

多相流

基于遗传算法的快速X射线计算机层析成像多相流测试技术(I)测试原理和数值仿真

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摘要 针对局部浓度场具有二值分布特征的特定多相流体系, 提出引入多相流物理特征的快速X射线计算机层析成像(XCT)技术, 基于围绕被测物有限角度的X射线投影数据, 建立了改进的遗传算法(GA)求解不完整投影数据集的二值图像重构算法。通过有限角度的同时投影, 实现对两相流浓度场的瞬间图像冻结和快速图像采集, 既拥有XCT的高空间分辨率特征, 同时满足高时间分辨率的动态测量要求, 并由投影角度数要求的大幅度缩减而降低了XCT的硬件成本。以气液两相流的多泡体系为研究对象, 通过详细的数值仿真实验获得了较理想的图像重构效果, 验证了GA-XCT的理论可行性。在3~24个有限角度投影数据的情况下, GA-XCT表现出明显优于传统CT图像重构算法(即滤波反投影算法)的二值图像重构能力。同时, GA-XCT具有很好的抗噪声能力, 而且不依赖于气泡形状。

关键词 [多相流测试技术; X射线计算机层析成像; 有限数据层析成像; 遗传算法; 数值仿真](#)

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Genetic algorithm based fast X-ray computed tomographic method for multiphase flow measurement (I) Principle and numerical simulation

Abstract

A new approach to the fast X-ray computed tomography (XCT) technique was proposed for the transient measurement of multiphase flow where the local phase concentration can be simplified to have binary values such as in a gas bubbling system. Limited projection data from a few view angles around an object were measured/simulated instantaneously for binary image reconstruction. An improved genetic algorithm (GA) incorporated with the prior understanding on the essential physics of the above-mentioned systems was established to solve the ill-posed mathematical problem of the proposed CT technique, i.e., an optimization problem. Such approach was expected to maintain the high spatial resolution of a CT measurement and at the same time to facilitate the high temporal resolution, with much less cost than a conventional medical CT. Numerical simulations were carried out to simulate the physical measurement of gas-liquid bubbling systems by using the established genetic algorithm based fast X-ray computed tomographic method (GA-XCT). A large amount of simulations demonstrated the feasibility and

strong capability of the new method in the application of “bubbles” reconstruction using just a few angles of projection data. GA-XCT also showed much better performance than the conventional CT reconstruction algorithm when dealing with the limited data tomography. Meanwhile, the GA based image reconstruction was robust to the noise, and not dependent on the bubble shapes.

Key words [multiphase flow measurement](#) [X-ray computed tomography](#) [limited data tomography](#) [genetic algorithm](#) [numerical simulation](#)

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