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Madala, Litshani Brian; Brian, Madala Litshani

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Green Machining of Aerospace Grade 7075 Aluminium Alloy with Improved Tungsten Carbide and Niobium Carbide Based Cutting Tool Inserts

Madala Litshani Brian

745325

School of Mechanical, Industrial and Aeronautical Engineering

University of Witwatersrand

Johannesburg, South Africa

Supervisor: Prof. R. M. Genga

Co-supervisor: Prof. C. Polese

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ABSTRACT

The performances of cutting inserts produced from samples of varied compositions were investigated, Tungsten Carbide (WC) and Niobium Carbide (NbC) based inserts were compared under different test conditions. The NbC offer advantages as an alternative to WC due to the high risk of supply associated with WC. This research study compared and analyzed the effects of spark plasma sintering (SPS), liquid phase sintering (LPS), and additions of TiC and Mo_2C on machining performance of WC-Co and NbC-Ni inserts. The SPS resulted in similar Vickers Hardness (HV_{30}) and Fracture Toughness (K_{IC}) to the LPS produced WC-Co samples and the SPS slightly increased HV_{30} for the NbC-Co samples. The additions of TiC and Mo_2C further improved HV_{30} and K_{IC} for both WC-Co and NbC-Ni samples. The SPS and Mo_2C addition resulted in NbC-Ni sample having similar HV_{30} to WC-Co samples. Inserts produced from the sintered samples were used for face milling of aluminium alloy 7075 at 200-800 m/min cutting speeds and 2-0.5 mm depths of cut. The feed rate was also altered to maintain a constant rate of material removal for each cutting insert. Each cutting insert machined under dry, flood, and MQL conditions for 20 minutes cutting time. Flank wear, temperatures, cutting forces, and machined surface roughness were recorded for each minute of cutting. The WC-Co inserts had lower Flank Wear Rates (FWR), machining forces ($F_{R, ave}$), and temperatures (T_a) than the NbC-Ni inserts during roughing, semi-finishing, and finishing under dry, flood, and MQL conditions. The SPS produced inserts had lower FWR than LPS produced inserts under dry and MQL conditions during roughing, semi-finishing, and finishing. The LPS produced inserts had lower FWR than SPS produced inserts under flood conditions during roughing, semi-finishing, and finishing. The application of MQL reduced FWR, $F_{R, ave}$, and T_a compared to dry during roughing, semi-finishing, and finishing. The application of flood lubrication increased FWR, $F_{R, ave}$, and reduced T_a compared to dry during roughing, semi-finishing, and finishing. The MQL application resulted in lower FWR, $F_{R, ave}$, and T_a than flood during roughing, semi-finishing, and finishing. During finishing, the SPS produced inserts achieved better surface integrity than LPS inserts under dry, flood, and MQL conditions. The application of MQL and flood lubricants increased machined surface roughness (R_a). Although the MQL produced the highest R_a, the R_a was within 0-0.9 μm.