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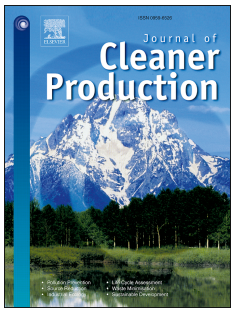

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PII: S0959-6526(16)30594-7

DOI: 10.1016/j.jclepro.2016.05.122

Reference: JCLP 7304

To appear in: *Journal of Cleaner Production*

Received Date: 16 December 2015

Revised Date: 9 May 2016

Accepted Date: 22 May 2016

Please cite this article as: Sarıkaya M, Yılmaz V, Güllü A, Analysis of Cutting Parameters and Cooling/ Lubrication Methods for Sustainable Machining in Turning of Haynes 25 Superalloy, *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2016.05.122.

Analysis of Cutting Parameters and Cooling/Lubrication Methods for Sustainable Machining in Turning of Haynes 25 Superalloy

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Abstract

While the use of cutting oils in machining operations facilitate material removal, the use of these oils are questioned based on the risks they pose for operator health and the environment. As an alternative to the excessive use of cutting oils, the Minimum Quantity Lubrication (MQL) method aims to reduce the use of cutting fluids as a step in achieving clean, environmentally friendly, and sustainable manufacturing. In this study, the machinability of cobalt-based Haynes 25 superalloy, which is a difficult-to-machine alloy used in strategic applications, was investigated under three separate cutting methods (dry, conventional cooling and lubrication, and minimum quantity lubrication). The experiments were conducted on a CNC turning machine using uncoated carbide cutting tools using four separate cutting speeds (15 m/min, 30 m/min, 45 m/min, and 60 m/min), three separate feed rates (0.08 mm/rev, 0.12 mm/rev and 0.16 mm/rev), and a fixed depth of cut value (1 mm). To determine the relationships among machining parameters and outputs, tool wear (VN) and surface roughness (R_a) values were measured. Additionally, the wear mechanisms acting on the cutting inserts were determined using scanning electron microscope (SEM). Following the conclusion of experiments, the Taguchi's signal to noise ratio (S/N) analysis was used to establish the optimal set of cutting parameters. In conclusion, when the MQL method was employed in conjunction with high pressure, the amount of oil used was reduced while the machinability of the material was improved. Tests conducted under all three methods of cutting revealed poor surface roughness at low cutting speeds, and high tool wear at high cutting speeds.

Keywords: Minimum quantity lubrication; Sustainable machining; Tool wear; Surface roughness; Optimization; SEM analysis