Multiscale effect of thermomechanical loads on the NbC-Steel microstructure obtained by SPS
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Abstract
The effects of thermomechanical loads are often evaluated considering materials as isotropic and homogenous. Therefore, these effects are studied in the macroscale. On the other hand, microstructural features strongly influence the mechanical behavior and damage occurrence. Based on this context, it is proposed here to conduct a study on which microscale has taken into account. Hence, materials analyzed in this study consisted of different volume fractions of NbC and tool steel, which were manufactured by SPS (Spark Plasma Sintering) technique. In terms of application, these materials are prospective to be used as tools in the hot forging process and, thus, the thermal gradient and plastic deformation are important results to evaluate material damage in microscale. The analysis of the microstructural effects on the stress and strain fields due to the loading (thermal and mechanical) was carried out, in this work, by means of Finite Element Method (FEM) in addition to microstructural characterization, numerical and experimental investigations of the materials mechanical behavior. According to this approach, NbC-Steel microstructure was firstly observed, and it was meshed by OOF2® software (NIST). After, the ABAQUS® commercial software was used to simulate by FEM thermomechanical loads applied in the tool throughout mechanical processing in the macro and microscale. The conducted analysis allowed to observe the effect of different phases and porosity on the stress and strain distributions at different temperatures and loads (multiscale effects). Moreover, phases mechanical properties are contrasting, such as the second phase toughness and matrix hardness. This fact has allowed to study different aspects and critical stress and strain regions, that can be favored microstructural damage in the tool material.

Keywords: Multiscale effects. Thermomechanical loads. SPS. FEM. NbC-Steel.