Directional cohesive elements for blade cutting simulations of layered shells

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The blade cutting of thin layered shell involves three small geometrical scales, the scale of layer thicknesses, the scale of blade radius of curvature, the scale of fracture and delamination process zones, which need be resolved when a numerical simulation is carried out by means of a finite element discretization.

Large deformations, material nonlinearity, contact, crack propagation and delamination make the problem highly nonlinear, so that an explicit dynamics approach based on the use of solid-shell elements is adopted to avoid convergence problems. A selective mass scaling technique [1,2] is developed to overcome the critical time step limitation, dictated by the layers thickness.

The prescribed blade trajectory drives crack propagation, so that it is possible to adjust the mesh with element edges along the expected crack path. To model crack propagation accounting for the interaction between the sharp blade and the cohesive process zone, special “directional cohesive elements” [3] are placed between separating element edges.

Crack propagation and delamination can be characterized by very small process zone sizes, depending on the type of material and on the layer thickness. Discretizations that are coarse with respect to these lengths may give rise to spurious oscillations and accuracy loss. Techniques for the mitigation of these problems are investigated.

Numerical applications to engineering problems are used to assess the effectiveness of the proposed simulation approach.

References

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