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后掠式叶片轴流泵固液两相流数值模拟与优化

Numerical simulation and optimization of solid-liquid two-phase turbulent flow in back swept axial pump

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中文摘要:

针对轴流叶轮在污水固液两相流介质中的磨损问题，该文设计了不同后掠式叶轮结构方案进行优化设计，分别对后掠角度为40°、65°、90°的后掠叶片和原型叶片进行固液两相流数值模拟和试验对比，并分析了不同后掠方案叶轮内固体颗粒的分布特性。数值模拟结果表明，随着后掠角度的增加，叶片压力面固相体积分数会逐渐减少，而叶片吸力面上固相体积分数会先增加后减小，叶轮内固相的径向流动越明显并且叶片后掠角度越大，固相就越难与叶片压力面接触，而越易与叶片吸力面接触；颗粒直径越大，后掠叶片压力面上固相体积分数越大，而叶片吸力面进口边靠近轮毂处的固相体积分数增加；颗粒浓度越大，后掠叶片压力面上固相体积分数减少，叶片吸力面上固相体积分数增加。当优化后的后掠叶片角为90°时，该叶片结构优化了固体颗粒的分布，可大幅降低叶片轮缘处的磨损，提高了轴流叶轮在污水介质中的使用寿命和运行可靠性。

英文摘要:

Abstract: By changing the inlet edge blade shape of the plane to get different degrees of the back swept blade, simulating the back swept degree of 40°, 65° and 90° of axial flow pump blades and original prototype blades pump of the three-dimensional solid-liquid two-phase flow channel to get the characteristic curves and distributions of solid particles within the impeller. Characteristic curves show that the back swept angle will reduce the efficiency and head of the pump, which means the reduction grows with the growth angle. With the increase of the particle diameter, the particle moves backward to the pressure surface, therefore the solid phase volume fraction increases, meanwhile the solid phase volume fraction at the suction surface near the hub of the inlet side also increases; with the increase of particle volume fraction, the solid phase volume fraction at the pressure surface reduces and the solid phase volume fraction at the suction surface of the blade increases. It is predictable that the solid phase moves according to the angle between the radial direction and the solid phase velocity direction. The smaller the angle is the more obvious the radical flow is and the bigger the backswept angle is, then the solid phase is more difficult to contact with the blade suction surface than the pressure surface. When the sweep angle is small, the degree of radial flow is the major factor affecting the distribution of the solid phase on the pressure surface of the blade, otherwise when the sweep angle is large, the sweep angle would be the major factor, the greater the sweep angle, the smaller volume fraction of the solid phase on the pressure surface of the blade. Because the 90° sweep angle is large enough, and the radial flow at the suction surface is the smallest, when the back swept angle is 90° the solid phase volume fraction is small and uniform at the suction surface and the pressure surface near the rim of the blade, severe local wear can be avoided. When the swept angle is 40° and 65°, the solid phase volume fraction on the pressure surface near the rim of the blade is large. So it will easily lead to severe wear. In order to verify the correctness of the simulated results, the 65° back swept blade model is compared with the back swept blade of the sludge axial flow pump in the Nanjing Jiangxin island sewage treatment plant, meanwhile the swept angle of the blade is also close to 65°. The actual operating condition of the back swept impeller is complex, and the particle concentration and diameter may not be uniform, but according to the 2.3 and 2.4 sections, the impact of the particle concentration and diameter on the distribution of the solid phase on the blade is small, the solid volume fraction is just changing in on the original position with the particle diameter and the concentration changes. So the wear leaf diagram of the back swept blade can be comprised with the solid phase distribution of the simulation results.Based on the above, increase the back swept angel can reduce the solid volume on the pressure surface of the blade and the 90° back swept angle condition is better than that of 40° and 65° according to the solid volume.

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