A unified constitutive model for two-phase titanium alloys under hot stamping condition

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Abstract

Components made of titanium alloys are usually very expensive partially because of the costly forming process. To reduce the manufacturing cost of titanium alloys component, hot stamping process for titanium alloys was proposed, where hot titanium alloys blank was formed into a desired geometric configuration with desired microstructure within cold forming dies. The potential forming temperature range for this process was determined to be from 750 to 900 °C, under which multiple softening and hardening mechanisms would affect the flow stress simultaneously. With the increasing temperature, softening mechanisms including phase transformation, dynamic recrystallization and recovery will become more active; on the other hand, material hardening due to accumulation of dislocation will become less active. With the increasing of strain rate and strain, the formation of voids and cavities may cause macroscopic softening. A set of mechanism based unified viscoplastic constitutive equations was built to characterize the flow behaviour of the two-phase Ti-6Al-4V alloy under temperatures ranging from 750 to 900 °C and strain rates ranging from 0.1 to 10 s^{-1}, in which dislocation density, phase transformation, dynamic recrystallization, recovery and damage were considered. Materials constants were determined by a genetic algorithm based optimisation method. Good agreement between the experiment and model was achieved. This model can predict the flow stress, phase fraction and grain size evolution accurately.