An enhanced failure approach for fracture simulation of laminated glass under impact loading

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ABSTRACT

In short-time simulations like impact, blast and crash, the explicit finite element method with rather coarse meshes and element erosion for crack propagation is commonly used. In the context of head impact on automotive windscreens for pedestrian protection, this method leads to underestimation of the stress tensor at the crack tip and thus to a non-physical fracture pattern. This leads to a large deviation between the head acceleration from experiment and simulation. To obtain a reliable prediction of the head injury criterion, the resultant acceleration through the different fracture stages of a windscreen during head impact has to be computed accurately.

A significant improvement in comparison to classical major stress approaches for simulating the head impact was achieved by Pyttel et al. [1] with a non-local failure criterion. Basically, an energy threshold criterion in a predefined area is used for the prediction of failure onset without consideration of the local stress. In order to overcome the disadvantage of the underestimation of the stress tensor at the crack tip, a global major stress criterion is used after the energy criterion is reached with rather low strength for the element erosion and thus for the prediction of the fracture pattern. Despite the improvement of the simulation e.g. the prediction of the resultant head acceleration an instantaneous reduction of the global strength is rather unphysically and leads to an unrealistic crack propagation.

The presented modelling technique uses a combination of linear elastic fracture mechanics and crack growth behavior of glass e.g. subcritical crack growth effects for the prediction of failure onset [2]. Thereby, the windscreen is subdivided into different areas of strength caused by manufacturing and handling processes of the screen. Instead of a global reduction of the fracture stress after the initial failure only the strength of elements in the direction of a crack is reduced. The reduction of the fracture stress depends on the element size and can thus also be used as a regularization method.

REFERENCES

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