THE STUDY OF MODIFICATIONS OF THE PARTICLE-IN-CELL NUMERICAL METHOD FOR SIMULATING GAS DYNAMIC FLOWS

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Recent advancements in computational technology have brought a wide range of numerical methods to the forefront, which are more computationally demanding than conventional ones but are more stable in response to changes in the flow geometry. For example, the Lagrangian Particle-in-Cell method [1], developed by a group of scientists led by F.X. Harlow, is successfully applied to describe gas dynamic flows of complex configurations and high compression ratios. However, significant fluctuations in gas dynamic quantities are observed due to the discrete nature of the numerical method itself. This work is dedicated to the modification of the Particle-in-Cell numerical method—by adding individual density values on particles into the finite difference scheme. Knowing the individual density and energy values [2] on the particles, the pressure for each particle is calculated using the equation of state for an ideal gas. After conversion from particles to the grid, the pressure is averaged and inserted into the difference scheme. To calculate the density evolution, the continuity equation (1) from the system of gas dynamics equations in Lagrangian variables [3] is used. By transforming this equation, a differential equation is derived that describes the natural logarithm of density in time (2):

$$\frac{d\rho}{dt} = -\rho div\vec{u}; \tag{1}$$

$$\frac{\mathrm{d}\ln(\rho)}{\mathrm{d}t} = -div\vec{u}. \tag{2}$$

Using the finite difference form of equation (2), the value of the individual density on the particles is calculated under the assumption of equal compressibility. Results were obtained for the «Blast Waves» test case [4] on an adaptive grid using linear and quadratic interpolation to obtain effective velocities for particle movement. A graphical comparison was made with the reference solution of the problem, obtained using the Lagrangian method.

References

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