轴流泵叶轮内空化流动的数值计算 Numerical Calculation of Cavitating Flow in Impeller of Axial-flow Pump

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关键词： 轴流泵 叶轮 空化流动 数值计算

摘 要： 首先通过轴流式模型泵外特性试验，确定了汽蚀性能曲线。基于完整空化模型和混合流体两相流模型，对轴流式模型泵设计工况下叶轮内空化流动进行全流道数值计算。选择空化开始发生、临界汽蚀点以及空化严重时3个工况比较分析叶轮内空化流动的发展情况。计算获得了不同汽蚀余量时叶片背面静压、空泡体积组分分布和不同轴截面上的空泡体积组分分布。计算结果表明空化最初发生在叶片背面进口靠近轮缘的局部低压区；在临界汽蚀点处，空化发生的区域位于叶片背面进口至出口弦长的2/3处，面积约占叶片背面面积的50%，随着空化程度的进一步加剧，空化区域逐渐向后发展且空泡体积组分逐渐变大，当叶轮流道内发生局部空化时，不会影响到泵的能量性能；空化严重时，靠近进口截面的过流面积受到严重堵塞，泵的能量性能严重下降。计算结果与外特性试验相吻合，较好地揭示了轴流泵叶轮内的空化流动的静态特征。 Cavitation performance curves of the model axial-flow pump were established on the basis of the hydraulic characteristic test with a numerical simulation of steady cavitating flow. Under the designed working conditions, the whole flow passage of the model axial-flow pump was carried out using a full cavitation model and a mixed two-phase flow model. The cavitation flow of the impeller was analyzed by comparing the primary cavitation, critical cavitation, and serious cavitation. The distribution of static pressure and vapor volume fraction of the blade’s suction surface were observed and the vapor volume fraction of the axial section was obtained. The simulation results showed that cavitation first occurred on the local low-pressure area on the back of the blade’s leading edge, which was close to the tip. When the pump ran at its critical cavitation point, the chord length of the cavitation region was 2/3 of the length from the back of blade’s leading edge to its trailing edge, approximately 50% of the back of the blade. After further increasing cavitation, the cavitation region extended towards the trailing edge and the fraction of its volume became larger. When local cavitation occurred in the impeller, it did not affect the power of the pump; however, when cavitation was serious, the over-current cross section close to the leading edge was obstructed, and the pump’s power declined seriously. The results of the simulation agreed with basis of the hydraulic characteristic test, revealed the axial flow impeller cavitation within the static characteristics.

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