EFFECT OF CURVATURE ON BLUNT BODIES

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ABSTRACT

Effect of curvature on blunt body is presented in this paper. Blunt bodies of elliptical and circular curvature having same hydraulic mean dia. are taken to study. Comparison is done with rectangular geometry having same hydraulic mean dia. at different Reynolds numbers of 100,200,300,400&500. Elliptical blunt body show significant effect at Reynolds 500. Circular blunt show significant effect at Reynolds number 400.

Keywords: Elliptical Blunt, Circular Blunt, Reynolds Number, Vortex Size, Contours.

I. INTRODUCTION

Solution of the viscous flow over a bluff body has been a challenging problem for a number of years. Such flows are of great interest because they display fundamental fluid dynamic phenomena such as separation of a boundary layer, the evolution of the shear layer, its growth and eventually the formation of vortices that are shed in the wake. These are the key features that characterize the flow over a bluff body. Many structures such as tall buildings, bridges, off-shore pipelines and risers may be considered as bluff bodies and the complex flow over them is of great interest. Also, some streamlined structures may behave as a bluff body at some operating conditions, such as an airplane wing at high angles of attack. A circular cylinder and a sphereare the representative bluff bodies of two and three dimensions, respectively. For inviscid flow, there is no friction to cause boundary layer separation, vortices or a subsequent wake. However, inviscid flow over a cylinder will generate areas of different pressure gradients. There are two stagnation points in which one is on the middle of the cylinder in the fluid flow direction and one behind the cylinder. At these points, C_p will be one. Since the cylinder is a symmetric body, there will be symmetric pressure regions around the body. In the direction perpendicular to the fluid flow, a suction force exists. In this inviscid scenario, aerodynamic forces will not show any effect due symmetry. The non-uniformity of the approach flow was found numerically to have significant influences on the aerodynamic forces acting on the bluff bodies as well as vortex shedding behavior. A cylinder in a linearly varying flow was studied [1-3]. It was found in their numerical study that the time-averaged lift force varied proportional to a shear parameter. Experimental investigations were also conducted on circular cylinders in linear shear flow, such as the works [4, 5]. Based on the results of the researchers, the effects of shear flow on bluff bodies are considerably different from that of uniform flow.

In the present work study the curvature effect on blunt bodies. Two dimensional computational model has taken to study having curvature of semi circle and elliptical. And it compared with rectangular blunt body. Flow analysis done at very low Reynolds number regions. Comparison made as the Reynolds number increase how models behaving, and at the same Reynolds number curvature influence on models.

II.COMPUTATIONAL METHODOLOGIES

Computational analysis is carried out to solve a flow field in two-dimensional blunt bodies of different models to analyze flow characteristics, and the effect of curvature on the recirculation of the separated flow. Fig. 2.1 shows the different models of varying curvature. The modeling and analysis is done in Ansys 14.0 Workbench for creating the desired geometries. Pure quadrilateral meshing is used to get structured mesh.

Standard $k-\varepsilon$ model is used to predict the flow field Flow past the step involves recirculation (swirl) and the effect of swirl on turbulence is included in the Standard model, due to which accuracy of the model further increases. A UN steady state based implicit solver is used to achieve convergence. Second-order upwind scheme was used for the discretization of all the equations to achieve higher accuracy in results. Velocity-pressure coupling is established by pressure-velocity correlation using a PISO algorithm. Under-relaxation factors are used for all equation to satisfy Scarborough condition. Residuals are continuously monitored for continuity, *x*-velocity, *y*-velocity, *z*-velocity, *k*, and *ε*. Convergence of the solution is assumed when the values of all residuals goes below 10^{-6} Enhanced wall treatment is used to solve for the near wall treatment, as *y*+ is more than 30 in the whole domain.

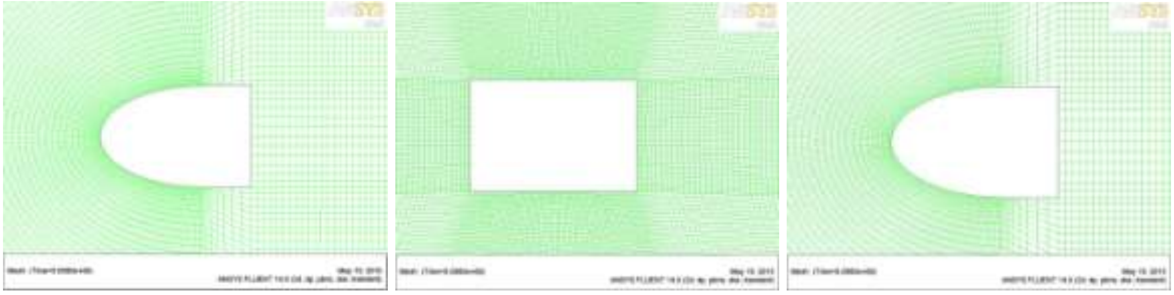


Fig 2.1 Circular Blunt, Rectangles Blunt, Elliptical Blunt

III. RESULT AND DISCUSSION

3.1 Flow Over Circular Blunt Body

Figure 3.1.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 100. Figure 3.1.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 200. Figure 3.1.3 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 300. Figure 3.1.4 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 400. Figure 3.1.5 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 500.

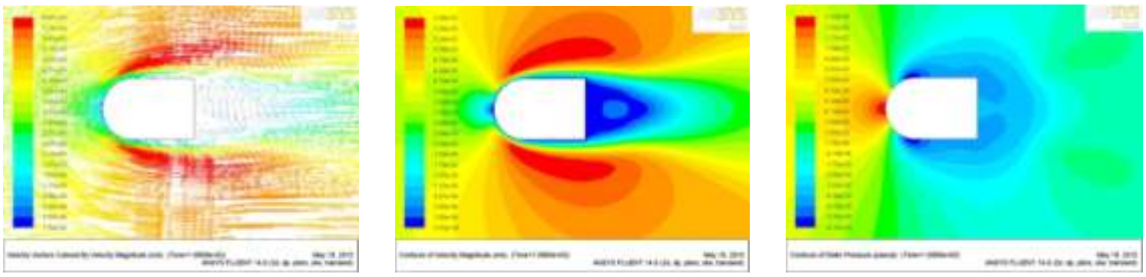
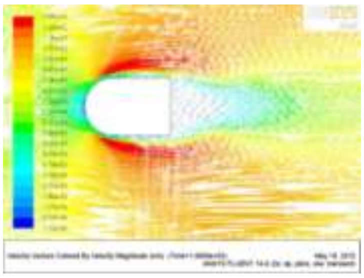


Fig 3.1.1(a) Velocity vectors Fig 3.1.1(b) Velocity contours Fig 3.1.1(c) Pressure contour



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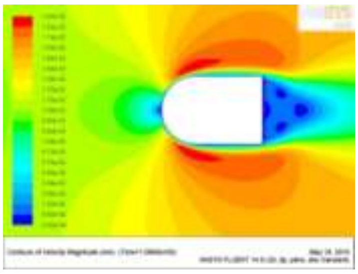

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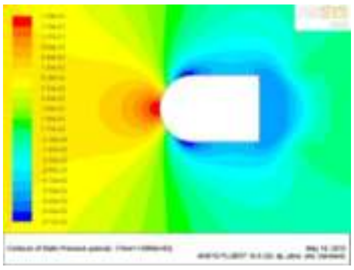

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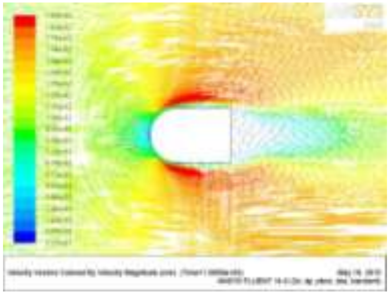

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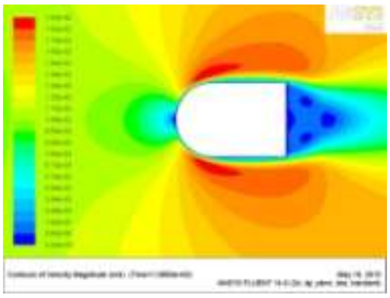

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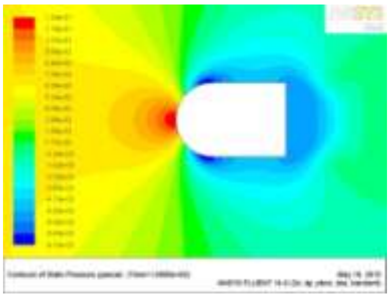

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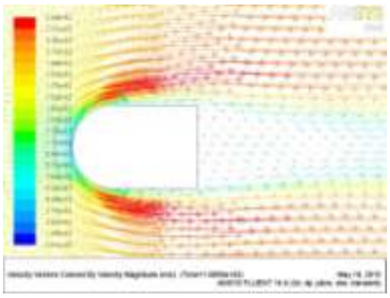

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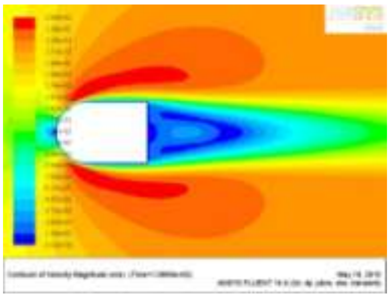

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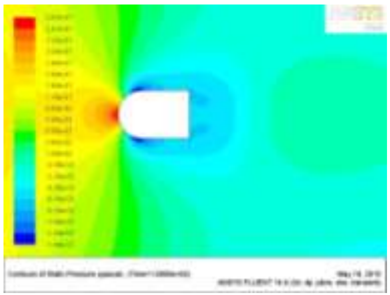

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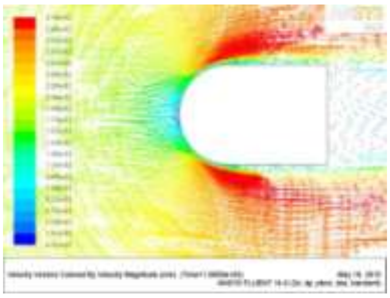

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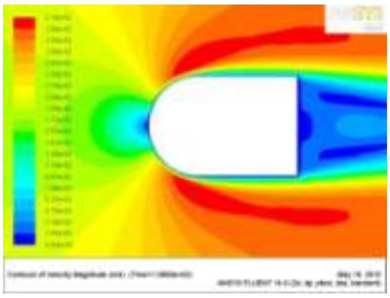

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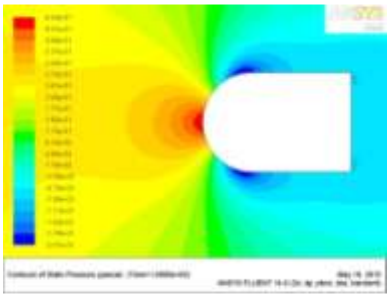


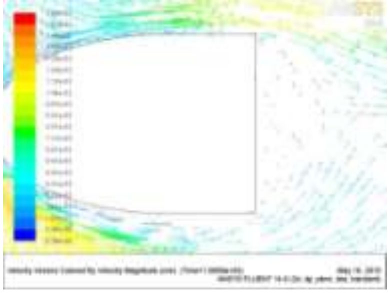
Fig 3.1.5(c) Pressure contour

As the Reynolds number increase from 100 to 500 the circular blunt shows significant variations in vortex size. Up to 300 Reynolds number vortex size decreases then after sudden incremental at Reynolds number 400 then after rapid decreases. At all Reynolds number except 400 right vortex size is more compared to left vortex size. And at Reynolds number 400 left and right vortexes are nearly equal. The region formed around the circular blunt show significant effect when Reynolds number increases. At Reynolds number 500 high velocity region surround to the circular blunt is more compared to all other Reynolds number.

3.2 Flow over Elliptical Blunt Body

Figure 3.2.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 100. Figure 3.2.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 200. Figure 3.2.3 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 300. Figure 3.2.4 (a, b,

&c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 400. Figure 3.2.5 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 500.



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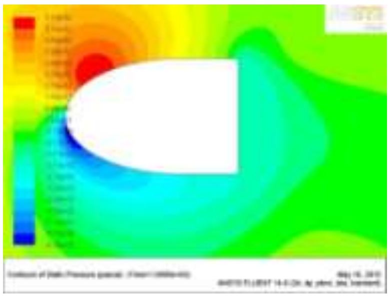

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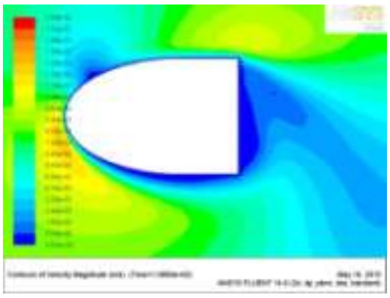

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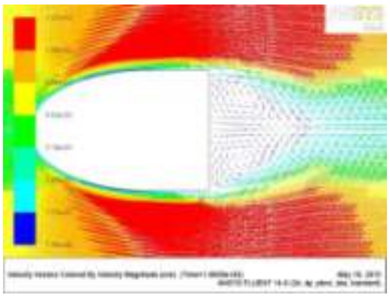

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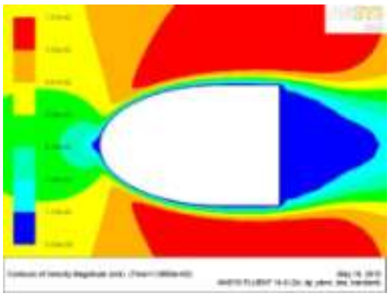

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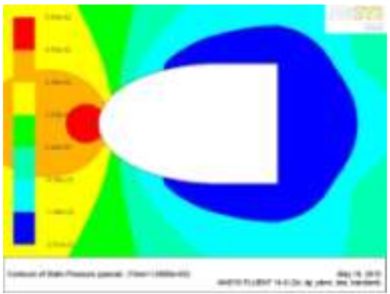

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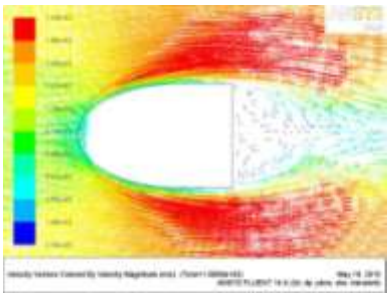

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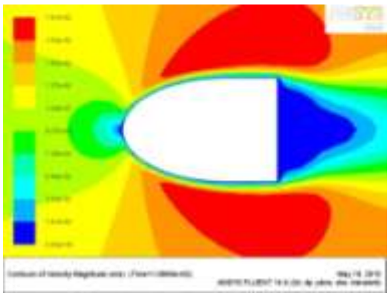

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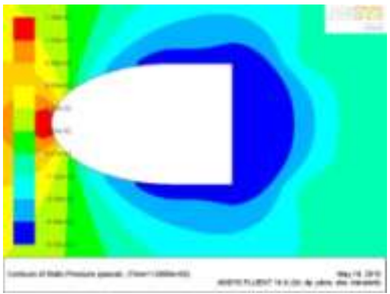

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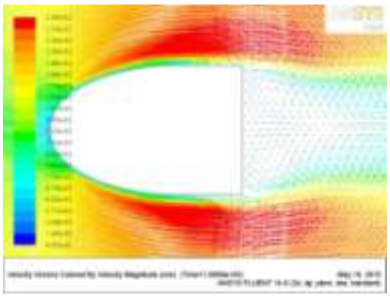

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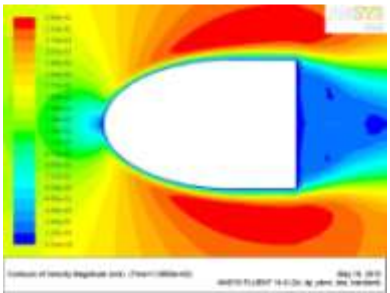

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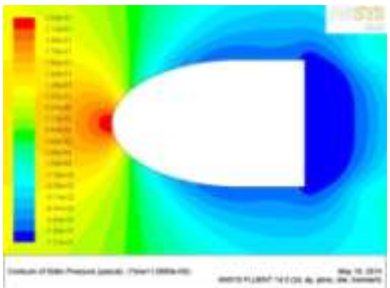

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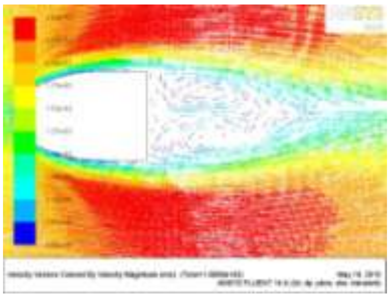

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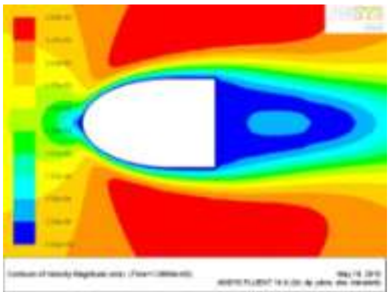

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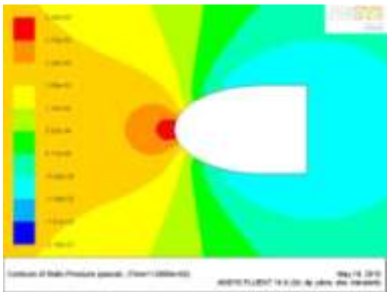
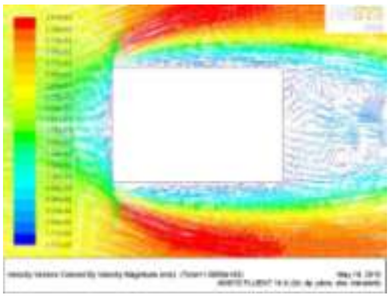


Fig 3.2.5(c) Pressure contour

As the Reynolds number increase from 100 to 500 the elliptical blunt shows significant variations in vortex size. As the Reynolds number increase vortex size decreases up to Reynolds number 400 then after sudden increment in vortex size. At all Reynolds number except 500 left and right vortexes are equal in size. At Reynolds number 500 right vortex size is more compared to left vortex size. The region formed around the elliptical blunt show significant effect when Reynolds number increases. As the Reynolds number increases high velocity region surround to the elliptical blunt is increases.

3.3 Flow over Rectangular Blunt Body

Figure 3.3.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 100. Figure 3.3.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 200. Figure 3.3.3 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 300. Figure 3.3.4 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 400. Figure 3.3.5 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 500.



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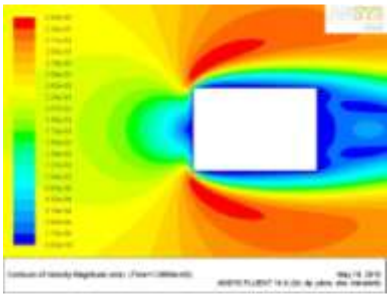

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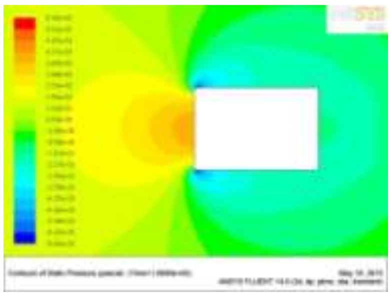
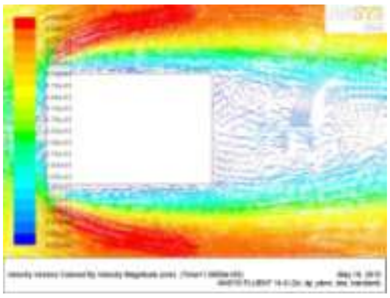


Fig 3.3.1(c) Pressure contour



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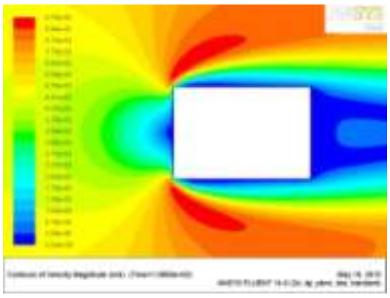

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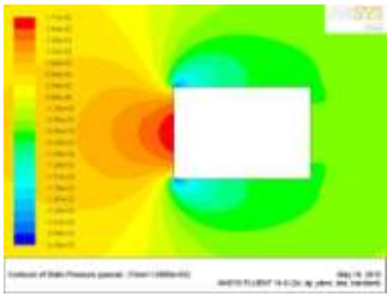

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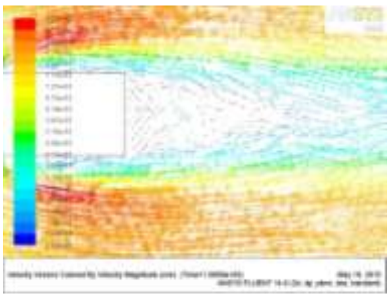

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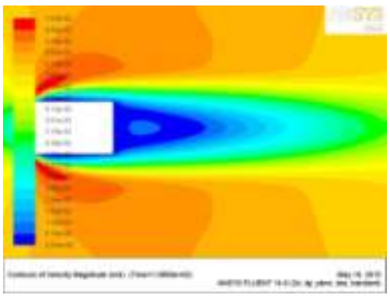

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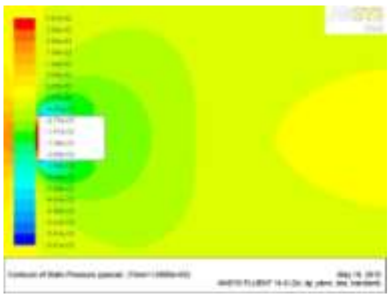

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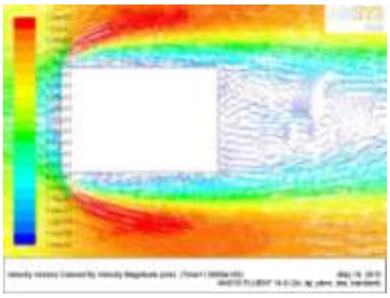

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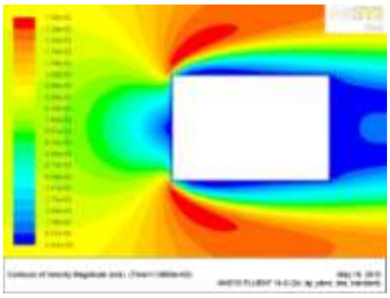

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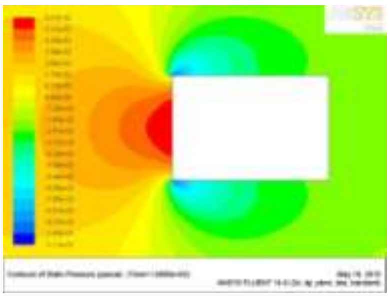

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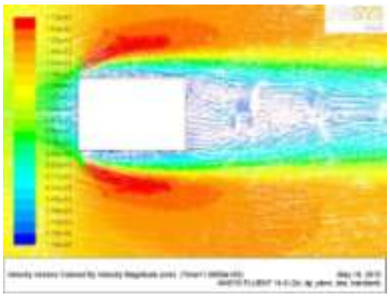

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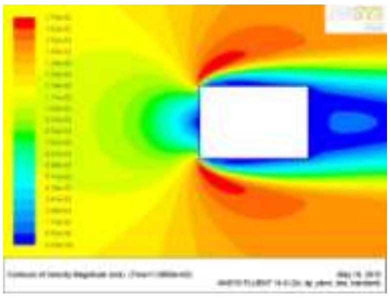

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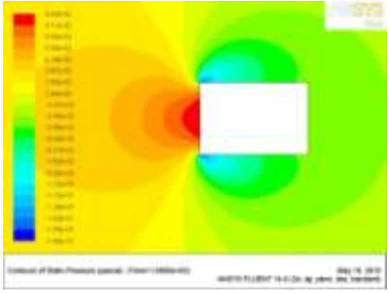

Fig 3.3.5 (c) Pressure contour

As the Reynolds number increase from 100 to 500 the Rectangular blunt shows significant variations in vortex size. As the Reynolds number increase vortex size decreases up to Reynolds number 200 then after sudden increment in vortex size at Reynolds number 300. Then after vortex size decreases. At all Reynolds number except 100 left and right vortexes are equal in size. At Reynolds number 100 right vortex size is more compared to left vortex size. The region formed around the elliptical blunt show no significant effect when Reynolds number increases.

IV CONCLUSION

Comparison has to done on different models at same Reynolds number and Flow analysis on a specific model as increasing Reynolds number.

4.1 Flow analysis at Different Reynolds Number

At Reynolds numbers 100, 200,400 and 500 circular blunt body and elliptical blunt body shows significant effect in vortex size. There is no significant effect of varying curvature at Reynolds number 300. Except Reynolds number 500 circular blunt has high vortex size compared to elliptical blunt. In all the cases rectangular blunt has more vortex size due to corner effect.

4.2 Flow Analysis of Different Blunt Models

As the Reynolds number increases flow over different models shows different effects. For elliptical blunt body sudden increase and decrease vortex size is observed. And it has high vortex size at Reynolds number 500.

For circular blunt body decrease of vortex size observed up to Reynolds number 300, then sudden increment and decrement observed. It has high vortex size at Reynolds number 400.

For Rectangular body a decrease of vortex size at Reynolds number 200, then after incremental in vortex size and it has high vortex size compared to all other models.

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