INDENTATION MODULUS AND YOUNG’S MODULUS OF CU-CR-ZR ALLOY AT MACRO-SCALE LEVEL

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In this communication the first experimental results of indentation modulus and Young’s modulus (tensile modulus) of seven samples of Cu-Cr-Zr alloy (chemical composition: 1%Cr, 0.06%Zr, rest Cu), in the macro-scale range at room temperature, are presented and compared.

Six Cu-Cr-Zr samples have been aged from different heat treatments for 2 hours in a vacuum furnace at 400C, 480C, 550C, 600C, 650C, 700C, and a single sample is kept as received. In the alloys here investigated, Cr is coherent in the Cu matrix for the as-received condition and the precipitates grow in size up to ~32 nm for the 700C condition.

The experimental procedures for the measurement of indentation modulus, by using the primary hardness standard machine at INRIM, and the Young’s modulus, by means of engineering tensile tests at CIRA, are described.

Indentation modulus is calculated on the basis of Doerner-Nix linear model and from accurate measurements of indentation load, displacement, contact stiffness and Vickers hardness impression imaging. Load is provided by dead-weight masses (3 kg, 30 kg and 100 kg) and displacement is measured by a laser-interferometric system, perpendicular with respect to the Vickers pyramid vertex. The geometrical dimension of the Diamond Pyramid Hardness impression is measured by means of a micro-mechanical system and optical microscopy imaging technique. Applied force and indentation depth are measured simultaneously, and the resulting indentation curve is obtained. Indentation modulus was determined on the basis of ISO 14577-1 Standard and improved methodologies (from literature).

Young’s modulus is determined on the basis of stress-strain measurements on the basis of Standard methodologies (e.g. ASTM E8, ISO 10275, ISO 6892-1). Geometrical dimensions are in accordance with proposed proportionality among dimensions as stated in international Standards. Samples (thickness 2 mm) have been cut mechanically. Engineering tensile tests have been performed by using an INSTRON 4505 “stress-strain” device. Measurements are performed monitoring deformations with an optical technique of digital-image correlation (VIC 3D measurement system). The displacement rate was set to 0.1 mm/min, as the alloy is expected to be strain-rate sensitive. A pattern is applied on the samples surface. Young’s modulus has been evaluated, from DIC technique, in several region of the sample under deformation, in order to evaluate the actual variability range of the Young’s modulus. Values of maximum and minimum Young’s modulus are highlighted.

Figure 1 – Experimental test for indentation and Young’s modulus measurements and preliminary results. From experimental results an interesting proportionality between indentation modulus and Young’s modulus is achieved, as depicted in the graph of tensile-indentation comparison, in Figure 1