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Influence of cutting fluid conditions on tool wear and surface roughness in hard turning AISI-D2 Steel using mixed ceramic tools

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Abstract. In the present work, the effects of machining factors and cutting fluid flow conditions on tool wear and surface roughness were studied. Response surface methodology technique with Face centered composite design was employed to minimize the number of experiments. The experiments were performed on a hardened AISI D2 rod using mixed ceramic (Al_2O_3/TiC) inserts in turning process. The effect of machining time was found to be the most influential parameter affecting tool wear, followed by cutting speed. However, machining time followed by feed rate were the most significant parameters on surface roughness. Moreover, cutting fluid condition showed substantial contribution towards decreasing tool wear rate and increasing surface finish.

1. Introduction

Hard turning is rapidly becoming the most suitable finishing process to obtain finished products directly from hardened parts. Hard turning is substituting traditional and costly finish machining process i.e. grinding process, because of the ability to machine intricate work-piece geometries in single step with greater process flexibility, increased MRR and decreased set up times [1,2]. Hard turning process is almost cited in literature using dry conditions, for the reason that the increases of temperature make chip deformation and shearing of the hardened materials easier. Conversely, the high temperature causes increase in friction and heat generation at the tool-work piece interface, which in turn leads to rapid tool wear, affects tribological properties, dimensional accuracy and surface integrity of the machined parts [3]. Conventionally, cutting fluid (CFs) has been used to cool down and lubricate the cutting process, therefore addressing these issues [4]. CFs also favour chip transportation and reducing heat produced during cutting. Despite the constant attempts to totally eliminate CFs from cutting process, cooling and lubrication is still necessary in many places where higher machining efficiency, tight tolerances, higher dimensional accuracies and machining of difficult to cut materials is involved [5,6]. Moreover, CFs is used in a machining operation to enhance the tribological properties of the tool-work piece and tool-chip interfaces. This is achieved only when CFs is able to provide good lubrication and cooling in the metal cutting process, particularly at the cutting edge and tool tip [7,8].The effectiveness of CFs depends upon the ability to access or penetrate the interface between the chip and the tool, and build a thin intermediate film between the surfaces. This intermediate layer or film emerges either by physical absorption or by a chemical reaction and must have low shear resistance than that of the materials at the interface [9]. In this manner, it will reduce the friction and hence the heat generation by acting indirectly as a coolant. Moreover, at higher cutting speeds, the conditions for fluid penetration at the interface are not favourable. In these conditions, water based fluids must be used, as cooling becomes more important. Recent studies of applying high pressure coolant (HPC) supplies in machining operations have reported noteworthy