冷洪飞,王福军,姚志峰,马亚飞.双吸泵叶轮切削后效率下降机理及切削定律[J].农业工程学报,2013,29(20):67-73

双吸泵叶轮切削后效率下降机理及切削定律

Trimming law and mechanism of efficiency decrease in double-suction centrifugal pump with cut impeller

投稿时间： 2013-04-27

中文关键词：离心泵,效率,数值计算,叶轮切削,切削定律

英文关键词:centrifugal pumps efficiency computer simulation impeller cut trimming law

基金项目:国家自然科学基金项目（编号：51139007）；国家科技支撑计划课题（编号：2012BAD08B03）

作者	单位
冷洪飞	中国农业大学水利与土木工程学院，北京 100083
王福军	中国农业大学水利与土木工程学院，北京 100083
姚志峰	中国农业大学水利与土木工程学院，北京 100083
马亚飞	中国农业大学水利与土木工程学院，北京 100083

中文摘要:

工程中经常存在双吸离心泵实际扬程远高于输水系统所需扬程的情况，通常采用切削水泵叶轮以达到泵站节能的目的。为了研究叶轮切削对双吸离心泵水力性能的影响，该文采用RNG k-ε湍流模型对叶轮切削后的双吸离心泵外特性和内部流场进行了CFD分析，首次揭示了叶轮切削后的水力损失机理，包括损失的位置、大小和原因。研究发现，随切削量增加，性能曲线上最优效率点位置向小流量工况显著偏移，双吸离心泵的最优效率值逐渐下降。叶轮切削而增加的水力损失主要产生在叶轮内部，这是由于叶轮切削后，叶片对水流控制能力变弱致流道内漩涡增多，造成叶轮部分水力损失明显增加；而隔舌间隙增大并未使压水室内的水力损失明显增加。在叶轮切削量一定前提下，在大流量工况，数值预测的结果与相似换算理论值近似相等；当切削量超过4%时，在小流量工况，依相似定律换算得到的扬程和轴功率值低于CFD计算结果。

英文摘要:

Abstract: Double-suction centrifugal pumps are widely used in water diversion, irrigation, drainage, and water supply engineering. In order to save energy, pump impellers often are cut a little if a double suction centrifugal pump head is much higher than the required one in a water delivery system. To investigate the influence of impeller cutting on the hydraulic performance of a double suction centrifugal pump, a general three-dimensional simulation of turbulent fluid flow was presented. The RNG κ-ε turbulence model and SIMPLEC arithmetic were adapted to analyze the external characteristics and the internal flow field of the pump equipped with a cut impeller. The impeller was trimmed seven times successively in this study, then all the cut impellers were installed into a 20SH9 type pump casing respectively. The entire computational domain was divided into 1 700 000 grid cells. According to the simulation results, it was found that with the increase of the cutting value, the pump operating point on the performance curve significantly moved towards the lower flow rate, and the best efficiency gradually decreased. The hydraulic losses induced by the impeller trimming were mainly generated inside the impeller. The vortex area in the impeller flow passage increased after impeller cutting due to the weak control of the blades over the flow. On the other hand, the increase of the tongue gap did not result in the increase of the hydraulic loss in the volute. This study also found that for a fixed cutting value, the pump head and shaft power predicted by CFD were approximately equal to the value calculated by the conventional trimming law at large flow rates. However, the pump head and shaft power were over-predicated by the conventional trimming law at low flow rates. Therefore, the impeller cutting values should not be selected simply by the trimming law if a double-suction centrifugal pump often runs at low flow conditions. The results of this study provide new references for the efficient operation of a double suction centrifugal pump in engineering applications.

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