2011년도 추계학술대회
장면 및 논문 초록집
Proceedings of the KSME 2011 Fall Annual Meeting

일시: 2011년 11월 2일(수)~4일(금)
장소: EXCO
후원: 한국과학기술단체총연합회

☆ 이 초록집은 2011년도 정부재정(교육과학기술부)으로
한국연구재단의 지원을 받아 발간되었습니다.
Bistability of flexible ring in a uniform flow
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동류 내에서 연성체 고리의 쌍안정성
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Key Words : bistability(쌍안정성), flow-structure interaction(유체-연성체 상호작용), immersed boundary method(가상 경계법)

Abstract

The immersed boundary method for simulating a flexible ring clamped at one point in a uniform flow has been developed. The penalty method derived from fluid compressibility is used to ensure the conservation of the internal volume of the flexible ring. We observed bistable states, one stationary stable state and the other a self-sustained periodically flapping state, which coexist over a range of flow velocities depending on the initial inclination angle. The Reynolds number range of the bistability region and the flapping amplitude were determined for various aspect ratios a/b. For a/b=0.5, the bistable region arises at the highest Reynolds number and the flapping amplitude in the self-sustained flapping state is minimized. A new bistability phenomenon was observed: for certain aspect ratios, two periodically flapping states coexist with different amplitudes in a particular Reynolds number range, instead of the presence of a stationary stable state and a periodically flapping state.

기호설명

\( k \): 용수철 상수
\( \gamma \): 굽힘 상수
\( u \): 유속
\( a/b \): 타원의 장축, 단축 비

1. Introduction

Systems involving flexible bodies interacting with a surrounding fluid flow are commonplace, e.g. flying birds, swimming fishes, and flapping flags on the macro scale and cells swimming in blood on the micro scale. The mechanics of elastic bodies immersed in a viscous flow has been studied by many researchers in biology, bioengineering, and chemical engineering. Analyzing fluid-structure interactions helps us understand how fishes, birds, and cells move in fluids such as water, air, and blood. More importantly, these results have potential applications in biomimetic engineering, bioengineering, and industrial engineering.

In the present study, we simulated the flapping motions of a flexible ring containing fluid in a uniform flow.