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EXPERIMENTAL STUDY OF THE AIR PHASE DEVELOPMENT IN A VENTURI

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ABSTRACT

This paper aimed to present an experimental study carried on a transparent venturi in order to observe how the air phase caused by the throat evolutes for different coming flows. This throat leads to a decreasing of pressure until a value equal to the vapor one for a given temperature. the most important parameter which will define this phenomenon is the cavitation number called Thoma’s coefficient calculated from tests measures .this number is related to the Reynolds number and the length of the developed white section.

KEYWORDS: Cavitation, Venturi, Throat, Pressure, Thoma’s Number

INTRODUCTION

The development of an air phase in a venturi defined as a cavitations phenomenon has attracted the intention of several investigators for its occurring in various fields .All noises in water are related to air bubbles created by cavitations[1] .A type of prawn use cavitations as a tool to capture the prey when its hypertrophied clamp is closed quickly as a bubble appears by cavitations and knocks the organism by its bursting .In medical field bubbles of air participate in the improvement of the image’s contrast used [2] but for hydraulic machinery this phenomena is the cause of several damages .channels are exposed too to this problem[3] and some instructions must be introduced in their calculus [4].

Flows containing gas bubbles are not always subject to rapid changes and in the case of a venturi the two interfaces liquid and vapor have a stable pressure on one side which is practically equal to the vapor pressure.

The aim of this paper is to contribute to explain how this phenomenon develops .we have used an experimental composed essentially by a transparent venture shown in figure 1. Experimental tests will chow that the air phase is tightly related to the arriving pressure. Thomas’s number is a decisive parameter in detecting when cavitations start, so this study aims too to give a relationship between this number, the Reynold’s number and the length of the air section.

THEORETICAL ASPECTS

The mass conservation through the interface gives [5]):

$$\frac{dm}{dt} = \rho_l \left(v_{ln} - \frac{dn}{dt} \right) = \rho_v \left(v_{vn} - \frac{dn}{dt} \right) \tag{1}$$

We assume that mass is preserved and we take:

$$\frac{dm}{dt} = 0$$

On the assumption that the bubble's shape is spherical, the normal velocity of the interface is:

$$v_{ln} = v_{vn} = \frac{dR}{dt} \quad (2)$$

Where 'R ' is a function depending on time.

Where' l 'indicates the liquid phase and' v 'the vapor one

The normal velocity is expressed by '$\frac{dn}{dt}$'

Assuming that the air bubble is spherical, its radius is given by [

$$\frac{dR}{dt} = \left[\left(\frac{2}{3}\left(\frac{Pv-P}{\rho_l}\right)\left(\frac{R_0^3}{R^3}-1\right)\right) + \frac{2S}{\rho R_0}\frac{R_0^3}{R^3}\left(1-\frac{R^2}{R_0^2}\right)\right] \quad (3)$$

So the surface tension will be taken in account if:

$$R_0 < \frac{3S}{P - P_v}$$

Otherwise:

The bubble radius may be calculated by the simplified Rayleigh Plesset equation as follows[6]:

$$\left(\frac{dR}{dt}\right)^2 = \frac{2}{3}\left(\frac{Pv-P}{\rho_l}\right) \quad (4)$$

With:

P is the pressure,

R is the radius,

Pv is the vapor pressure,

And ρ_l is the density of water.

When vaporization happens,it requires heat transfer from the liquid to the liquid/vapor interface and the thermal delay increases.

Heat transfer via conduction is expected in the case of buibbles. convection is predominant in the case of attached cavities.

CAVITATIONS NUMBER

Called cavitations parameter or Thomas's number, it is given by the following formulas ,for different cases:

Case of Gate [5]

$$\sigma = \frac{P_{downstream} - P_v}{P_{upstream} - P_{downstream}} \quad (5)$$

Case of foil at submersion depth 'h' in a horizontal free surface channel:

$$\sigma = \frac{Po + \rho gh - P_v}{\frac{1}{2}\rho V^2} \quad (6)$$

Case of a pump:

$$\sigma = \frac{P_{inlet} - P_v}{\rho V_p^2} \quad (7)$$

Where $'V_p$ 'is the velocity at the periphery of the runner

Case of a venturi:

$$\sigma = \frac{P - P_v}{\frac{1}{2}\rho V^2} \quad (8)$$

With 'P 'and $'V'$ are the reference parameters

CAVITATION REGIMES

The cavitation development is characterized by two regimes :

- First we distinct the cavitation inception.
- In second it is the full developed cavitation

SYSTEM OF VENTURI

It corresponds to the Italian physician GIOVANNI Battista. Venturi is a hydraulic system related on a dynamic fluid phenomena based on an increasing of velocity and a decreasing of pressure caused by . the existence of a throat.

EXPERIMENTATION

Experimental set up is an apparatus referenced EH505.it contains:

A venturi ,corresponding to the British Standards BS1042 ,its dimensions are shown by the following figure .

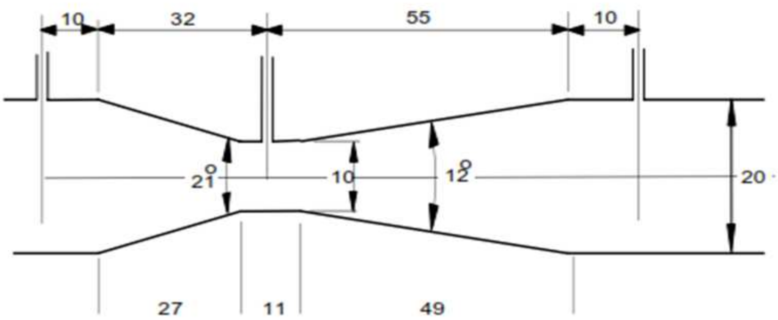


Figure 1

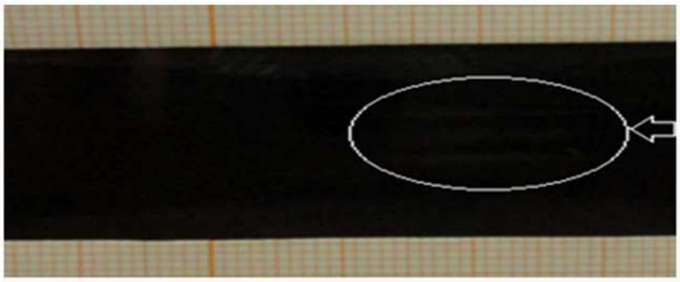
A rotameter, used for measuring flow discharge.

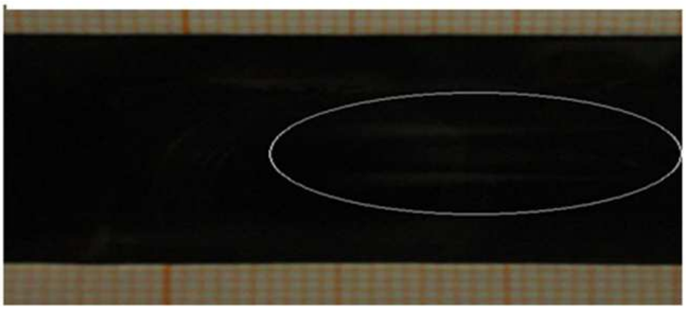
And two apparatus to read the pressure values

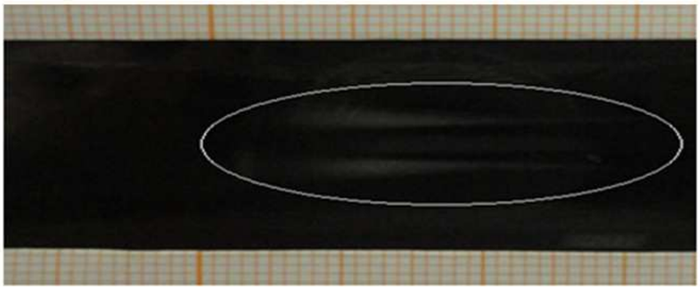
Tests are carried in order to measure the coming flow discharge using the rotameter and pressures respectively at the entrance and the throat.the liquid is at 20 °c.

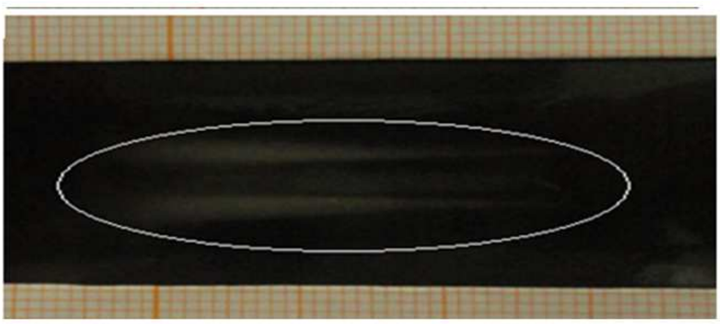
EXPERIMENTAL RESULTS

As results, we have the discharge, arrived pressure, throat pressure and the length of the white cloudy section. In addition, we have taken the following photos in order to show how this section develops:









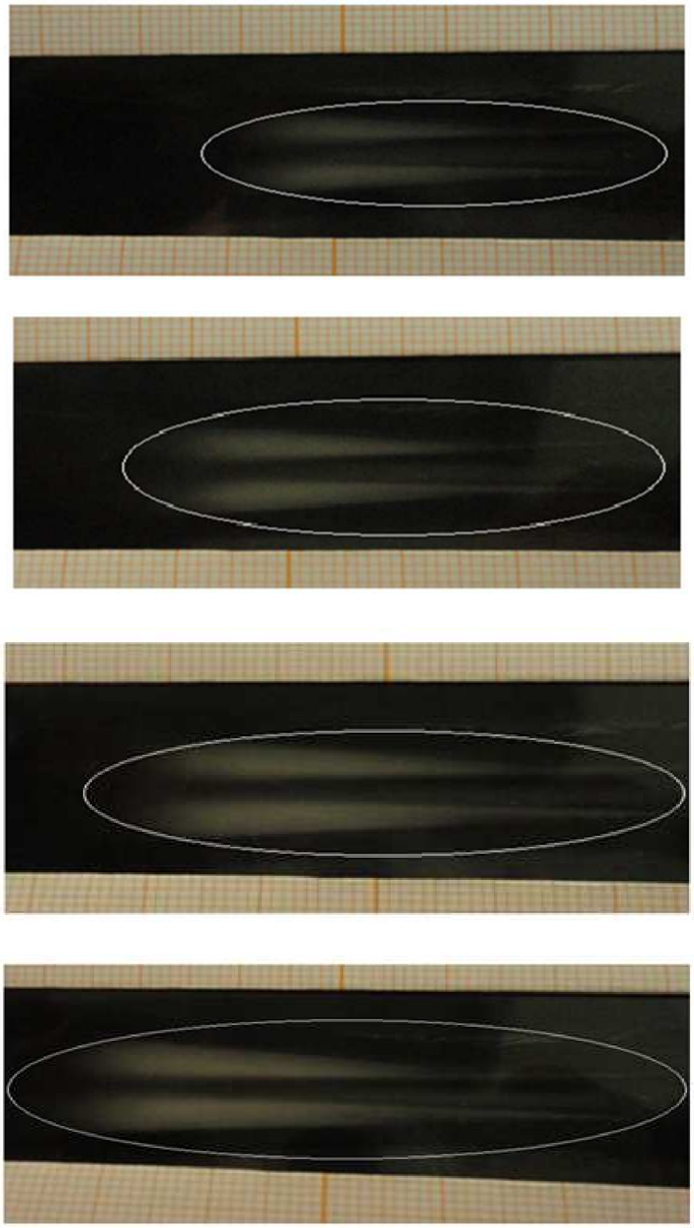


Figure 2: Evolution of Cavitation Section in Venturi

RESULTS ANALYSIS

Numerical results shows that cavitation begins for values of pressure at the large section of the venturi lower than 0.1bars.when the entrance pressure increases the throat pressure decreases and becomes negative.

If we observe carefully our photos we will deduce that the evolution of cavitation can be explained by the increasing of its section length. so the formulation relating these two parameters will be a good manner to represent the development of the cavitation phenomenon in a venturi.

Our experimental results are given in the following graphics.

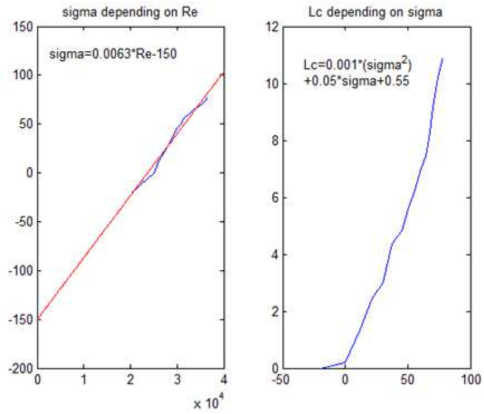


Figure 3: Evolution of Cavitation Number

Thomas number depends on the nondimensionel Reynolds number in a linear form:

$$sigma = 0.0063Re - 150$$

And in a parabolic one for the relation between sigma the cavitation number and Lc its length :

$$Lc = 0.001sigma^2 + 0.05sigma + 0.55$$

Where sigma represents the Thoma's number .which is insignificant for values of *Re* lower than 20000 which is confirmed by small values for *Lc* the cavitation length. So we constate that the density of bubbles increases with turbulence.

CONCLUSIONS

Through this study,we have followed the developing of the phenomenon of cavitation formed by a cloud of cavities in a transparent venture .the change in the entrance flow and pressure has permitted us to change also the throat pressure .for each value of discharge we have visualed a white section composed of bubbles of air .the length of this section increases with the cavitation number in a parabolic form .this number is related to the Reynolds number by a simple linear relationship. All of experimental tests were carried on for entrance pressure values comprised between 0.1 bars and 1.5bars and we have observed stables states of cavitation in this case.

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