ABSTRACT

Residual stresses are an important issue as they affect both the manufacturing processes as well as the performance of the final parts. Taking into account the whole process chain of hot forming, the integrated heat treatment provided by a defined temperature profile for cooling of the parts offers a great potential for the targeted adjustment of the desired residual stress state. However, in addition to elastic, plastic and linear thermal strain components, the complex material phenomena arising from phase transformation effects of the polymorphic steels have to be considered in order to predict the residual stresses. These transformation strains account for the plastic deformation at the phase boundary between the emerging and the parent phase. In addition, they are strongly related to the transformation induced plasticity (TRIP) phenomena which depend on the stress state.

The aim of this study is the investigation of TRIP effects and their impact on residual stresses regarding the typical hot forming steels 42CrMo4 and 100Cr6 by means of an experimental-numerical approach. The TRIP behaviour of the materials under consideration is integrated into an FE simulation model in the commercial software Simufact.forming for the purpose of residual stress prediction.

The experimental thermo-mechanical investigations are carried out using a quenching and forming dilatometer. These experiments are numerically modelled by means of FEM which allows TRIP coefficients to be determined phase-specifically by numerical identification. For validation of the improved FE-model, an experimental thermo-mechanical reference process is considered, in which cylindrical specimens with an eccentric hole are hot formed and subsequently cooled by different temperature routes. Finally, the numerical model is validated by means of a comparison between residual stress states determined with X-ray diffraction and predicted residual stresses from the simulation.