ADVANCED MACHINING TOWARDS IMPROVED MACHINABILITY OF DIFFICULT-TO-CUT MATERIALS

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Wear mechanisms in End Milling of Inconel 718

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1.0 INTRODUCTION

Nickel-based, creep-resistant, superalloy Inconel 718 is amongst the most difficult alloys to machine. The main reason for the poor machinability of the alloy is the high work-hardening rate by the precipitation of a γ' phase and the presence of hard abrasive phases such as titanium carbide, niobium carbide and the Ni_3AlTi phase. Generally, increasing the amount of γ' phase by increasing the amount of titanium and aluminum increases the rate of tool wear [1]. The nickel-based alloys also retain their strength at elevated temperatures and this result in high cutting forces even at high cutting speeds for which high temperatures are generated [2].

It is very complicated to predict tool life in end milling with sufficient accuracy on the basis of controllable process parameters. Nevertheless, it is an essential part of a machining system in the automated factory to change tools automatically due to wear or catastrophic failure. A number of tool materials were used by the researchers in an attempt to increase machinability of Inconel 718 so far, such as, coated tungsten carbide, alumina (Al2O3), SiC whisker-reinforced alumina and cubic boron nitrate (CBN) etc. [3],[4],[5]. Of these materials coated tungsten carbide is the most widely used. Currently, it is estimated that over 80-85% of all carbide tools sold are coated [6]. In general, coated tools perform better when machining nickel-based superalloys due to the coatings increased hardness, ability to act as a barrier to thermal and atomic diffusion and by altering the coefficient of friction [7]. Derrien et al found that TiN coated tools resulted in higher tool life and lower surface roughness that uncoated tools when milling Inconel 718 [8]. Gatto et al recommended that CrN and TiAlN coatings improved tool performance by acting as a thermal barrier and therefore preventing the high temperature generated in the cutting process from softening the substrate [9]. TiAlN and CrN coated carbide tools were compared in end milling of Inconel 718 by Sharman et al [10] and it was found that TiAlN gave on an average three times better performance compared to CrN in terms of metal removal, due to the lower hardness (lower abrasive wear resistance) and higher chemical affinity of CrN to Inconel 718. It concluded that under conditions where thermal rather than mechanical stresses predominate, the TiAlN coating would be expected to give better results.