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Static analysis of Orifice plate for Different Geometries

AVRK Teja, J.Sri Harsha, N.S.K.Teja, V.S.Gangadhar, T.Hari.Sainadh

skt041@gmail.com

Final Year Students

Department Of Mechanical Engineering, K L University-522502.

Abstract:

Orifice plate is a mechanical element used for measuring rate of flow by restricting flow, hence it is often called a restriction plate. The flow exerts some force on the plate due to impact of jet. The orifice plate acts an as obstacle for the flow. Here in our work we have done static analysis for three different geometries for orifice maintaining net impact area and orifice area same in all three cases. At the end we calculated maximum stress and maximum deformation for all the three geometries of orifice for the assumed working conditions, and found the best geometry which has the minimum stress and minimum deformation.

Introduction:

The orifice plate interrupts the flow, creates a pressure difference along the flow. The jet moving with certain velocity hits the plate and bounces back due to change in direction of flow some force will be exerted on the plate which can be calculated by applying Newton's law. Due to this impact some stresses will be developed on the plate, hence deformation occurs. Here in our work we have selected geometries such that the net impact area and orifice area will be the same so that impact force is equal in all three cases.

Working conditions:

Flow type: Laminar.

Working fluid: Water.

Velocity of flow: 20 m/sec.

Diameter of pipe: 120mm.

Area of flow: 11309.7 mm^2.

Area of orifice (A_o): 1963.49 mm^2.

Selection of Geometries:

1. Circular orifice plate.

   A_o =1963.49 mm^2. Therefore, Diameter of orifice (D) =50mm.

2. Square orifice plate.

   A_o =1963.49 mm^2. Therefore, Side of square (S) =44.31mm.

3. Rectangular orifice plate.

   Let length of rectangle be L, Breadth be B, L:B =2:1(assumed).

   Therefore, B= 31.33mm, L=62.66mm.

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Modelling:

The modelling of orifice is done using solid works.

Outer boundary of orifice plate: 150mm.

Hinged boundary diameter: 120mm.

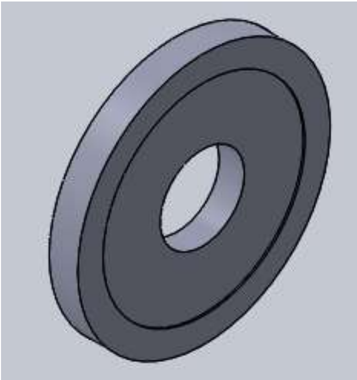
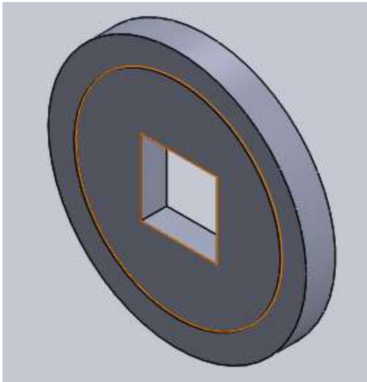
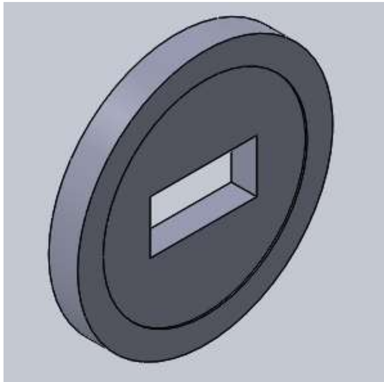

Fig: 1- Circular Orifice. Fig:2- Square Orifice. Fig:3- Rectangular Orifice.

Meshing:

Fine meshing was done for all the three geometries.

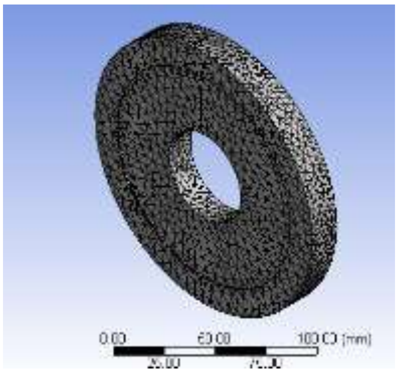
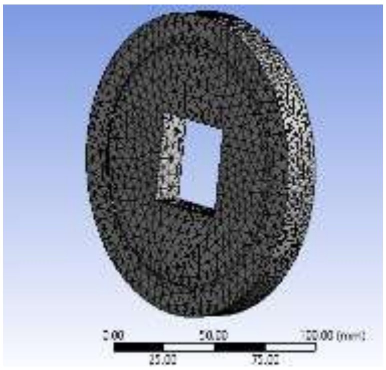
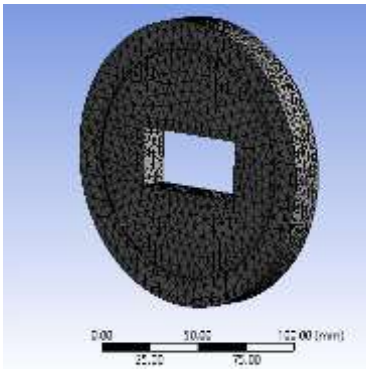

Fig: 4- Meshing of Circular Fig: 5- Meshing of Square Fig: 6- Meshing of Rectangular

Details of "circular orifice mesh"	
Advanced	
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Pinch	
Pinch Tolerance	Please Define
Generate on Refresh	No
Statistics	
Nodes	21701
Elements	12360

Details of "square orifice mesh"	
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Fine
Minimum Edge Length	15.0 mm
Inflation	
Advanced	
Pinch	
Statistics	
Nodes	21086
Elements	11975

Details of "rectangular orifice mesh"	
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Fine
Minimum Edge Length	15.0 mm
Inflation	
Advanced	
Pinch	
Statistics	
Nodes	21364
Elements	12131

Fig:7-Mesh details(Circular) Fig:8-Mesh details (Square) Fig:9- Mesh details(Rectangular)

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Load calculation:

F=dp/dt.

Hence, F= $\rho a v^2$.

a (impact area)= 0.011309-1.9634*10^{-3}

a =9.3456*10^{-3}

v = 20 m/sec.

Density (ρ)= 1000 kg/m^3

F= 1000*9.3456*10^{-3}*20^2.

F= 3738.24 Kg.

F= 36672.1344 N.

Application of Constraints and Loads in Ansys:

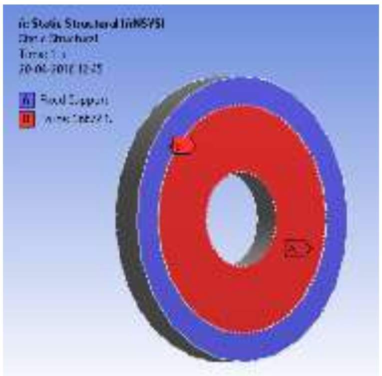


Fig:10- Circular.

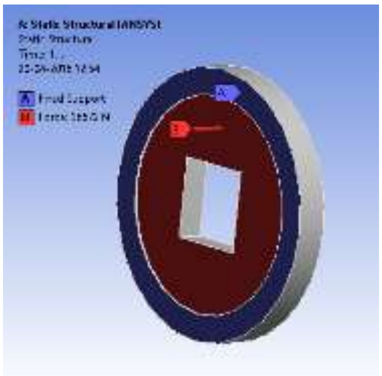


Fig: 11- Square.

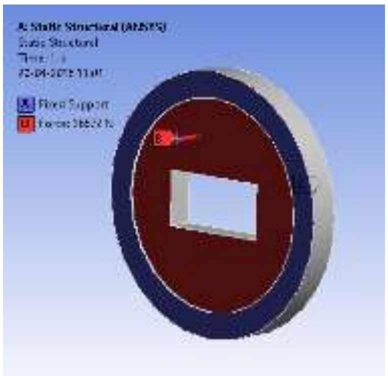


Fig: 12- Rectangular.

Analysis: 1.Circular Orifice.

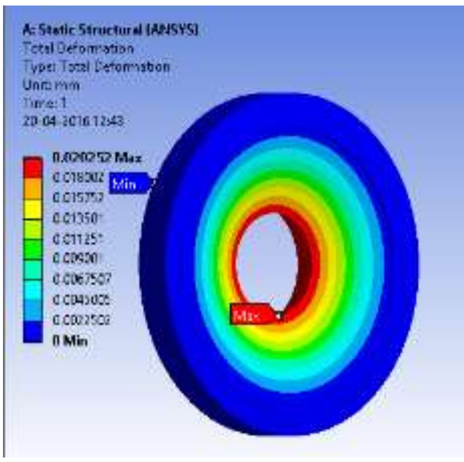


Fig: 13- Total Deformation.

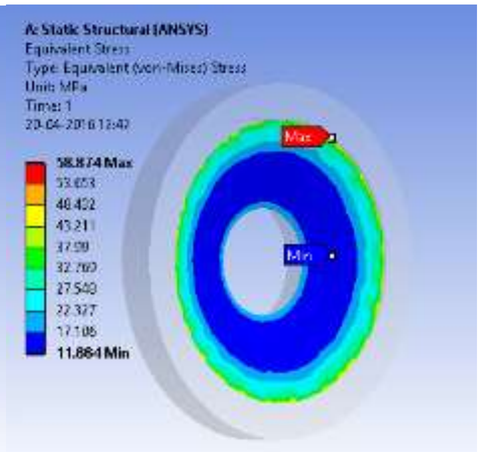
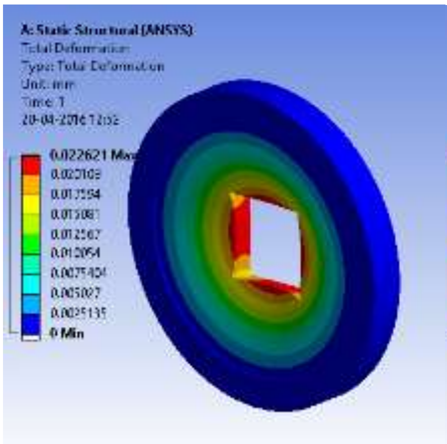


Fig: 14- Stress Distribution.

2. Square Orifice.



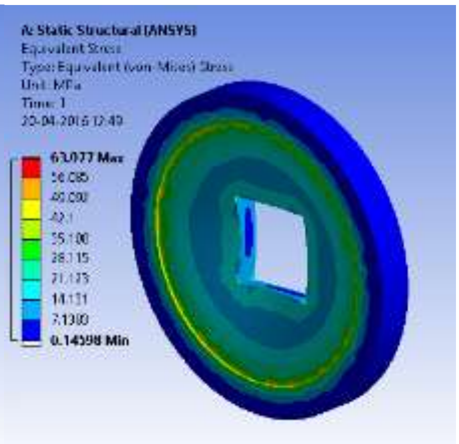
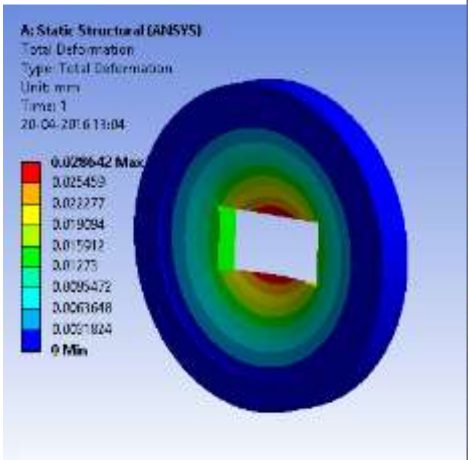


Fig: 15.Total Deformation. Fig: 16. Stress Distribution.

3. Rectangular Orifice.



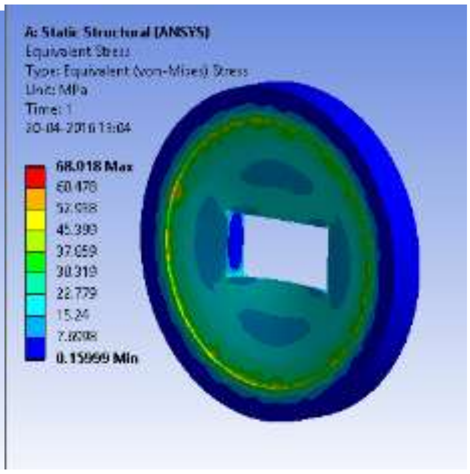


Fig: 17- Total Deformation. Fig: 18- Stress distribution.

Results:

S.no	Geometry	No. Of elements	No. Of nodes	Maximum Stress (Mpa)	Maximum Deformation(mm)
1.	Circular	12360	21701	58.877	0.0202
2.	Square	11975	21086	63.077	0.02261
3.	Rectangular	12131	21364	68.018	0.0286

Table: 1- Analysis results for different geometries.

Conclusion:

From the above results we can conclude that circular orifice is best suited to the above working conditions as maximum stress and deformation are less when compared to other geometries.

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