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二维泊肃叶流场中荷电颗粒动力学分析及固液分离试验

Kinetics analysis of charged particles in two-dimensional Poiseuille flow field and solid-liquid separation experiment

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中文摘要:

液固两相流中的细小且体积浓度低的固相颗粒在液相流动影响下，除受颗粒重力作用外，还有Stokes阻力、Saffman力、压力梯度力、附加质量力等的共同作用，并在液相流场中作不可控的运动。为了有效控制固相颗粒运动，该文在二维泊肃叶流场的垂直方向上设计一高压静电场，使电场力作用于荷电固相颗粒，并建立了有界黏性流体在二维泊肃叶流场和高压静电场同时作用下带电颗粒的运动力学模型，分析了固相颗粒的运动规律，并设计了多物理场耦合条件下的固液两相分离装置。利用该装置对清洁度为NAS12的L-HM32#抗磨液压油进行颗粒分离试验，12 h后，2～100 μm的颗粒数目显著减少，颗粒分离效率高达到95%，液压油清洁度达到NAS4级，实现高效的固液分离和固相颗粒分选。

英文摘要:

Abstract: In a liquid-solid two-phase flow, small and low volume concentration of the solid particles make the uncontrollable movement in liquid phase flow field under the gravity, the Stokes drag force, the Saffman force, the pressure gradient force, the virtual mass force and so on. In order to control the law of the particle's motion, it is necessary to add the external controllable force to the liquid-solid two-phase flow field. Therefore, the particle's motion is changed by changing the value of the external force. In the vertical direction of the two-dimension Poiseuille flow field, a high-voltage electrostatic field was designed. That is to say, the controllable electrostatic field force was applied to the charged solid particles. In addition, the charged particle's kinematics model was established under the two-dimension Poiseuille flow and the high-voltage electrostatic field in the bounded viscous fluid field, then the movement law and the main conditions effecting the movement of the charged solid particle were analyzed. According to the charged particle's kinematics model in the multi-physics field coupling conditions, solid and liquid two-phase separators were designed in this paper.The folding-shaped dust collection media was installed on the separator at the direction of liquid phase flow, and 15 kV electrostatic was added to the positive and negative electrode of the separator. A particle separation experiment was conducted using this separator on L-HM32# used antiwear hydraulic oil provided by the Shandong Hengye Electromechanical Technology Company, and the used oil cleanliness level was NAS12. In the case of maintaining a constant liquid velocity, the hydraulic oil sample was taken once from the oil storage tank of the solid-liquid separator every three hours, and then the number of particles in the oil sample was measured respectively for the 2-5, 5-15, 15-25, 25-50, 50-100 μm diameter particles using the AMF particle counter designed by the Markus Klotz Gmbh company. After working 12 hours, the number of 2-100 μm particles were significantly reduced, the various size particles separation efficiency was about 95%, and the hydraulic oil cleanliness level reached NAS4. After working 24 hours, the number of 2-5 and 5-15 μm particles in the oil were continuously reduced, but the purification effect was not obvious. On the contrary, the number of 15-100 μm particles in the oil were increased slightly. Moreover, the largest increase in the number was the 50-100 μm big particles. That is to say, the solid-liquid separation efficiency will decrease when the separator works more than 12 hours.The experiment illustrated that the movement law of the charged particles in two-dimensional Poiseuille flow field was effectively controlled. At the same time, the experiment achieved a highly efficient solid-liquid separation and sorting of solid particles, which improved the purification rate and recycling utilization rate of waste oil. By studying the kinetics law of the particles in the two-phase flow of the two-dimensional Poiseuille under the external force, a valuable reference is provided to recycling and reuse of the waste industrial oil, purification of the pollution water, and energy conservation.

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