Deformation and failure mechanisms of thin sheet materials for automotive applications

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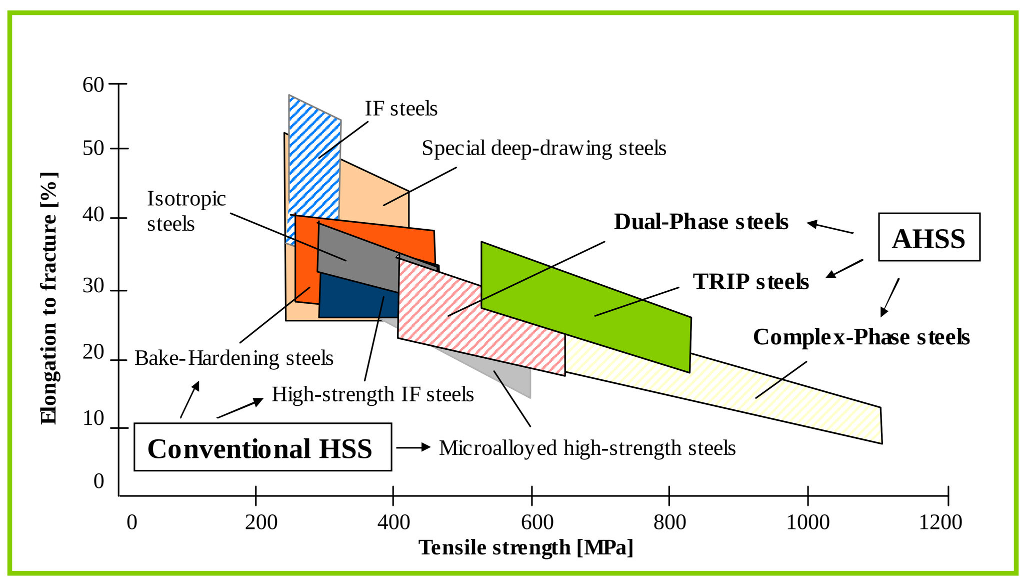
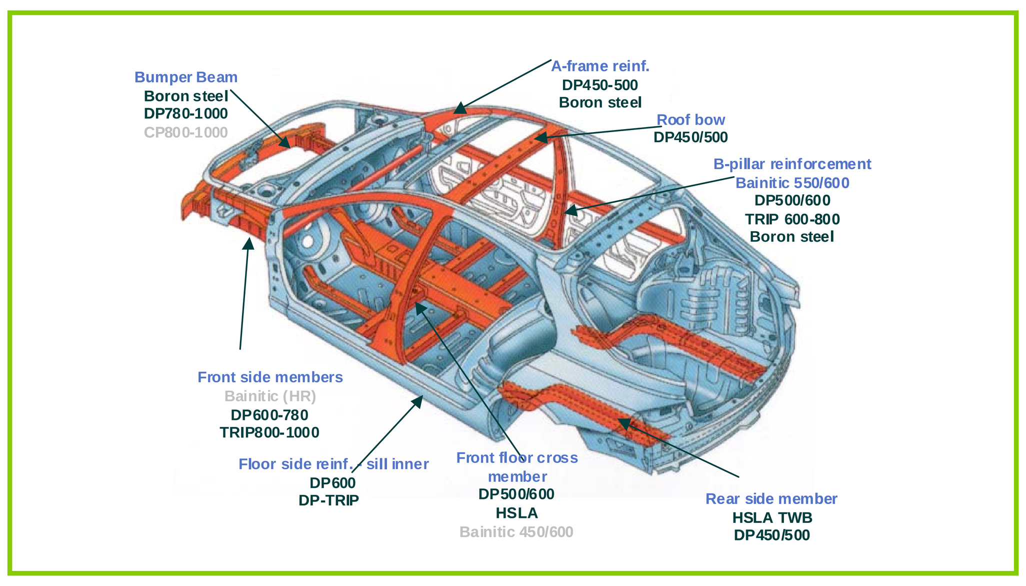
Introduction



In the automotive industry, new design concepts for vehicle light-weighting, reducing gas emissions by improving fuel consumption and increasing passenger safety call for stronger and more ductile materials. The applications of **A**dvanced **H**igh **S**trength **S**teels (AHSS) are expanding as one of the means satisfying these demands.



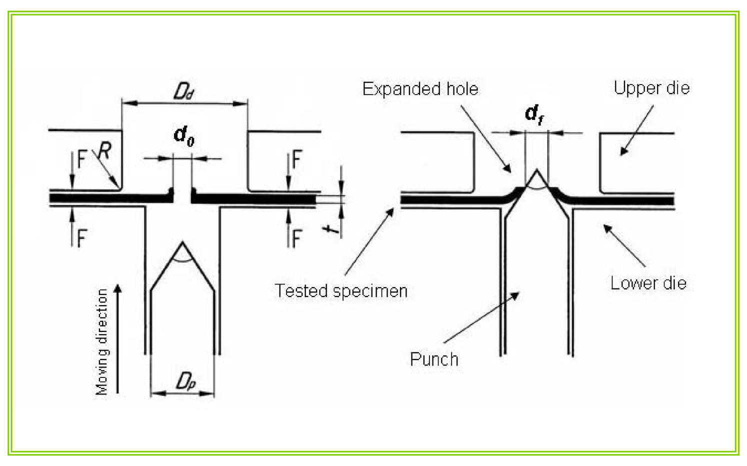
Investigated materials

Different grades of industrially produced high strength steels (DP - dual phase, CP – complex phase, TRIP – transformation induced plasticity) covering the strength range of 600-800 MPa are investigated. The alloying concept involves a common based composition (Mn, Cr, Si). Cold rolled steel sheets are either hot dip galvanized or continuously annealed.

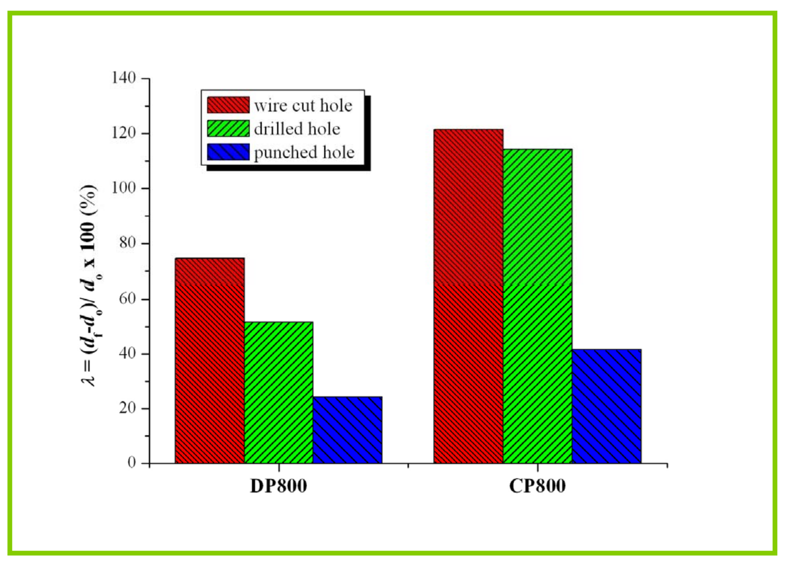
Chemical composition (wt.%)				Mechanical properties			
C	Si	Mn+Cr+Mo	P	$R_{p0,2}$ (MPa)	R_m (MPa)	A_g (%)	A (%)
~ 0,14	~ 0,14	~ 2,5	~ 0,01	350-750	600-850	6,5-12,5	11,5-28,5

Formability characterization

Formability of chosen materials is characterized in uni- and multi-axial (quasistatic) deformation experiments, representing typical conditions in the production of complex shaped parts. The main focus is placed on the hole expansion testing, hence hole expansion is one of the most important properties describing formability of the steel sheets with respect to the stretch flangeability. The impact of the specimen preparation method (stamping, drilling, wire cutting) on the results of hole expansion test is of main interest.



Schematic illustration of hole expansion test



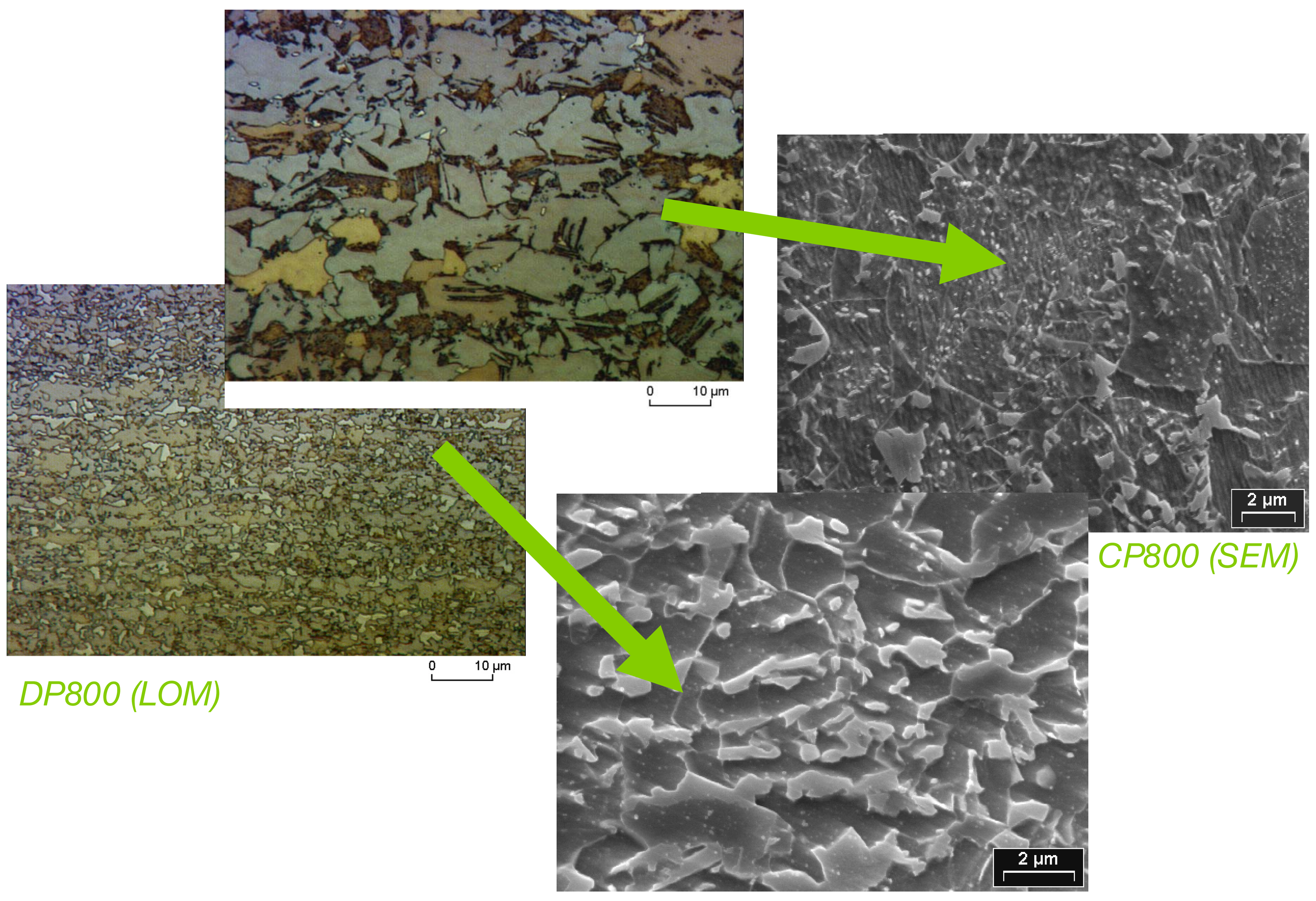
The influence of the hole edge condition (expressed by λ-ratio) on the hole expansion testing results of steel grades DP800 and CP800

The evaluation of results will help to identify the mechanisms controlling and limiting formability and to understand the relationship between microstructure and parameters describing formability of investigated materials.

Microstructure characterization

Standard light optical microscopy (LOM) and scanning electron microscopy (SEM) are used to analyze the microstructure of investigated materials. Quantitative characteristics of the microstructure such as phase fractions and mean grain sizes are determined by line intercept measurements.

CP800 (LOM), LePera's etched



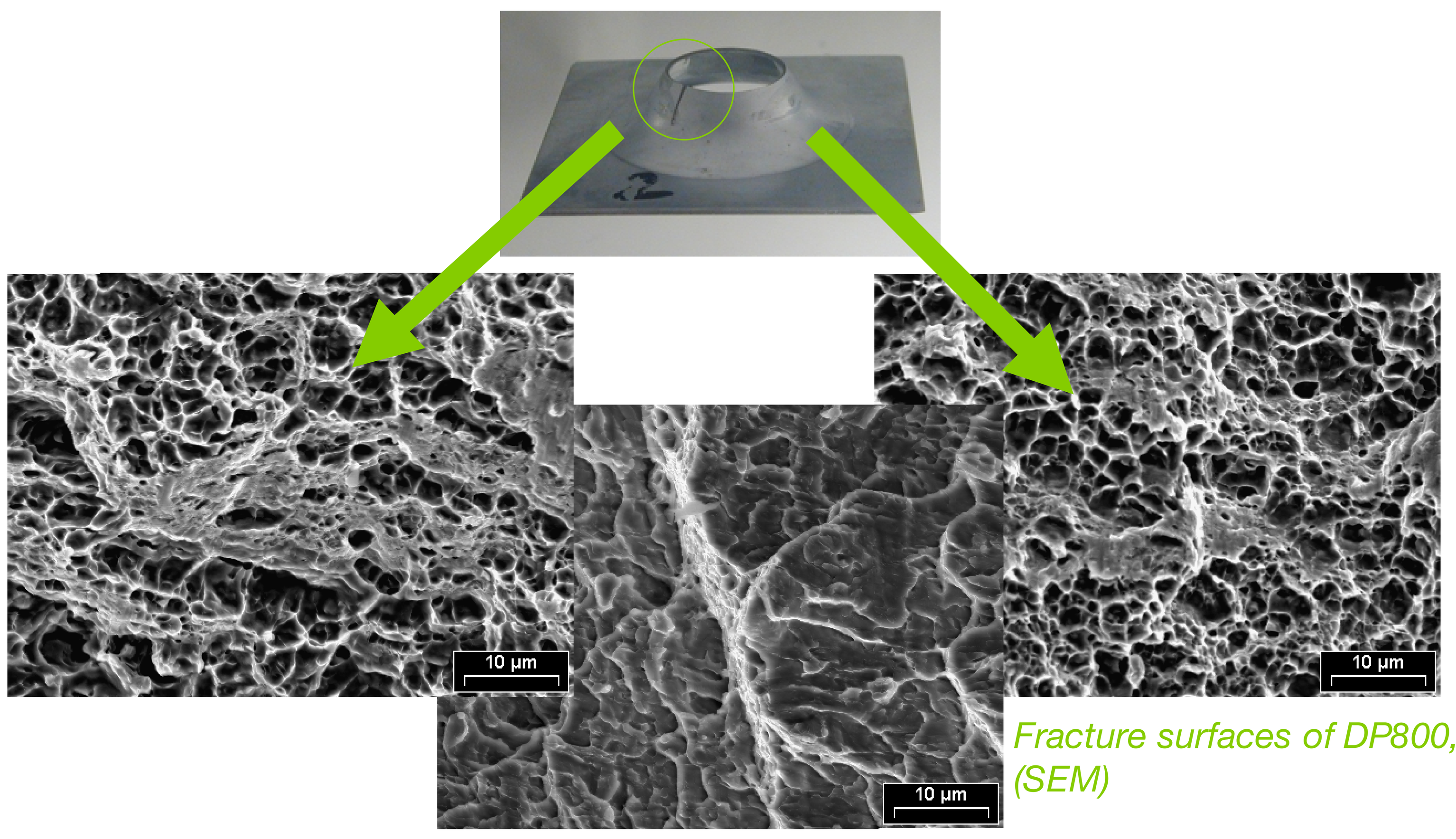
CP800 (SEM)

DP800 (LOM)

DP800 (SEM), nital etched

Fracture analysis

Detailed analysis of fracture surfaces is conducted to explain the influences and characteristics of multiaxial loading state taking place during hole expansion, particularly to determine the crack formation mechanism and the fracture mode.



Fracture surfaces of DP800, (SEM)

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