



An experimental study of sheet to cloud cavitation



Xiongjun Wu*, Etienne Maheux, Georges L. Chahine

Dynaflow, Inc., 10621 J Iron Bridge Road, Jessup, MD 20794, USA

ARTICLE INFO

Article history:

Received 29 September 2016

Received in revised form 25 December 2016

Accepted 4 January 2017

Available online 5 January 2017

Keywords:

Two-phase flow

Cavitation

Shock wave

ABSTRACT

A 2D convergent-divergent test section was built to study experimentally sheet cavitation followed by bubble cloud formation. Flow visualizations and pressure measurements enabled correlating high speed photography observations with the pressures on the cavitating surface. These indicate that the frequency of the recurring sheet cavity decreases with increased inlet flow velocity. As the inlet velocity increases, the flow structure changes from vortex shedding with entrapped thin cavities, to a sheet cavity with a reentrant jet producing bubble cloud shedding, to a shock dominant cavity collapse flow regime. The two-phase bubbly flow shock front moves upstream at a speed higher than the local sound speed, creating a pressure surge clearly measured as the shock front passes over a pressure gauge. The sheet cavity breakdown during collapse leaves behind vortical bubble clouds.

© 2017 Elsevier Inc. All rights reserved.

1. Introduction

Sheet cavitation occurs over a lifting surface when the pressure drops to the vapor pressure over a large portion of this surface. The cavity then fills with vapor. As the cavitation condition becomes more severe, cavity length oscillation, unsteadiness, and shedding of vapor clouds take place. These periodic sheet to cloud cavitation events can have deleterious effects on the performance of marine propellers and hydrofoils [3,5].

Many authors have attributed the occurrence of cloud cavitation to the development and dynamics of reentrant jets, which move upstream under the cavity and then break it into two pieces [9,19,15,18,20,12,4]. By blocking the reentrant jet with an obstacle, the periodic shedding could be prevented [14]. Adverse pressure plays an important role in the formation of the reentrant jets [4,11,16].

It has also been noted that the cavity closure line formed by the reentrant jet is perpendicular to the flow direction for two-dimensional cavities. However, the orientation of the reentrant jet in three-dimensional cavities depends strongly on the span wise geometric variations of the objects [7,1,2,13,18]. Then, the periodic shedding could be affected or prevented from occurring [8,16].

Measurements of the void fractions in the cavity and the clouds have been attempted [22,23,21,6]. However, the measured quantities varied significantly from one study to another due to the complexity of flows. More recently, extensive studies using X-ray were

achieved by Ganesh et al. [10]. In their study, in addition to reentrant jet observation, condensation shock waves were observed and were associated with strong periodic cloud shedding and collapse.

In this paper, we describe results from experiments conducted in a divergent-convergent test section in an effort to add information to existing studies and to provide essential data to numerical modeling, including flow visualizations and pressure measurements in order to develop a better understanding of the physics behind sheet to cloud cavitation.

2. Experimental setup

A sketch of the test section with the main dimensions is shown in Fig. 1 and a sketch of the overall setup is shown in Fig. 2. The flow passage in the acrylic test section is formed using profiled top and bottom inserts sandwiched between two side walls 2.22 cm apart to enable good visualization. The inlet and outlet sections have the same dimensions: height 10.16 cm and width 2.22 cm. When designing the convergent-divergent a small flat region 2.54 cm long was placed in the minimum cross sectional area between the convergent and divergent sections of the profile to enable slower transition to a large cavity and facilitate observation as the velocity is increased. Four pressure transducers along the diverging section, labeled from T1 to T4, are used to monitor the acoustic signature of the cavitation.

The liquid flow is driven by a 15 HP pump (Goulds Model 3656), which is capable of a flow rate of 36 L/s at 180 kPa. In this setup the inlet velocity can reach 15.4 m/s. Instrumentation is provided for

* Corresponding author.

E-mail address: wxj@dynaflow-inc.com (X. Wu).

Download English Version:

<https://daneshyari.com/en/article/4992724>

Download Persian Version:

<https://daneshyari.com/article/4992724>

[Daneshyari.com](https://daneshyari.com)