MATHEMATICAL MODEL OF DIAMOND PARTICLE IN METALLIC MATRIX

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1. Introduction

Circular saw blades containing diamond-metal segments brazed to a steel disc are used for cutting construction materials and natural stones (Fig.1). Segments are working elements of a saw blade produced by means of the powder metallurgy technology. A significant feature of the segment metallic matrix is diamond particle retention during the operation of a diamond impregnated tool. Diamond particles are retained in the matrix by either chemical or mechanical bonding or by the combination of the two ones simultaneously [1].

Mechanical bonding is obtained during cooling after the hot pressing stage. Compared with metals, diamond has a very low coefficient of thermal expansion, and therefore diamond particles are tightened by the contracting matrix [1]. Proper mechanical bonding depends on elastic and plastic properties of the matrix.

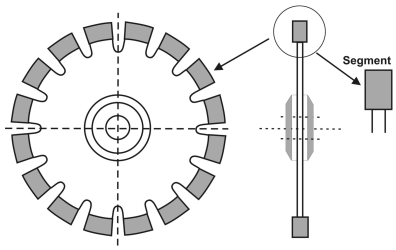

Figure 1. Schematic representation of a circular saw blade.

2. Synthetic diamond crystal

Depending on synthesis conditions, diamond crystallization results in different shapes ranging from a cube to an octahedron (Fig.2). The truncated octahedron, the size of which was determined by the distance of 0.350 mm between the opposite square facets, was selected for the 3D numerical analysis (Fig.2). The truncated octahedron is the most spherical object of semi-regular convex polyhedrons in Fig. 2.

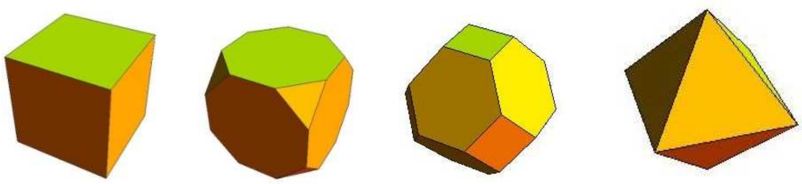

Figure 2. Typical shapes of a synthetic diamond crystal: cube, truncated cube, truncated octahedron, octahedron.

3. Analysis of diamond particles retention in metallic matrix

The research was carried out for selected matrices containing cobalt, iron and copper. Relevant mechanical and thermal properties were assumed for the particle and the metallic matrix [2,3].

Hot pressing simulation was performed at a given temperature and pressure. Finite element method using Abaqus software was implemented to perform the calculations (Fig. 3).

Mechanical fields in the particle and around the truncated-octahedronal particle in the metallic matrix were obtained. Elastic and plastic energy as well as the plastic zone size around the particle after hot pressing were also obtained.

Strain field in the particle protruding above the matrix surface was calculated (Fig. 3). Strain distribution in the particle was compared with the experimental data [4] and satisfactory results were obtained.

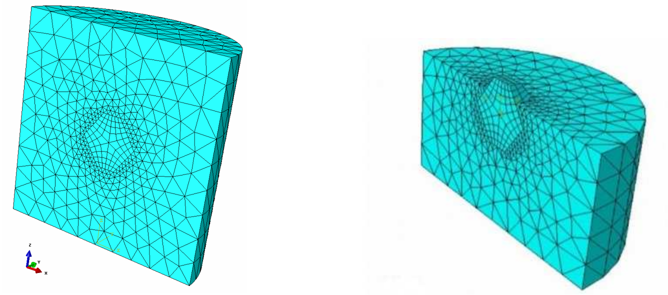

Figure 3. Model of a diamond crystal embedded in the matrix and protruding above the matrix surface.

The calculations were performed again for the spherical particle model with a radius r=0.173, the volume of which is equal to the volume of formerly analysed truncated octahedron. The 2D axisymmetric model was generated for the particle in the matrix. The results were compared with the results obtained for the 3D model.

The analytical model of the spherical elastic particle in the elastic-ideally plastic matrix was presented. Elastic stress in the particle and the matrix were defined according to the Lame solution [5] and the plastic zone size around the particle employing the study results [6]. The stress values and the plastic zone size obtained in the model were compared with the results of the computer simulation for the 3D and axisymmetric models.

4. Conclusions

The obtained results allow selecting the parameters which merely depend on the particle shape and size These are mainly the following parameters: pressure within the diamond particle and the plastic zone size around the particle. The parameters could be used as the indexes of the diamond particle retention in the metallic matrix.

5. References

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