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材料化学工程与纳米技术

纤维悬浮聚合物熔体中纤维影响的数值模拟

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摘要

采用一种多尺度模型研究了纤维悬浮聚合物熔体的流动过程，通过宏观流体的流动状态、纤维所在尺度上的纤维取向表征和聚合物溶液大分子哑铃模型尺度上的哑铃概率分布三尺度信息，实现了纤维悬浮聚合物熔体流动控制方程和本构关系的三尺度共同表征。使用SIMPLER-FDMS算法对多尺度控制方程组进行了求解，并通过4∶1等温平板收缩流的数值模拟验证了该多尺度模型的有效性。通过对纤维浓度、纤维间相互作用以及纤维长径比的分析，研究了纤维参数对聚合物基熔体悬浮体系及纤维取向的影响。

关键词

多尺度模型 纤维取向 聚合物熔体 收缩流 数值模拟

分类号

Numerical simulation of effect of fiber in polymeric fluid with fiber suspensions

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Abstract

For polymeric fluid with fiber suspensions，a multi-scale model was developed.The model coupled the rheologic behavior of incompressible flow field on the macro-scale，the effect of transient orientation of the fiber on the meso-scale，and the information of probability distribution of finite extensible nonlinear elastic(FENE) dumbbell model on the polymeric molecular level.The governing equations for the polymeric flow field，the composite stress，the distribution of molecular chain configurations and fiber orientation were coupled and solved simultaneously.The semi-implicit method for pressure linked equations revised and finite difference method on source term（SIMPLER-FDMS）method was used to calculate the multi-scale governing [JP2]equations.In the simulation of 4∶1 isothermal planar contraction flow，the validity of the multi-scale model was proved by the analysis of distribution of normal stress difference，shear stress，and the fiber orientation ellipse.For investigating the effects of fiber parameters on the viscoelastic behavior and fiber orientation probability of polymeric fluid with fiber suspensions，a parametric study about the fiber concentration，fiber-fiber interaction and [JP]fiber aspect ratio was conducted.

Key words

multi-scale model fiber orientation polymeric melt contraction flow numerical simulation

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