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

Edited by:
A.K.M. Nurul Amin (Chief Editor)
Dr. Erry Yulian Triblas Adesta
Dr. Mohammad Yeakub Ali

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Advanced Machining

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Chapter 32

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 NiTiAlTi 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.