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Modelling of Hydrodynamic Cavitation with Orifice: Influence of different orifice designs

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Highlights

- Multiphase CFD models can reproduce experimental trends in cavitating orifice flows
- Orifice geometry has a significant influence on cavitation inception and growth
- Sharp edged orifice designs produce higher cavitation activity than rounded inlets
- Orifice thickness has a factor of 10 influence on pressures required for cavitation
- Angled orifice walls increase pressures required for cavitation by 30-40%

Abstract

Hydrodynamic cavitation (HC) may be harnessed to intensify a range of industrial processes, and orifice devices are one of the most widely used for HC. Despite the wide spread use, the influence of various design and operating parameters on generated cavitation is not yet adequately understood. This paper presents results of computational investigation into cavitation in different orifice designs over a range of operating conditions. Key geometric parameters like orifice thickness, hole inlet sharpness and wall angle on the cavitation behaviour is discussed quantitatively. Formulation and numerical solution of multiphase computational fluid dynamics (CFD) models are presented. The simulated results in terms of velocity and pressure gradients, vapour volume fractions and turbulence quantities etc. are critically analysed and discussed. Orifice thickness was found to significantly influence cavitation behaviour, with the pressure ratio required to initiate cavitation found to vary by a factor of 10 for orifice thickness to diameter (l/d) ratios in the range of 0 – 5. Inlet radius similarly has a pronounced effect on cavitational activity. The results offer useful guidance to the designer of HC devices, identifying key parameters that can be manipulated to achieve the desired level of cavitational activity at optimised hydrodynamic efficiencies. The models can be used to simulate detailed time-pressure histories for individual vapour cavities, including turbulent fluctuations. This in turn can be used to simulate cavity collapse and overall performance of HC device. The presented approach and results offer a useful means to compare and evaluate different cavitation device designs and operating parameters.

Key words: Hydrodynamic cavitation, orifice, CFD, multiphase, turbulent, design

Nomenclature

d	Orifice hole diameter	[mm]
k	Turbulent kinetic energy	[m^2/s^2]
l	Orifice hole length	[mm]
n	Bubble number density	
r	Orifice hole inlet radius	[mm]
u,	Velocity [m/s]	
x	Distance	[mm]
c_a	Cavitation number	
c_{ai}	Cavitation inception number	
C_c	Contraction coefficient	

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