

Low-speed milling of stainless steel with TiAlN single-layer and TiAlN/AlCrN nano-multilayer coated carbide tools under different lubrication conditions

Abstract

This paper evaluates the performance of TiAlN/AlCrN nano-multilayer coated, TiAlN single-layer coated and uncoated carbide tools in low-speed milling of STAVAX (modified 420 stainless steel) under flood and mist lubrication. Scanning electron microscope, energy dispersive X-ray analysis system and Raman spectroscopy were used to examine the tool wear and determine the type of oxide formed on the tool surface during machining. In machining STAVAX with a hardness of 40 HRC, the coated tools were subjected to delamination, attrition and abrasive wear throughout the duration of testing. During machining STAVAX with a hardness of 55 HRC, three distinct stages of tool wear occurred, (i) initial wear by delamination, attrition and abrasion, followed by (ii) cracking at the substrate and (iii) the formation of individual surface fracture at the cracks which would then enlarge and coalesce to form a large fracture surface. The TiAlN/AlCrN coated tool exhibited higher resistance against delamination and abrasive wear than the TiAlN coated tool. The cracking resistance and hardness of the coating, and oxidation of the coating during machining appeared to have significant influences on the resistance of the tool against these wear mechanisms. A longer cutting distance was required to cause TiAlN/AlCrN coated tool to crack and fracture. This was due to the substrate receiving greater protection against cracking and fracture as a result of the coating being removed at a slower pace by abrasion and delamination. The likeliness of the uncoated tool to chip, crack and fracture, and the severity of abrasion increased with an increase in the hardness of the workpiece. Small quantity of mineral oil sprayed in mist form was effective in reducing the severity of delamination and abrasive wear, and delaying the occurrence of cracking, fracture and chipping. The influence of the ductility of the workpiece, tool wear and the lubricants on the surface finish are also discussed. © 2010 Elsevier B.V.