Deformation Behavior of High-Strength Steel Rivets for Self-Piercing Riveting Applications

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Abstract. Multimaterial design has become increasingly important for the manufacturing of lightweight car bodies. The material mix used in a modern body-in-white may include advanced and ultra-high-strength steels (AHSS, UHSS), aluminum alloys (5xxx, 6xxx, 7xxx) as well as plastics and composites. However, joining dissimilar materials is quite challenging. A popular and efficient technology to meet this challenge is self-piercing riveting (SPR), where the stack of the blanks is joined using rivets made of high-strength steel. A variety of different rivet/die/blank-combinations is required for producing vehicles. In order to reduce the experimental efforts for testing and qualifying novel joint combinations numerical simulations are applied in the pre-development phase. The results of these simulations depend strongly on the input data, in particular on the material properties influencing the deformation behavior of the rivet. Therefore, in the present work the actual deformation behavior was experimentally determined by combining high speed compression tests and inverse numerical modelling. In order to produce the samples for compression testing both the head and the tip of the rivet were cut off. The remaining hollow cylinder, i.e. the shaft of the rivet, was then compressed using a Gleeble 3800-GTC machine. Based on this test the flow curve of the rivet material was determined. The final geometry of the deformed sample was captured using a GOM ATOS III Triple Scan 3D measurement system. Compression testing was modeled using the finite element (FE) software simufact.forming and the experimentally determined flow curve of the rivet material. Figure 1 shows the calculated plastic strain field inside the sample. Process parameters (e.g. the friction coefficient) and material properties (e.g. the flow curve) were varied until the shape of the deformed sample was almost identical in both the simulation and the experiment. Agreement between the shapes indicated the obtained flow curve to describe the deformation behavior of the rivet properly.

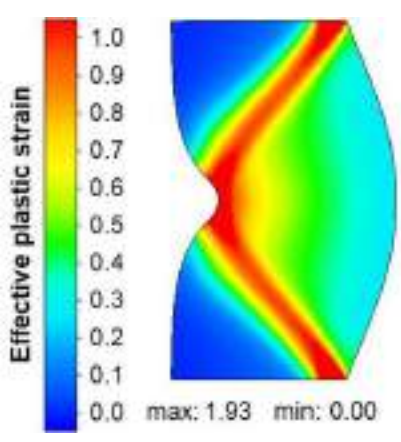

Figure 1. Calculated effective plastic strain inside a compressed sample cut from a self-piercing rivet