冯 吉,孙昊苏,李云开.滴灌灌水器内颗粒物运动特性的数字粒子图像测速[J].农业工程学报,2013,29(13):90-97

滴灌灌水器内颗粒物运动特性的数字粒子图像测速

Visualizing particles movement characteristics in drip irrigation emitters with digital particle image velocimetry

投稿时间： 2013-02-26 最后修改时间： 2013-06-11

中文关键词：灌溉,测试,设备,颗粒物,DPIV,运动特性

英文关键词:irrigation measurement equipments particle digital particle image velocimetry movement characteristics

基金项目:国家自然科学基金资助项目（50609029）；教育部新世纪人才支持计划（NETC-10-0780）

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中文摘要:

明确灌水器内部水流和颗粒物运动特性是解决灌水器堵塞问题的关键。但由于灌水器结构复杂、流道狭小、外观不透明性，测试其内部临界尺度流体流动情况难度很大。目前还鲜见有灌水器内部水沙两相流动全场测试的研究报道。因此，该文提出了一种灌水器简化模型和一种流道透明模型加工方法，并应用改进的数字粒子图像测速（DPIV，digital particle image velocimetry）测试系统可视化了灌水器内部流动特征和颗粒的运动特性，结果表明：灌水器内部流动为紊流状态，灌水器工作压力升高并未改变灌水器内部流动形态、涡的分布位置、流线密集程度以及颗粒物跟随性；相同工作压力条件下，颗粒物最大速度随着颗粒粒径的增大而减小，但不同粒径颗粒物流线及涡量分布趋势较为一致；在中心区和近壁区颗粒物跟随性均随粒径的增加而减小。研究可为灌水器内部固-液两相流动分析及抗堵塞设计提供理论依据。

英文摘要:

Abstract: Understanding the movement characteristics of particles is very important for solving the clogging problem in drip irrigation emitters. The key to solve this problem is to make sure that the emitter itself has a high resistance to clogging. Particles are the main component of clogging substance in emitter, accounting for 99% or more. Through selecting the appropriate emitter flow path structure parameters and optimizing the flow boundary, a good flow condition in the path could be ensured, in addition, the transport capacity of particles in the flow path gets improved. Furthermore, the intention of controlling near-wall attachment of particles can be achieved. However, it is very difficult to test the flow in the critical scale flow path due to its complicated structure, narrow flow path, and non-transparent appearance. There were a few reports on the whole field measuring about water-sand two-phase flow in emitters. Therefore, this paper researched flow characteristics in a simplified model of emitter, which only reserved the flow path for energy dissipation. We tested the flow characteristics in the terminal unit structure. At the same time, a processing method for transparent model was proposed in this paper, and we improved the Digital Particle Image Velocimetry (DPIV), by changing the lens of the CCD camera into the close-up lens of Nikon D50. We visualized the movement characteristics of particles in emitters with improved DPIV test system. The results showed that it was feasible to test the motion characteristic of particles in simplified transparent model with the improved DPIV test system. It was turbulent in emitter. And the flow state, vortex distribution, the intensity of flow lines, as well as following performance of particles did not change as the increasing working pressure in emitters. There was a linear relationship between size of flow path and working pressure. The small change of pressure did not significantly change the following characteristic of particles in the central region and the near-wall region. Under the same working pressure, the particles maximum velocity decreased with the increasing particle size, but the distribution trends of the flow lines and the vorticity of particles with different sizes were consistent. The particles following characteristics decreased with the increasing size, in both the central region and the near-wall region. The research could provide the theoretical basis for the analysis on the solid-liquid two-phase flow and the anti-clogging design in emitters.

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