Electron beam welding of copper‒niobium microcomposites for pulsed power applications

Keywords: electron beam welding, copper–niobium microcomposite, welding joint, electric cable, electrical contact connection

The main objective of this work is to explore the possibility of electron beam applying for the connection of copper–niobium conductors. Electron beam welding of copper–niobium microcomposite wires was investigated. The evaluation of welded joints properties was carried out according to the methodology, which is applied to contact electrical connections. The major electrical and mechanical properties of welded joints were established. The microscopic examination of the joint cross-section showed that welded joints of copper–niobium conductors have minimal thermal effect on the structure of the conductor and propagation of welding defects thanks to the welding in a vacuum. According to the non-destructive radiographic test, the joint structure does not have welding defects. The difference in electrical resistances of the conductor and welded joint was below 20 %. The welded joint can withstand the maximum load, which is equal to 31.25 % of the load-bearing capacity of microcomposite conductor.

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**Figure 1**. Scheme of electron beam welding and the steps: 1 – welded samples; 2 – weld pool

**Figure 2.** Sample of electron beam welding joint of copper–niobium microcomposite wire: a – front view; b – longitudinal section of joint area (welding was done with spot diameter of ~5 mm)

**Figure 3.** Secondary electron images of electron beam welding joints: a – longitudinal section of joint, b – cross section of joint, c – fusion area, d – niobium dendrites morphology

**Figure 4.** View of the temperature distribution in the welded joint: a – before the heating; b – after 2 min of heating; 1 and 2 – points where the measurements were made

**Figure 5.** Stress‒elongation curve of: a ‒ copper–niobium wire [26]; b ‒ copper–niobium wire with electron beam welding joint (break point – welding seam near fusion area)

**Figure 6.** Energy-dispersive X-ray analysis results: a – quantitative X‒ray map of niobium; b ‒ quantitative X‒ray map of copper; c ‒ point analysis of niobium dendrites

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**Table 1.** Characteristics of electron beam welding equipment [31]

**Table 2.** Electron beam welding power and energy density, penetration depth and width of joint dependence on the beam spot size

**Table 3.** Calculated heat input, penetration depth and width of joint according to equations (4), (6–8)