Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 20 (2018) 18–23

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

2nd International Conference on Materials Manufacturing and Design Engineering

Experimental Investigations into Turning of Hardened AISI 4340 Steel using Vegetable based Cutting Fluids under Minimum Quantity Lubrication

Shrikant U. Gunjal[a], Nilesh G. Patil[b]*

[a]*Sandip Foundaiton Group of Institutions- SITRC, Mahiravani, Trimbak Road, Nashik, India*
[b]*Marathwada Institute of Technology, Beed Bypass Road, Aurangabad, India*

Abstract

Machining is the key process in every manufacturing and production industry. Heat generated during machining cause several negative impacts on tool and overall machining environment. Minimum Quantity Lubrication (MQL) is the key process, which signifies the exact amount of cutting fluid during machining. Current industrial practices are moreover inclined towards environment friendly processes. In view of the same, we have chosen vegetable based cutting fluids namely; canola oil, coconut oil and soybean oil for investigation of surface roughness and tool life of the hardened AISI 4340 steel during turning operation at higher cutting speed range, keeping feed rate and depth of cut at constant level. This experimental investigation is the successful move towards evaluation of machining characteristics at aggressive cutting speed. Overall study shows that, canola oil gives better performance comparatively. At higher cutting speed, use of traditional oil with MQL shows longer tool life than vegetable based cutting fluids. Surface roughness is studied under the additional environment of dry cutting. Varying cutting speed did not show any significant impact on surface roughness, as feed rate was constant throughout the experiment. Tool wear is observed after every machining cut by virtue of average flank wear.

Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.

Keywords: Environment friendly; hardened steel; machining; MQL; surface roughness; tool life

* Corresponding author. Tel.: +91- 9421084764; fax: *+91* - 240 - 2375275*, 2376154*.
E-mail ngpatil2007@gmail.com

2351-9789
Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.
10.1016/j.promfg.2018.02.003

1. Introduction

Good machinability can be defined as an optimal combination of factors such as low cutting force, good surface finish, low power consumption, high material removal rate, accurate and consistent work piece geometrical characteristics, low tool wear, longer tool life and good chip breakdown of chips. In recent manufacturing trends, manufacturers are striving for higher productivity, quality, customer satisfaction etc., which also brings technical challenges like tool life, surface integrity and extreme machining temperature. In recent years, tough and hard steels are gaining importance in view of their properties and applications. In present work, AISI 4340 hardened steel (53-55 HRC) is used for investigation. The said material is widely used in power transmission gears and shafts, aircraft landing gear, and the other structural parts.

Researchers are working to investigate various useful parameters of machining and implementation of sustainability concepts in manufacturing. On the other hand, there are critical needs to reduce the usage of conventional cutting fluids and traditional applying methods in machining process in order to reduce the environmental burden and economic cost. Conventional cutting fluids are essentially petroleum based, the continual application of which creates many techno- environmental problems, such as environmental pollution and biological problems to the operators. Besides, the cutting fluids also incur a major portion of the total manufacturing costs. Minimum quantity lubrication is one of the most prominent method in recent times leading to achieve sustainable machining efforts. Additionally, the tool coating is a key factor to realize high speed machining and sustainable manufacturing. Coating material is widely employed to extend tool life and cutting performance of cutting tools due to their advanced wear resistance and superior performance under corrosive or high temperature conditions. Higher cutting forces are required for hardened steel which are mostly dependent on depth of cut followed by feed rate, whereas cutting speed dominates the tool life [1, 2] followed by depth of cut [3]. Das et al. (2015) performed turning on AISI 4340 steel (52 HRC) and found that cutting speed affects flank wear and contributes 25-35% [4]. Feed rate is the major significant factor affecting surface roughness followed by cutting speed and depth of cut [3, 5-8]. In varying cutting speed range from 100 to 300 m/min, Chinchanikar and Choudhury (2014) found that cutting speed is the most significant factor for interface temperature followed by feed rate [5]. Better results of MQL over dry and wet environment are experimentally proved by many past researchers [2, 9-10].

2. Experimental work

AISI 4340 steel was used as a workpiece material. The material was heat treated to achieve hardness above 50 HRC. Hardness achieved after heat treatment was 52-54 HRC. Dimensions of workpiece were 90 mm length and 250 mm diameter. PVD AlTiN coated carbide inserts were used to conduct experimentation. They had the general specification of CNMG 120408. The tool holder with general specification of DCLNL 2525 M12 was selected. Cutting inserts and tool holder were both of Sandvik made. Three types of vegetable based cutting fluids namely canola oil, coconut oil and soybean oil were used under minimum quantity lubrication. All three are in the category of edible oil. Vegetable based cutting fluids are compared with synthetic oil and dry cutting environment. Table 1 shows properties of cutting fluids used for experiment.

Table 1. Properties of bio cutting fluids [11-13].

Cutting fluid	Viscosity index	Heat transfer coefficient W/(m^{2}K)	Density (kg/m^3)
Soybean	219	269.7@180°	885
Coconut	130	947@750°	805
Canola	215	251.4@150°	962

The machine used for turning of AISI 4340 is ACE CNC LATHE JOBBER XL.