Cutting force and friction characterisation of a valve seat cutting process involving p-cBN tools, an experimental and numerical analysis

***Mr James Fletcher, †Dr Emrah Demirci, Professor Vadim V. Silberschmidt**

The Wolfson School. Mechanical, Electrical and Manufacturing Engineering. Loughborough University, UK.

*Presenting author: j.fletcher@lboro.ac.uk
†Corresponding author: e.demirci@lboro.ac.uk

Abstract

Modern high-pressure, high-temperature IC engines call for increasingly hard valve seat materials, in turn calling for even higher performance cutting tool materials, such as, polycrystalline cubic-Boron Nitride (p-cBN). This work focuses on a process used by Ford Motor Company in which the three angles of three-angle valve seats are cut simultaneously with a single tool holder hosting three p-cBN inserts spaced 120° about the axis of rotation. When used in this way, the life of p-cBN tools is highly variable thus negating any advantages offered by p-cBN. P-cBN, of low fracture strength, is particularly vulnerable throughout three-angle cutting due to vibration which develops as a result of unopposed radial forces from each angle (cutting insert) [1,2].

In this study, experimental cutting force data are captured from a series of cutting experiments performed using a custom built measurement tool which has been designed to hold the p-cBN insert. The cutting force data are used as parametric input into a representative friction model for the cutting system. Using the friction model, a numerical simulation is created which takes into account measured friction characteristics of the system, copper-filled porosity of AR20 and chatter-induced fracture damage of the p-cBN substrate.

The numerical model shows good agreement with experimentally captured results. Furthermore the model allows for easy investigation on the effect of edge preparation of the p-cBN insert which highlights the importance of edge preparation when cutting with high-hardness materials such as p-cBN.

Keywords: Experimental cutting force measurement, polycrystalline cubic boron nitride (pCBN p-CBN CBN) cutting tools, MSC.MARC, numerical modelling of cutting.

References

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