materials

MDPI

Article

Laser-Assisted High Speed Machining of 316 Stainless Steel: The Effect of Water-Soluble Sago Starch Based Cutting Fluid on Surface Roughness and Tool Wear

Farhana Yasmin [1], Khairul Fikri Tamrin [1,*], Nadeem Ahmed Sheikh [2], Pierre Barroy [3], Abdullah Yassin [1], Amir Azam Khan [4] and Shahrol Mohamaddan [5]

1 Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan 94300, Sarawak, Malaysia; priankaipe@gmail.com (F.Y.); yabdulla@unimas.my (A.Y.)
2 Department of Mechanical Engineering, Faculty of Engineering & Technology, International Islamic University, Islamabad 44000, Pakistan; ndahmed@gmail.com
3 Laboratoire de Physique de la Matière Condensée, Université de Picardie Jules Verne, 80025 Amiens, France; pierre.barroy@u-picardie.fr
4 School of Chemical & Materials Engineering (SCME), National University of Sciences & Technology (NUST), Islamabad 44000, Pakistan; amir.khan@scme.nust.edu.pk
5 Department of Bioscience and Engineering, College of System Engineering and Science, Shibaura Institute of Technology, Fukasaku 307, Minuma-ku, Saitama 337-8570, Japan; mshahrol@shibaura-it.ac.jp
* Correspondence: tkfikri@unimas.my; Tel.: +60-111-565-3090

Citation: Yasmin, F.; Tamrin, K.F.; Sheikh, N.A.; Barroy, P.; Yassin, A.; Khan, A.A.; Mohamaddan, S. Laser-Assisted High Speed Machining of 316 Stainless Steel: The Effect of Water-Soluble Sago Starch Based Cutting Fluid on Surface Roughness and Tool Wear. *Materials* **2021**, *14*, 1311. https://doi.org/10.3390/ma14051311

Academic Editor: Grzegorz Królczyk

Received: 19 January 2021
Accepted: 5 March 2021
Published: 9 March 2021

Abstract: Laser-assisted high speed milling is a subtractive machining method that employs a laser to thermally soften a difficult-to-cut material's surface in order to enhance machinability at a high material removal rate with improved surface finish and tool life. However, this machining with high speed leads to high friction between workpiece and tool, and can result in high temperatures, impairing the surface quality. Use of conventional cutting fluid may not effectively control the heat generation. Besides, vegetable-based cutting fluids are invariably a major source of food insecurity of edible oils which is traditionally used as a staple food in many countries. Thus, the primary objective of this study is to experimentally investigate the effects of water-soluble sago starch-based cutting fluid on surface roughness and tool's flank wear using response surface methodology (RSM) while machining of 316 stainless steel. In order to observe the comparison, the experiments with same machining parameters are conducted with conventional cutting fluid. The prepared water-soluble sago starch based cutting fluid showed excellent cooling and lubricating performance. Therefore, in comparison to the machining using conventional cutting fluid, a decrease of 48.23% in surface roughness and 38.41% in flank wear were noted using presented approach. Furthermore, using the extreme learning machine (ELM), the obtained data is modeled to predict surface roughness and flank wear and showed good agreement between observations and predictions.

Keywords: machining; laser-assisted milling; sago starch; surface roughness; tool wear; response surface methodology (RSM); extreme learning machine (ELM)

1. Introduction

A number of critical components, installed in nuclear power plants working under critical temperature ranges, are manufactured using austenitic stainless steel. This material offers high toughness, resilient strength with high ductility and thermal conductivity. Moreover, it requires high cutting force to machine; while processing it especially at higher speed and feed rate leads to excessive tool wear along with poor surface finish [1–3]. Nguyen, et al. [4] showed that surface roughness decreases approximately 57.65% at lower feed rate per tooth (0.09 mm/z) in dry milling of 304 stainless steel. While tool wear, which is due to adhesive wear, occurred in high speed milling of stainless steel as discussed by Liu, et al. [5].