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A REVIEW ON ANALYSIS AND EVALUATION OF COEFFICIENT OF DISCHARGE ON ORIFICE PLATE AND FLOW NOZZLE

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Abstract - An orifice plate is a gadget utilized for estimating flow rate. Either a volumetric or mass stream rate still up in the air, contingent upon the estimation related with the opening plate. A spout is a gadget intended to control the bearing or attributes of a liquid stream (particularly to increment speed) as it exits (or enters) an encased chamber or line. Stream spout has high coefficient of release than hole plate. Differential strain gadgets, for example, orifice plates and nozzles are broadly applied in industries to estimate the mass flow rate running through a conductor by corresponding the deliberate pressure loss and the mass flow rate. The current work is coordinated towards the to concentrate on the course through an orifice plate and a long radius flow nozzle obstruction flow meters are ordinarily being used to measure flow rates in pipes. Computational Fluid Dynamics (CFD) is utilized to anticipate the flow highlights in the orifice flow meter. Results of the CFD simulations in terms of profiles of velocity and pressure are examined exhaustively.

Key Words: Computational Fluid Dynamics (CFD), Flow nozzle, Orifice plate, Pressure, Velocity.

1.INTRODUCTION

Computational Fluid Dynamics (CDF) is the investigation of liquid streams utilizing mathematical arrangement strategies and information construction to break down and tackle issues that associated with liquid streams. PCs are utilized to play out the estimations expected to mimic the free stream of the liquid and the connection of the liquid (fluids and gases) with surfaces characterized by limit conditions.
CFD is applied to a wide scope of examination and designing issues in many fields of study. In designing fields where CFD examinations are every now and again utilized for instance streamlined features and hydrodynamics, where amounts, for example, lift and drag or field properties as tensions and speeds are gotten. Influenza id elements is associated with actual regulations as incomplete differential conditions.
Liquid move through pipe: Computational liquid elements is utilized to decide speed and tension of stream of liquid in a line and contrast it and the outcome acquired in the research facility for example liquid stream module. It is additionally used to notice the hotness move during the progression of liquids in a line and contrast it and the outcomes acquired in the research center for example heat move module

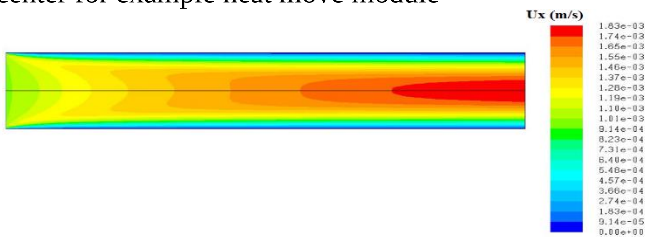

Fig-1: Flow through pipe

ORIFICE PLATE

A hole plate is a gadget utilized for estimating stream rate, for diminishing tension or for limiting stream. An opening plate is a slender plate with an opening in it, which is generally positioned in a line. At the point when a liquid (whether fluid or vaporous) goes through the opening, its tension develops somewhat upstream of the opening however as the liquid is compelled to join to go through the opening, the speed increments and the liquid strain diminishes. Somewhat downstream of the hole the stream arrives at its place of greatest combination, where the speed arrives at its maxi-mum and the tension arrives at its base. Past that, the stream extends, the speed falls and the strain increments. By estimating the distinction in liquid tension across upstream and downstream of the plate, the stream rate can be acquired from Bernoulli's guideline which expresses that there is a relationship between the strain of the liquid and the speed of the liquid. At the point when the speed builds, the tension declines as well as the other way around.

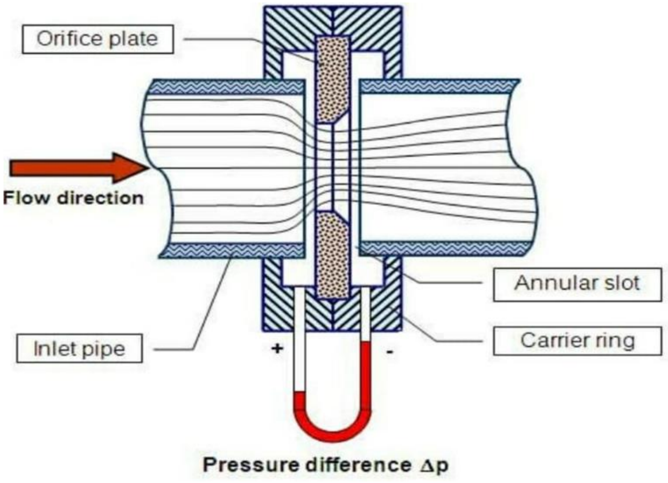

Fig-2: Orifice Plate

FLOW NOZZLE

Stream Nozzle has a smooth circular gulf prompting a throat segment with a sharp outlet. Limitation in the liquid stream causes a tension drop, which connects with the stream rate by applying Bernoulli's condition.

The stream spouts are a stream tube comprising of a smooth concurrent segment prompting a barrel shaped throat region. The throat is the littlest segment of the spout. Pressure taps are situated on the upstream side of the spout plate and on the downstream side of the spout outlet. They might be as an annular ring, for example similarly separated openings associated together which open into the pipeline, or as single openings bored

$$Q^2 = K * DP$$

Q = flow rate of the fluid

K = Constant value for the particular nozzle
DP = pressure differential

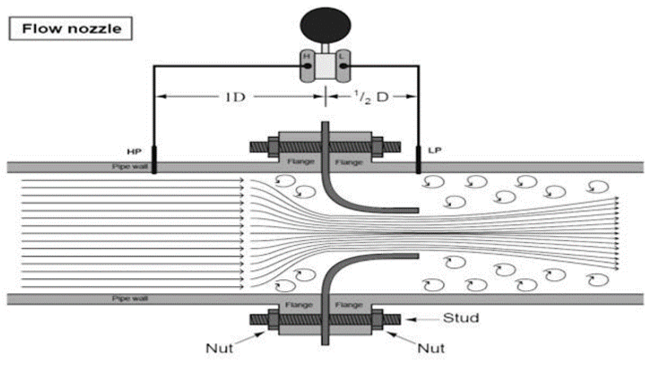

Fig-3: Flow Nozzle

2. LITERATURE SURVEY

Tom Bruce [1] published a short course in flow measurement methods. His publish aim was to generate an awareness of the range of contemporary flow measurement devices and methods available for application to both industrial and research flow problems in Mechanical Engineering. He reviewed well-established mass and volume flow rate measuring devices, and discussed the strengths and weaknesses of various meters and meter classes. He conferred also modern non-invasive methods, magnetic and ultrasonic, as well as velocimetry (or anemometry) methods, with a distinction drawn between point measurement methods and 2-D methods. He described in detail the former category, Laser-Doppler anemometry and Particle Image Velocimetry under 2- D methods for a range of applications.

A L Ling [2] provided an engineering guide line for fluid flow measurement selection and sizing which is helpful to understand the func-tions and types of flow measurement instrumentation, to size flow measure-ment instrumentation (Orifice plate, Venturi tube, Pitot tube, nozzle, Rotameter, vane meter, positive displacement flow meter and etc.). All the important parameters used in the guideline were explained in the definition section which help the reader to understand the meaning of the parameters used. The method of selection of the several types of the flow measurement instrumentation, such as from the differential pres-sure flow meter, variable area flow meter, positive displacement flow meter, turbine flow meter, electromagnetic flow meter and etc. is also explained. In the theory section of the guide line, selections of the flow meters are included and the general theories applied for the sizing for each type of the flow meters are detailed. In the applica-tion section, several case studied are shown and discussed in detail. His case studied is found helpful to do the selection and sizing for the several flow meters based on own systems.

Gerry Pickens and Kevin Brown [3] made an overview of flow principles and pressure-based flow measurement, they covered in details the flow types, the flow principles, the Reynolds number concept, the pressure drop, the mass flow Versus volumetric flow, the influence of pressure on volu-metric flow and laminar differential pressure flow measurement. Their overview was found very useful and helped to understand the basis issues related to the current re-search topic.

E.L. Upp and Paul J. LaNasa [4] published a practical guide to accurate flow measurement. He highlighted first the basic princi-ples, particularly with respect to differential and linear meters and the types used in the oil and gas industry for fluid flow measurement. Then he reviewed the basic refer-ence standards followed by an overview of fluids and the fluid characteristics, oper-ating and maintenance concerns. He also described how various practical considera-tions make effective meter accuracy and highlighted the limitations of obtaining accurate flow measurement. He concluded by reviewing the necessary concerns of operating the meters properly with examples of real problems found in the field.

Richard Steven [5] discussed in details the flow me-ter types and their principles, the appropriate meter type in many industrial plants. He came up with conclusions that the ability to conduct accurate flow measurements is so important that it can make the difference between making a profit or taking a loss and that inaccurate flow measurements or failure to take measurements can cause serious (or even disastrous) results.

Roger C. Baker [6] published flow measurement handbook and detailed the principle types of meters available in industry. Both mechanical and non-mechanical meter types were detailed. For pressure based meters, Venturi, Ori-fice plate, Dall tube, Pitot-Static tube, Multi-hole pressure probe and cone meters were focused on.

ASME standards [7,8] the design constraints in measurements of fluid flow in pipes using Orifice, Nozzle and Venturi were clearly set and then used as a guide to size the meter in task.

Allen Chandler [9] provided a comprehensive review study of all im-portant topics in the subject, which include interesting theoretical and experimental studies and innovative industrial developments and applications. The advances in fundamental understanding and technology development are clear-ly identified. Future directions in various areas together with some open questions were also outlined.

Colter L. Hollingshead [10] studied the discharge coefficient performance of Ven-turi, standard concentric Orifice plate, V-cone, and Wedge flow meters. They investigated The relationship between the Reynolds number (Re) and discharge coefficients (Cd) through differential pressure flow meters. The focus of their study was directed toward very small Reynolds numbers commonly as-sociated with pipeline transportation of viscous fluids.

Mark Skelton and Simon Barrons [11] studied the effects of the latest revision of ANSI/API 2530/AGA 3 on Orifice meter primary el-ements. They highlighted The most significant changes affecting fittings and meter tubes such as eccentricity of plate to fitting bores, seal gap/seal recesses and pro-trusions, internal diameter tolerances and surface finish, pressure tap and plate seal leak tests and Orifice plate bore dimensions.

Jiunn-Haur Shaw and John D. Wright [12] dealt with advances in flow measurement and calibration. They investigated the calibration of three laminar flow meter designs at four pressures with five fluids over a 10:1 flow range. Their found a maximum error of 0.8% for Reynolds num-bers Re < 500. Their range of investigation was 500 < Re < 2000.

Smith Eiamsa-ard, Artit Ridluan, Prachya Somravysin, and Pongjet Promvonge [13] investigated numerically turbulent flow through a circular orifice. They dealt with the simulation of turbulent flow through an orifice plate with a view to increasing the knowledge of orifice meter flow. Their study was concerned with the concentric, round, beveled orifice plate and focused almost en-tirely on the determination of discharge coefficients. Their work lead to one conclu-sion that knowledge concerning details of the orifice flow field will lead the way to improvements in metering accuracy. They compared the calculated gas axial ve-locity in 3D with the measured data to evaluate the turbulence models used. Their predicted and experimental results show good agreements.

M. Aichouni, B. Laribi, and P. Wauters [14], investigated experimentally the installation effects on Venturi and Orifice flow me-ters. They presented results of an experimental investigation on the effects of non-standards operating conditions (axisymmetric and swirling flows) on the accuracy of the Venturi and the orifice flow meters. Their results showed that the error caused by such non-standards operating conditions can be very important and are well beyond the tolerated error limit by the existing international standards. They came up with a conclusion that the accuracy of these devices depends mainly on their position in a pipe network and that pipe fittings such as valves, bends and other fixtures generate tur-bulence and swirl and distort the flow distribution in the pipe. They showed that this disturbance altered significantly the measurement performances of the meters.

E.Farsirotou, D.Kasiteropoulou, and D.Stamatopoulou [15], conducted experimental investigation of fluid flow in horizontal pipes system of various cross-section geometries. They dealt with incompressible fluid flow in pipes. Their experimental equipment consisted of a horizontal pipe including a gate valve, a Venturi meter, a wide angle diffuser, an orifice plate, a 90-degree el-bow and pressure tapings, with an elbow that connects the pipe to a rotameter with fur-ther pressure tapings. They heled all pressure tapings connected to manometers on a vertical panel behind the pipe work and showed pressure at various points. They present-ed the effect of the pipe geometry in the flow pattern and estimated the head losses at specific stream-wise cross sections, for mass flow rate numbered from 0.056 to 0.411 l/s. They presented the diagrams of mass flow rate and head losses in specif-ic cross-sections, where geometry changes. Their measurements were calibrated and validated in a maximum standard deviation difference of 5%. Their end results showed that the head losses decrease as the mass flow rate decreases, for all pipe geometries.

C. P. Ukpaka1 and V. M. Ndor2 [16], examined the flow characteristics of fluid and its effectiveness on orifice plate using pneumatic proportional control. The aim of their work was to examine the flow characteristics upon the influence of temperature as well as the effectiveness response of orifice plate using pneumatic proportional control. Their results showed that changes in compo-sition can change the effect of temperature on the flow characteristics in a flow line system. The particular aspects of temperature impact on their research work highlight-ed are density, viscosity and pressure characteristics. They examine the effect of temperature on flow characteristics within the temperature range of 283 to 323 K and used Bernoulli's equation in developing a mathematical model. They simulated their models using the numerical concept of polynomial expression of the best fit.

H.S. Sondha, S.N. Singhb, V. Seshadrib, B.K. Gandhic [17], were concerned with the design and development of variable area orifice me-ter. They use a variable area orifice meter to indicate the flow rate as a linear dis-placement of a symmetrical body placed concentrically downstream of an orifice inside a constant area duct. They used three shapes of symmetrical body namely, a frustum of cone, frustum of cone with hemispherical base, and frustum of cone with hemi-spherical base and parabolic apex downstream of an orifice to develop a variable area orifice meter. They performed such experiments at different positions of the sym-metrical bodies to evaluate the performance of the variable area orifice meter. They proved that the frustum of cone having hemispherical base and parabolic apex gives nearly linear variation of the flow rate with its position for a constant pressure differen-tial.

Kei Takahashi and Hiroyuki Matsuda [18], studied the cavitation characteristics of restriction orifice. They conducted two experimental investigations for cavitation characteristics of restriction orifices. Their first ex-periment was about the spatial distribution of cavitation shock pressure in a pipe at the downstream of restriction orifices. Their second experiment was the investiga-tion of butterfly valve throttling to the cavitation in a multi-perforated orifice installed piping. From the results of their experiment for the cavitation shock pressure, it can be concluded the maximum shock pressure remarkably increases with the decrease of cavitation number regardless of the orifice types. The maximum shock pressure be-comes smallest on cone type orifice, and largest on single hole orifice. Multi-perforated orifice is between this two. Their results of the experiment for occurrence of cav-itation due to the interference of butterfly valve showed that the cavitation occurs at a relatively high cavitation umber when the multi-perforated orifice is placed at 1D downstream of the butterfly valve. The butterfly valve throttling accelerates the cavita-tion at the multi-perforated orifice because of the closed orifice installation.

Lalit Kumar Bohra [19] research was about flow and pressure drop of highly viscous fluids in small aperture orifices. He studied the pres-sure drop characteristics of the flow of highly viscous fluids through small diameter orifices was conducted to obtain a better understanding of hydraulic fluid flow loops in vehicles. He measured pressure drops for each of nine orifices, including orifices of nominal diameter 0.5, 1 and 3 mm, and three thicknesses (nominally 1, 2 and 3 mm), and over a wide range of flow rates ($2.86\times10^{-7} < Q < 3.33\times10^{-4}$ m3 /s). He found that the fluid under consideration exhibits steep dependence of the properties (changes of several orders of magnitude) as a function of temperature and pressure, and is also non-Newtonian at the lower temperatures. His data were non-dimensionalized to obtain Euler numbers and Reynolds numbers using non-Newtonian treatment. He found that at small values of Reynolds numbers, an increase in aspect ratio (length/diameter ratio of the orifice) causes an increase in Euler number. He also found that at extremely low Reynolds num-bers, the Euler number was very strongly influenced by the Reynolds number, while the dependence becomes weaker as the Reynolds number increases toward the turbu-lent regime, and the Euler number tends to assume a constant value determined by the aspect ratio and the diameter ratio. A two region (based on Reynolds number) model was developed to predict Euler number as a function of diameter ratio, aspect ratio, viscosity ratio and generalized Reynolds number. He included data in his model at higher temperatures ($20 \le T \le 50$oC), while results show that for such highly vis-cous fluids with non-Newtonian behavior at some conditions, accounting for the shear rate through the generalized Reynolds number resulted in a considerable im-provement in the predictive capabilities of the model. Over the laminar, transition and turbulent regions, his model predicted 86% of the data within ±25% for $0.32 < l/d$ (orifice thickness/diameter ratio) < 5.72, $0.023 < \beta$ (orifice/pipe diameter ratio) < 0.137, $0.09 <$ Regeneralized < 9677, and $0.0194 < \mu$generalized < 9.589 (kg/m-s)

R. G. Teyssandier and Z. D. Husain [20], conducted experimental investigation of an Orifice meter pressure gradient by including wall and plate pressure gradients in a 89 mm air flow orifice meter facility for 3 orifice plates covering a pipe Reynolds number range of 21,000 to 160,000. They found that the influence of the orifice plate on the upstream wall pressure gradient extended to 0.62D location, while this pressure gradient was a weak function of the orifice plate β ratio and the downstream location of the minimum pressure point located at about 3.3 dam heights. Their results of pressure gradient on the face of the orifice plate showed that the deflection calculation based on any differential pressure taps was conserva-tive.

Meng, Z., Huang, Z., Wang, B., Ji, H., Li, H., Yan, Y [21], measured air-water two phase flow by using a Venturi meter and an electrical resistance tomography (ERT) sensor. During their work, the real-time flow pattern of the two-phase flow is using the ERT sensor was firstly identified. They calculated secondly the void fraction of the two-phase flow from the conductance values through a void fraction measurement model, developed using a regression method. Thirdly, they determined the mass quality from the void fraction through void fraction-quality correlation. And finally, they calculated the mass flow rate of the two-phase flow from the mass quality and the differential pressure across the Venturi meter. Their experimental results demonstrated that the proposed method is effective for the measurement of the mass flow rate of air-water flow. Their proposed method introduced the flow pattern information in the measurement process, which min-imizes the influence of flow pattern on the conventional differential pressure based methods. In addition, they calculated the mass quality from the void fraction, so the difficulty to obtain the mass quality in conventional methods was also overcame. Meanwhile, their method was capable for providing concurrent measurements of multiple parameters of the two phase flow including void fraction, mass quality and mass flow rate as well as an indication of the flow pattern

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