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Procedia Manufacturing 20 (2018) 154–159

Procedia MANUFACTURING

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2nd International Conference on Materials Manufacturing and Design Engineering

Acoustic Study and Behavior of Flow through orifices

Akshay R. Kadam[a], Mangesh B. Chaudhari[b]*

[a,b]*Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune 411046, India*

Abstract

Orifice is designed either to decrease pressure or to increase velocity of fluid flow. When pressurized turbulent flow or normal fluid flow flows through an orifice, it creates sound waves, disturbances, pressure fluctuations leads to vibrations, generation of noise and cavitation at orifices. So to prevent such things, there is need to study the acoustic behind such flows, to analyze the frequency spectrum, power spectra, acoustics wave transmission for flow through orifice. For such acoustic study, different literatures have been studied and presented in this research paper. Different types of flows are analyzed through different shapes of orifices by depicting sound power spectra, frequency spectra etc. Some experimental results have presented for one-phase and two-phase high pressurized flow through single-hole and multi-hole thick orifices. The most of studies over acoustic wave behaviour in flow through sharp edge orifices placed in circular, square and rectangular duct have been presented. The research was carried out presented on the acoustic source created by turbulent flow through orifices and large eddy simulation of acoustical flow through an orifice. The entrainment of cavitation and sound waves into the fluid flow through an orifice is also presented. Flow acoustic study can be applied various industries and fields where acoustic study counts to overcome problems, to determine effects of sound waves on orifices, to determine behaviour of flow through different shapes of orifice and to analyze the effects of entrainment of sound waves into the fluid flow on power and frequency spectrum.

Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.

Keywords: *Orifice, Sound waves, Acoustics, Cavitation.*

1. Introduction

The acoustic study of turbulent flow at various wind speed with low noise over orifices is explained. The acoustics study has been done by investigating the sound spectra for flow over orifice for different wind speed in the

* Corresponding author. Tel.: +91 20 2420 2234; fax: +91 20 2428 0926.
E-mail address: chaudharimb@gmail.com (M. B. Chaudhari)

2351-9789
Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.
10.1016/j.promfg.2018.02.022

semi anechoic, subsonic wind tunnel [1]. It is found that the study of acoustic is more interesting when flow through orifices rather than flow over orifices. Instead of analyzing sound spectra, analysis of acoustic energy wave transmission through orifice plate to study the internal reflected energy from FFT signals are explained [2]. Further, the research has extended to the sound generation by steady flow through human glottis shape orifice to characterized broadband sound emissions and spectrums. Straight, convergent and divergent type of rubber orifices are made to imitate the exact shape of human glottis to have the same effect to study the radiated sound pressure spectra downstream of orifice for varying mass flow rates, orifice shapes and different gas mixture [3]. In addition to the previous study, it has explained that the flow through single-hole orifice has a particular natural frequency and having their harmonics which can be seen in sound spectrum. The orifice which has contraction area increases the pressure fluctuation level and disturbance in the flow leads to vibrations which concentrate at low frequency range [5]. Further the study has been extended to multi-hole orifices from single-hole orifice in water pipe [6]. In addition to the effects of flow disturbances causing vibrations, the effects of cavitating flow through an orifice are also studied. The effects of collapse of cavitation bubble increases disturbances and vibration inside the liquid flow are explained. Mainly three mechanism i.e. monopole, quadruple and vorticities are suggested due to which cavitation occurs causes disturbances and instabilities in the flow [6, 7]. It is found that, the experimental study is not sufficient to analyze the acoustical wave transmission, sound spectra and other acoustical things. Emma L. Alenius [8, 10] has presented large eddy acoustical simulation work which is used to solve complex flow phenomenon, acoustic scattering and sound generation. A. Kierkegaard, [9] has performed one more step of simulation methodology to observe the whistling caused by acoustic flow instability of an orifice plate in flow duct. The acoustics study of one phase flow has extended to high pressurized cavitating two-phase flow through a thick orifice plate in a pipe of constant c/s section [11]. Now recent study on acoustics of flow through orifice is done by multi-port method which uses to extract complex mode amplitude from the experimental data for single and tandem in-duct orifices [12].

Nomenclature

t	thickness of orifice (in m)
d	diameter of single-hole orifice ($d = 2.2 \times 10^{-2}$ m)
d_o	diameter of orifice plate (in m)
L_o	length of orifice plate (in m)
f_o	whistling frequency (in Hz)
c	speed of sound measured downstream of the orifice (in ms^{-1})
$p\text{-}^2$	backward propagating plane wave spectra (in Pa^2/Hz)
U	volume flux divided by pipe cross-sectional area (in ms^{-1})
St	Strouhal number
Re	Reynold's number

2. Literature Review

Glenn Eric Cann and Patrick Leehey et.al. explained that turbulent flow is responsible for making noise when it flows over orifice. This phenomenon is identified to detect the vibrations and decibels levels caused by interaction of flow over orifice. The experiments were conducted using semi-anechoic wind tunnel with low turbulence, subsonic wind in the Acoustics and Vibration Laboratory at MIT [1]. The semi-anechoic construction was effective for the frequency between 200 Hz and 2000 Hz. Three orifice samples were tested. Air flows at free speed velocity at 20, 30, 40 and 50 m/s over the orifice which has either rectangular shape or circular shape. To determine the contribution of orifice in this experiment, mainly two experimental methods have been conducted. First is to determine acoustic power radiated by the duct when the orifice was covered and the other is to measure acoustics