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Experimental and modelling study of an approach to enhance gas bulging formability of TA15 titanium alloy tube based on dynamic recrystallization

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Abstract

In order to further improve the hot gas bulging formability of laser-welded TA15 titanium alloy tube, studies about the effects of initial microstructures on the formability were carried out at 800 °C. Vacuum annealing procedures were performed to obtain different microstructures. The formability of these TA15 titanium alloy sheets with different microstructures was subsequently investigated by hot tensile tests and hot gas free bulging. A unified physically based material model considering dislocation density, work hardening, recrystallization, grain size and damage was built to analyze the deformation process. Results show that a good agreement was achieved between the unified material model and experiment results. The evolution of physical variables such as recrystallization fraction, and grain size can be predicted properly by the model. In the unified material model, the initial dislocation density would affect the dynamic recrystallization (DRX) rate. The DRX rate would increase with the increasing dislocation density. Therefore more DRX occurred at the early stage of deformation of initial material with higher dislocation density, while most of the DRX occurred at the middle-late stage of deformation of the annealed material with lower dislocation density. The initial material demonstrated the best formability due to the wide occurrence of DRX at the early stage of deformation, which increased the fraction of high angle grain boundaries, refined the microstructure, promoted the occurrence of grain boundary sliding and enhanced the formability of the material. However, most of the DRX occurred at middle-late stage of deformation of annealed material, which may increase the softening rate and lower the formability. Hence increasing the occurrence of DRX at the early stage of deformation by increasing the initial dislocation density in the material is an efficient approach to improve the gas bulging formability.

Key words: Hot gas bulging; unified model; titanium alloy tube; recrystallization;