Abstract:

This paper deals with an advanced model for spotwelds in finite element structures of car bodies under crash loads. The treatment is elasto-plastic, whereas the elastic part as well as the perfectly-plastic part is based on a special hybrid Trefftz element representing the entire spotweld, the cylindrical nugget, heat affected zone and an annulus made of base material. The linking to the residual finite element mesh, consisting of bilinear standard shells, is accomplished via a displacement frame, an arbitrary polygon. By definition the Trefftz-type solution satisfies a priori all governing differential equations within the element area and fulfils inner boundary conditions. The modelling of plastic deformation accounts for geometrically nonlinear behaviour (stress stiffening) within the metal sheet annulus and permits the forming of plastic hinges along the circumference of the comparatively rigid nugget. Isotropic hardening is considered by Hollomon's power law leading to a high resolution of the stress/strain field in the vicinity of the spotweld nugget, and enables the introduction of more accurate stress/strain-based failure criteria. The developed model is mapped on an auxiliary "beam spider", whose elasto-plastic parameters are adapted so that it yields nearly the same mechanical resultant behaviour including failure. We assess the numerical stability within the framework of explicit time integration using the central difference scheme