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机械工程

SPH和FEM耦合法模拟磨料水射流中单磨粒加速过程

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摘要:

针对Eulerian和ALE(arbitrary lagriange eulerian)方法仿真研究磨料水射流喷嘴中磨料粒子加速过程的局限性,提出采用SPH(smoothed particle hydrodynamics)耦合FEM(finite element method)的方法研究后混式磨料水射流喷嘴中低速磨料粒子在高速水射流作用下的流体动力学特性和磨粒加速后撞击靶材的全过程。水用SPH建模,磨料粒子、喷嘴和工件用FEM建模,通过接触算法实现SPH和FEM的耦合以模拟后混式磨料水射流加工的全过程。仿真研究了磨粒和水在喷嘴中各自的速度变化过程;单磨粒在喷嘴中的运动轨迹;不同直径的磨料粒子在不同水压作用下的速度变化过程;不同直径的磨粒在不同直径的混合管中出口速度的变化规律;磨料粒子在工件上的撞击深度。通过与相关实验及理论数据的比较,验证了仿真模型和结果的正确性。

关键词: 磨料的混合与加速 SPH耦合FEM;磨料水射流加工;撞击深度

Numerical simulation of single particle acceleration process by SPH coupled FEM for abrasive water-jet cutting

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Abstract:

The existing eulerian and arbitrary lagrange eulerian (ALE) grid-based algorithms were limited to study the hydrodynamic characteristics of pre-mixed abrasive waterjet (AWJ) in a cutting head. Smooth particle hydrodynamics (SPH) coupled finite element method (FEM) algorithm was adopted to establish a new AWJ model, by which the abrasive particle could enter into the mixing chamber in a low velocity and chould be accelerated in the focus tube by a high-speed waterjet from the orifice. SPH particles were used to model the high-speed waterjet and the FEM was applied to model the discrete abrasive particle, cutting head and workpiece. Consequently, the evolution of abrasive and waterjet velocities along focus tube was analyzed and the trajectory of single abrasive particle in focus tube was sighted. The relationships between abrasive particle velocities and different water pressures were studied and the rule of outlet velocities of abrasive particle vs. dimensionless ratio of diameter were conducted. The penetration depth caused by single abrasive particle impact was obtained. This model was validated by the existing theoretical and experimental data.

Keywords: abrasive mixing-and-acceleration SPH coupled FEM AWJ cutting penetration depth

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