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轻密度颗粒在搅拌槽内悬浮特性的数值模拟

Numerical simulation of solid-liquid suspension characteristics for low-density particles in stirred vessel

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中文摘要:

轻密度颗粒在搅拌槽内的悬浮特性是其在工业应用中非常关键的问题。该文采用多重参考系（multiple reference frame，MRF）法和以颗粒动力学为基础的Euler-Euler双流体模型，对轻密度颗粒在双层圆盘涡轮桨搅拌槽内的悬浮特性进行数值模拟，得到了槽内的宏观流动场和固含率分布等，采用文献试验数据对模拟结果进行了验证。结果表明：总体上轻密度颗粒固含率分布沿轴向高度增大而增大，并存在分区现象，在液面中心处颗粒浓度最高，颗粒易在此处堆积，而在槽底中心处则固含率最低。在循环涡涡心和桨叶后部，颗粒浓度相对较高。轻密度颗粒的加入使搅拌槽内液相速度略有降低。搅拌转速增加或颗粒粒径减小有利于颗粒的均匀悬浮，颗粒含量的变化对固液悬浮的均匀性影响不大。该研究可为轻密度颗粒悬浮搅拌反应釜设计、优化和放大等提供参考。

英文摘要:

Abstract: Low-density particles solid-liquid suspension characteristics are very critical problem in stirred vessels industrial process. Solid-liquid suspension characteristics for low-density particles in a dual six-blade-Rushton-turbine(6-DT) impeller stirred vessel was simulated numerically by using computational fluid dynamics (CFD).The multiple reference frame (MRF) and Euler-Euler two fluid model based on the kinetics of granular were used in the simulation. Flow field and solid holdup distribution in the stirred vessel were obtained and realized visualization. Furthermore, the influences of the operating condition on solid-liquid suspension were investigated. The simulated results are in good agreement with experimental data in the literature, which verified the feasibility of our numerical method. The research results show that the flow pattern in a dual-radial-impeller stirred vessel was closely related to the clearance of the two impellers. When the clearance is greater or equal to a half diameter of the vessel, parallel flow will form, since the effect among the circulation flows is less. A typical double circulation pattern is formed for every disc turbine, and there are four circulation loops in the stirred vessel. Liquid velocity decreases slightly with low-density particles adding to the vessel. On the whole, solid holdup increases along the axial height. The highest solid concentration is found in the center of the liquid surface region for low-density particles which easily accumulate there, while the lowest solid holdup is in the center of the bottom region. Solid holdup in the center of the circulation loops and behind the blades is relatively high. The phenomenon of solid holdup regional distribution is also observed in the dual-radial-impeller stirred vessel. Taking the height of h=0.5T as a boundary, the vessel can be subdivided into upper region and lower region, and solid holdup in upper region is obviously higher than that in lower region. With the increasing of impeller speed, solid holdup in the liquid surface region and upper region decreases significantly, while it increases in lower region of the stirred vessel. Solid suspension is even for very small size particles. The uniformity of solid suspension worsened with the increasing of particles size or the reducing of impeller speed. The effect of particles content on solid suspension is not very obvious. The study can provide helpful references for design, optimization, and scale-up of the stirred vessel for low-density particles suspension.