Chair of Metal Forming and Casting
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Hydrogen-induced cracking

Influence of the cutting strategy on the embrittlement tendency

Motivation

The use of high-strength steels in industrial sheet-metal forming is hindered by their susceptibility to hydrogen-induced cracking, leading to high scrap rates and rework. This time-delayed failure mechanism occurs unexpectedly below material tensile strength and depends on material properties, hydrogen content, and mechanical load. The effects of the hydrogen-induced failure from the residual stress state occurring from the cutting process, the local work hardening and the changes in microstructure of the cut surface are still not sufficiently researched.

Approach

This research project investigates how various cutting parameters and shear-affected zone properties affect the hydrogen embrittlement susceptibility of three dual-phase high-strength steels. An experimental setup for the loading of the different material specimens with hydrogen is used to replicate the introduction of hydrogen during industrial manufacturing processes. In order to evaluate the influence of shear cutting parameters on hydrogen-induced failure, the loaded samples are manufactured with different configurations (see *Figure 1*) and then subjected to a Constant Load Test (CLT) developed for this purpose. A two-dimensional FEM shear cutting simulation is used to investigate the distribution and gradients of the residual stresses induced by the different cutting parameters.

The experimental and simulation results will be used for the creation of a metamodel that describes the relationships between the cutting parameters, the properties of the shear-affected zone, and the hydrogen embrittlement susceptibility of the selected materials. The metamodel will contribute to the selection of the best cutting strategy for materials exposed to hydrogen.

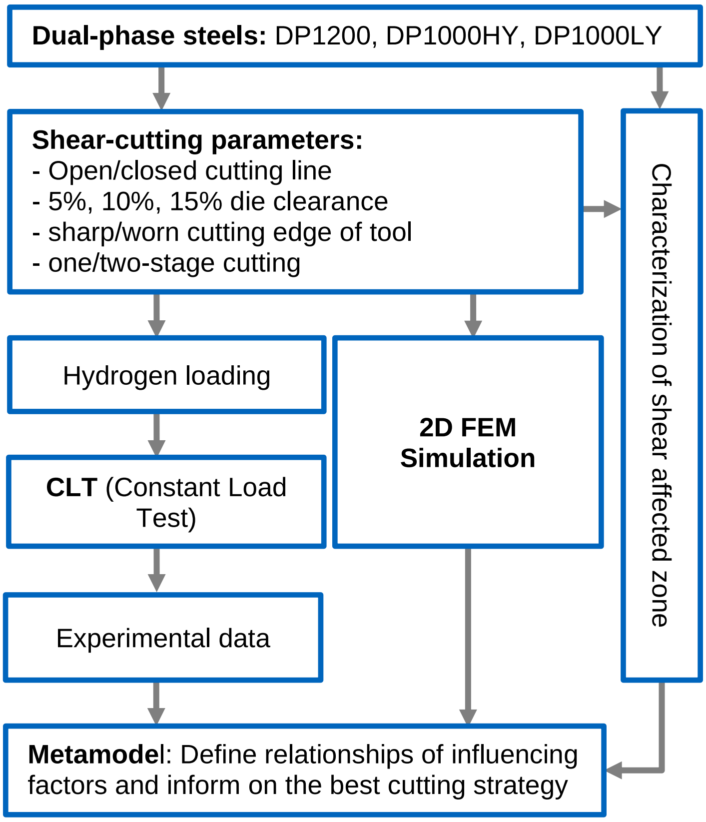

Figure 1: The approach to identify the effect of different cutting strategies on hydrogen-induced cracking.

Outlook

The findings of this project aim to provide an in-depth understanding of the relationship between cutting parameters, shear-affected zone properties, and hydrogen embrittlement susceptibility, forming the basis for the development of a metamodel. The metamodel will enable the selection of the best shear cutting strategy to prevent hydrogen-induced failure. This approach will enhance process reliability in sheet metal forming of high-strength steels, reduce scrap rates, and promote resource conservation.

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