CAVITATION DYNAMICS AT SUB-MILLIMETER SCALE

Kunpeng Long[1], Matevz Dular[2], Olivier Coutier-Delgosha[3, 1]

[1]Arts et Metiers Paris Tech, 8 boulevard Louis XIV, 59046 Lille, France
[2]Laboratory for Water and Turbine Machines, Univ. of Ljubljana, Askerceva 6,1000 Ljubljana, Slovenia
[3]Virginia Tech, Aerospace and Ocean Engineering Dept., 460 Old Turner St, Blacksburg 24061 VA, USA

Abstract

Cavitation dynamics has been studied extensively at scales consistent with practical applications, such as hydrodynamic propulsion, rocket engine pumps, or industrial hydraulic systems. In these cases, where the characteristic length scale is usually between a few centimeters and a few meters, various cavitation-induced instable behaviors have been observed, from random small-scale oscillations to large scale fluctuations, sometimes including periodical vapor shedding in the downstream part of the liquid/vapor area. The latter case is characterized by a non-dimensional frequency (Strouhal number), based on the cavity mean length and flow velocity, usually in the range 0.2 – 0.4.

The question of transposition of this knowledge at smaller scale is now open, due to current development of millimetric machinery and new applications where controlled cavitation in micro-channels is involved. For given cavitating conditions, the global flow behavior as well as the instability frequencies and the bubble size may be impacted by the downscale of the model. A first attempt to address this issue has been made a few years ago at a scale of a few millimeters (see Dular & Coutier-Delgosha, 2010) where significant differences have been observed, compared with usual scale: cloud cavitation is generally more complex, with more than one single characteristic frequency.

The present work is focused on even smaller scales, between 0.1 and 10 mm. As cloud cavitation is difficult to obtain in usual Venturi section, a simpler geometry consisting in a nozzle jet impacting a wall at 90° and then flowing radially between two plates is used. Cavitation is obtained between the two plates, due to the flow acceleration. The scale of the experiment was changed by varying the gap between the two plates, and the effect of the nozzle diameter was also investigated. Observations were performed from the transparent bottom plate, using a high-speed camera and intense illumination, for various flow rates, sizes of the gap, and nozzle diameters. The analysis has been focused on the comparison between flow conditions resulting in constant Reynolds numbers or constant cavity length. The results mostly show a significant modification of the flow behavior at very small scale, with a modification of the Strouhal numbers together with a change of the cavitation structure.

Key words: Small Scale, Cavitation, instability, flow imaging