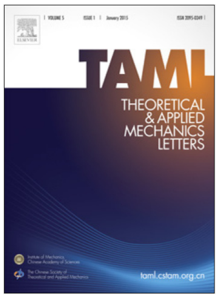
Accepted Manuscript



A numerical model for cloud cavitation based on bubble cluster

Tezhuan Du, Yiwei Wang, Chenguang Huang, Lijuan Liao

PII: S2095-0349(17)30081-8
DOI: http://dx.doi.org/10.1016/j.taml.2017.08.001
Reference: TAML 173

To appear in: *Theoretical & Applied Mechanics Letters*

Received date : 28 April 2017
Revised date : 17 July 2017
Accepted date : 19 July 2017

A numerical model for cloud cavitation based on bubble cluster

Tezhuan Du[1, 2] *, Yiwei Wang[1, 2], Chenguang Huang[1, 2], Lijuan Liao[1, 2]

[1](Key Laboratory for Mechanics in Fluid Solid Coupling Systems, Institute of Mechanics， Beijing 100190, China)
[2] (School of Engineering Science, University of Chinese Academy of Sciences, Beijing 100049, China)

*Corresponding author.

E-mail address: dutezhuan@imech.ac.cn (Tezhuan Du)

Fund: The authors acknowledge the financial support from the National Natural Science Foundation of China (11402276)

Highlights

1. The structure of cloud cavitation is needed to accurately predict collapse pressure.

2. A cavitation model was developed through dimensional analysis and CFD simulation.

3. Bubble number density was used to characterize the internal structure of cavitation.

4. This model is implemented on cavitating flow over a projectile with conical head.

5. The results show that the collapse pressure is affected by bubble number density.

ABSTRACT： The cavitation cloud of different internal structures results in different collapse pressures owing to the interaction among bubbles. The internal structure of cloud cavitation is required to accurately predict collapse pressure. A cavitation model was developed through dimensional analysis and direct numerical simulation of collapse of bubble cluster. Bubble number density was included in proposed model to characterize the internal structure of bubble cloud. Implemented on flows over a projectile, the proposed model predicts a higher collapse pressure compared with Singhal model. Results indicate that the collapse pressure of detached cavitation cloud is affected by bubble number density.

Cloud cavitation, as one of the most common type of cavitation for the marine vessels and projectile, consists of a large amount of small bubbles. The pressure pulse generated by the bubble collapse in the cloud cavitation is usually considered to be the major cause of the structure failure and the noise radiation. Numerical simulations are commonly used to study cavitating flows in many applications, such as hydrofoils, projectiles, turbo machines, etc. Most of the researches were focused on the homogeneous flow modelling, which is based on the Navier–Stokes equations of mixture phase [1-7]. However, the homogeneous cavitation modeling is only capable of providing macro-solutions of vapor volume fraction while the micro mechanism of cavitation evolution remains unknown. For example, bubble clusters with different distributions may lead to different collapse pressures because of the interaction of bubbles under identical vapor volume fractions. Therefore, a numerical model considering the internal structure of cloud cavitation is essential to understand bubble evolution and improve the accuracy of predicting bubble collapse pressure. Evans et al. [8] developed a population balance model to predict bubble size distribution in the wake region below a ventilated gas cavity. Du et al. [9] proposed an evolution model of bubble number density is proposed to simulate bubble breakup and transportation.

In this letter, a cavitation model based on bubble cluster is deduced by dimensional analysis and direct