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Destructive and Nondestructive Characterization of Advanced High Strength Steels DP1000/1200

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Abstract : Advanced high-strength steels (AHSS) are increasingly being used in automotive components. The use of AHSS sheets plays an important role in reducing weight, as well as increasing the resistance to impact in vehicle components. However, the large-scale use of these sheets becomes more difficult due to the limitations during the forming process. Such limitations are due to the elastically driven change of shape of a metal sheet during unloading and following forming, known as the springback effect. As the magnitude of the springback tends to increase with the strength of the material, it is among the most worrisome problems in the use of AHSS steels. The prediction of strain hardening, especially under non-proportional loading conditions, is very limited due to the lack of constitutive models and mainly due to very limited experimental tests. It is very clear from the literature that in experimental terms there is not much work to evaluate deformation behavior under real conditions, which implies a very limited and scarce development of mathematical models for these conditions. The Bauschinger effect is also fundamental to the difference between kinematic and isotropic hardening models used to predict springback in sheet metal forming. It is of major importance to deepen the phenomenological knowledge of the mechanical and microstructural behavior of the materials, in order to be able to reproduce with high fidelity the behavior of extension of the materials by means of computational simulation. For this, a multi phenomenological analysis and characterization are necessary to understand the various aspects involved in plastic deformation, namely the stress-strain relations and also the variations of electrical conductivity and magnetic permeability associated with the metallurgical changes due to plastic deformation. Aiming a complete mechanical-microstructural characterization, uniaxial tensile tests involving successive cycles of loading and unloading were performed, as well as biaxial tests such as the Erichsen test. Also, nondestructive evaluation comprising eddy currents to verify microstructural changes due to plastic deformation and ultrasonic tests to evaluate the local variations of thickness were made. The material parameters for the stable yield function and the monotonic strain hardening were obtained using uniaxial tension tests in different material directions and balanced biaxial tests. Both the decrease of the modulus of elasticity and Bauschinger effect were determined through the load-unload tensile tests. By means of the eddy currents tests, it was possible to verify changes in the magnetic permeability of the material according to the different plastically deformed areas. The ultrasonic tests were an important aid to quantify the local plastic extension. With these data, it is possible to parameterize the different models of kinematic hardening to better approximate the results obtained by simulation with the experimental results, which are fundamental for the springback prediction of the stamped parts.

Keywords : advanced high strength steel, Bauschinger effect, sheet metal forming, springback
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