Analysis of Machining Properties in Dry, Near Dry & Wet Machining on EN9 Steel

Narinder Gupta
Mechanical Engineering
Guru Kashi University
Talwandi Sabo, Punjab, India

Naveen Singla
Mechanical Engineering
Giani Zail Singh College of Engineering & Technology
Bathinda, Punjab, India

Kanwal jeet Singh
Mechanical Engineering
Guru Kashi University
Talwandi Sabo, Punjab, India

Abstract **- The increasing demand for high productivity of machining which increases the cutting velocity and feed rate. With the high cutting velocity and feed rate these machines inherently produces a high cutting temperature, which reduces the tool life, product quality and machining properties. In all machining processes, tool wear is a natural phenomenon and tool failure leads with it. To decreases the temperature, cutting fluid is used at cutting point which changes the performance of machining operation because of their lubrication, cooling and chip flushing function. The use of cutting fluid has become a problem in terms of human health and environment. The use of cutting fluid generally causes economy of tools and it becomes easier to keep tight tolerance and maintain work piece surface properties without damage. To eliminate the problem of cutting fluid, a new approach is introduced i.e. Near Dry Machining (NDM) and Minimum Quantity of Lubrication (MQL).**

In present research, the comparisons of machining properties of three different types of machines like: DRY MACHINE, NEAR DRY MACHINE and WET MACHINE. The machining will be done on EN-9 STEEL, which is to be used in automobiles industries and automation industry, due to their low tensile strength. The advanced technique will be applied to check the interaction of parameters on the machining properties. The CNMG120408 tool is used for turning, widely used in industry because of the cheaper cost. The input parameters are selected according to the recommendation of tool manufacturer for achieving best machining performance. The surface roughness, cutting temperature and cutting forces are compared to find the optimum machining by analysis of machining properties in dry, near dry and wet machining.

Keywords – Minimum quantity lubrication, Dry machining, Wet Machining, Metal working fluids.

Introduction- Now a day, due to the increasing productivity and quality of product at minimum cost, the use of cutting fluid is common strategy to improve tool life, product surface finish and size accuracy in metal cutting processes. On the other hand consumption of metal working fluid increases with material removal rate which helps to increase 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. Cutting fluid also make chip transport easier at significant distance. So the wet machining is introduced. In wet machining the metal working fluid is flooded in cutting zone. The basic function

of metal working fluid as a coolant is to decrease the temperature of chip tool interface, as well as provide lubrication simultaneously. It also decreases the effect of cutting forces. The high cost is associated with the use of cutting fluid. When the strict environmental laws are to be enforced, some alternatives are to find out to minimize or even avoid the use of cutting fluid in machining operations, such as Dry machining, Near Dry Machining.

The concept of NDM is based on the principle of minimum quantity of lubrication in machining process. Therefore, Near Dry Machining (NDM) is also recognized as Minimum Quantity Lubrication (MQL). In NDM a very small amount lubricant flow (ml/h instead of l/min) is used. The lubricant is directly sprayed on the cutting area and the cooling action is very small and the chip removal mechanism is obtained by the air flow used to spread the lubricant. [1] By using NDM, it is possible to achieve effective lubrication of the cutting process with extremely small quantity of oil. The results are not only higher productivity due to fast cutting speed, but also longer tool life and good surface quality at low cost because of saving of amount of coolant. It was observed that if 10% boric acid with SAE 40 base oil chip thickness is reduced upto 12% in NDM. [2] The total typical end-user cost of machining is consumed, 30% in machining, 25% in tool change, 16% in coolants, 3% in tool, 7% downtime and 19% other. [3] In NDM a minimal amount of oil is supplied into a cutting point, carried by and mixed with water droplets and this type of machining method reduces the cutting forces in milling as compared by the same amount of oil droplets alone. [4]

Selection of tool – The tool is selected accordingly the work material and machining properties. Our work material is EN9 steel which is low carbon steel and this material is used for medium size components so the machining time of these components is more.

Carbide insert (CNMG120408) was used for performing the turning operation on the work-piece samples. [2] To perform effective cutting, the selection of proper cutting tool is very essential. Generally cutting tool face: wear at the cutting edge, heat generated during the cutting processes, and thermo mechanical shock. According to cutting conditions and tool manufacturer's recommendation carbide insert is selected for experimentation.

Selection of Process Parameter-The parameters like speed, feed and depth of cut were taken as input parameters. The depth of cut was kept constant because it has not any major effects on machining properties [5, 6, 7, 10, 14]. The speed and feed rates are selected according to the recommendation of tool manufacturer and referred for CNC machining to achieve the optimal results of machining. All of these parameters are presented in table no. 1 and used to perform experimentation with wet, dry and near dry machining

Selection of work piece material - The material of work-piece used was EN9 steel for the experiment. EN9 was selected because it is used for manufacturing of medium size components like axle shafts, cams, gears and shafts etc which are important products of mechanical industry. The machining of these components require more time due to size. We know as the time of machining increase, the temperature of cutting zone also increases which has adverse effects on work material and tool. So to improve the machining, EN9 steel is selected. EN9 steel of diameter 65mm has been used because of availability in market.

Metal working fluid applicator – (MQL) refers to the use of only a minute amount of cutting fluids typically at a flow rate of 50–500ml/h [9] so the aim of experiment is to investigate the effects of dry, near dry and wet machining at different input parameters,
is achieved by atomizer which is specially manufactured for aerosols generation. The aerosols are oil drop-lets dispersed in a jet of air. The small oil droplets carried by the air, flow directly to the tool working zone through nozzle, providing the needed cooling and lubricating actions

Table 1 -Experimental conditions

Machine Tool	CNC :Lath Machine	HMT Stalion 100HS	
Work Specimens	EN-9		
Hardness	180-230 HB		
Size	110*65mm (Circular Road)		
Cutting Insert	CNMG120408		
Feeds	0.10 mm/rev.	0.15 mm/rev	0.20 mm/rev.
Speeds	79 m/min.	96 m/min	130 m/min.
Depth of cut	1mm		
Environment	Dry Machining	Near Dry Machining	Wet Machining

Experimental procedure -The total number of experiment has selected 27 and 9 number of pieces, each piece have three parts. The response variables had been selected- temperature and surface roughness.

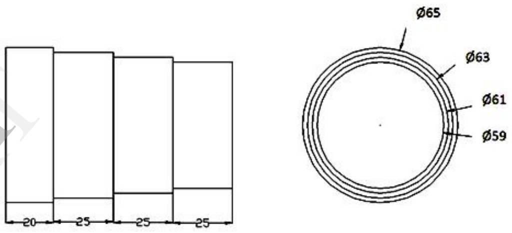

Figure 1 Drawing of Specimen

Measurement of Surface Roughness
Surface roughness is measured in the metrology lab with the 'SJ-201P' surface roughness tester manufactured by "Mitutoyo" shown in figure 2. The surface roughness measured by this instrument in micro meter (µm) & inch meter (µinch). The measuring range of "SJ-201P" is -200µm -+150µm. A stylus attached to the detector unit of SJ-201P will trace the minute irregularities of work-piece surface. The vertical stylus displacement during the trace is processed and digitally displayed on the liquid crystal display of instrument.

Figure 2 Surface-roughness test equipment

ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

MEASUREMENT OF CUTTING TEMPERATURE

To achieve our aim of measuring and analyzing the cutting temperature, the infrared thermometer is used. The temperature of cutting zone is to be measured during the machining time of every set of parameter at different machining environment (Dry, Near Dry and Wet). The basic working principle of infrared thermometer is "It measures the surface temperature of an object. The unit's optics sense emitted, reflected and transmitted energy, which is collected and focused onto a detector. The unit's electronics translate the information into a temperature reading which is displayed on the unit. In units with a laser, the laser is used for aiming purposes only".

Hold the meter by its handle grip and point it towards the surface to be measured. Pull and hold the trigger to turn the meter on and being tested. While continuing to push the trigger the laser pointer is concentrated at the cutting zone. Release the trigger and the hold, display will appear on the LCD indicating that the reading is being held. We can select the temperature units ^{0}C and ^{0}F.

Figure 3 Temperature measuring instrument

RESULTS AND DISCUSSION

Effects Of MQL On Cutting Temperature

The major part of work regarding temperature in metal cutting has been focused on the chip-tool interface temperature (cutting temperature), this being due to the wear of cutting tool and tool life and quality of work surface etc. The wear is sensitive to the cutting temperature in metal cutting zone. After conducting the experiment on CNC lathe machine, the effect of dry, wet and near dry machining on chip-tool interface temperature under three different cutting speeds (37, 49 and 61 m/min.) and feed rate (0.15, 0.20 and o.25mm/rev.) with constant depth of cut (1mm).

It is clearly shown in figure 4 with the consistently increase of feed rate, temperature increases due to increase in push of the tool in the work-piece and that eventually results into the more material removal rate from the work-piece surface as well as induces more friction forces which causes of high temperature and leads to enhance temperature. The cutting temperature is increase as well as speed increases, because as speed increases friction force increases which is cause of heat and heat transfer rate to environment is directly proportional to time. The trend noted down in this graph is in descending order because of the decrease in temperature leads to enhance the need of near dry machining and seems to better in turning under the application of near dry lubrication technique

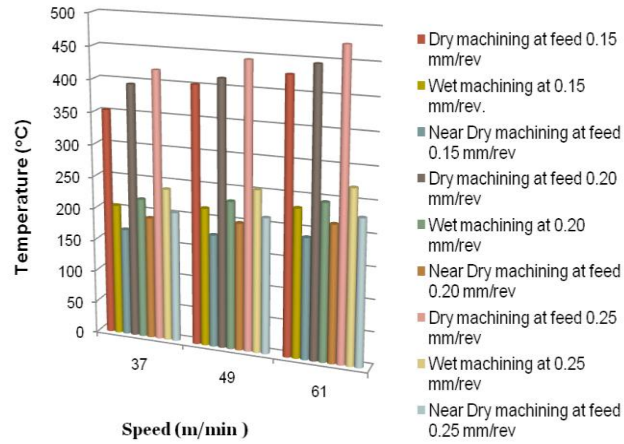

Figure 4 Graph of cutting temperature

Effects Of NDM On Surface Roughness –

Figure 5 shows the surface roughness for dry, wet and near dry machining of EN9 steel turning. It clearly reveals that surface roughness is less in near dry machining as compare to dry and wet machining. Because of the decrease in surface roughness it leads to enhance the need of near dry machining and seems to be better alternative in turning under the application of near dry lubrication technique. The consistent increase of feed rate, leads to increased surface roughness, because due to increase of push force on tool in the work-piece eventually results into the more material removal rate from the work-piece surface as well as produces vibrations in tool leads to enhance surface roughness. The surface roughness is less in near dry machining when compared with the dry and wet machining so the near dry machining is best alternative for machining.

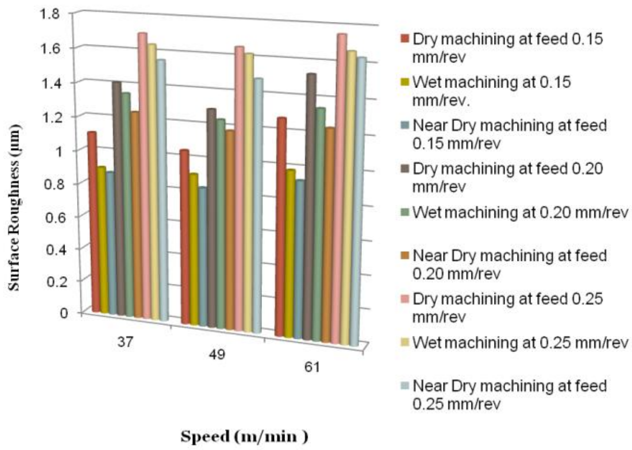

Figure 5 Graph of surface-roughness

CONCLUSIONS

Experimental results are obtained from the best combination of input and output process parameters. The present work helps in optimizing the use of cutting oil under the application of near dry machining and ensures the safer working conditions. The amount of cutting oil is to optimize the appropriate cooling and lubricating effects are produced to achieve better machining results at lowest cost and environmental safety. So it can be concluded from the experiment that near dry machining is a technique that could reduce many cutting problems coming from high consumptions of petroleum based lubricants, like high machining costs or environmental and worker health problems. Therefore, it is important to know all advantages and limitations of this technique.

The results from experimental tests are summarized here. It can thus be concluded that the use of cutting fluid at minute amounts can potentially improve the surface integrity. Surface finish also improved mainly due to reduction of cutting temperatures and damage at the tool-tip by the application of near dry machining. As the results indicate the cutting temperature are decreased by the use of near dry machining. The trend has been extended to formulate environmental friendly metal working fluids. The major problems in the area of high temperatures of machining, tool costs and wastage and disposal of harmful metal working fluids can be resolved by near dry technique but further research in these directions is still suggested.

REFERENCES

1. Attanasio, A., Gelfi, M., Giardini, C. and Remino, C. (2006) “Minimum quantity lubrication in turning: Effect on tool wear”, International Journal of Wear, vol. 260, pp. 333-338.
2. Abhang, L. B. and Hameedullah, M. (2010) “Experimental investigation of minimum quantity lubrication in alloy steel turning”, International Journal of Engineering Science and Technology, vol. 2(7), pp. 3045-3053.
3. Canter, N. (2009) “The possibilities and limitations of dry machining”, Tribology and Lubrication Technology, Special Section, pp. 40-44.
4. Kurnosov, N.E. and Tarnopol’skii, A.V. (2007) “Air- liquid lubricant and coolant aerosols in machining”, Russian Engineering Research, vol. 27, pp. 689-691.
5. Dhar, N.R., Islam, S. and Kamruzzaman, M. (2007) “Effect of minimum quantity lubrication (MQL) on tool wear, surface roughness and dimensional deviation in turning AISI-4340 steel”, G. U. Journal of Science, vol. 20(2), pp. 23-32.
6. Dhar, N. R., Islam, M.W., Islam, S. and Mithu, M.A.H. (2006) “The influencing of minimum quantity of lubrication on cutting temperature, chip and dimensional accuracy in turning AISI-1040 steel”, Journal of Material Processing Technology, vol. 171, pp. 93-99.
7. Hadi, Y. (2010) “Study of minimum quantity coolant on surface roughness during turning operation on aluminum”, IEEE (Institute of Electrical and Electronics Engineers), pp. 370-374.
8. Hwang, Y. K. and Lee, C.M. (2010) “Surface roughness and cutting force prediction in minimum quantity lubrication and wet turning process of AISI-1045 using design of experiments”, Journal of Mechanical Science and Technology, vol. 24, pp. 1669-1677.
9. Jayal, A.D. and Balaji, A.K. (2009) “Effect of cutting fluid application on tool wear in machining: interaction with tool-coatings and tool-surface features”, Journal on Wear, vol. 267, pp. 1723-1730.
10. Khan, M.M.A., Mithu, M.A.H. and Dhar, N.R. (2009) “Effect of minimum quantity lubrication on turning AISI-9310 alloy steel using vegetable oil based cutting fluid”, Journal of Material processing Technology, vol. 209, pp. 5573-5583.
11. Li, K. M. and Liang, S.Y. (2007) “Performance profiling of minimum quantity lubrication in machining”, International Journal on Advance Manufacturing Technology, vol. 35, pp. 226-233.
12. Leooert, T (2011) “The Effect of cooling and lubrication on tool wear in turning 316L steel”, IEEE (Institute of Electrical and Electronics Engineers).
13. Leppert, T. (2011) “Effect of cooling and lubrication condition on surface topography and turning process of C45 steel”, International Journal of Machine Tool and Manufacture, vol. 51, pp. 120-126.
14. Marksberry, P.W. and Jawahir, I.S. (2008) “A comprehensive tool-wear/ tool-life performance model in the evaluation of near dry machining for sustainable manufacturing”, International Journal of Machine Tools and Manufacture, vol. 48, pp. 878-886.
15. Mall, H.B. and Lobo, N.V. (1995) “Determining wet surfaces from dry”, IEEE (Institute of Electrical and Electronics Engineers), pp. 963-968.
16. Sharma, V.S., Dogra, M. and Suri, N.M. (2009) “Cooling technique for improved productivity in turning”, International Journal of Machine Tool and Manufacture, vol. 49, pp. 435-453.
17. Shokrani, A., Dhokia, V. and Newman, S.T. (2012) “Environmentally conscious machining of difficult-to-machine materials with regards to cutting fluids”, International Journal of Machine Tool and Manufacture, Article in Press.
18. Thakur, D.G., Ramamoorthy, B. and Vijayaraghavan, L. (2009) “Optimization of minimum quantity lubrication parameter in high speed turning of super-alloy inconel 718 for sustainable development”, World Academy of Science, Engineering and Technology, vol. 54, pp. 224-226.
19. Varadarajan, A.S., Philip, P.K. and Ramamoorthy, B. (2002) “Investigations on hard turning with minimal cutting fluid application and its comparison with dry and wet turning”, International Journal of Machine Tool and Manufacture, vol. 42, pp. 193-200.
20. Wakabayashi, T., Suda, S., Inasaki, I., Terasaka, K., Musha, Y. and Toda, Y. (2007) “Tribological action and cutting performance of minimum quantity lubrication in machining of aluminum”, Annals of CIRP, vol. 56, pp. 97-100.
21. Wakabayashi, T. (2010) “The role of tribology in environmentally friendly minimum quantity lubrication machining”, JTEKT Engineering Journal, English Edition No. 1007E, pp. 2-7.