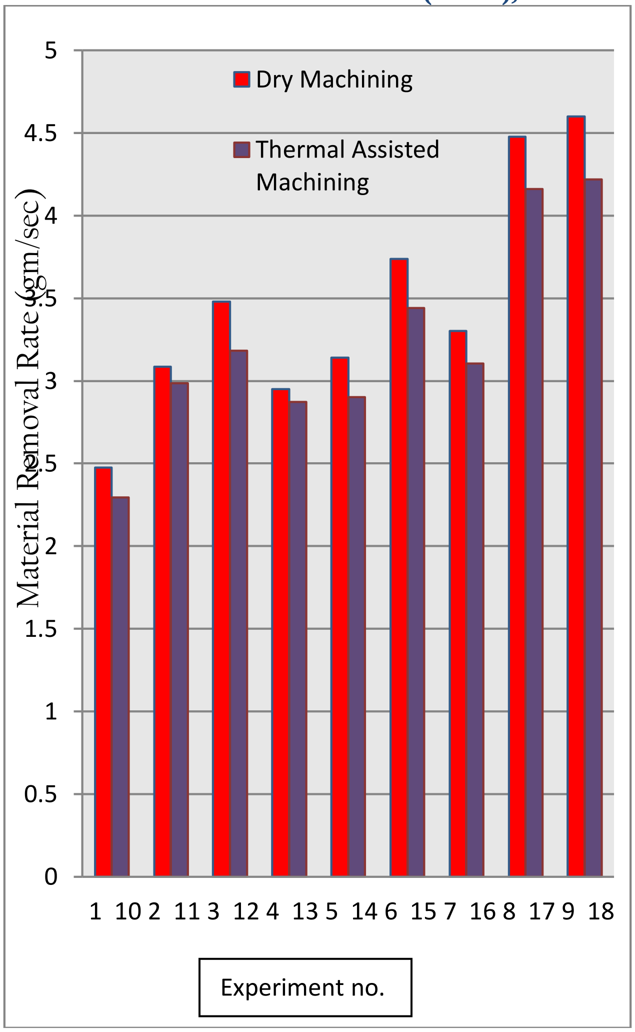


**Figure 4** Material removal rate at different machining parameters

**3.1 Effects of dry and thermal assisted machining on Material removal rate.**

Material removal rate is measured with Digital weighing machine and calculated. In order to calculate the material removal rate, machining time was noted for every experiment using stop watches. Workpieces were weighted before and after experiment. In order to calculate the material removal rate following formula was used-

Material removal rate = $\frac{\text{initial wt.–final wt.}}{\text{machining time}}$ (g/sec).

The graphs clearly reveal the effect of TAM on material removal rate at various speed, feeds and depth of cut as shown in figure 4. At higher depth of cut the values of material removal rate increased but the surface roughness and hardness is also increases. To increase the material removal rate, the thermal assisted machining is adopted with fewer effects of surface roughness and micro-hardness. This is also beneficial as the EN8 steel is used for axle shafts, gears and nut bolts, surface hardness is required in most of its application.

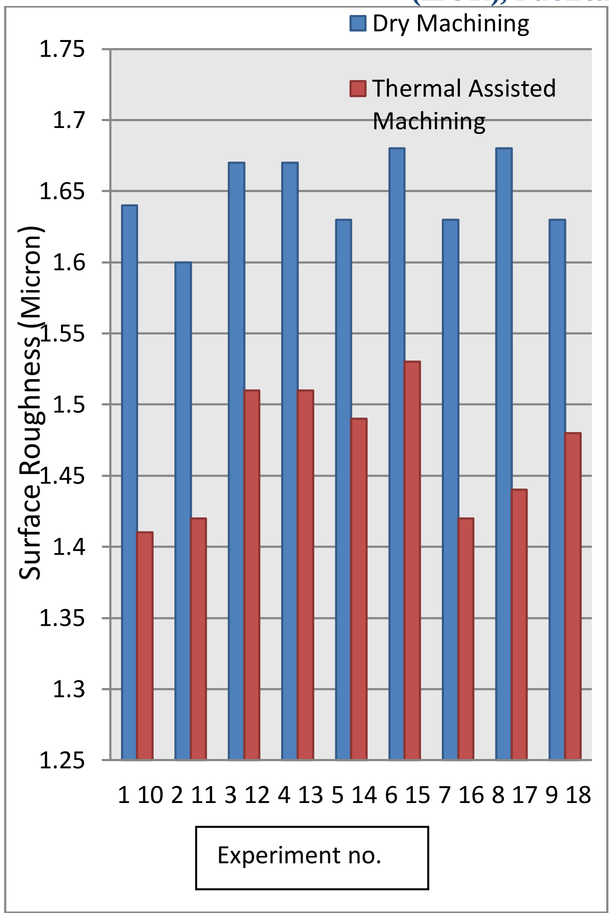


**Figure 5** Surface roughness at different machining parameters

**Effects of dry and thermal assisted machining on Surface roughness.**

The Surface roughness was measured after machining by using an mitutoyo roughness tester sj-201. The line graph is plotted in between surface roughness and input parameters at different machining environment. This graph consists of two different colour columns. The colour represents type of machining environment. The experimental results of surface roughness are as shown in Figure 5.

The graphs clearly reveal the effect of thermal assisted machining on surface roughness at various speed, feed and depth of cut. As the bar chart reveals surface roughness values for thermal assisted machining are very less as compared to dry machining. In dry machining due to higher tool temperatures and higher cutting forces, tool fails to produce smoother surfaces. In TAM cutting forces reduce significantly as the work material gets soften with the application of heat causes surface finish values to raise.

## CONCLUSION

In the present research, an investigation of effects of various input parameters was done on EN 8 steel. Surface roughness has been decreased in thermal assisted machining significantly, due to the ease in machining by application of heat. Heat softens the material and helps in easy removal of the material, hence lesser tool wear, lesser cutting forces and ultimately lesser surface roughness. Material removal rate is also an important parameter in machining operations. In TAM machining, material removal rates increase significantly. As discussed above due to softening of material , it is easy to shear of the hard materials, and hence high rates of removal of material.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

## REFERENCES


1. Ezugwu, E., Key improvements in the machining of difficult-to-cut aerospace superalloys. International Journal of Machine Tools and Manufacture, 2005. 45(12): p. 1353-1367.
2. Abdalla, H., et al., Development of novel sustainable neat-oil metal working fluids for stainless steel and titanium alloy machining. Part 1. Formulation development. The International Journal of Advanced Manufacturing Technology, 2007. 34(1-2): p. 21-33.
3. Shivade, A.S., et al., Optimization of Machining Parameters for Turning using Taguchi Approach. International Journal of Recent Technology and Engineering (IJRTE) ISSN: p. 2277-3878.
4. Baili, M., et al., An Experimental Investigation of Hot Machining with Induction to Improve Ti-5553 Machinability. Applied Mechanics and Materials, 2011. 62: p. 67-76.
5. Bermingham, M.J., et al., Tool life and wear mechanisms in laser assisted milling Ti–6Al–4V. Wear, 2015. 322–323(0): p. 151-163.
6. Rawat, U.M. and V. Potdar, A Review on Optimization of Cutting Parameters in Machining Using Taguchi Method. 2014.
7. Amin, A.K.M.N., M.I. Hossain, and A.U. Patwari, Enhancement of Machinability of Inconel 718 in End Milling through Online Induction Heating of Workpiece. Advanced Materials Research, 2011. 415-417: p. 420-423.
8. Jakhale Prashant, P. and B. Jadhav, Optimization of surface roughness of alloy steel by changing operational parameters and insert geometry in the turning process. Int. J. Adv. Engg. Res. Studies/II/IV/July-Sept, 2013. 17: p. 21.
9. Rebro, P.A., Y.C. Shin, and F.P. Incropera, Design of operating conditions for crackfree laser-assisted machining of mullite. International Journal of Machine Tools and Manufacture, 2004. 44(7): p. 677-694.
10. Germain, G., P. Dal Santo, and J.-L. Lebrun, Comprehension of chip formation in laser assisted machining. International Journal of Machine Tools and Manufacture, 2011. 51(3): p. 230-238.
11. Pfefferkorn, F.E., et al., A metric for defining the energy efficiency of thermally assisted machining. International Journal of Machine Tools and Manufacture, 2009. 49(5): p. 357-365.
12. Chang, C.-W. and C.-P. Kuo, An investigation of laser-assisted machining of Al 2 O 3 ceramics planing. International Journal of Machine Tools and Manufacture, 2007. 47(3): p. 452-461.
13. Anderson, M., R. Patwa, and Y.C. Shin, Laser-assisted machining of Inconel 718 with an economic analysis. International Journal of Machine Tools and Manufacture, 2006. 46(14): p. 1879-1891.
14. Leshock, C.E., J.-N. Kim, and Y.C. Shin, Plasma enhanced machining of Inconel 718: modeling of workpiece temperature with plasma heating and experimental results. International Journal of Machine Tools and Manufacture, 2001. 41(6): p. 877-897.