EXPERIMENTAL COMPARISON BETWEEN FLOW OVER CYLINDER AND CYLINDER WITH CONE CROSS SECTION

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Abstract - Flow over cylinder is major issue to deal because when flow moves over circular cylinder it involves many complex features like separation, attachment and re-circulation reverse flow and boundary layer thickness. These complex features are responsible for increase the flow losses. In order to minimize such losses the shape of the circular cylinder is modified to circular with cone cross section. And the set of modified objects are placed in different orientation with direction of flow. The present work aim to understand the flow behavior on cylinder with cone cross section and this improved flow can be utilized for power generation purpose like wind turbine blade design.

Keywords - Flow losses, Attachment Point, Reverse flow , Vortex size.

I. INTRODUCTION

When flow takes place over a cylinder forms many complex features like separation, attachment re-circulation, reverse flow and vortex. Mainly at the rear portion that is flow after passing the center line of the cylinder tries to attach again but this attachment is possibly occur far away from the cylinder after attachment, flow come back towards the cylinder which forms reverse flow. These reverse flows joins with free stream flow and go to downstream which creates pockets of eddies known as vortex, this is responsible for the drag force on the cylinder. In order to reduce this drag force, cone cross section is added to rear portion of the circular cylinder so that, flow after passing through the center line of the cylinder takes smooth curve as the cone geometry is decreased gradually and attached at the end of the model, forms no reverse flow and vortex which is very much desirable for any power generation systems like wind turbine blade design. Hence cylinder with cone cross section gives more interesting point to deal with. For further improvement of power thrust with reduced loss, multiple objects are used in series and parallel connection. When objects are placed in series the effective area for power thrust may be less but recirculation zone size is reduced tremendously, the scenario is revers when objects are placed parallel to each other that is the effective area is increased to two times but vortex zone size also increased. This is happened because of presence two attachment point, two reverse flows and two re-circulated regions. But the relative increment in power output is quite larger than the relative increment in vortex formation, hence objects are placed parallel to each other is the best suitable for power generation.

II. LITERATURE REVIEW

Ashokachary et al. [1] Conducted experiments to know the flow pattern on cylinders which are in series and parallel to the direction flow. He observed that flow over cylinder when they are arranged in parallel connection has given the maximum effective area with reduced losses. Takahiro et al. [2] Experimentally investigated The flow characteristics on a truncated cone with a cylinder at Reynolds number 3.8×10^5 and Schlieren photography measurement techniques is used. He was found that the distance of the external shock wave from the conical surface depends on the truncation ratio. Sudarsana Reddy et al. [3] Numerically examined the impact of Brownian motion and thermophoresis on heat and mass transfer flow over a horizontal circular cylinder and identified that with increase in velocity temperature profile changed to great extent.WeiHuang et al. [4] Identified the design requirements for hypersonic vehicles for the reduction of drag and aerodynamic heating. An aero disk is attached to the tip of the rod to reduce the drag. The influences of the length of rod and the diameter of aero disk on the drag reduction mechanism are analyzed. And concluded that The dynamic pressure in the recirculation area is highly reduced and thus leads to the decrease in drag on the surface of the blunt body. Lee et al. [5] The flow characteristics of a long-cone cyclone with twice as long a conical section as that of the Stairmand cyclone were analyzed numerically to see the effect of the cylinder shape on the flow. the interface shape is in turn strongly affected by the distance from the bottom of the inlet to the cylinder-cone junction. Aljure et al. [6] Performed the DNS simulations on the flow around a circular cylinder at Re=5000 were. Observed the three dimensional behavior in the wake and two instability mechanisms are found to coexist in the near wake. Namit et al.[7] Studied the flow around triangular prism with effect of apex angle and PIV, hotwire and flow visualization are used to characterize the flow field. Observed that A linear relationship between vortex shedding frequency and apex angle is found. Shuyang et al.[8] investigated the flow over a circular cylinder in oscillatory flows

with zero-mean and non-zero-mean velocities. And identified that unsteady flow pattern around a circular cylinder depends strongly on both Keulegan–Carpenter number and amplitude ratio number, in addition to Reynolds number.

III. RESULTS AND DISCUSSION

Case (I):Flow over Cylindrical Object with and WithoutCone Cross Section.

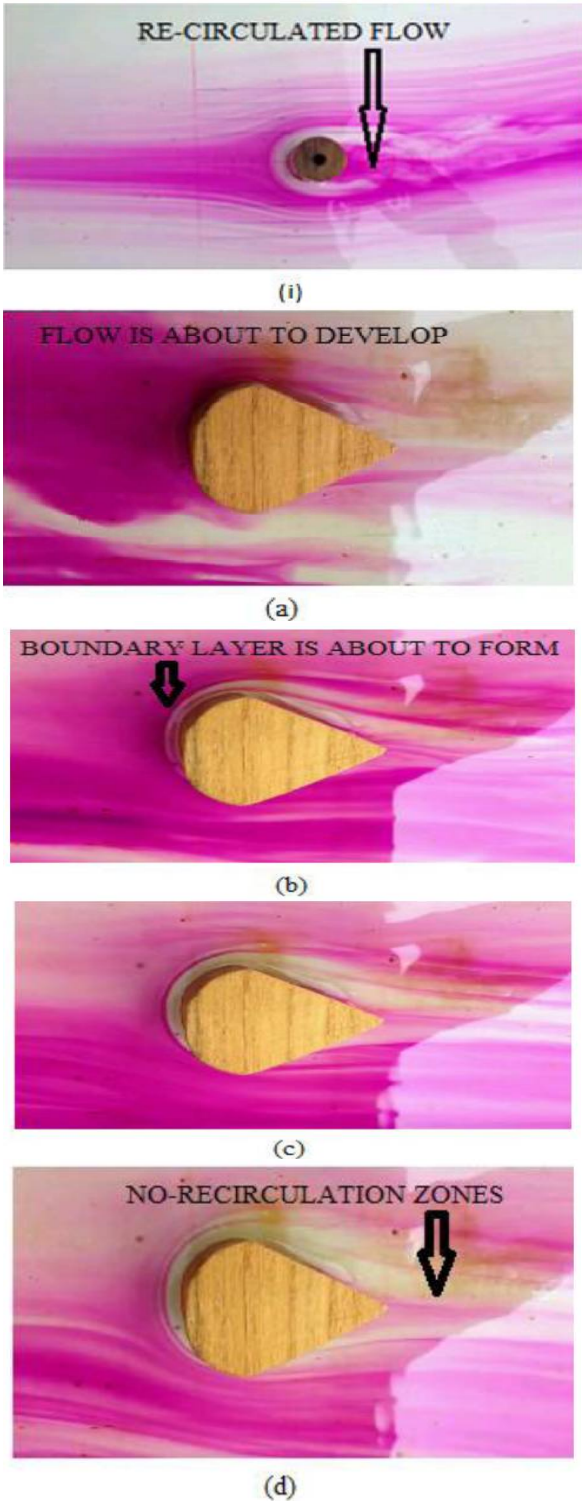
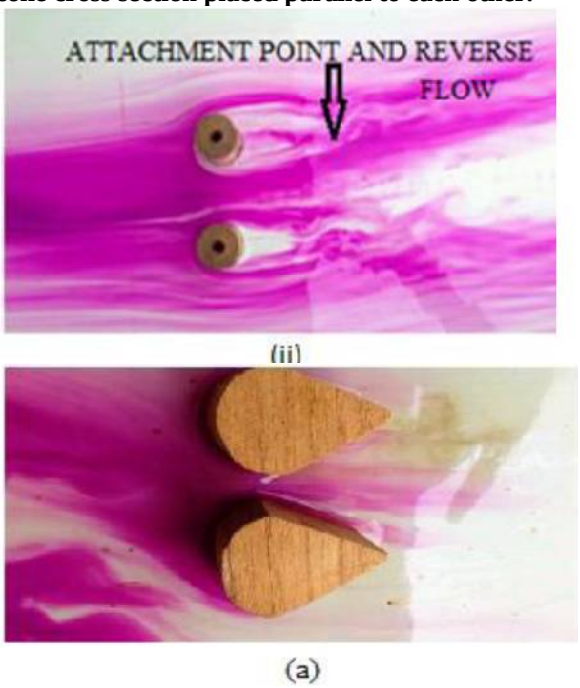


Fig1. Flow over Cylindrical Object with and Without Cone Cross Section.

Fig (i) represents the flow over a cylinder, where the cylinder acts as a stumbling block obstructing the fluid flow. The main objective of this experiment is to experience a broad range of flow measurement technology that is available in aero-dynamics and ocean engineering. Flow past a circular gets many complex features like separation, attachment, reverse flow, vortex and boundary layer. As seen in above figure, fluid initially obstructs the cylinder and diverge its path, which again gets attached at a distance of 4 cms away from the cylinder. Here, the fluid past the cylinder before getting rejoin, the fluid tries to reverse flow back to the cylinder which we call as recirculated flow, thereby this re-circulated flow is rejoins with free stream flow and go to downstream. The formation of vortex due to the recirculated flow tries to decrease the fluid velocity across the boundary layer which may result in various losses. In order to reduce the losses and remove the conditions for the formation of recirculation zone, we conducted experiments by modifying the cylindrical object to cone cross section on the rear end. As we know that the fluid that flows over an object possess various complex features like separation, attachment, reverse flow, vortex and formation of boundary layer, while conducting experiments on a cylindrical object with cone cross section we observed that the fluid which initially got obstructed by the object tried to diverge its path, there by resulted to form a boundary layer around it. Later we found that the fluid past the sharp edge gets attached at a distance of 3 cms and never recirculate back to the cone edge as there is no mean to show low pressure due to the sharp edge. It can be clearly seen in fig (d) that there is no formation of recirculation zone.

Case (ii): Flow over two cylindrical objects with cone cross section placed parallel to each other.



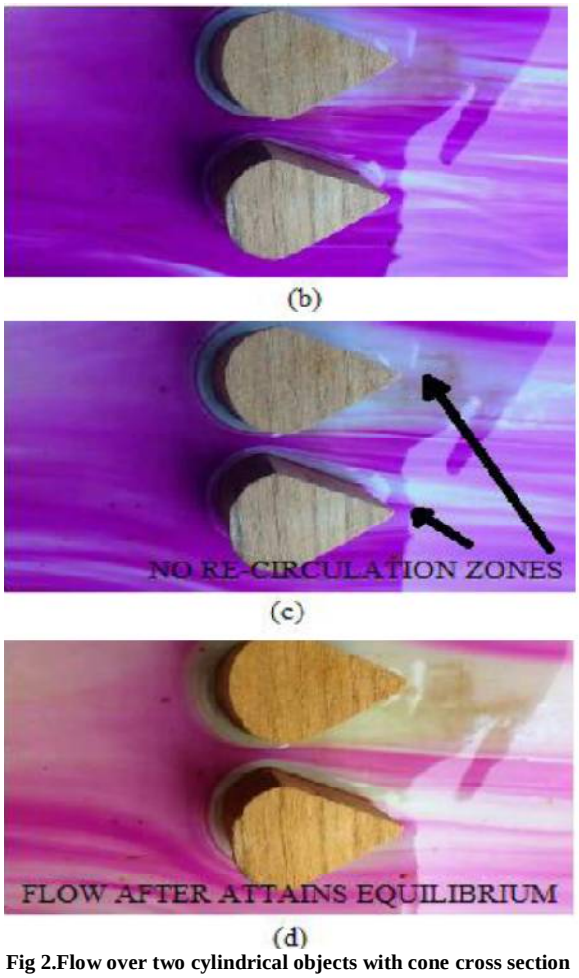


Fig 2.Flow over two cylindrical objects with cone cross section placed parallel to each other.

Fig (ii) shows the flow of fluid over two cylinders which are placed parallel to each other in the direction of flow. As seen above, in early stages flow gets obstructed by the two circular cylinders and gets diverged, thereby forming a boundary layer over them. Once the boundary layer is formed, flow tries to move over the boundary region where the two diverged flows gets compressed and moves between the center of two cylinders causing two attachment points in the downstream. Due to low pressure at each cylinder, eddies are created, resulting in the formation of two re-circulation zones.The effect on stream lines is up to 1.5cm from each cylinder towards another cylinder because the effect of presence of one cylinder exists over the other. Fig (a), (b), (c), (d) shows the flow over two cylindrical objects with cone cross section parallel to the flow direction. From fig (b) it can be seen that the developed flow slowly forms the boundary layer over the cylinders with cross section. As seen in fig (i), in the case of circular cylinders the flow over the boundary layer gets attached and recirculates back to the rare end of cylinders forming vortex and recirculation zones. But from the current experiment on cylinders with cone cross section, since there is a leading edge at the tip of cone, the flow over the boundary layer gets attached but never recirculates. Thus it confirms that the formation of recirculation zones and vortex zones (as seen in fig (c) and (d)) are nullified there by increasing the efficiency.

Case (iii): Flow over two cylindrical objects with cone cross section placed in series.

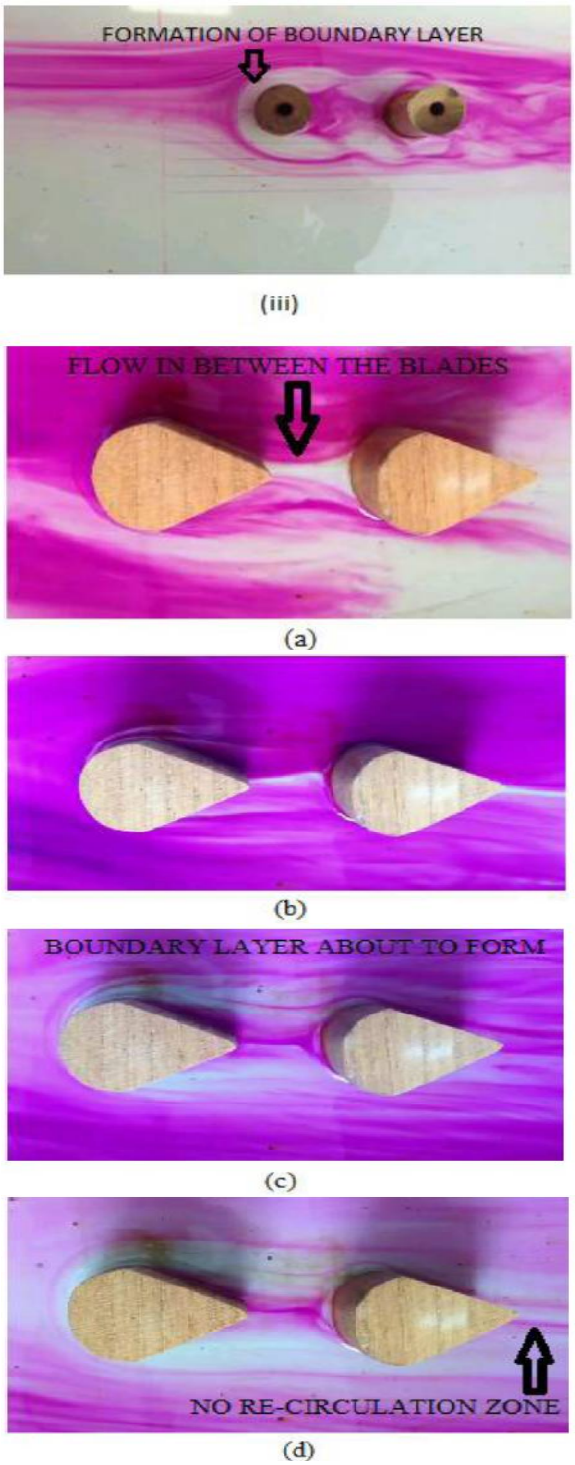


Fig 3.Flow over two cylindrical objects with cone cross section placed in series.

The flow over twin cylinders, which are arranged in series, is as shown Fig.3. Once the flow gets developed , it starts showing same complex features

as seen in fig (i) and (ii). The flow initially gets halted by the two cylinders and thereby forms a boundary layer over the each of it. Due to the presence of two cylinders arranged in series, this makes the flow diverge over the first cylinder and gets attached at the second cylinder, then the flow diverges over the second cylinder and attaches at 4 cm from the second cylinder in the downstream.Due to low psressures at each cylinder, the flow moves back in negative direction and creates eddies, resulting in the formation of recirculation zones at both cylinders, resulting in the formation of vortex at both cylinders as shown in the Fig. (iii).with a view to remove such complex features which reduces the efficiency, we again conducted experiments on the cylinders with cone cross section which are placed in series and the whole setup parallel to the direction of flow. Here, as like in previous cases the flow gets halted by the first cylinder and moves over the other. Once the flow gets stabilized, a boundary layer is formed over the each cylinder and the flow again passes over the boundary layer of second cylinder as like in previous case seen in fig (iii). But, Due to the presence of a sharp edge at the rear end of each cone, there is no way to form low pressure, where the fluid never reverse flow and never form recirculation and vortex zones.

CONCLUSION

Flow over cylinder is the emerging topic because it involves many practical applications in that aspect improved flow pattern will results in improved performance of power generation systems. So for this purpose we studied different orientation of present model with the direction of flow. Flow over cylinder with cone cross section gives improved flow pattern and that to when this models are placed parallel to each other with the direction of flow giving best results because both the models are exposed to fluid flow hence maximum amount of surface of the models are effective to extract thrust from the fluid with reduced losses.

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