In-situ 3D synchrotron laminography assessment of damage evolution in blanked dual phase steels

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The mechanical performance of automotive structures made of advanced high strength steels (AHSS) is often seen reduced by the presence of cut-edges. Indeed, during forming steps, cases of failure in Dual Phase steel grades, which initiate on cut-edges after blanking were detected.

The objective of this study is to gain insight into the initial damage state and the damage evolution during loading of a cut-edge. This is assessed in 3D and in-situ by synchrotron radiation computed laminography (SRCL) observation during simultaneous tensile and bending loading of two types of edges : a cut-edge produced by stamping and a machined edge. Laminography is a new 3D imaging technique that allows to observe regions of interest in thin sheet-like objects. It is found for the DP600 laboratory steel grade that the fracture zone is very rough and that needle voids from the surface and in the material bulk follow ferrite-martensite flow lines. During loading the needle voids grow from the fracture zone surface and coalesce with voids in the bulk. The needle cracks coalesce with the burnish zone though narrow zones, called void sheets. The formed cracks are inclined by 45^o compared to the load direction. In contrast, for the case of the machined edge the damage does not start from the edge but in the material bulk that has undergone substantial necking during loading.

Surface digital image correlation has been performed during laminography observation, and allowed us to determine the displacement fields in the region of interest. These displacement fields were used as boundary conditions in 3D numerical simulation using an elasto-plastic constitutive law. The mapping of the stress triaxiality has been calculated in order to understand the influence of the edge profile on the stress triaxiality distribution and interpret the behaviour of cut and machined edges.