

Simulations of dynamic crack propagation using the material point method

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Dynamic crack growth is simulated by implementing a cohesive zone model in the generalized interpolation material point (GIMP) method. Multiple velocity fields are used in GIMP to enable handling of discrete discontinuity on either side of the interface. Multilevel refinement is adopted in the region around the crack-tip to resolve higher strain gradients. Numerical simulations of crack growth in a homogeneous elastic solid under mode-II plane strain conditions are conducted with the crack propagating along a weak interface. A parametric study is conducted with respect to varying impact speeds ranging from 5 to 60 m/s and cohesive strengths from 4 to 35 MPa. Numerical results are compared qualitatively with the dynamic fracture experiments. The simulations are capable of handling crack growth with crack-tip velocities in both sub-Rayleigh and intersonic regimes. Crack initiation and propagation are the natural outcome of the simulations incorporating the cohesive zone model. For various impact speeds, the sustained crack-tip velocity falls either in the sub-Rayleigh regime or in the region between $\sqrt{2} c_s$ (c_s is the shear wave speed) and c_D (c_D is the dilatational wave speed) of the bulk material. The Burridge-Andrews mechanism for transition of the crack-tip velocity from sub-Rayleigh to intersonic speed of the bulk material is observed for impact speeds ranging from 9.5 to 60 m/s (for normal and shear cohesive strengths of 24 MPa). Within the intersonic regime, sustained crack-tip velocities between $1.66 c_s$ (or $0.82 c_D$) and $1.94 c_s$ (or $0.95 c_D$) were obtained. For the cases simulated in this work, within the stable intersonic regime, the lowest intersonic crack-tip velocity obtained was $1.66 c_s$ (or $0.82 c_D$).