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An Experimental Investigations in Turning of Incoloy 800 in Dry, MQL and Flood Cooling Conditions

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Abstract

The current research involves the performance analysis in turning Incoloy 800 in dry, minimum quantity lubrication (MQL) and flooded cutting scenario. Two types of MQL namely MQL1 (150 ml/h) and MQL2 (230 ml/h) have been implemented. Flooded cooling rate has been fixed as 600 ml/h. Low budget uncoated tungsten carbide tool of ISO designation CNMG 120408 tool is utilized to accomplish the turning experiments. Grey relational method is used to ameliorate the cutting process restrictions (feed, cutting-speed, and depth of cut), in order to have minimum roughness of surface and tool flank wear. Later analysis of variance (ANOVA) is carried out to analyze the impact of turning variables on responses. The outcomes obtained show that the roughness of surface and the tool wear both are minimal under MQL conditions whereas performance under MQL2 is more favorable than MQL1.

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Keywords:Minimum quantity lubrication, Surface roughness, Tool wear, Grey, Regression analysis, ANOVA

1. Introduction

In metal cutting manufacturing the consumption of cutting lubricants has become additional challenging for employee's physical and environmental conditions. Manufacturing and research institution are searching for advanced resources of reducing the need or usage of cutting fluids, regarding cost-effective and environmental issue. But the application of cutting coolant increases tool life as well as the surface topography of the workpiece. In conventional machining, the cutting fluid applied fails to enter at the chip-tool-interface. However dispersing the heat is difficult. Attanasio et al. [1] described the aftermath of MQL upon wear at the flank surface during turning of

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Normalized 100Cr6 steel. The tool tip corner was subjected to MQL cooling which reduced the wear growth of the tool thus improved working life of tool noticed. Dhar and Islam [2] studied the outcome of MQL on cutting tool flank wear, dimension of cutting workpiece and finish machining on AISI-1040 grade steel alloy. The cutting effect in the MQL machining is improved than the conventional and flooded condition. Dhar et al. [3] emphasized on the cutting performance in MQL, dry and flood machining and MQL outperformed over others. Hascalik and Caydas [4] noticed that the machined workpiece surface roughness and cutting tool life mainly influenced by feed as well as the speed determine by via Taguchi method. The roughness of finish workpiece was mainly correlated to the cutting-speed, and the axial depth of cut which affected the cutting tool life.Thamizhmanii et al. [5] examined the aftermath of the MQL on the Inconel 718 steel during milling. It was found that the MQL assisted results were more favourable than the results of dry machining. Borkar et al. [6] described the function of the MQL strategy and its subsequent effects on the cutting-tool wear for mild steel being machined and it is observed that MQL systems declined the cutting tool wear. Abhang and Hameedullah [7] examined the variation in the cutting force, cutting temperature, thickness of chip and surface roughness in various conditions using 10% boric acid among base oil/SAE 40 used as mql in the turning method. The results specified the significant progress in machining performance among the MQL assists machining relative to dry machining. Leppert [8] investigates the property of the cooling strategy and lubrication of the erosion in cutting tool during hard-turning of 316L steel. It was found that there was a significant influence on conditions of cooling as well as on wear of cutting insert. MQL machining facilitates large drop in adhesion of machined material at cutting tool flank surfaces. Luato et al. [9] confirmed that the MQL system lowered cutting tool wear and surface roughness values as compared to the usual flood and dry cutting conditions. Improvement in the cutting tool life as well as in turned surface of workpiece can be achieved by utilize the higher oil flow rate with higher compacted pressure of air. Mamun and Dhar [10] designed an empirical model to predict the surface quality during machining on AISI 1045 grade steel using CBN wheel under MQL condition. Hada and Sadeghi [11] found that the machining performances in MQL conditions during the machining of AISI 4140 grade steel was improved compared to dry and flooded conditions. Babuet.al [12] implemented response surface methodology for development of predicted models to correlate the involved input process variables with roughness of the turned surface. Kibak [13] studied machinability of hardened steel using CVD coated cutting tool and PVD coated carbide inserts during dry working condition in milling with taguchi method. Outcome revealed that among all the parameters feed was extensively affected the surface roughness whereas cutting speed was the main aspect which affects the flank wear most. Sahoo and Sahoo [14] found that the abrasion and diffusion were most influencing mechanisms associated with flank wear. It was also implemented grey relational approach to optimise the turning data set.

However from literature review studied, very few works were reported in MQL and flood cutting situations. Low budget uncoated carbide inserts implementation in finishing operation is rarely investigated. However a comparative analysis of machining performance under dry, MQL and flooded conditions is highly essential for academic as well as industrial implementation concern.

2. Experimental method

The work piece material used was two cylindrical bars of Incoloy 800 of 200 mm length and 32 mm diameter. The surface of each of the work pieces was divided at steps of 20mm sample length and experiments were performed. The cutting inserts used for the experimental work was uncoated tungsten carbide with ISO specification CNMG-120408 manufactured by SECO. Lubricant used was sunflower seed oil. The tool holder used in the experiment work was PCLNR-2020-M12 (approach angle: 95°, back rake angle: -6° and inclination angle: -6°). Machine tool used was GEDEE WEILER LZ300G. Fig. 1a and Fig. 1b shows the experimental and schematic diagram of turning setup and Table 1 shows the chemical composition of Incoloy 800.
The MQL set-up consisted of a burette which had a capacity of 50 ml to supply lubricant at controlled rate. The burette was fixed over the tool post so that it moved along with the tool movement. A compressor system with nozzle at one end with maximum working pressure of 4 kg/ cm^2 (approx 4Pa) was employed as the external source to supply air to impinge between tool and work piece during machining. The experiments were conducted at cutting speed of 40, 50 and 60 m/min; the feed was fixed as 0.033, 0.066 and 0.132 mm/rev; and depth of cut as 0.5, 0.75 and 1.0 mm as listed in Table 2. At the end of each experimental run surface roughness (Ra) was measure at three