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A comprehensive predicting model for thermomechanical properties of particulate metal matrix nanocomposites

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Abstract. A reliable and optimal design of metal matrix nanocomposites (MMNCs) reinforced by nanoscale particles critically requires establishing the accurate material-characterizing relations of such new systems. So, this paper presents an inclusive model to predict the elastic modulus, thermal expansion coefficient, yield strength and ultimate tensile strength of MMNCs containing nanoparticles. Size factor and the agglomerated state for the nanoparticles into the metal matrix, generation of dislocations by thermal mismatch and Orowan strengthening mechanism are considered in the analysis. The influence of volume fraction and diameter of nanoparticles, material properties of matrix and temperature difference on the MMNCs effective thermoelastic and strength properties are studied in detail. Generally, the predicted values match well with experimental data. The results prove that for accurate estimations of the elastic modulus and thermal expansion properties of the MMNCs reinforced with uniformly dispersed nanoparticles, the size factor must be considered. The more realistic characterizations of the yield strength and ultimate tensile strength of the MMNCs containing uniformly distributed nanoparticles could only be achieved with considering both thermal mismatch and Orowan strengthening mechanism. Additionally, when the nanoparticles are not well dispersed into the metal matrix, speculating the nanoparticles agglomerated state to acquire a more realistic prediction is critically essential. The MMNCs thermomechanical characteristics can be significantly improved by (i) increasing volume fraction, (iii) decreasing the nanoparticle diameter and (iii) uniform dispersion into the metal matrix.

Keywords: Metal matrix nanocomposite; Nanoparticle; Elastic modulus; Yield strength; Ultimate strength; Thermal expansion coefficient.