A Generalized Transport-Velocity Formulation for SPH

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ABSTRACT

As a fully Lagrangian, meshless method, the Smoothed Particle Hydrodynamics (SPH) was proposed by Lucy[1] and Gigold and Monaghan[2]. However, Standard SPH method suffers from tensile instability and Swagle[3] studied this instability problem and pointed that tensile instability is related to the sign of the pressure and the sign of second derivative of the smoothing function. In fluid dynamics, tensile instability will occur where the pressure is negative and result in particle clumping. In solid mechanics, tensile instability is known to occur when extreme tensile stress happens and produce unphysical fracture. Many attempts have been studied to eliminate the tensile instability since this instability was observed. Monaghan [5] developed an artificial pressure or stress approach to remove tensile instability. Grey [6] generalised this artificial stress algorithm and extended to elastic dynamics for the simulation of oscillating plat and collision of rings. However, Liberstky [7] pointed that the artificial stress algorithm fail to eliminate the tensile instability when elastic material has a high Poisson ratio. Furthermore, this artificial stress algorithm effect the momentum equation and leads to artificial dissipation.

Adami et al. [8] proposed a simple and effective transport-velocity formulation to remove tensile instability in fluid-dynamic simulation due to negative pressure. Applications have been investigated in internal flow and the results showed that this algorithm has good performance in remove tensile instability and stability in internal flow, and achieved unprecedented numerical accuracy.

In this work, the transport-velocity formulation is modified and generalised to eliminate tensile instability in SPH method for general computational solid and fluid dynamics. Applications to wide range of numerical cases show that this method achieves very good stability and great improvement of numerical accuracy.

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