Shape Optimization of Splitter Plate in Vertex Flow Meter

Mr. Shivendra Singh[1] Sitaram Sahani[2] Mohammad Quiser[3] Mr. Pankaj Kumar Yadav[4]
[1,2,3]M. Tech Student [4]Associate Professor
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]Suyash Institute of Information Technology Hakkabad Gorakhpur, 273016 (UP), India

Abstract— The investigation of different blunt body shape and preferable shape of blunt body that can be utilized for vertex low meter application numerical reenactment of blunt body shape .for example rectangular, roundabout and equilateral rectangular have been complied to comprehend wonder of vertex shedding. Theodore von Karman, a Hungarian-American physicist, was the first to depict the impact where a non-streamlined question (additionally challenged a false front body) set in the way of a quick streaming stream, makes the liquid then again isolate from the protest on its two downstream sides, and, as the limit layer ends up disengaged and twists back on itself, framing vortices (likewise called whirlpools or vortexes). He likewise noticed that the separation between the vortices was consistent and depended exclusively on the extent of the stone that shaped it. In favor of the blunt body where the vortex is being shaped, the liquid speed is higher and the pressure is lower. As the vortex moves downstream, it develops in quality and estimate, and in the long run confines or sheds itself. This is trailed by a vortex's being framed on the opposite side of the blunt body. The substituting vortices are dispersed at measure up to separations.

Keywords: Splitter Plate, Drag Coefficient, Reynolds Number, Vertex Flow Meter and Buff Body

I. INTRODUCTION

The vortex flow meter is a device that works on the principle of vortices shedding behind a blunt body sink in a flow. Vortex flow meter plays an important role for flow rate measurements of liquid and gas. These devices provide high precision, accuracy, low maintenance required and there measurement is independent on material properties and Reynolds number.

The flow over different shape of bluff body such as circular, rectangular and square cylinder having different flow properties. Frequency of vortexes are shed depend on the size and shape of body.

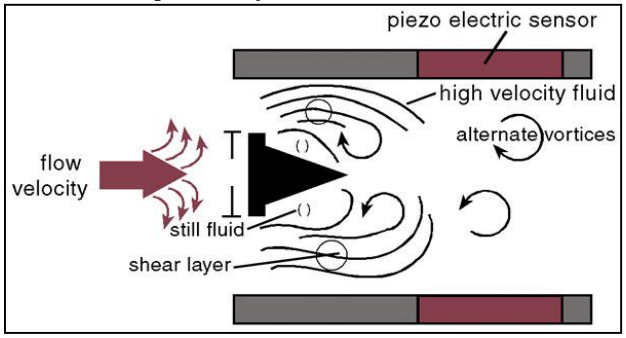

Fig. 1: Diagram of Vortex Flow meter

II. METHODOLOGY

In vortex flow meter different types of blunt body with attached splitter plate is used to analyzed vortex shedding frequency in CFD simulation by using ANSYS 15.

A. Material

Fluid – water, Density – 998.2 kg/m^3 and Viscosity – 0.001003 kg/m-s

B. Boundary Condition

Inlet velocity – 0.1256m/s, 0.2512m/s and 0.3768m/s, Turbulent intensity (%) – 5,Turbulent viscosity ratio – 10,Initial gauge pressure – 3 bar, Pressure at outlet – 1 bar, Back flow turbulent intensity (%) – 5,Back flow turbulent viscosity ratio – 10

C. Solution method

Pressure-velocity coupling, Scheme – SIMPLE, Spatial Discretization, Gradient – least square cell based, Pressure – second order, Momentum – second order upwind Turbulent kinetic energy – first order upwind, Turbulent dissipation rate – first order upwind
Transient order input – second order implicit

III. RESULT AND DISCUSSION

In this chapter we deal with analysis of three different bluff bodies shape with attached splitter plate. And detail of geometry dimension and analysis is performed of flow around Circular, Rectangular and Quadrilateral triangle with attached splitter plate Pre-processing, Setup process boundary condition, Residual convergence, Grid independence test Post-processor. Different meshing cross sections may comprise of tetrahedral, cells.
Geometry

Different shape	Dimensions in mm	Splitter plate dimension in mm
Circular with attached splitter plate	D = 10, r = 5	L = 10, b = 2
Triangular with attached splitter plate	L = 15, θ = 60	L = 10, b = 2
Rectangular with attached splitter plate	L = 15, b = 10	L = 10, b = 2

Table 1: Dimension on different bluff body

A. Meshing of Geometry

Meshing giant and complicated Geometries with ANSYS Fluent. With ANSYS 15.0, Fluent Meshing is even a lot of powerful and usable. Unstructured grid generation program that may handle meshes of nearly unlimited size and quality.
Domain size 100*40

Physics Preference	CFD
Solver Preference	Fluent
Mesh Method	Triangle Method

In mesh sizing using advanced size function proximity and curvature and relevance centre is fine initial size seed active assembly smoothing high, span angle centre fine, minimum size 1.5723e-002 mm, maximum face size 1.57230 mm, maximum size 3.14460 mm. Inflation first layer thickness, first layer height 0.002, maximum layer 20 ,

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growth rate 1.2 inflation algorithm pre and in edge sizing method taken different element sizing like 0.2, 0.5, 1.2 etc and every element size having a different number of node & element using the global coordinate system mesh morphing is disable element midsize node.

1) Circular with Attached Splitter Plate

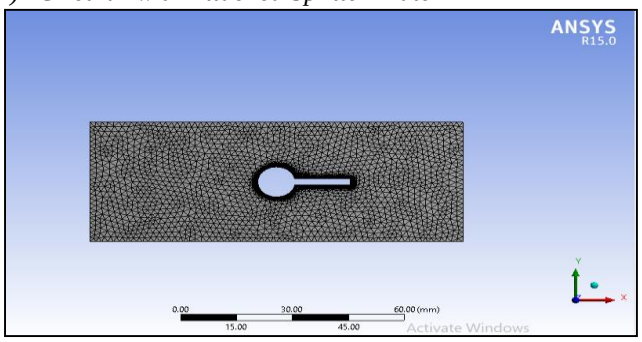

Fig. 2: Computation mesh for circular cylinder with attached splitter plate

Element Size	Number of Node	Number of Element
0.5	5327	9984
1	3378	6330
1.5	2877	5408
2	2665	5024
2.5	2490	4702
3	2405	4548
3.5	2337	4416
4	2202	4158
4.5	2168	4094
5	2135	4040

Table 2: Number of element and node for circular cylinder

a) Element Quality

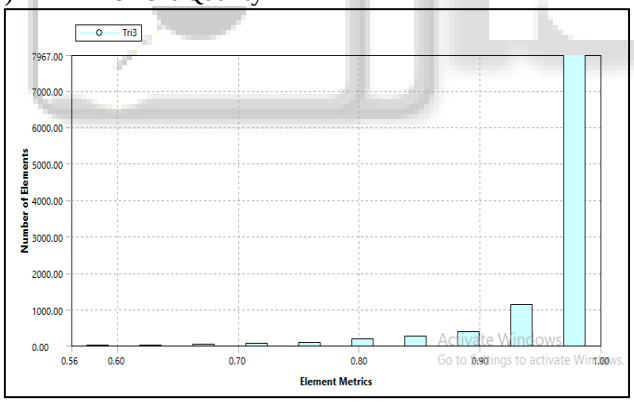

Fig. 3: Element quality

Nodes	5327
Elements	9984
Mesh Metric	Element Quality
Min	0.561443495750536
Max	0.999990350125102

b) Orthogonal Quality:

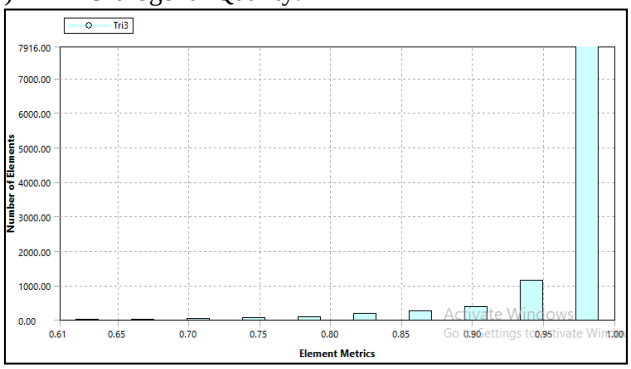

Fig. 4: orthogonal quality

2) Triangular with Attached Splitter Plate

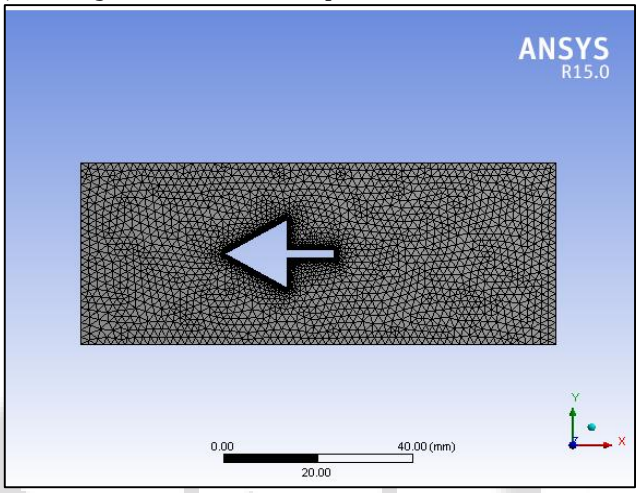

Fig. 5: Computation mesh for triangular cylinder with attached splitter plate

Element Size	Number of Node	Number of Element
0.5	5428	10158
1	3506	6570
1.5	2939	5516
2	2695	5072
2.5	2531	4776
3	2411	4544
3.5	2336	4410
4	2301	4366
4.5	2207	4160
5	2186	4134

Table 3: Number of element and node for triangular cylinder

a) Aspect ratio:

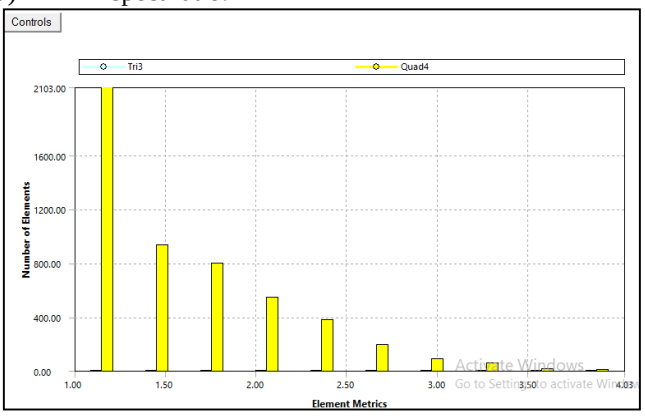

Fig. 6: Aspect ratio

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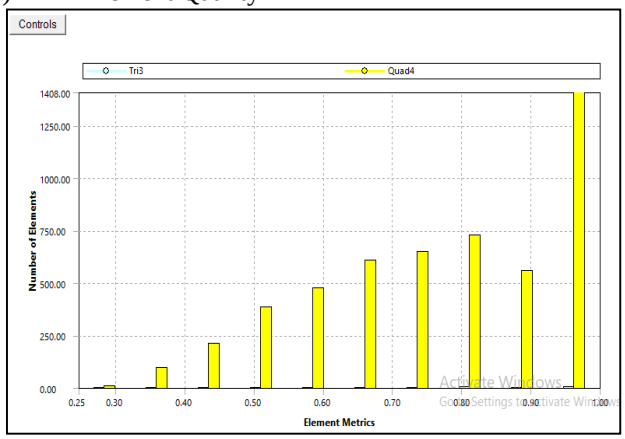
b) Element Quality



Nodes	5469
Elements	5126
Mesh Metric	Element Quality
Min	0.246537135199243
Max	0.999454095245785
Average	0.772274572780589
Standard Deviation	0.179264572857296

Fig. 8: Element quality

3) Rectangular with Attached Splitter Plate

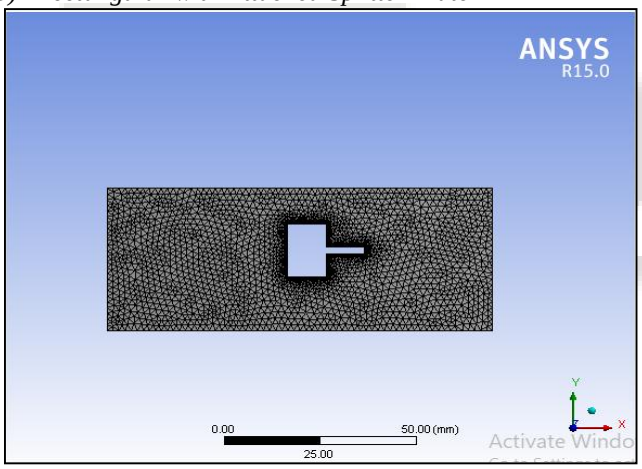
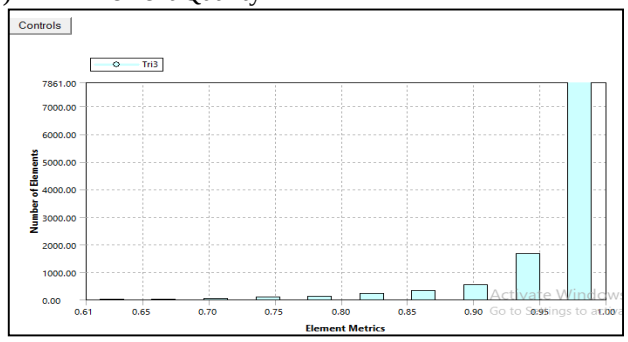


Fig. 9: Computation mesh for rectangular cylinder with attached splitter plate

Element Size	Number of Node	Number of Element
0.5	6944	12974
1	4101	7652
1.5	3274	6114
2	3007	5640
2.5	2800	5266
3	2641	4968
3.5	2581	4872
4	2367	4448
4.5	2334	4390
5	2241	4216

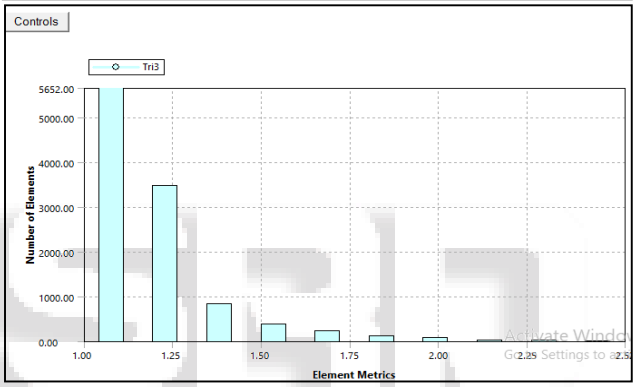
Table 4: Number of element and node for rectangular cylinder

a) Element Quality



b) Aspect ratio

Nodes	5758
Elements	10778
Mesh Metric	Aspect Ratio
Min	1.0017
Max	2.5235
Average	1.19649510113194
Standard Deviation	0.178109138842666



4) Effect of Drag and Pressure Coefficient

When the length of splitter plate 20mm in circular bluff body drag coefficient will be 0.4699999972104 and by increases splitter plate length 50mm Cd will be 0.46999995312 and plate length 75mm then Cd will be 0.47475588 and 100mm length Cd 0.47475610401, 125mm length Cd 0.00015465766. Pressure coefficient at inlet and outlet of cylinder -0.4 & 0.5.

a) Contour of velocity magnitude Re = 5000

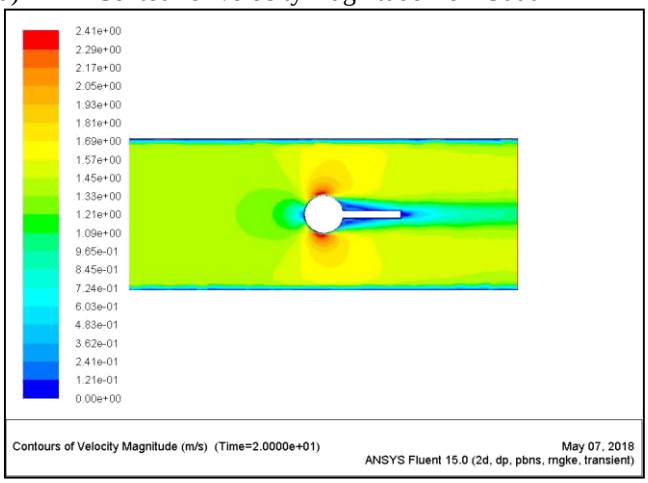


Fig. 13: Velocity contour of Re = 5000

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b) Contour of velocity magnitude Re = 10000

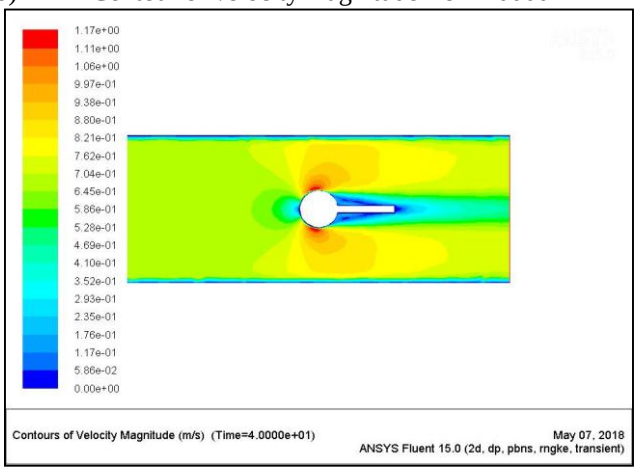

Fig. 14: Velocity contour of Re = 10000

c) Contour of velocity magnitude Re = 15000

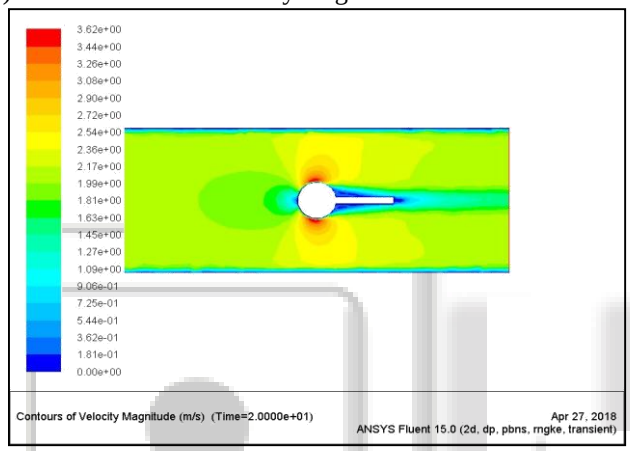

Fig. 15: Velocity contour of Re = 15000

5) Analysis of Rectangular Cylinder with Attached Splitter Plate

a) Effect of drags and Pressure Coefficient

The drag coefficient with related to different Reynolds number & where drag and pressure loss depend on dimension of bluff body with attached splitter plate and also value of drag coefficient is differ for different bluff body. In rectangular bluff body with attached splitter plate length 20mm drag coefficient will be 1.15000000001 and splitter plate length 50mm Cd 1.14999 and plate length 75mm then Cd 1.14, plate length 100mm then Cd 1.533, plate length 125mm then Cd 0.75028075369. Pressure coefficient at inlet and outlet of cylinder -0.5 & 0.05.

6) Pressure Coefficient at Different Position

a) Contour of Velocity Magnitude Re = 5000

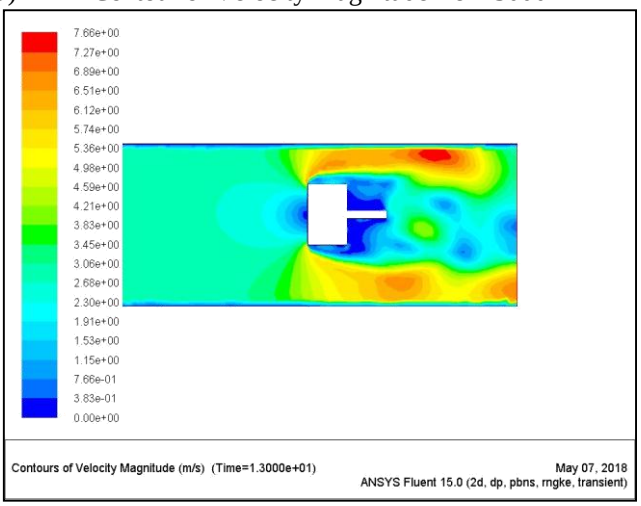

Fig. 16: Velocity contour of Re = 5000

b) Contour of velocity magnitude Re = 10000

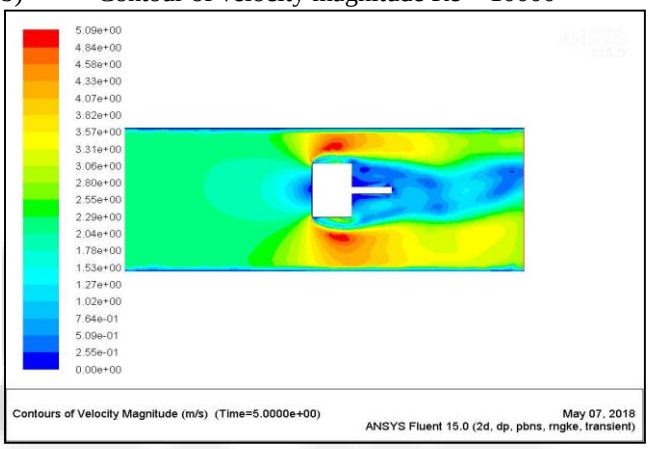

Fig. 17: Velocity contour of Re = 10000

c) Contour of velocity magnitude Re = 15000

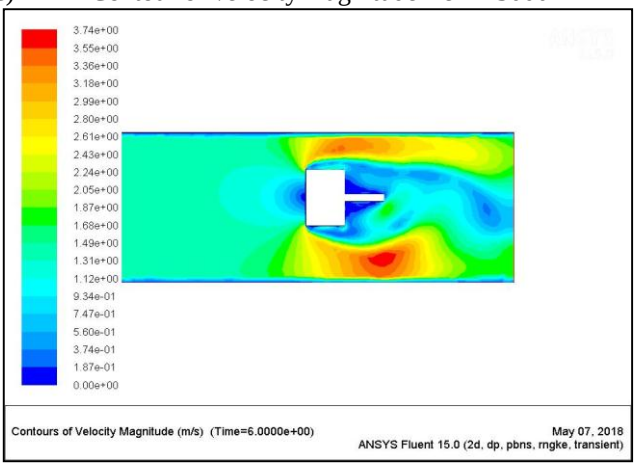

Fig. 18: Velocity contour of Re = 15000

7) Analysis of Triangular Cylinder with Attached Splitter Plate

a) Effect of drags and pressure coefficient

In triangular bluff body with attached splitter plate length 20mm drag coefficient will be 4.0 and plate length 30mm then Cd 0.5, plate length 40mm then Cd 0.5, plate length 50mm then Cd 5.004. Pressure coefficient at inlet and outlet of cylinder of -0.4 & 0.06.

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8) Pressure Coefficient at Different Position

a) Contour of velocity magnitude Re = 5000

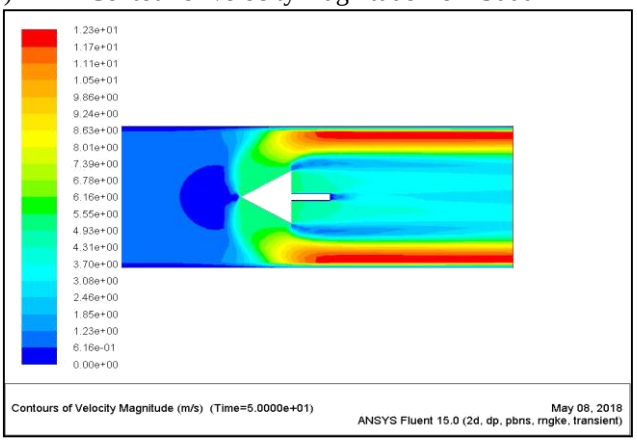

Fig. 19: Velocity contour of Re 5000

b) Contour of velocity magnitude Re = 10000

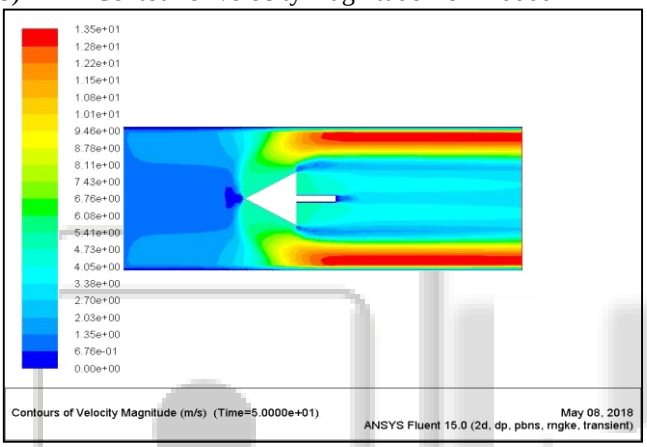

Fig. 20: Velocity contour of Re = 10000

c) Contour of velocity magnitude Re = 15000

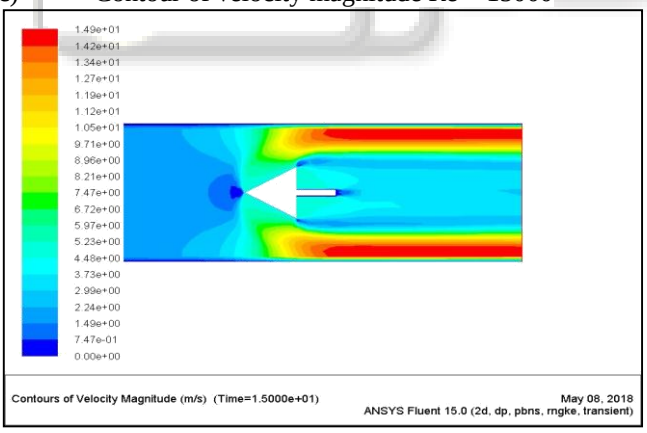

Fig. 21: Velocity contour of Re = 15000

Authors	Nature of study	Re	Cd
Li and Humphrey (1995)	Numerical (2D)	500	1.98
Shankar (1999)	Numerical (3D)	400	1.67
Saha (2003)	Numerical (2D)	500	2.14
Dutta (2007)	Experimental	420	2.03

Table 5: Comparison of time - Average drag coefficient on stable square cylinder with past published result

IV. CONCLUSION

It is found that triangular shape gives a low coefficient of pressure loss of value 0.06 and the low coefficient of drag coefficient is rectangular shapes relate to 0.05. By including splitter plate behind the blunt body, it can decrease drag force and pressure loss. A triangular with splitter plate give a most high level of loss pressure and drag force with 29% from 0.00191 to 0.000061 for loss pressure and 1.746 to 1.2515 for drag drive.

V. FUTURE SCOPE

In a present work there is a limited scope in a computational fluid dynamic mostly use in a analysis and study of approximate solution not give the accurate result some error are occur in analysis of geometry problem. And in my topic shape optimization of splitter plate in vortex flow meter the most of research is done on analysis is works on experimentally and on this topic CFD analysis in limited.

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