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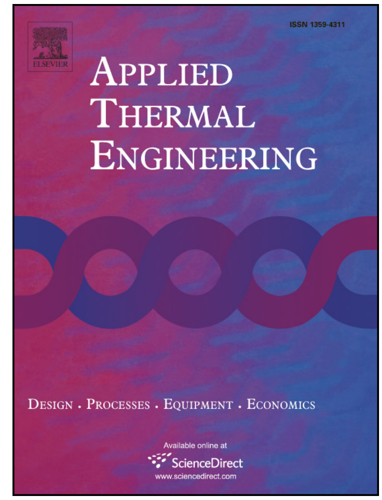

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Flow-pattern recognition and dynamic characteristic analysis based on multi-scale marginal spectrum entropy

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Highlights

- Novel flow regime detection technique for longitudinal sweep channel is presented
- Differential pressure signal is converted into multi-scale frequency-domain entropy
- Dynamic characteristics of two-phase flow in a 6 × 6 rod bundle are revealed
- Flow-pattern distribution of the multi-scale frequency-domain entropy is visualized

Abstract: Rod bundles are widely used in energy chemical equipment. The prediction and dynamic characteristics of flow patterns have been expansively studied in the last few decades because of their significant influence on heat transfer. In most studies, flow patterns were usually predicted by analyzing the temperature distribution on the tube and by visualization using high-speed cameras. Further, the studies used a square channel composed of 6 × 6 rod bundles as the experimental section. However, owing to the limitations of various temperature sensors, the measurement accuracy is low and the experimental setup is unreliable. In the present study, fine bubble flow, fine churn-bubble flow, churn flow, and annular flow were experimentally observed, and the pressure-difference signals for fast reaction flow patterns were collected. An innovative method based on multi-scale marginal spectrum entropy was developed to identify flow patterns precisely, and the results revealed the dynamic characteristics. Multi-scale marginal spectrum entropy is a characteristic quantity, and the input support vector machine can recognize the flow pattern. The results indicate that the new method is feasible for the identification of flow patterns and analysis of the dynamic characteristics of different gas-liquid two-phase flows, which provide a reliable guide for flow-pattern control design and the safe operation of equipment.

Keywords: Multi-scale marginal spectrum entropy; Two-phase flow; Flow-pattern identification; Dynamic characteristics

1. Introduction

Bundle channels are widely applied in evaporators, reactor core components, and other chemical equipment[1-3]. Flow patterns play an important role in two-phase flow and heat transfer because of their significant influence on the pressure gradient of two-phase flow, heat and mass transfer rate, the measurement accuracy of flow process parameters, and other relevant characteristics[4-6]. The concept of the flow pattern was first proposed by Kosterin[13] in 1954, who completed the flow chart of a horizontal pipe. Subsequently, Taitel et al.[14-16] successively conducted experimental and simulation studies on the gas-liquid two-phase flow patterns of horizontal and vertical tubes.

Owing to the importance and complexity of two-phase flow systems, research on two-phase flow has attracted much attention[7-11]. A prerequisite for two-phase flow control is the accurate determination of the