MANTECH Publications

Journal of Modern Mechanical Systems and Machining
Volume 5, Issue 2, July-December 2022

A Study on the Effect of Cryogenic Cooling Environments Using CO_2 Cryogenic Cooling's Impact on the Turning Process' Cutting Temperature

Rohit Maheshwari[1], Abhinav Singh[2]

Assistant Professor[1], Student[2]

Department of Mechanical Engineering

GNIT Guru Nanak Institutions, Mullana ambala

Corresponding Author's Email: -*maheshswari61@gmail.com[1]*

Abstract

AISI 1045 steel is machined in this study's turning process using a CNMG 120412 multi-coated carbide insert. Different machining conditions were used for the machining procedures. In terms of the cutting temperature, the impact of cryogenic cooling with CO_2 as the cutting coolant is investigated and contrasted with dry and traditional wet machining. Cryogenic machining has been shown to be a successful alternative technique for lowering the cutting temperature that develops during the machining process. When compared to wet machining, a reduction in cutting temperature in the range of 9–19% was seen at high speed (145 m/min). The study's findings may help practitioners and the industry increase productivity and lessen the environmental impact of using coolant.

Keywords: - *Temperature, CNMG, Environmental Impact, Machining*

INTRODUCTION

High production machining involves the use of strong, heat-resistant materials and is accompanied by high heat and cutting temperatures. A temperature increase this high leads to early cutting tool failure and dimensional distortion in the work item. Additionally, the product's surface integrity is compromised. Typically, flood cooling with a regular coolant is used to control these issues. Conventional cooling techniques produce hazardous fumes and smoke, which not only render them inefficient but also ruin the working

Page 71-75 © MANTECH PUBLICATIONS 2022. All Rights Reserved

environment. Many studies have reported using the cryogenic machining method to achieve improved tool life, lower cutting temperatures, higher surface finishes, and lower cutting forces (De Chiffre et al. 2007, Liu et al. 2007). In the past, steels were machined using cryogenic machining (Dhar et al. 2002), which used liquid nitrogen as the cutting fluid. According to a study of the aforementioned literature, cryogenic machining improves cutting tool life through greater surface smoothness, lower cutting temperatures, and lower cutting forces.

LITERATURE REVIEW

Bartley initially studied cryogenic machining in 1953, using liquid carbon dioxide as the coolant. The phrase "cryogenic machining" refers to machining processes carried out at extremely low temperatures, usually lower than 120 K. although the word "cryogenic" is occasionally used to refer to greater temperatures. A very cold medium, often liquefied gases, is injected into the cutting zone during cryogenic machining in order to lower the cutting zone temperature and cool the tool and/or work piece. Since the early 1950s, cryogenic gases such as carbon dioxide and liquid nitrogen have been known to be used as cutting and grinding fluids (Dhar et al., 2002). In contrast, the cryogenic method lowers the temperature in the cutting zone to a very low level. Researchers used cryogenic coolants (cryogen) for machining in order to explore favorable cutting conditions because standard cutting fluids were unsuitable. The workpiece or chip generated using the cryogenic pre-cooling process is chilled using liquid nitrogen cryogen. This technique aims to modify the character of the metal-cutting chip, turning it from ductile to brittle upon application of the cryogenic coolant (Hong and Ding 2001). The mechanism of tool wear in the turning of reaction bonded silicon nitride with CBN inserts was studied by Wang and Rajurkar in 1997. It was discovered that liquid nitrogen cooling enhanced tool life. In order to machine C45 steel, Reddy et al. (2008) investigated the performance of cryogenically treated tungsten carbide cutting tool inserts. In order to assess the workpiece's machinability, cutting forces, surface roughness, and flank wear are considered. Cryogenically treated cutting inserts outperformed untreated cutting inserts in terms of performance. Yakup and Muammer's (2008) study of liquid nitrogen's use in material removal operations included a thorough investigation of its application techniques, effects on the material properties of the

Page 71-75 © MANTECH PUBLICATIONS 2022. All Rights Reserved

cutting tool and work piece, cutting temperature, surface roughness, tool wear/life, dimensional deviation, friction, and cutting forces. According to Ahsan and Mirghani (2008), the cryogenic chilling method increased the tool life of the cutting inserts used by up to four times. In this study, cutting inserts that have been changed are employed to deliver liquid nitrogen. Venugopal et al. (2007) examined the tool life and tool wear of uncoated carbide cutting tool inserts when milling Ti-6Al-4V alloy under dry, wet, and cryogenic chilling regimes. When compared to dry and wet machining, cryogenic cooling significantly increased tool life. A case study that highlights the significance of sustainable machining technologies in accomplishing sustainable development goals was provided by Pusavec et al. in 2010. In comparison to traditional machining, a sustainability assessment of cryogenic and high-pressure jet-assisted machining was looked at. Contrary to traditional machining, it was found that sustainable machining alternatives provide a practical means of enhancing social, environmental, and economic performance. Carbon dioxide was employed as one of the cutting coolants by Liu et al. (2010), who tested how well it performed in terms of tool wear and surface roughness. With CO_2 acting as the cutting coolant, the surface quality was enhanced, tool wear was decreased, and the friction coefficient was decreased. Shokrani et al. (2012) investigated the use of TiAlN-coated solid carbide tools for CNC end cutting of Inconel 718, a nickel-based alloy. According to experimental research, cryogenic cooling offers a greater potential than dry machining to reduce the surface roughness of machined objects. Cryogenic machining is therefore the most advantageous alternative approach for traditional cooling, according to the literature study, in terms of lowering the cutting temperature, cutting forces, and tool wear, as well as enhancing surface roughness. For the purpose of improving tool life and attaining desired cutting temperature control, cryogenic cooling is an eco-friendly, clean technique. To fully investigate the potential benefit of cryogenic cooling, additional research is necessary. As a result, experimental work is done in this study to examine how well cryogenic CO_2 works as a coolant to lower the cutting temperature. The outcomes of dry and wet machining are contrasted with those produced with the use of cryogenic carbon dioxide coolants.

PROCEDURE AND SETUP FOR EXPERIMENTATION

Page 71-75 © MANTECH PUBLICATIONS 2022. All Rights Reserved

Turning AISI 1045 steel workpieces at various speed-feed ratios was used for the experimental work in this study. The materials for each workpiece underwent various machining conditions, including dry machining, traditional wet machining, and machining using cryogenic CO2 as coolant. When employing carbon dioxide as the cutting coolant during cryogenic machining, the cutting temperature parameter was examined, and the results were compared to those of conventional and dry machining. For the turning operation in this investigation, solid AISI 1045 steel with dimensions of 60 mm external diameter and 300 mm length was employed.

CONCLUSIONS AND RESULTS

The outcome of cryogenic machining is explained below, along with comparisons to dry and traditional wet machining. Figures 3 illustrate the relationship between cutting temperature, feed rate, and cutting velocity while machining AISI 1045 steel in various machining settings. It is believed that as feed and speed rise, so does the cutting temperature. Depending on the other machining parameters, including cutting speed and feed rate, the results show that there is a drop in the cutting temperature during cryogenic CO2 machining in the range of 9–25% when compared to wet cutting. Using cryogenic CO2 as the coolant results in a percentage decrease in cutting temperature that is in the range of around 10 to 25% at low speed (41 m/min), but at high speed (145 m/min), a reduction in cutting temperature in the range of 9 to 19% is seen in comparison to wet machining.

REFERENCES

1. Aggarwal, A., Singh, H., Kumar, P., & Singh, M. (2009). Simultaneous optimisation of conflicting responses for CNC turned parts using desirability function. International Journal of Manufacturing Technology and Management, 18(3), 319-332.

2. De Chiffre, L., Andreasen, J. L., Lagerberg, S., & Thesken, I. B. (2007). Performance testing of cryogenic CO 2 as cutting fluid in parting/grooving and threading austenitic stainless steel. CIRP Annals-Manufacturing Technology, 56(1), 101-104.

3. Dhar, N. R., Paul, S., & Chattopadhyay, A. B. (2002). Role of cryogenic cooling on cutting temperature in turning steel.

Page 71-75 © MANTECH PUBLICATIONS 2022. All Rights Reserved

Journal of manufacturing science and engineering, 124(1), 146-154.

4. Hong, S. Y., & Ding, Y. (2001). Cooling approaches and cutting temperatures in cryogenic machining of Ti-6Al-4V. International Journal of Machine Tools and Manufacture, 41(10), 1417-1437.

5. Neşeli, S., Yaldız, S., & Türkeş, E. (2011). Optimization of tool geometry parameters for turning operations based on the response surface methodology. Measurement, 44(3), 580-587.

6. Wang, Z. Y., & Rajurkar, K. P. (1997). Wear of CBN tool in turning of silicon nitride with cryogenic cooling. International Journal of Machine Tools and Manufacture, 37(3), 319-326.

Page 71-75 © MANTECH PUBLICATIONS 2022. All Rights Reserved