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EFFECT OF SPLITTER EDGE BEHIND DIFFERENT GEOMETRIES ON THE FLOW

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ABSTRACT

Analysis of flow over different geometries having splitter edge at Reynolds numbers of 600 and 900 presented in this paper. Splitter edge effect on flow is compared with flow over same geometries without splitter edge at same Reynolds number. Geometries of triangle square and rectangle of equivalent area is taken to study and triangular model having splitter edge show significant effect at Re 600 & 900.

***Keywords*: Splitter Edge, Reynoldsnumber, Vortex, Triangular Model, Square Model**

I. INTRODUCTION

In many mechanical engineering applications, separated flows often appear around any object. Tall buildings, monuments, and towers are permanently exposed to wind. Similarly, piers, bridge pillars, and legs of offshore platforms are continuously subjected to the load produced by maritime or fluvial streams [1]. The flow details behind these geometries depend on Reynolds number, blockage ratio, and free stream turbulence. For square/rectangular cross section geometries, the orientation with respect to the mean flow is another important parameter. At low Reynolds number, aspect ratio and end conditions play a significant role in determining the flow properties. Flow past a square cylinder resembles flow past a circular cylinder as far as instabilities are concerned. But the separation mechanism and the consequent dependence of lift, drag, and Strouhal number on the Reynolds number are significantly different. The separation points are fixed for the square cylinder either at the leading edge or the trailing edge, depending on the Reynolds number. Square cylinder has broader and longer vortex compared to the circular. Wake of square cylinder cross section is sensitivity to aspect ratio and orientation with respect to the mean flow.The effect of cylinder orientation 0, 10, 13.5, 20, and 45°at high Reynolds number. A reduction in drag coefficient and a sharp rise in Strouhal number was seen at an angle close to 13.5°. This effect was attributed to the shear layer reattachment over one of the edges of the cylinder [2]. Significant variation on Strouhal number of rectangular cylinders with side ratios in the range of 0.04–1 and angles of incidence from 0 to 90°. A sharp rise in Strouhal number for a small angle of incidence is significant.[3]The effect of aspect ratio for a circular cylinder at low Reynolds number using flow visualization and hotwire anemometry. For an aspect ratio greater than 60, a discontinuity in the Strouhal number value in the Reynolds number range 64 to 130 studied. There is a stabilization effect on the wake for a small aspect ratio cylinder. The wake width increases with a reduction in aspect ratio [4]. The effect of end plates on the shedding frequency of circular cylinders in the intermediate range of Reynolds numbers 300–5,000. Near the end plate, the shedding frequency is lower than that at midspan. The end effect faded away with the increase in Reynolds number [5].The Strouhal number Reynolds number relationship at various aspect ratios and end conditions. The discontinuity in the relationship was attributed to the oblique shedding angle and transition in discrete shedding modes [6].

The effect of aspect ratio 0.25–12 and end plates for flow past a circular cylinder at high Reynolds number 8000 to 140000. With appropriate end plates they showed that wake flow is two dimensional. A splitter plate in the wake show how flow feature was linkedto a shear layer instability [7].This instability has been studied almost exclusively for low Reynolds numberfor rectangular cylinders.Turbelent vortex shedding for a rectangular cylinder of a k-ε modelright shedding frequency results are fall in the range of experimental results. Present work analyzing the flow over different geometries having splitter edge at end.

II.COMPUTATIONAL FLUID DYNAMICS

Computational analysis is carried out to solve a flow field in two-dimensional geometries of triangle, square and rectangle of equivalent area. And adding splitter edge at end of these geometries, analyzing the flow behavior by considering parameters of recirculation of the separated flow, vortex size and regions formed at behind the model. 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$k$-ε model is used to predict the flow field Flow past the models 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.

III.RESULT AND DISCUSSION

3.1 Flow Over a Rectangular Body

Figures 3.1.1 (a, b, &c) show the velocity vectors, contours of velocity and pressure at Reynolds no. 600. Figures 3.1.2(a, b, &c) show the velocity vectors, contours of velocity and pressure at Reynolds no 900.

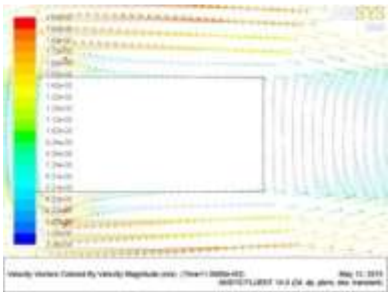


Fig 3.1.1(a) Velocity vectors

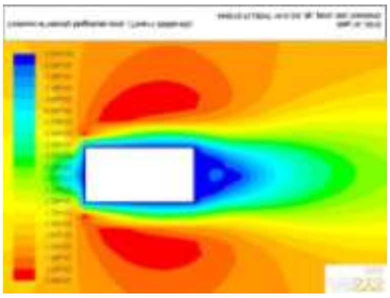


Fig 3.1.1(b) Velocity contours

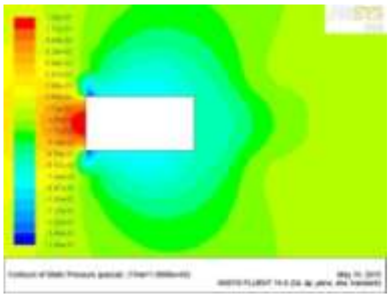


Fig 3.1.1(c) Pressure contour

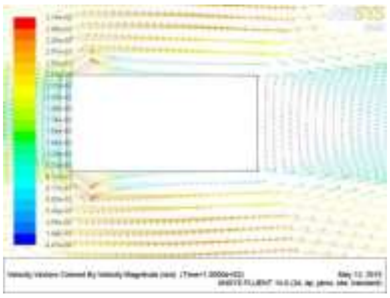
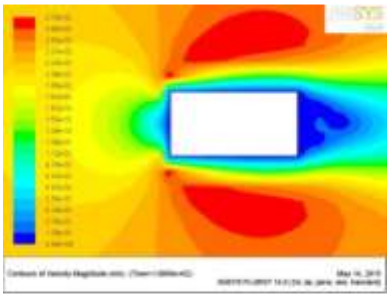
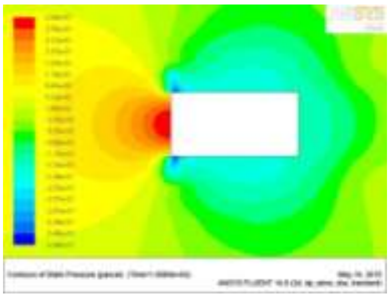




Fig 3.1.2(a) Velocity vectors Fig 3.1.2(b) Velocity contours Fig 3.1.2(c) Pressure contours

There is a significant effect in the increase in the Reynolds number on the flow over rectangular model. The left and right vortex size is 6.11mm and 5.98mm at Reynolds number 600 and 9.50mm and 9.30mm at Reynolds number 900. As increase in Reynolds number vortex size increases. There is no variation in left and right vortex sizes at these Reynolds numbers.

3.2 Flow over a square body

Figure 3.2.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 600. Figure 3.2.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 900.

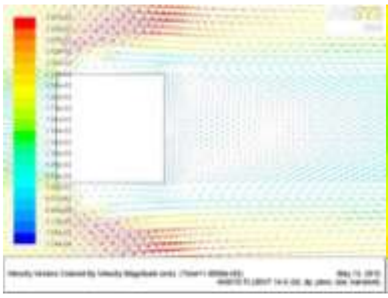
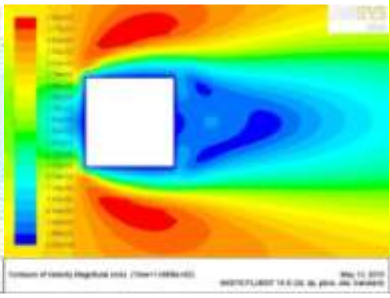
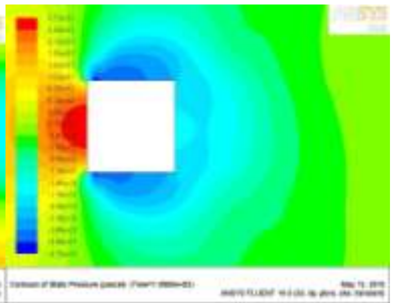




Fig 3.2.1(a) Velocity vectors Fig 3.2.1(b) Velocity contours Fig 3.2.1(c) Pressure contours

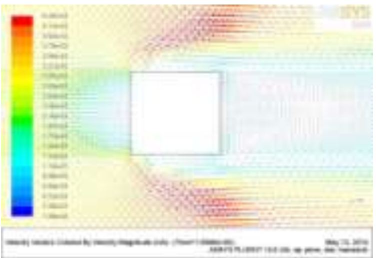
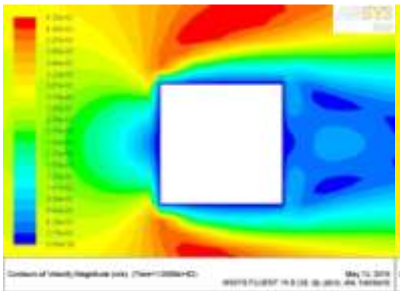
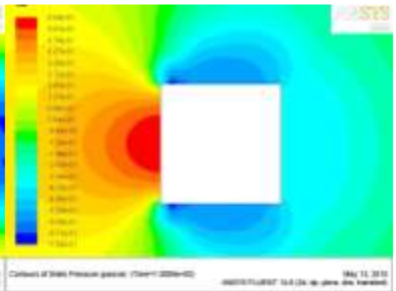
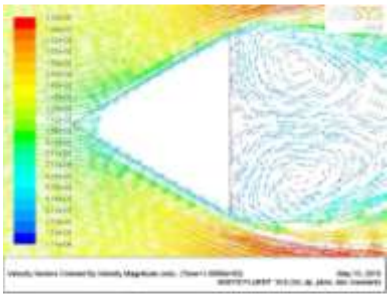
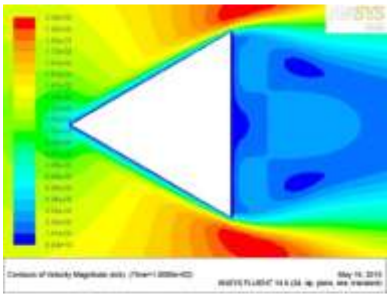
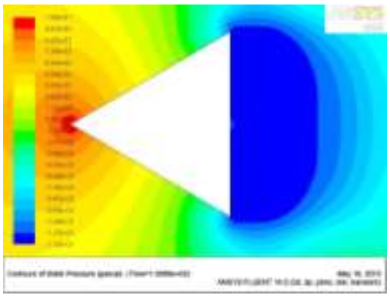




Fig 3.2.2(a) Velocity vectors Fig 3.2.2(b) Velocity contour Fig 3.2.2(c) Pressure contours

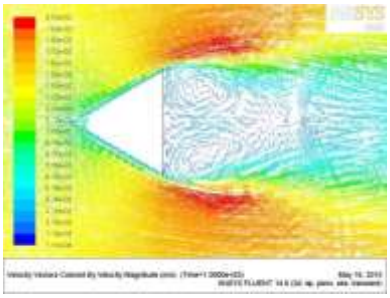
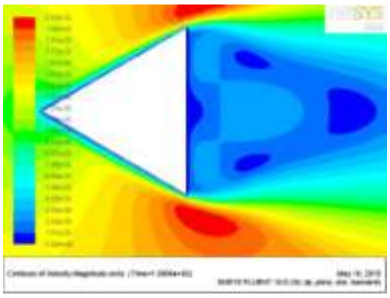
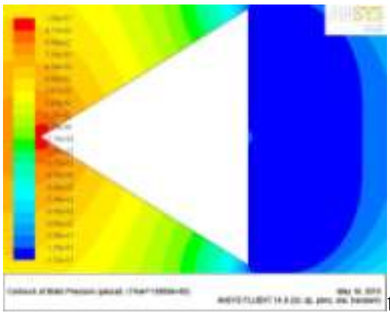
There is a significant effect in the increase in the Reynolds number on the flow over square model. The left and right vortex size is 8.54mm and 7.97mm at Reynolds number 600 and 14.901mm and 13.68mm at Reynolds number 900. As increase in Reynolds number vortex size increases drastically. The left vortex size is more compared to the right vortex size at these two Reynolds number.

3.3 Flow Over a Triangular Body

Figure 3.3.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 600. Figure 3.3.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no.900.

3.3.1(a) Velocity vectors **Fig 3.3.1(b) Velocity contour** **Fig 3.3.1(c) Pressure contours**

3.3.2(a) Velocity vectors **Fig 3.3.2(b) Velocity contour** **Fig 3.3.2(c) Pressure contour**

As increase in Reynolds number there is no significant effect on vortex size and regions of contour of velocity profiles. The left and right vortex size is 26.03mm and 27.77mm at Reynolds number 600 and 27.44mm and 27.69mm at Reynolds number 900. The right vortex size is more compared to the left vortex size at these two Reynolds number.

3.4 Flow Over a Square with Splitter Edge Body

Figure 3.4.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 600.

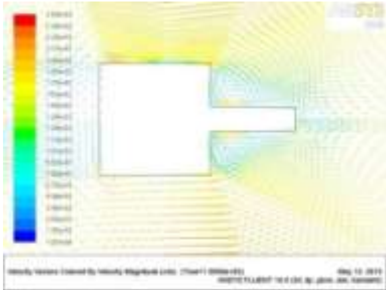
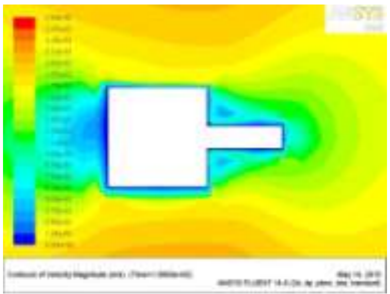
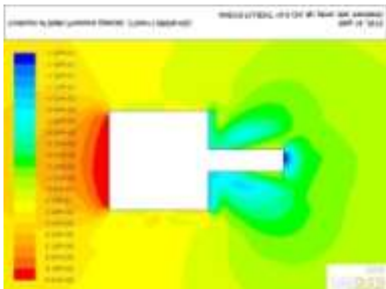




Fig 3.5(a) Velocity vectors **Fig 3.5(b) Velocity contours** **Fig 3.5(c) Pressure contours**

There is no significant effect in the left and right vortex size at Reynolds number 600 on the flow over square model with splitter edge. The left and right vortex size is 5.51mm and 5.88mm at Reynolds number 600.

3.5 Flow Over a Triangle with Splitter Edge Body

Figure 3.5.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 600. Figure 3.5.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 900.

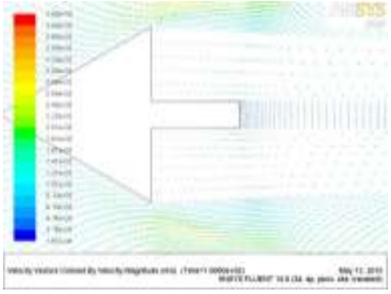


Fig 3.5.1(a) Velocity vectors

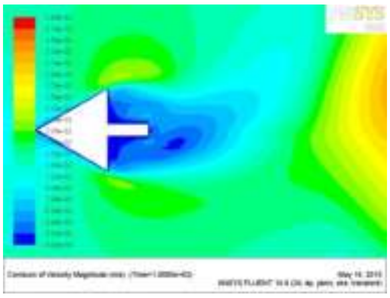


Fig 3.5.1(b) Velocity contours

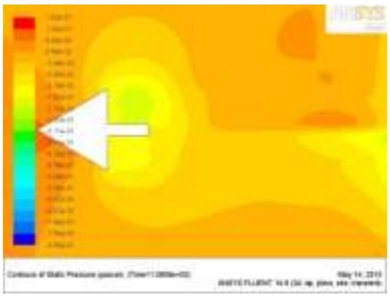


Fig 3.5.1(c) Pressure contours

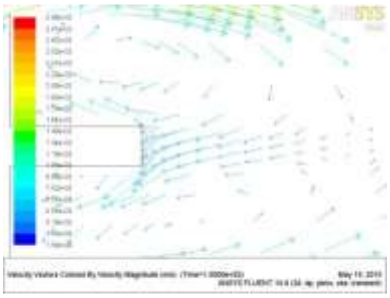


Fig 3.5.2(a) Velocity vectors

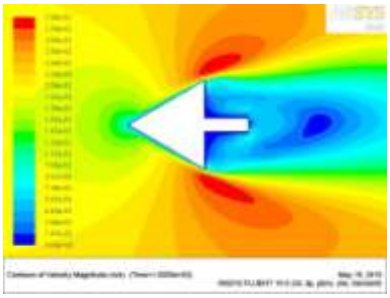


Fig 3.5.2(b) Velocity contours

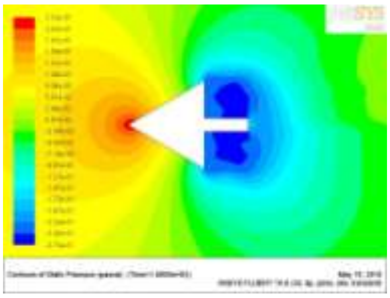


Fig 3.5.2(c) Pressure contours

As increase in Reynolds number there is no significant effect on left vortex size but a significant effect is observed on the right vortex. The left and right vortex size is 28.93mm and 25.48mm at Reynolds number 600 and 25.97mm and 32.80mm at Reynolds number 900. With increase in Reynolds number left and right vortex behaves in an opposite manner.

3.6 Flow Over a Rectangle with Splitter Edge Body

Figure 3.6.1 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no. 600. Figure 3.6.2 (a, b, &c) shows the velocity vectors, contours of velocity and pressure at Reynolds no 900.

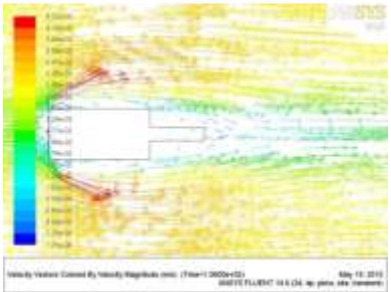


Fig 3.6.1(a) Velocity vectors

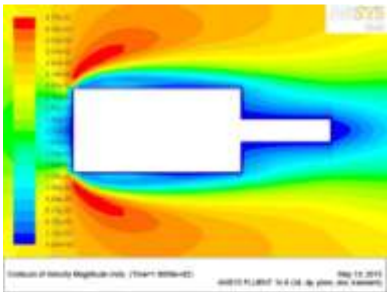


Fig 3.6.1(b) Velocity contours

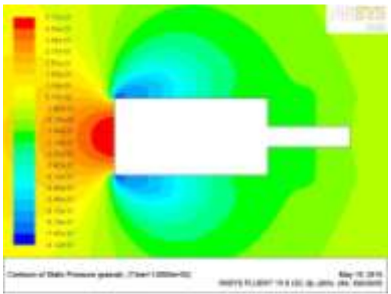


Fig 3.6.1(c) Pressure contours

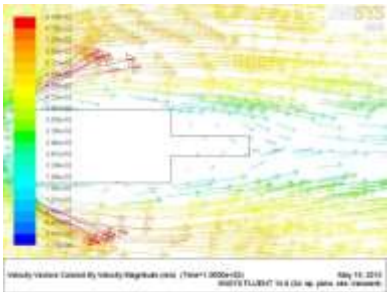


Fig 3.6.2(a) Velocity vectors

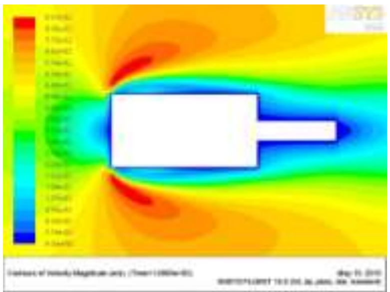


Fig 3.6.2(b) Velocity contours

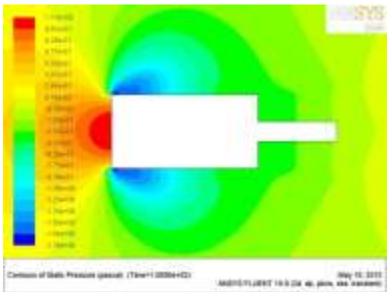


Fig 3.6.2(c) Pressure contours

Due to splitter edge behind the rectangular model, there is no large scale vortex formation observed and due to more corners, small vortex are observed because of placing the splitter edge on minor axis.

IV.CONCLUSION

Splitter effect on the different models at two Reynolds numbers is compared with same models without splitter edge. Triangular model shows significant effect when the splitter edge is placed behind it when compared to the square and rectangular models having splitter edge. No effect is shown by the rectangular model having the splitter edge on the minor axis because of small altitude between the corner of the rectangle to the corner of the splitter edge. With increase in Reynolds number, the triangular model having splitter edge shows significant effect in left and right vortex in opposite manner.

REFERENCES

[1] O. Almeida, S. S. Mansur and A. Silveira-Neto "On the flow past rectangular cylinders:physical aspects and numerical simulation"EngenhariaTérmica (Thermal Engineering)June 2008 . 55-64.

[2] Obasaju, E. D. _1983_. "An investigation of the effect of incidence on the flow around a square section cylinder." Aeronaut. Q., 34, 243–259.

[3] Knisely, C. W. _1990_. "Strouhal numbers of rectangular cylinders at incidence: A review and new data." J. Fluids Struct., 4, 371–393.

[4] Lee, T., and Budwig, R. _1991_. "A study of the effect of aspect ratio on vortex shedding behind circular cylinders." Phys. Fluids A, 3_2_, 309–315.

[5] Stäger, R., and Eckelmann, H. _1991_. "The effect of endplates on the shedding frequency of circular cylinders in the irregular range." Phys. Fluids A, 3_9_, 2116–2121.

[6] König, R., Noack, B. R., and Eckelmann, H. _1993_. "Discrete shedding modes in the Von Karman vortex street." Phys. Fluids A, 5_7_, 1846–1848.

[7] Szepessy, S., and Bearman, P. W. _1992_. "Aspect ratio and end plate effects on vortex shedding from a circular cylinder." J. Fluid Mech., 234, 191–217.