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STUDY OF THE INFLUENCE OF BUSBAR THICKNESS ON THE LEVEL OF MAXIMUM AXIAL RESIDUAL STRESSES IN CERAMICS DURING BRAAZING OF CERAMIC-METAL PRESSURE SEAL

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Abstract: The research on the influence of Kovar tube thickness on the residual stress level during the brazing ceramic-metal pressure seal.

Keywords: Pressure seal; brazing, stress-strain state.

Metal-ceramic pressure seal are utilized in electron beam setups. During their operation, it was found that the stiffness of the joint is affected by the thickness of the current lead, and increasing the thickness leads to a rise in residual stress levels during their fabrication using brazing methods [1, p. 143]. In this study, computer simulations were conducted to assess the residual stress levels at different current lead thicknesses.

The research was carried out on an actual joint and a model composed of two ceramic rings with a Kovar metal current lead between them [1, p. 143]. The thickness of the Kovar layer (0.3 mm, 0.55 mm, and 0.8 mm) and the magnitude of compressive pressure (5 MPa, 17.5 MPa, and 30 MPa) were varied. Two cooling regimes were considered: rapid cooling, accounting for only instantaneous plastic deformations, and slow cooling (over 4 hours), accounting for both instantaneous plastic deformations and creep.

Material properties were assumed to be the same as in previous studies, taking into account temperature effects [2, pp. 31-37].

The study analyzed fields and plots of plastic deformations (short-term and creep) in the current lead material and stresses in the ceramics during temperature reduction from 900°C to 300°C.

The analysis of results indicated that the nature of fields, plots, and patterns established in prior research was generally preserved, but stress levels underwent slight changes. The magnitudes of maximum tensile stresses on the outer and inner surfaces were significantly influenced by both the interlayer thickness and the applied compressive pressure.

The analysis of plots of residual (after removing compressive pressure) axial tensile stresses in ceramics along the interfaces and across the junction under different combinations of current lead thickness and compressive pressure during slow cooling was conducted. In all variations of thickness and compressive pressures, maximum tensile stress peaks were located at the interfaces between the current lead and the ceramics. As one moved away from the interface, these stresses rapidly diminished and transitioned into compressive stresses. Notably, the magnitudes of these peaks increased with thicker interlayer dimensions. An exception was the inner surface where the peak value at 30 MPa initially increased (for thicknesses of 0.3 mm and 0.5 mm) and then decreased for a thickness of 0.8 mm.

The influence of current lead thickness is more clearly observed through curves depicting the dependence of maximum stresses in ceramics (Figure 1).

The curve analysis revealed that on both surfaces, maximum tensile stresses noticeably increased with thicker Kovar layers. With rapid cooling, they escalated from 10-20 MPa for a thickness of 0.3 mm to 60-70 MPa for 0.8 mm on the outer surface and from 0-15 MPa to 5-30 MPa on the inner surface.

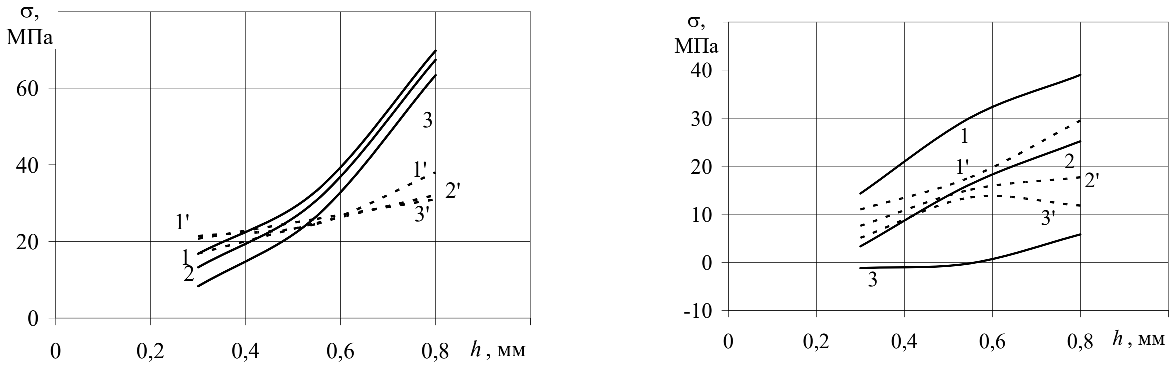

Figure 1. Dependencies of maximum axial residual stresses in ceramics on the outer (a) and inner (b) surfaces on Kovar thickness at compressive pressures of 5 MPa (1, 1'), 17.5 MPa (2, 2'), and 30 MPa (3, 3') (solid curves – rapid cooling, dashed curves – slow cooling).

Under slow cooling, they also increased but to a lesser extent: from 20 MPa to 30-40 MPa on the outer surface and from 5-10 MPa to 10-30 MPa on the inner surface, as the current lead thickness increased from 0.3 mm to 0.8 mm.

In conclusion, to reduce the risk of crack formation in ceramics, it is desirable to minimize the thickness of the current lead made from precision alloy 29NK.

Literature

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