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ORIFICE PLATE DESIGN AND CFD ANALYSIS AT DIFFERENT VELOCITY RATIOS

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Abstract

Flow measurement is measurement of the quantity of the fluid that passes through the pipe, duct or an open channel. Flow may be measured by measuring the velocity of fluid over a known area. Differential pressure measuring devices such as orifice plates and nozzles are extensively applied in several industries to estimate the mass flow rate running through a channel by correlating the measured pressure loss. In this paper, an orifice plates with different geometry were designed and compared on the basis of their coefficient of discharge. This was done with the help of simulations done with k-ε and model on CFD as a solver. Simulations were carried out on a single hole, perforated (6 holes, 8 holes) at different Reynolds numbers (6000, 8000 and 10000).In this thesis the CFD analyses to determine the pressure drop turbulence intensity, and velocity. 3D modeled in parametric software CATIA and analysis done in ANSYS.

1.INTRODUCTION

An orifice plate is a device used for measuring flow rate, for reducing pressure or for restricting flow (in the latter two cases it is often called a restriction plate). Either a volumetric or mass flow rate may be determined, depending on the calculation associated with the orifice plate. It uses the same principle as a Venturi nozzle, namely Bernoulli's principle which states that there is a relationship between the pressure of the fluid and the velocity of the fluid. When the velocity increases, the pressure decreases and vice versa.

An orifice plate is a thin plate with a hole in it, which is usually placed in a pipe. When a fluid (whether liquid or gaseous) passes through the orifice, its pressure builds up slightly upstream of theorifice:85–86 but as the fluid is forced to converge to pass through the hole, the velocity increases and the fluid pressure decreases. A little downstream of the orifice the flow reaches its point of maximum convergence, the vena contracta (see drawing to the right) where the velocity reaches its maximum and the pressure reaches its minimum. Beyond that, the flow expands,

the velocity falls and the pressureincreases. By measuring the difference in fluid pressure across tappings upstream and downstream of the plate, the flow rate can be obtained from Bernoulli's equation using coefficients established from extensive research. Orifice plates are most commonly used to measure flow rates in pipes, when the fluid is single-phase (rather than being a mixture of gases and liquids, or of liquids and solids) and well-mixed, the flow is continuous rather than pulsating, the fluid occupies the entire pipe (precluding silt or trapped gas), the flow profile is even and well-developed and the fluid and flow rate meet certain other conditions. Under these circumstances and when the orifice plate is constructed and installed according to appropriate standards, the flow rate can easily be determined using published formulae based on substantial research and published in industry, national and international standards.

WORKING PRINCIPLE

As the fluid approaches the orifice the pressure increases slightly and then drops suddenly as the orifice is passed. It continues to drop until the "vena contracta" is reached and then gradually increases until at approximately 5 to 8 diameters downstream a maximum pressure point is reached that will be lower than the pressure upstream of the orifice. The decrease in pressure as the fluid passes thru the orifice is a result of the increased velocity of the gas passing thru the reduced area of the orifice. When the velocity decreases as the fluid leaves the orifice the pressure increases and tends to return to its original level. All of the pressure loss is not recovered because of friction and turbulence losses in the stream. The pressure drop across the orifice (P in

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Fig. 1) increases when the rate of flow increases. When there is no flow there is no differential. The differential pressure is proportional to the square of the velocity, it therefore follows that if all other factors remain constant, then the differential is proportional to the square of the rate of flow.

LITERATURE SURVEY

1. CFD Analysis and Comparison of Fluid Flow Through A Single Hole And Multi Hole Orifice Plate.

Abstract- Flow measurement is one of the most important tasks in many industries. Even today there does not exist a universal flow measuring instrument in many flow applications. The fluid flow through a single hole orifice plate and multi holes orifice plate were analyzed in this paper by using Computational Fluid Dynamics (CFD). For analysis water is used as fluid and is allowed to pass through a pipe across the orifice plate. The geometry of the orifice plate and the pipe section has made using CATIA V5 R20 and the model has meshed using HYPER MESH 11.0, the flow characteristics are studied using ANSYS FLUENT 6.3.26. This paper also presents the effect of orifice holes arrangement or distribution in a plate on the performance of flow characteristics such as flow rate, pressure drop, velocity and turbulent intensity. The parameters used for designing the orifice plate are non standard conditions. The analysis is carried out for four diameter ratio (d/D= 0.60, 0.30, 0.20, 0.15 for single hole, four, nine and sixteen holes respectively). The inner diameter of the pipe used is 50 mm and the plate thickness used for analysis is 3 mm for all the plates. The simulation results shows that multi holes orifice plate have better flow characteristics compare to single hole orifice plate for the same area of departure.

2. Numerical analysis of the performance characteristics of conical entrance orifice meter

ABSTRACT: Orifice meters are one of the most widely used flow meters in industrial applications due to their simplicity, accuracy and economy. However, the sharp edge orifice plates cannot be used for low Reynolds number flows, due to a large variation in discharge coefficient with Reynolds number. Conical entrance orifice plates are developed for this purpose. In the present study, a CFD methodology using ANSYS, FLUENT software has been adopted for analyzing flow through conical orifice plate assemblies. The methodology has been validated by analyzing flow through standard orifice plate assembly (as per ISO 5167). K-ω SST model is found to be best suited for this class of problems.. The flow is assumed to be steady and axisymmetric and the fluid is incompressible and Newtonian. The computed values of discharge coefficient and other parameters are in excellent agreement with the values given BS 1042 as long as operating conditions are within the specified range. The parametric study has demonstrated that the acceptable range of Reynolds number can be extended to 50 to 106 as compared to 80 to 80000 as specified by BS 1042.Pipe roughness does not have significant effect on the value of discharge coefficient.

3. Flow characteristics of fluid and its effectiveness on orifice plate using pneumatic proportional control

A number of studies on effect of temperature on the flow characteristics of various fluids have been carried out. The aim of this work was to examine the flow characteristics of hexane upon the influence of temperature as well as the effectiveness response of orifice plate using pneumatic proportional control. Knowledge of the past on temperature impact as one aspect of the information set held by various scientific and a well established finding in engineering is that changes in composition can change the effect of temperature on the flow characteristics of hexane in a flow line system. The particular aspects of temperature impact on the research work highlighted are density, viscosity and pressure characteristics. The effect of temperature on flow characteristics of hexane was examined within the temperature range of 283 to 323 K and Bernoulli's equation knowledge of the past was used in developing the model for this paper. The mathematical models developed were simulated using the numerical concept of polynomial expression of the best fit. The effects of temperature on the functional parameters were examined and proportional gain at various error range of E = 0.1 to 0.5 were considered during the investigation. These effects on the variation of the results were attributed to the temperature, flow characteristics of the hexane and its effectiveness on orifice plate using pneumatic proportional control.

MODELING AND ANALYSIS

CATIA is an abbreviation for Computer Aided Three-Dimensional Interactive Application. It is the most capable, ground-breaking and exceptionally mainstream CAD for example PC helped plan programming. It is made, created and possessed by Dassault Systemes of France. IBM was the main advertiser of CATIA till 2010. In light of its high ease of use, CATIA accreditation is perhaps the most famous and sought after confirmation in market.

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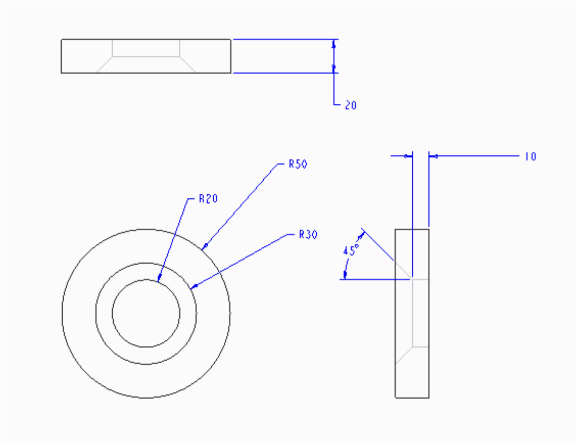


Fig : 2D model of orifice plate

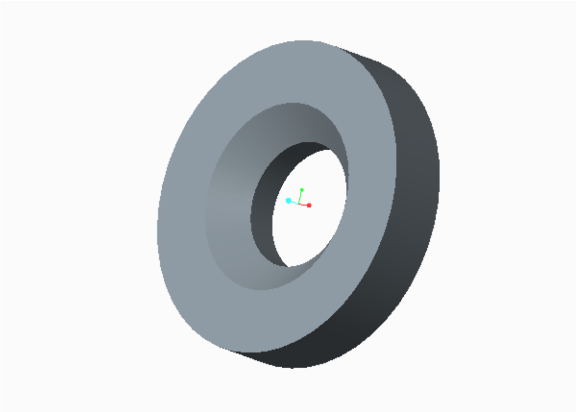


Fig : 3D model of orifice plate

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial experimental validation of such software is performed using a wind tunnel with the final validation coming in full-scale testing, e.g. flight tests.

CFD ANALYSIS OF ORIFICE PLATE

The orifice plate is very inexpensive for it is just a flat plate and thin orifice plate. The flow through conventional single hole ,six holes, eight holes and twelve holes orifice meter and integrated CFD simulation with measurements .CFD tools are also widely used in modeling and analyzing orifice plates.

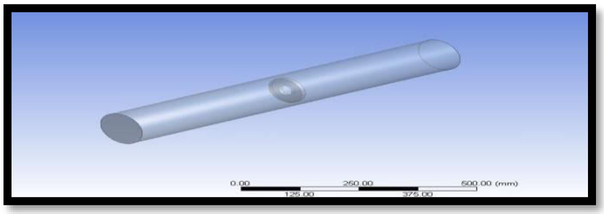
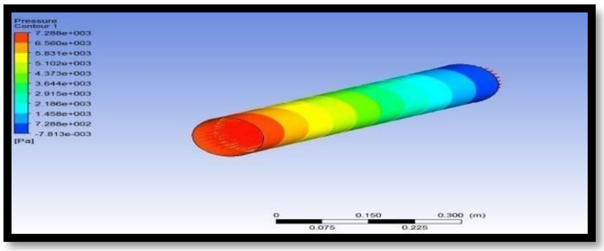
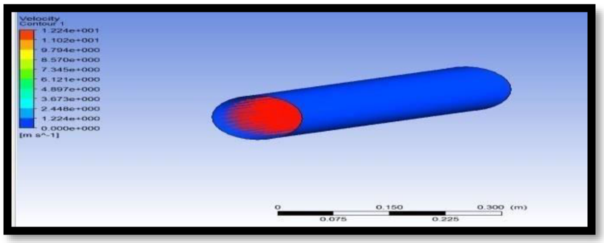


Fig :imported model

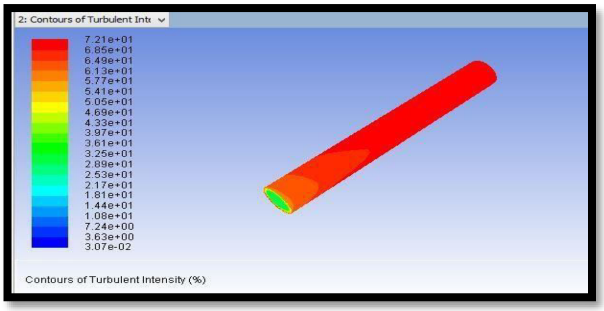
Static Pressure



Velocity Magnitude



Turbulence Intensity



Results tables

At 6000 Reynolds number

Cases	Pressure (Pa)	Velocity (m/s)	Turbulence intensity (%)
1 hole	3.222e+03	8.165	4.98e+01
6 holes	3.917e+03	8.184	4.99e+01
10 holes	3.919e+03	8.186	5.0e+01

At 8000 Reynolds number

Cases	Pressure (Pa)	Velocity (m/s)	Turbulence intensity (%)
1 hole	4.86e+03	1.03e+01	6.10e+01
6 holes	5.859e+03	1.023e+01	6.11e+01
10 holes	5.940e+03	1.024e+01	6.12e+01

At 10000 Reynolds number

Cases	Pressure (Pa)	Velocity (m/s)	Turbulence intensity (%)
1 hole	7.288e+03	1.224e+01	7.21e+01
6 holes	8.234e+03	1.227e+01	7.22e+01
10 holes	8.319e+03	1.23e+01	7.23e+01

CONCLUSION

In this thesis, an orifice plates with different geometry were designed and compared on the basis of their coefficient of discharge. This was done with the help of simulations done with k-ε and model on CFD as a solver. Simulations were carried out on a single hole, perforated (6 holes, 10 holes) at different Reynolds's numbers (6000, 8000 and 10000).

By observing the CFD analysis results, the pressure and turbulent intensity increases by increasing the standard orifice plate & conical orifice plate holes and Reynolds numbers.

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