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Mechanism for the macro and micro behaviors of the Ni-based superalloy during electrically-assisted tension: local Joule heating effect

Xin ZHANG, Hongwei LI*, Mei ZHAN

State Key Laboratory of Solidification Processing, School of Materials Science and Engineering, P.O. Box542, Northwestern Polytechnical University, Xi'an, 710072, P.R. China

Abstract

Electrically-assisted manufacturing (EAM) is used for forming difficult-to-form materials such as the Ni-based superalloy in recent years. Compared to the hot deformation, EAM is a more convenient and effective method. However, the mechanism for the macro and micro behaviors of the materials with EAM is still a controversial issue. Thus, in this work, the electrically-assisted (EA) tension tests of the Ni-based superalloy were carried out with different parameters, and the macro and micro behaviors of the material were studied and discussed. Besides the reduction of yield strength (YS) and flow stress, the Portevin-Le Chatelier (PLC) effect appears during the EA tension and is more significant than that during the hot tension at the same temperature. The critical temperature for the PLC effect is the same with different strain rates under a fixed peak current density. Essentially, the directional distribution of dislocations and the earlier precipitation of the second phase can also be the main causes for the PLC effect. According to the existing theories and the electric treatment experiments that the higher percentage of defects or the second phase in metal result in more significant temperature rise, the local high temperature which induced by local Joule heating effect exists in the critical areas. It may be the main mechanism resulting in the macro and micro behaviors of alloy during the EA tension. Furthermore, recrystallization is experimentally observed when the measured temperature is much lower than the critical temperature for recrystallization due to the local Joule heating effect.

Keywords: Ni-based superalloy; Electrically-assisted tension; Flow stress; Portevin-Le Chatelier effect; Microstructural evolution; Local Joule heating effect.