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Calculation of Coefficient of Discharge of Orifice Plate and Flow Nozzle

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ABSTRACT:

An orifice plate is a device used for measuring flow rate. Either a volumetric or mass flow rate may be determined, depending on the calculation associated with the orifice plate.A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe. Flow nozzle has high coefficient of discharge than orifice plate .The present work is directed towards the to study the flow through an orifice plate and a long radius flow nozzle' obstruction flow meters are commonly in use to measure flow rates in pipes. Both the orifice and nozzle are modeled inside a pipe with an inner diameter of 50 mm and a length of 1m water in the pipe flows with a mean velocity of 1m/s corresponding to Reynolds number 50,000.Thedischarge coefficients are determined and compared with experimental values.The cut plots ,XY-plots ,flow trajectories for orifice plate and flow nozzle are displayed.The centerline velocity varies along the length of the pipe for both the cases and plotted pressure , velocity fields .

INTRODUCTION:
INTRODUCTION TO ORIFICE PLATE:

An orifice plate is a device used for measuring flow rate. 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.

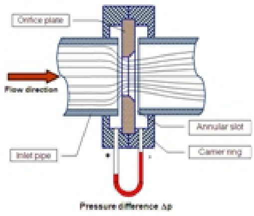

Figure : Orifice plate

DESCRIPTION:

An orifice plate is a thin plate with a hole in the middle. It is usually placed in a pipe in which fluid flows. When the fluid reaches the orifice plate, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called vena contracta point (see drawing to the right).

As it does so, the velocity and the pressure changes. Beyond the vena contracta, the fluid expands and the velocity and pressure change once again. By measuring the difference in fluid pressure between the normal pipe section and at the vena contracta, the volumetric and mass flow rates can be obtained from Bernoulli's equation.

MODELLING OF ORIFICE PLATE AND FLOW NOZZLE
MODELLING OF ORIFICE PLATE :

Firstly on front plane extruding the pipe of50 mm diameter as shown.

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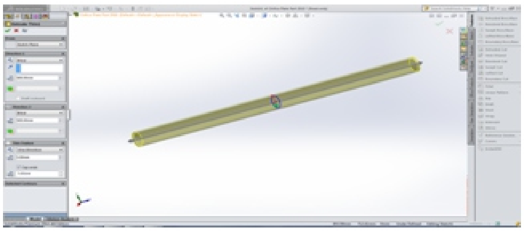

Figure : extrusion of pipe

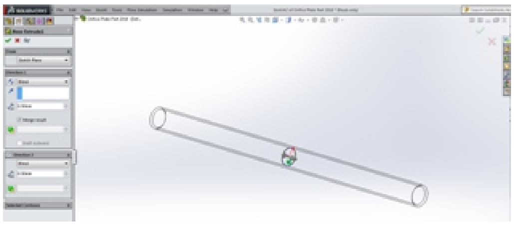

Figure : extrusion of plate for 0.5mm depth

Then extrude cut of plate is done. A 10mm radius circle is drawn and extrude cut is performed as shown.

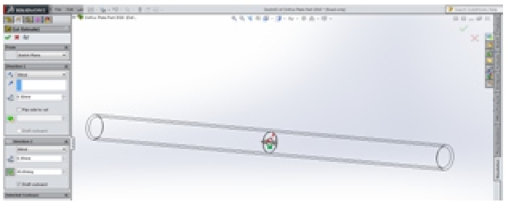

Figure : extrude cut of plate

Final orifice plate in pipe is as below:

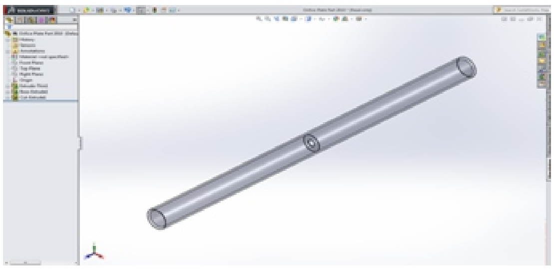

Figure : orifice plate in pipe

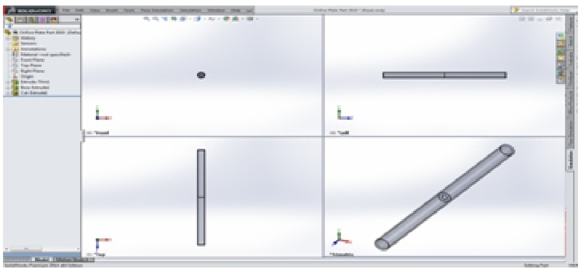

Figure : different views of orifice plate

MODELLING OF FLOW NOZZLE :

Firstly on front plane extruding the pipe of50 mm diameter as shown.

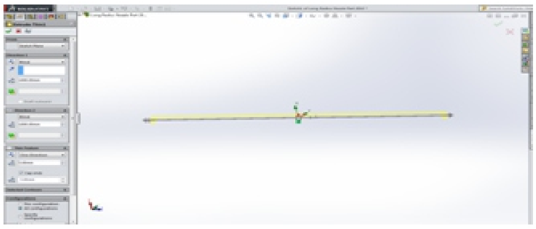

Figure : extrusion of pipe of dia 50mm

Then by using a revolve option flow nozzle is obtained as shown

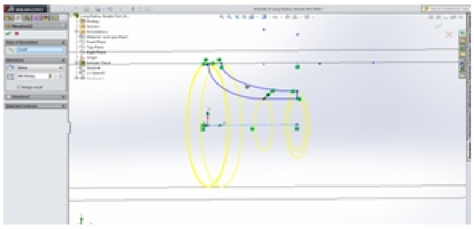

Figure : flow nozzle extrusion

The four different views of flow nozzle is shown below.

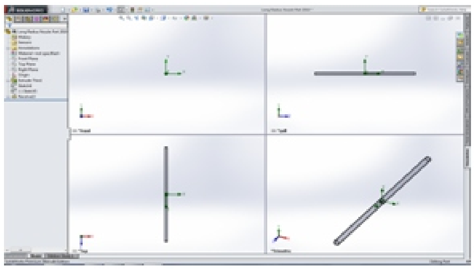

Figure : different views of flow nozzle

FLOW SIMULATION OF ORIFICE PLATE :

Flow Simulation to study the flow through an orifice plate .water in the pipe flows with a mean velocity of 1 m/s corresponding to a Reynolds number Re =50000 .The centerline velocity variesalong the length of the pipe for both cases and plot both pressure and velocity fields. Thedischarge coefficients will be determined and compared with experimental values.

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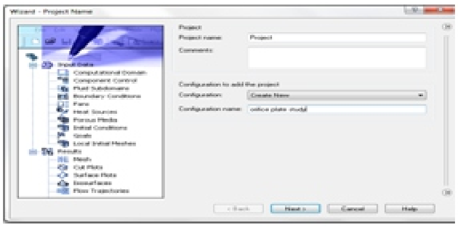

Figure : creating study name orifice plate

Selecting default SI units , default INTERNALanalysis type and water as a project fluid.

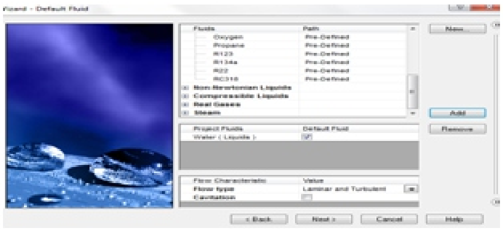

Figure : selecting water as a project fluid

Using default wall and initial conditions setting result resolution to 5.

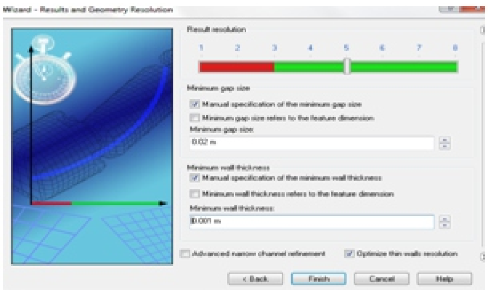

Figure :settting result resolution to 5.

INSERTING BOUNDARY CONDITIONS:

By setting result resolution the flow simulation tree will appear on left side .Inserting the boundary condition by selecting inner face of end capand setting inlet velocity to 1m/s for fully developed flow.

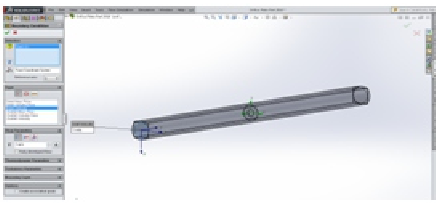

Figure : inlet velocity as 1m/s.

Inserting another boundary condition by selecting inner face of pipe outflow cap and setting environment pressure as shown.

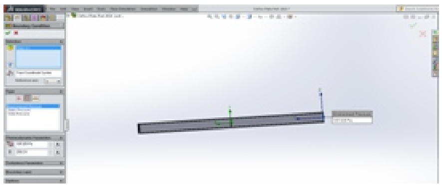

Figure : Environment pressure at the outlet

INSERTING GOALS :

On the flow simulation tree inserting point goal by selecting static pressure and adding the coordinates as shown.

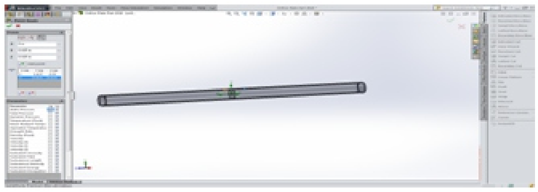

Figure : inserting point goals

RUNNING THE FLOW SIMULATION :

Then running the flow simulation as follows :

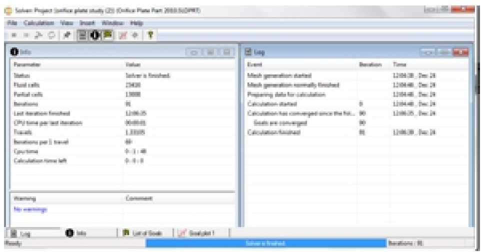

Figure : solver window for orifice plate

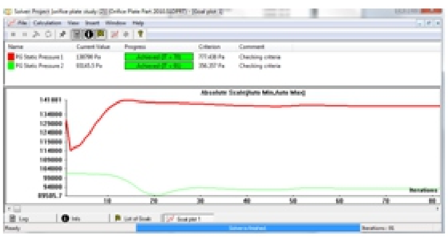

Figure :Variation of static pressure goals before and after orifice plate

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RESULTS :
INSERTING CUT PLOTS :

Inserting cut plot by selecting z-velocity component and the velocity distribution befire and after orifice plate can be determined.

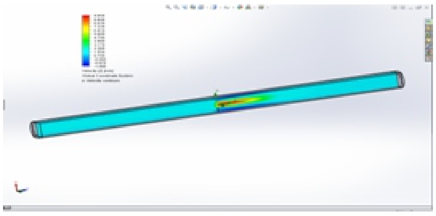

Figure : z-velocity distribution before and after orifice plate

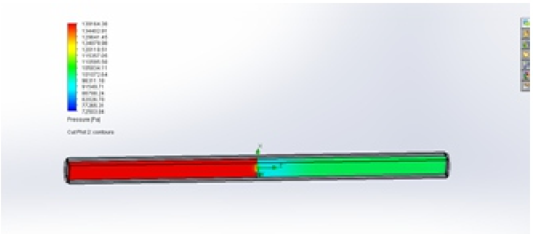

Figure : pressure distribution before and after orifice plate.

INSERTING FLOW TRAJECTORIES :

Flow trajectories show the streamlines of the flow for the orifice plate .On the flow simulation tree inserting flow trajectories on front plane by selecting velocity as parameter .

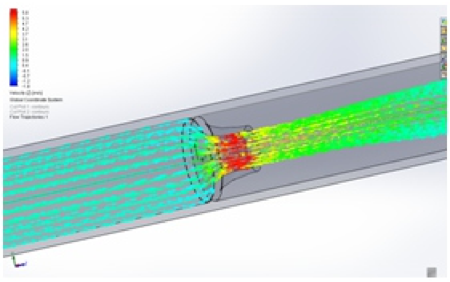

Figure : flow trajectories for flow nozzle

CONCLUSIONS:

* The orifice plate and flow nozzle terminology ,working and applications has been studied.
* The orifice plate and flow nozzle in the pipe has been modeled in a CAD tool called SOLIDWORKS 2014.
* SOLIDWORKS FLOW SIMULATION has been studied .
* Flow simulation is performed on orifice plate and flow nozzle.
* Coefficient of discharge of orifice plate from flow simulation result and experimental equation has been compared. There exists a difference of 6.5% between those two.
* Coefficient of discharge of flownozzle from flow simulation result and experimental equation has been compared. There exists a difference of 13%.
* Cut plots ,XYplots and flow trajectories has been displayed for orifice plate.
* Cut plots ,XYplots and flow trajectories has been displayed for flow nozzle.
* The centerline velocity varies along the length of the pipe for both the cases and plotted pressure , velocity fields .