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Abstract

The effects of spark plasma sintering (SPS), NbC as a major carbide phase and Ni as a Co binder substitute on the microstructure, mechanical properties and cutting insert wear during face-milling of grey cast iron (GCI) BS1452, grade 17, were investigated. Spark plasma sintering refined microstructures increasing the hardness, but lowered the fracture toughness, due to poor binder distribution. Both SPS and liquid phase sintered (LPS) WC based samples had higher hardness than all the NbC based samples. Substitution of Co with Ni in the NbC cemented carbides significantly increased the fracture toughness (by ~ 5.5 MPa.m$^{1/2}$). During face-milling using inserts produced from the NbC and WC based cemented carbides, the cutting speed (v_c) was varied between 100 - 300 m/min and the depth of cuts (a_p) between 0.5 - 1 mm. Face-milling was done under dry and minimum quantity lubrication (MQL) conditions. Wear was evaluated by optical microscopy and high angle annular dark field scanning transmission electron microscopy (HAADF-STEM). The spark plasma sintered $NbC_{1.0}$-12Co (wt%) insert had lower flank wear rates than the SPS and LPS WC-0.8Cr_3C_2-12Co inserts in all machining tests, due to the combination of good chemical stability, attrition and abrasion wear resistance from the refined microstructure. The lower flank wear rate was also attributed to the shorter chamfer width. Use of MQL at a v_c of 300 m/min and a_p of 0.5 mm, reduced the cutting temperatures, but increased the cutting force and flank wear rates of all the inserts.

Keywords

Spark plasma sintering, Niobium carbide, Microstructure, Chemical stability, Flank wear

1. Introduction

Cemented carbides are types of cermets that consist of a hard carbide phase (WC, TiC) embedded in a ductile metallic (Co, Ni and/or Fe) binder matrix. Due to their good combinations of high hardness, heat stability, fracture toughness, strength and wear resistance [1,2], they are employed in several different tribological applications such as cutting tools, metal forming dies, mining, drilling, machining, and coatings for wear resistant parts in aerospace domain [3]. These