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Authors: Ulrich Schmitt-Radloff, Frank Kern, Rainer Gadow

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Wire-electrical discharge machinable alumina zirconia niobium carbide composites – Influence of NbC content

Ulrich Schmitt-Radloff ^{a*}, Frank Kern ^a and Rainer Gadow ^a

^a Universität Stuttgart, Institut für Fertigungstechnologie keramischer Bauteile (IFKB), D- 70567 Stuttgart, Germany

Abstract:

Alumina zirconia (ZTA) ceramics can be made electric discharge machinable by addition of a percolating network of an electrically conductive phase. In this study the influence of NbC content on the mechanical and electrical properties as well as the ED-machinability of ZTA-NbC ceramics containing 17 vol.% zirconia and 24-32 vol.% NbC were investigated. Samples were hot pressed from mixed and milled starting powders. Surface morphology and surface roughness of wire electrical discharge machined surfaces were studied by SEM and perthometry. Cutting speed was determined to benchmark the ED-machinability.

Rising NbC contents progressively impede sinterability. Maximum strength, Young's modulus and hardness were found at intermediate NbC contents. Conductivity evidently rises with NbC content, the cutting performance showed an adverse tendency. The surface quality of the materials was improved by increasing the content of conductive phase. Additional trimming operations can reduce the mean roughness of machined surfaces to 1 μm .

Keywords: zirconia, alumina, niobium carbide, electrical discharge machining, mechanical properties

1. Introduction

Applications of hard materials such as ceramics range from inserts for powder injection molding to cutting tools for the manufacturing industry. Ceramics are e.g. beneficial in acid or alkaline environments where other hard materials as cemented carbides suffer from corrosion [1–5]. The high abrasion resistance of ceramics is however detrimental when it comes to final machining of components which is generally restricted to grinding, lapping and polishing with diamond tools. These machining processes typically offer limited cutting speed and a limited degree of freedom concerning the final geometries. Especially for complex shaped customized components produced in small lot sizes electrical discharge machining can be the most economical solution, provided that the ceramics are made conductive by adding a sufficiently high volume fraction of transition metal carbides, borides or nitrides [6–9]. Recently dispersions of carbon nanotubes or graphene were proposed to boost electrical conductivity [10]. Such electrically conductive ceramics offer the required hardness, bending strength and chemical resistance for the desired applications and the possibility to apply electric discharge machining - a technology with a performance independent of the hardness of the workpiece. König et al. reported that a minimum electrical conductivity of 1 S/m is required [11] to make ceramics ED-machinable in principle. Recent studies suggest that much higher electrical conductivity is necessary to carry out the ED-machining process economically and

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