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Numerical simulation of fiber conveyance in a confined channel by the immersed boundary-lattice Boltzmann method. (English) Zbl 07073389

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Summary: Fluid-structure interaction (FSI) phenomenon is very common in pneumatic-type textile field. However, the motion of flexible bodies, for instance, fibers or yarns, are usually difficult to simulate due to their large fineness ratio and high flexibility. Conventional FSI solvers based on the body-fitted grid method are difficult to handle the large deformation due to severe grid distortion. In this paper, we studied the fluid-fiber interaction for fiber conveyance in a fiber transport channel (FTC) using the immersed boundary-lattice Boltzmann method (IB-LBM). The effect of three parameters on fiber conveyance, i.e., the conical degree of the FTC ($\tan\alpha$), the bending rigidity of fiber ($\hat{K}_b$) and the flow Reynolds number (Re), are particularly investigated. The calculated results indicate that the converging shape of FTC helps to straighten fiber and adjust its orientation to a more horizontal degree during the conveyance, however, it may not improve fiber delivery efficiency. A larger conical degree would bring a better straighten effect and a smaller leading angle if fiber-wall contact does not occur. Under the conditions that $\tan\alpha > 0$, $\mathrm{Re} < 400$ and $\hat{K}_b < 1e-3$, the straightness undergoes a "leap-slump-grow-drop" evolution process and the leading angle follows an "increase-decline" tendency. Moreover, the simulation results show that the bending rigidity have a significant effect on fiber configuration and orientation during its conveyance. A fiber with a larger bending rigidity is more likely to maintain a straighter configuration and a more horizontal orientation during its conveyance. As Re increases in simulations, the fiber gets less straight in configuration and more vertical in orientation, and deviates more from the horizontal path.

MSC:

76-XX Fluid mechanics

Keywords:

fluid-structure interaction; fiber conveyance; immersed boundary method; lattice Boltzmann method

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