Analysis on a Kinetic Theoretical Model of the Straight-Curved Pipe Conveying Fluid

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A kinetic theoretical model for the straight-curved pipe conveying fluid was proposed and studied in this paper. Firstly, the new equations of static equilibrium and motion about equilibrium position were derived by applying perturbation method to the motion equations of the curved pipe conveying fluid. Then, the kinetic equations of the straight pipe were derived by ignoring the terms containing the curvature of the curved pipe in these equations. Subsequently, considering different factors, four segmental kinetic theoretical models of the straight-curved pipe were built. Lastly, based on the present theoretical models and finite element method, the static deformations and natural frequencies of the pipes with three typical boundary conditions were simulated. The simulation results show that the applicability of these kinetic theoretical models is closely related to the boundary conditions: 1) For the pipes with any one of three boundary conditions, the geometrical non-linearity and the nonlinear force caused by the deformation of straight pipe segment, have a great effect on the static deformation of the pipes, while they have little effect on the natural frequencies of the pipes. 2) When the natural frequencies of the pinned-pinned pipe or the pinned-sliding bearing-pinned pipe are solved, the static deformation of the pipes must be considered. 3) When the natural frequencies of the pinned-pinned-pinned pipe are solved, the static deformation of the pipe can be ignored.

1. INTRODUCTION

Flow-induced vibration of the pipe conveying fluid is a difficult problem in many industrial projects. It contains so many dynamic phenomena and has attracted the attention of many scholars. For the past decades, scholars at home and abroad have carried out a large number of related researches and obtained so many fruitful results. From the perspective of pipe geometries, the previous literatures mainly focused on the vibration research of single-configuration pipes, such as straight pipes or curved pipes separately. However, flow-induced vibration of multi-conformational pipe conveying fluid has been studied little. In actual project, the pipe conveying fluid is always composed of straight pipe segments and curved pipe segments. Therefore, the geometric model of multi-configuration pipe is closer to engineering practice, and its research results have more practical significance.

According to the different boundary conditions, straight pipe can be divided into two kinds: pipes supported at both ends and cantilever pipes. The two forms of pipe have differ-