Modelling Tailored Forming Joining Zones With Internal Thickness Extrapolation Elements

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Abstract. Tailored Forming is a manufacturing process where two metallic materials are joined and formed subsequently. This processing order allows for new designs of hybrid material components. However, the joining zone is heavily loaded during forming. The thickness of the joining zone depends on manufacturing process parameters but is small in general. To evaluate the possible occurrence of damage within the joining zone in coarse scale simulations, a material model has to be developed that captures the complex microstructural behaviour effectively at macroscopic length scale. An initially flat element like a cohesive zone element (CZE) is beneficial for meshing due to the small thickness of the joining zone. The material behaviour in CZEs is characterized by traction separation laws (TSLs). TSLs are curves modelled using e.g. the maximum strength and the decohesion energy that depend on the stress triaxiality, i.e. TSLs phenomenologically describe specific decohesion situations. Using TSLs is not sufficient for taylored forming as different, not previously known stress triaxialities, may arise and further damage causing deformation modes (shearing or size changes of the joining zone) may occur. Three-dimensional continuum material models are able to take all deformation modes into account and their material parameters are independent of a pre-known stress triaxiality. In contrast to TSLs they use strain instead of separation. Hence continuum material models cannot be combined directly with initially flat elements like CZEs. Internal Thickness Extrapolation (InTEx) of a flat element enables the use of three-dimensional material equations. The idea of the InTEx formulation is presented together with its discretisation.