Modelling High Strain Rate Tear Open Behavior of a Bilaminate Consisting of Foam and Plastic Skin Considering Tensile Failure and Compression

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Abstract : Premium cars often coat the instrument panels with a bilaminate consisting of a soft foam and a plastic skin. The coating is torn open during the passenger airbag deployment under high strain rates. Characterizing and simulating the top coat layer is crucial for predicting the attenuation that delays the airbag deployment, effecting the design of the restrain system and to reduce the demand of simulation adjustments through expensive physical component testing.Up to now, bilaminates used within cars either have been modelled by using a two-dimensional shell formulation for the whole coating system as one which misses out the interaction of the two layers or by combining a three-dimensional formulation foam layer with a two-dimensional skin layer but omitting the foam in the significant parts like the expected tear line area and the hinge where high compression is expected. In both cases, the properties of the coating causing the attenuation are not considered. Further, at present, the availability of material information, as there are failure dependencies of the two layers, as well as the strain rate of up to 200 1/s, are insufficient. The velocity of the passenger airbag flap during an airbag shot has been measured with about 11.5 m/s during first ripping; the digital image correlation evaluation showed resulting strain rates of above 1500 1/s. This paper provides a high strain rate material characterization of a bilaminate consisting of a thin polypropylene foam and a thermoplasctic olefins (TPO) skin and the creation of validated material models. With the help of a Split Hopkinson tension bar, strain rates of 1500 1/s were within reach. The experimental data was used to calibrate and validate a more physical modelling approach of the forced ripping of the bilaminate. In the presented model, the three-dimensional foam layer is continuously tied to the two-dimensional skin layer, allowing failure in both layers at any possible position. The simulation results show a higher agreement in terms of the trajectory of the flaps and its velocity during ripping. The resulting attenuation of the airbag deployment measured by the contact force between airbag and flaps increases and serves usable data for dimensioning modules of an airbag system.

Keywords : bilaminate ripping behavior, High strain rate material characterization and modelling, induced material failure, TPO and foam
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