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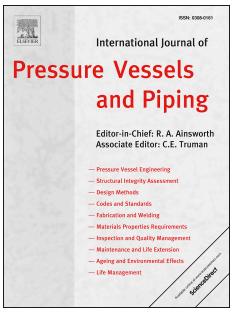

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On the Steady/Quasi-steady Dissipation Term in the classic Discrete Vapour Cavity Model for Simulating Column Separation

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Abstract

Different families of the Discrete Vapour Cavity Model (DVCM) are developed, including the frictionless, steady and quasi-steady friction models. A relaxation-dissipation approach is proposed to improve the timing of pressure pulses predicted by the classic DVCM. In this approach, a friction correction factor is introduced into the steady/quasi-steady friction term to reduce the local value of the dissipation term in regions facing with cavitation. The proposed approach is completely consistent with the classical water-hammer framework. The importance of the steady/quasi-steady friction term is investigated by comparing numerical results of different DVCMs with the experimental data for various cavitation problems. Based on a frictionless study, it is shown that there exists an unrealistic attenuation in pressure pulses of the classic DVCM. For problems with high-intensity cavitation, it is shown that the frictionless, steady and quasi-steady friction models generally produce different results, especially in terms of the pressure pulses timing. Within the range described in the manuscript, the timing of the classic DVCM pressure pulses can generally be improved by applying the proposed relaxation-dissipation approach on the steady/quasi-steady friction term.

Keywords: Water-hammer, Cavitation, Discrete vapour Cavity Model (DVCM), Friction correction factor, column separation, relaxation-dissipation approach

1. Introduction

The *water-hammer* phenomenon, in fact, is a transient condition occurring in the hydraulic systems. It describes the effects of generation, propagation and reflection of pressure waves in the system [1]. Sudden or rapid changes such as pump failures and valve closures in a system of pipelines can cause water-hammer [2]. During the water-hammer, large pressure oscillations can be observed. The pressure can increase and may cause damage or even destroy the hydraulic systems, or it can also decrease to reach to or fall under the saturation (or vapour) pressure where *vaporous cavitation* occurs. As a result, the hydraulic systems may experience water-hammer along with the vaporous cavitation during transient events [3–5]. In the case of vaporous cavitation, the liquid is vaporized and cavities (vapour bubbles) are produced and grown very rapidly [6]. Due to the local vaporization of the liquid phase, two (or more) liquids

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