Vibration and Dynamic Pressure Estimation in Two-phase Turbulent Swirl Flow

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1. Introduction

Vibration increased more as air increased than water increased. Twisted wire made vibration higher at low quality. At high water mass flux, water effect on vibration increased but air effect decreased when twisted wire inserted. Pressure fluctuation was effected by water mass flux more than air mass flux. Twisted wire decreased pressure fluctuation at low water mass flux, but increased at high water mass flux.

2. Background

Flow induced vibration prediction is very important to prevent fuel damage in nuclear reactor. But, it is very complicated problem for mixture of fluid mechanism and vibration mechanism. Flow induced vibration can be easily predicted using Au-Yang's correlation (1975) after measuring dynamic pressure fluctuation. Pressure fluctuation is important variable to predict flow induced vibration. Today, swirl flow in hot issue for turbulent mixing and heat transfer. Swirl flow has centrifugal force that concentrate bubble at the center resulting liquid film thickening. It make early fow pattern transition (Takeshima et al. 2002)

3. Experiment

Test section is constructed with circle pipe of acryl of 25 mm inner diameter. Total length of test section is 2 m , it is composed with 1 m entrance part for fully developed flow, 50 cm detection part and lasting 50 cm outgoing part . 4 type swirl generator can be inserted in the middle part of test section changing wire thickness and twisting pitch length. Thickness is 2mm and 3mm and pitch length is 25 mm and 50 mm. Swirl generator is twisted wire of steel. Honey comb is inserted at the water inlet to stabilize flow. 3 PCB dynamic pressure gauge is attached at the middle detecting part of test section to detect pressure fluctuation, its position is inlet, middle and outlet having 25 cm distance. 2 B&K vibration accelerometer is attached at center position of middle part of test section for vibration detection. All sensors use B&K NEXUS amplifier for band filtering from 1 Hz to 1 kHz and all signals transfer personal computer with data acquisition book. All random data has sampling rate of 2500 sample/s and total sampling 4 seconds.

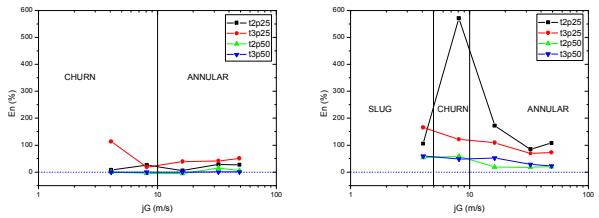
4. Results and Conclusion

Dynamic pressure detection is performed in 5 test condition and 2 detection position. Pipe vibration is detected at the center of test section with 2 cross positioned accelerometer. Experiments were performed changing water superficial velocity from 0.10 m/s to 3.06 ms and changing air superficial velocity from 4.08 m/s to 49 m/s. Fig 1 shows the vibration enhancement ratio at each flow regime. Fig 2 shows the dynamic pressure enhancement ratio at each flow regime. Wire thickness is represented by 't' and pitch length is 'd'.

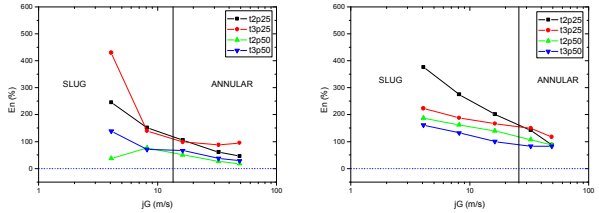
Vibration increased more as air increased than water increased. Twisted wire made vibration higher at low quality. At high water mass flux, water effect on vibration increased but air effect decreased when twisted wire inserted. So, swirl flow effected by water mass flux mainly at high mass flux and air effect on vibration decreased as mass flux increased. Twisted wire make vibration high at slug flow and especially at churn flow, but twisted wire effect on vibration in very low at annular flow.

Pressure fluctuation was effected by water mass

flux more than air mass flux. Twisted wire decreased pressure fluctuation at low water mass flux, but increased at high water mass flux. Slug made pressure fluctuation high but, pressure fluctuation decreased at churn flow.

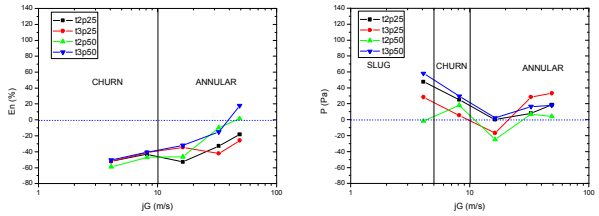


(a) j_L = 0.10 m/s (b) j_L = 0.41 m/s



(c) j_L = 1.02 m/s (d) j_L = 3.06 m/s

Fig. 1 Vibration Enhancement ratio



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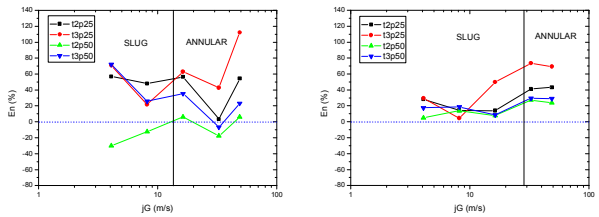

(c) j_L = 1.02 m/s (d) j_L = 3.06 m/s

Fig. 2 Pressure Fluctuation Enhancement ratio

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