Analysis of thermal residual stresses in brazed Diamond-Metal joints considering creep and plasticity in 316L stainless steel and filler alloy

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ABSTRACT

Brazed diamond-metal joints are used in engineered grinding tools (EGT) which can feature high performance grinding. High bonding strength in diamond-metal joints results in an increase in grain protrusion and thus creates more chip space and improves lubrication conditions. Diamond is the favoured abrasive component for EGT due to its high strength and hardness. In the present work, the residual stresses in a block-shaped monocrystalline diamond which was brazed to the low carbon steel, 316L, has been analysed numerically and compared with experimental results. During the brazing process, a silver-copper-titanium active filler alloy has been used. The brazing temperatures were in the range of 850-910 ˚C for 10-30 min dwell time [1].

One of the major problems in brazed diamond-metal joints is the formation of residual stresses which arises from the mismatch of thermal expansion between parts. These thermal residual stresses change in different conditions such as with brazing temperature and dwell time. Since the thickness of the intermetallic layers are in the order of nano- and micrometers, and the rest of the model are in the order of millimetres, modelling techniques such as tie constraints and sub-modelling has been used.

In the simulation part, the Abaqus® software was used. Thermal conduction between the different parts and air at low pressures, as well as the thermal radiation to the furnace walls has been considered. All parts in the brazing process started to cool down from solidus temperature of the filler alloy up to room temperature. Isotropic hardening and a hyperbolic-sine creep law for 316L and the filler alloy were used. This creep law can describe the transition between the power law (PL) and power law breakdown (PLB) during the cooling process. In the experimental part, Raman-active optical phonon modes at three points in the diamond were measured by Raman spectroscopy. The splitting in phonon frequencies and the mixing of phonon modes contain information about the thermal residual stresses in diamond [2]. Finally the shift in the phonon frequencies was calculated from the different numerical residual stress components and compared with the experimental results.

Numerical and experimental phonon frequencies were derived for three locations in the diamond and the corresponding residual stresses were calculated. A good agreement between the numerical and experimental results was achieved. For instance, a reference point 10 µm above the diamond-filler alloy interface was selected. From the diamond surface up to a depth of 250 µm, the normal stress component increases from 0 up to 500 MPa respectively.

REFERENCES

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