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Experimental Investigation on Pulsating Flow in a Bend

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Extended Abstract

Most of the studies on flow in bends have been concerned mainly with steady flows. On the other hand, the research on unsteady laminar flows has recently intensified in relation to blood flow in arteries (Sumida, 2007). For flows in industrial piping systems, it is desirable to investigate turbulent unsteady flows.

In this paper, we report an experimental investigation on the pulsating turbulent flow through a circular-sectioned 90-degree bend with a curvature radius ratio of R_c=4. In the bend, an instantaneous axial velocity averaged over the cross section, W_a, in the form of $W_a=W_{a,ta} + W_{a,os} \sin\Theta$ was effectuated. Here, Θ is the phase angle and the subscripts *ta* and *os* indicate time-mean and amplitude values, respectively. Experiments were conducted for a moderate Womersley number of α=20, a mean Reynolds number of Re_{ta}=20000 and an oscillatory Reynolds number of Re_{os}=10000 (with a flow rate ratio of η=0.5). The conditions were selected with reference to a previous work (Sumida et al., 1984).

Velocity measurements were executed by laser Doppler velocimetry, and time-dependent velocity fields of the primary and secondary flows were obtained at several longitudinal stations. The distributions of their phase-averaged velocities, *W* and *U*, and the turbulence intensities, *w'* and *u'*, respectively, are illustrated for representative phases and were examined. In particular, changes in *W* and *U* with time were investigated. Moreover, other characteristics of the pulsating bend flow, such as the deviation of the primary flow and the intensity of the secondary flow, are presented. We simultaneously discuss the transition of phenomena in the axial direction and with time.

From the discussion, the following findings were derived. The flow exhibits very complicated behavior significantly different from that for steady flow, and the velocity distribution changes in a complex manner with the phase Θ and also in the streamwise direction. The axial velocity *W* near the bend entrance is large near the inner wall when the flow rate is large, while *W* near the bend exit exhibits a depression in its distribution. Meanwhile, the changes in the distribution of the axial-velocity amplitude W_{os} along the bend axis strongly affect the time-dependent distributions of *W*. On the other hand, the secondary flow is strongest near the bend exit and then gradually attenuates. Nevertheless, it does not disappear even at a distance of ten times the tube diameter downstream from the bend exit, at which the flow has still not recovered to a straight pipe flow.

References

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