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MODELLING AND EXPERIMENTAL INVESTIGATION OF LARGE-STRAIN CYCLIC PLASTIC DEFORMATION OF HIGH STRENGTH DUAL-PHASE STEELS

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Car manufacturing is always the key industry behind sheet metal forming thus the requirements and developments in car manufacturing have decisive role in the development of sheet metal forming, too. The automotive industry faces with very contradictory demands and requirements: better performance with lower consumption and lower harmful emissions, more safety and comfort are hardly available simultaneously with conventional materials and conventional manufacturing processes. These requirements are the main driving forces in the automotive industry and in the material and technological developments in sheet metal forming, as well. During the recent years significant developments can be observed in the application of high strength steels. In this respect the application of various dual-phase steels are one of the best examples to meet these contradictory requirements. These materials are mainly used for car body making in the automotive industry.

During sheet metal forming of high strength automotive steels, the springback of the formed parts is an important theoretical and practical issue; however, the springback phenomenon is one of the main problems in sheet metal forming. In most of the forming processes several part sections are undergoing cyclic plastic deformation, e.g. bending and straightening over a tool radius, or passing through a drawbead, etc. It is also experienced that the hardening behaviour has significant differences for forward and reverse loading due to the well-known Bauschinger effect.

Traditionally, the springback problem is handled by time and cost consuming trial and error methods. Recently, finite element simulation is used to predict the springback after forming: good simulation is the precondition of determining the accurate shape of the part. The springback phenomenon is strongly connected to several physical and material properties. From the point of view of continuum mechanics the Young-modulus and particularly its changes during cyclic loading, as well as the yield strength are the most important mechanical properties, but many experiments indicate the importance of microstructure as well.

For more accurate modelling of springback phenomena and for more accurate production of final parts, it is absolutely essential to analyse the stress-strain behaviour of sheet metals during loading and unloading (i.e. cyclic plastic deformation). There are several investigations to study the so-called cyclic plasticity both theoretically and experimentally.

Many experimental devices were also elaborated for studying this cyclic plastic behaviour (e.g. bending, shearing, tension-compression tests) having some limitations or disadvantages. In this paper, a new experimental device will be introduced to overcome the difficulties during experimental determination of the main parameters in cyclic plastic deformation that can be applied in numerical modelling of springback phenomena during sheet metal forming. For the experimental determination of material properties various grades of high strength steels (e.g. DP600, DP800 and DP1000) were applied. The experimentally obtained results were validated by numerical simulation applying the AutoForm code. The results of the experiments and the numerical simulation are in good agreement and can be successfully used to predict the springback behaviour of the tested high strength steels.

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