Fracture Behavior of a Typical Adhesive Joint in a Car Body under Static Loading

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Abstract:

A post-processing work has been developed here on the basis of a pre-existing GM car structure model. First, a sub-model including the adhesive joint was extracted from the original geometry and remodeled in LS-DYNA. An elastoplastic adhesive layer was then inserted between the parts and meshed as solid elements. The adherends' nodal displacements were then interpolated from the original result file. The implicit solver of LS-DYNA was used to determine the adhesive stress field and nodal forces produced from the new nodal displacements. The strain energy release rate in the adhesive layer was determined from the results by using a virtual crack closure technique. This was then compared with the experimentally-measured critical energy release rate obtained for the toughened heat-cured adhesive of this study. The validity of results was also verified by performing similar analysis on the standard double-cantilever-beam joint after comparing the results with available experimental data.

FRACTURE BEHAVIOR OF A TYPICAL ADHESIVE JOINT IN A CAR BODY UNDER STATIC LOADING

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The recent advancements in light-weight materials engineering progressively motivated the development of adhesive joining technology in automobile industries. Although the adhesive bonds are of great importance for joining the body skin to the main car structure, they are modeled as no-failure elastic or elastoplastic materials in numerical simulations. The difficulty mainly comes from two facts, (1) the singularity, material non-linearity and high gradient in adhesive stress field requires a complex fracture mechanics approach for modeling the adhesive joint behavior, and (2) due to geometric disparity, the thin adhesive layer needed a very fine mesh comparing to the other parts in the car structure model. In order to evaluate a more realistic behavior of adhesive joints, a post-processing work has been developed here on the basis of a pre-existing GM car structure model. First, a sub-model including the adhesive joint was extracted from the original model and the adherends (steel parts) were remodeled in LS-DYNA as shell elements after a mesh refinement of 4.0 × 4.0 mm. An adhesive layer with a constant thickness of 0.4 mm was then inserted between the parts in the form of solid elements (0.1 × 1.0 × 1.0 mm), Fig. 1. The nodal displacements of steel sheets in *x*-, *y*-, and *z*- directions were then determined by interpolating from the original mesh for the particular loading case. In the new sub-model, an elastic behavior was considered for the steel sheets while an isotropic elastoplastic model represented the adhesive mechanical characterization. The implicit solver of LS-DYNA was used to determine the adhesive stress field and nodal forces produced from the new nodal displacements. The strain energy release rate (G) in adhesive layer was determined from the results by using a virtual crack closure technique, Ref. [1]. The maximum calculated value of G was about 200 J/m^2 for the particular loading case of this study that was much lower than the experimentally measured critical value G_c for the toughened heat-cured epoxy adhesive, i.e. 2500 to 9000 J/m^2 for the quasi-static tests ranging between mode-I and -II. The validity of results was also verified by performing similar analysis on the standard double-cantilever-beam joint after comparing the results with available experimental data.

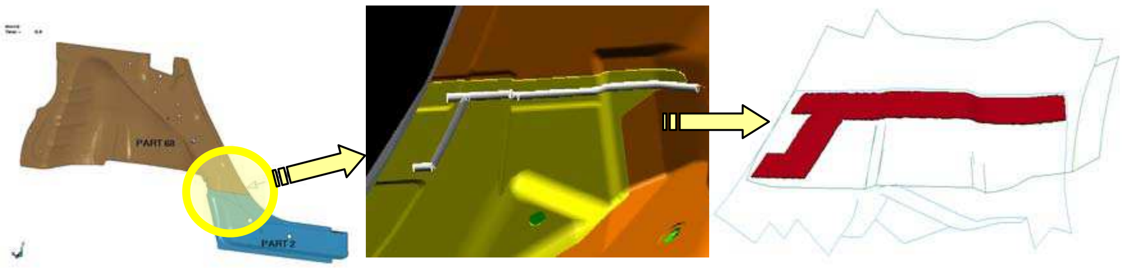

Fig. 1: Remodeling a typical adhesive joint in car structure by LS-DYNA

REFERENCE

1. R. Krueger, "The virtual crack closure technique: History, approach and applications, NASA/CR-2002-211628, April 2002.