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Ph.D. Seminar Talk 1

Title: **Effect of Carbide Substrate Microstructure on the Grinding Quality and Machining Performance of the Micro-Drills on SS316 Steel**

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Venue: **Offline and NAC-2 ME Seminar Hall (Room no: 363)**

Abstract

The performance of WC-Co carbide micro-drills in micro-manufacturing is strongly influenced by substrate microstructure, particularly tungsten carbide (WC) grain size and cobalt (Co) binder content, which govern the hardness-fracture toughness balance and grinding response of the tool material. This study systematically investigates the influence of ultrafine (0.2-0.5 µm) and submicron (0.5-0.8 µm) WC grain sizes with cobalt contents ranging from 6-12 % on both grinding quality and micro-drilling performance during machining of SS316 stainless steel. Micro-drills were fabricated under identical grinding conditions and characterized using SEM analysis, 3D surface profilometry, Vickers hardness (HV30), and fracture toughness evaluation. Grinding-induced defects and cutting-edge degradation were quantified using maximum edge failure width (Rw). Ultrafine grades demonstrated superior grinding quality, lower surface roughness, and minimal cutting-edge damage due to enhanced microstructural constraint. However, during micro-drilling, most ultrafine tools exhibited premature brittle edge chipping owing to insufficient fracture toughness. In contrast, submicron grades provided improved drilling performance, particularly with intermediate cobalt contents. Tools containing 9-10 % Co showed enhanced edge stability, consistent hole quality, stable machining signals, and superior resistance to catastrophic failure. The submicron grade with 9 % Co exhibited the best overall balance between edge integrity and tool life. Acoustic emission (AE) frequency-domain analysis using power spectral density (PSD) revealed a strong correlation between elevated dominant frequency peaks and subsequent severe edge chipping, demonstrating the effectiveness of AE-based monitoring for early prediction of tool failure. Overall, the results highlight that optimal micro-drill performance requires a balanced combination of WC grain size and cobalt content, ensuring both grinding-induced edge integrity and in-process fracture resistance during micro-drilling.