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STUDY ON AIR FLOW PATTERN IN ORIFICE METER USING CFD MODELING

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ABSTRACT
Air flow is measured by the quantity of the fluid that passes through the pipe, duct or an open channel. The devices like orifice plates and nozzles are extensively used in several industries to estimate the mass flow rate through a channel by correlating the measured velocity, pressure loss with air flow. In the present experiment focus has been given on the flow velocity, volume flow rate, residual calculation, pressure inside the orifice plate, determination of turbulence zone near the orifice and also to calculate the Reynold's no. of the flow in the orifice plate using ANSYS V18.2 fluent. Navier-Stocks equations have been employed to describe the velocity, pressure and to determine the zone of Vena-contracta using CFD code of ANSYS for incompressible fluid. Later on this model is being validated by a wind tunnel with a regulator plate inserted in it at a distance of 30cm from the inlet. The study helps in better understanding of the effect of orifice or regulator on the air flow behavior in the wind tunnel and in determination of the zone of vena contracta at the orifice point.

Keyword: Orifice meter, ANSYS, κ-ε turbulence model, vena-contracta, CFD, wind tunnel.

1. INTRODUCTION

The measurement of flow rate is important in many industrial applications including rocket propellant stages. It is the determination of the quantity of the fluid that passes through the pipe, duct or an open channel. Flow can be measured by measuring the velocity of fluid over a known area. The accurate measurement of a fluid is important to obtain specific proportions as per process requirements. It is important to maintain a definite flow rate for maximum efficiency and production. Without accurate measurements precise quality control is impossible. Flow measuring instruments are venturi meter, orifice Plate, rotameter, pitot tube, flow nozzles, etc. Out of these orifice-meter is having least coefficient of discharge. It is widely used for its simplicity of design, reliability (no moving parts), and low manufacture cost[1]. They have been standardized and approved for measurements relative to financial clearings. A conventional orifice has a single circular opening made in the centre of the disc which is usually mounted inside a pipe line. It suffers from high pressure dtop due to lower discharge coefficient This can be overcome by the use of multi hole orifice flow meter. This is due to early reattachment of flow in case of multi-hole orifice meter. According to the Bernoulli and continuity equations, the pressure drop on the orifice can be used for mass flow estimation when the duct geometry and fluid density is known. Combining these two equations leads to the following relation for mass flow rate:

$$q_m = \frac{1}{\sqrt{1-\beta^4}}\frac{\pi}{4}d^2\sqrt{2\rho\Delta p}\quad\text{[1]}$$

Contraction coefficient β is the square root of orifice to duct cross-section area ratio.

$$\beta = \sqrt{\frac{A_{or}}{A_d}} = \frac{d}{D}\quad\text{[2]}$$

The contraction coefficient is the most important parameter describing the orifice. According to Equation (1), there is a strong dependency between the mass flow rate and contraction coefficient and is valid only for the laminar flow of an incompressible, frictionless fluid in a horizontal channel. The effects of ratio on mass transfer rate behind the orifice was numerically studied by [2] and [3]. CFD tools are widely used in modelling and analyzing orifice meter [4-6]. Some studies have focused on obtaining the associated discharge coefficient [7] and pressure drops [8]. The characteristic length and velocity scales in different regions of orifice flows using PIV was studied by