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"NUMERICAL STUDY OF UNSTEADY FLOW OVER DIFFERENT BLUFF BODIES"

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ABSTRACT

A wide range of scientific disciplines have used an unstable viscous flow around a bluff mass. The wakes of various cross-sectional bluff bodies, including cylinders with circular, square, triangular, and rectangular cross sections, are discussed in this work. Reynolds number and cylinder geometry, for example, are two of the most important characteristics that taken into consideration that can substantially change the wake. Dependence on the two Strouhal parameters Investigated are the vortices that form in the aftermath of bluff bodies in terms of quantity, vorticity, circulation, and efflux angle. The wake characteristics for various bluff-body forms at various Reynolds are determined and compiled.

Keyword: *Strouhal number, vorticity, circulation, square prism , cylindrical geometry*.

I. INTRODUCTION

When a fluid flows around a stationary body, there is a relative velocity between the body and fluid. These flows are referred as flow over immersed bodies. Depending on overall shape of the immersed body, it is said to be streamlined body or bluff body. In a streamlined body, streamlines in the flow conforms to the boundaries of the body. However, a bluff body tends to block the flow and subdivides it by separation at or near leading edges. Bluff bodies are used to enhance unsteadiness, mixing in the flow and heat transfer. The flow of fluid over bluff body finds wide engineering applications e.g. in electronics cooling, heat exchangers, nuclear reactors, design of flow dividers, probes and sensorsetc.

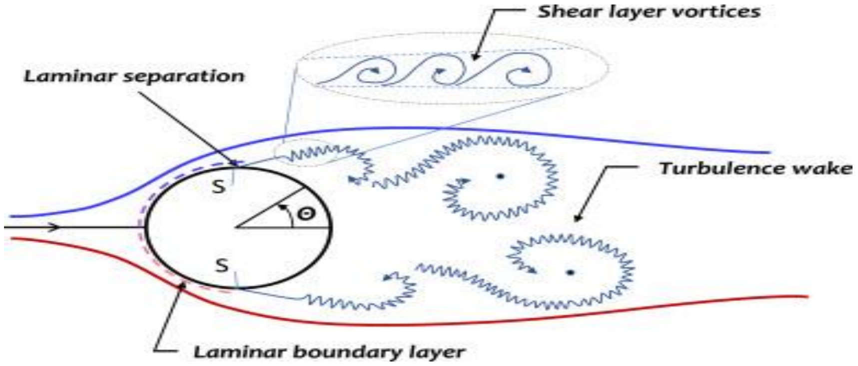

Fig. 1. Flow features behind the bluff body (Borgoltz et al., 2020).

Fundamental aspects related to the fluid flow and heat transfer around bluff-bodies are discussed below.

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1.1 Flow past bluff-bodies

When a fluid separates from a bluff body, it forms a separated region behind the body called wake. In all bluff body flows, there is the periodic formation and shedding of circulating flow structures (vortices) in the wake region and is referred to as vortex shedding. Vortex shedding generates unsteadiness in the flow and thermal fields that governs fluid flow and heat transfer behavior around bluff bodies. Bluff bodies of different cross sections (e.g. circular, square, elliptical and triangular etc.) have been studied by the researches.

1.2 Sharp-Edged triangular cylinder

The literature reveals that the most of the studies have been done on circular cross-section cylinder. The significant changes in the flow and thermal field can be obtained with the sharp edged cylinders (e.g., cylinders of square and triangular cross section, etc.).Square cylinder has also received a fair attention in literature due to its importance in flows over Buildings, heated electrical components etc. However, triangular cylinder being a potential vortex generator has literature available. The flow past sharp edged cylinders

issimilar to that of circular cross-section cylinder in terms of flow instabilities, but differs in the separation mechanism. The sharp corners of square and triangular cylinders provide the points of flow separation.

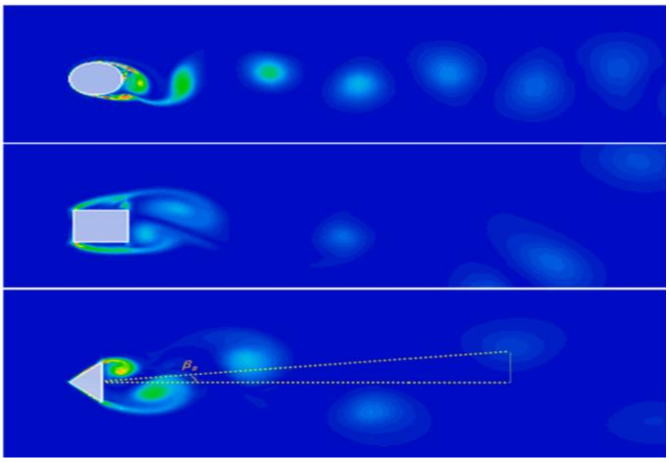

Fig. 2. Instantaneous vorticity contours in the wake of different bluff bodies with identical dimension (D) at Re ¼ 2000; a) circular cylinder, b) square cylinder, and c) triangular cylinder. The angle of βs is the efflux angle of the vortices in the wake of the triangular cylinder.

II. Result

a. Flow over stationary cylinder

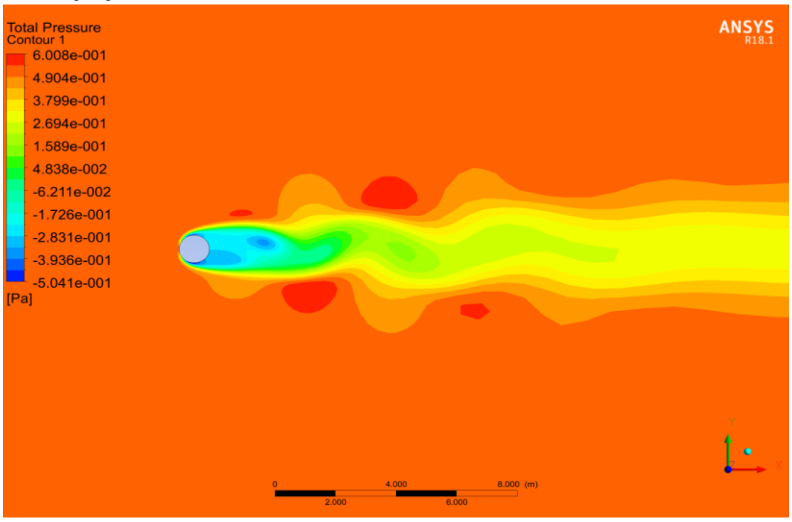

Fig.3 Two dimensional pressure distribution in the wake of stationary circular cylinder for Re = 120.

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The results for flow over stationary circular cylinder show that the pressure distribution along the surface of the bluff body is non-uniform. The pressure in the wake of the body varies along the length due to the effect of the vortex flow in the fluid. The pressure distribution over the wake of the body.. The figure shows that the vorticity and the shear layer affect the pressure across the flow field. The vortex street in the wake is generated due to the interaction of shear layer with opposite vorticity. This causes a non-uniform pressure distribution in the wake of the cylinder. The figure shows that the region behind the cylinder has negative pressure and due to this negative pressure the flow is accumulated in that region.

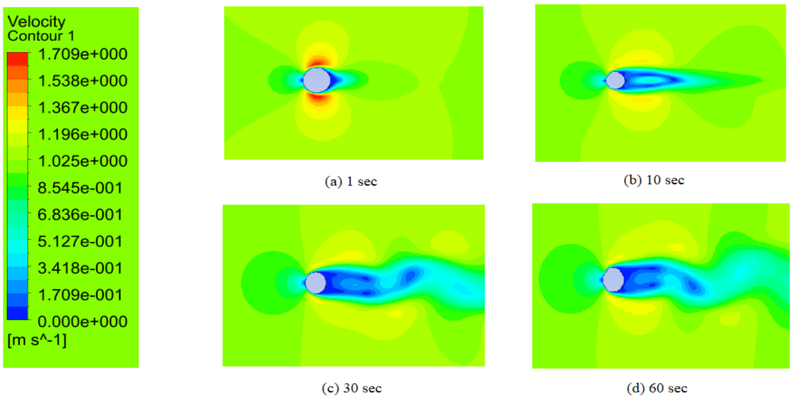

Fig.4. Velocity contour in the wake of stationary circular cylinder

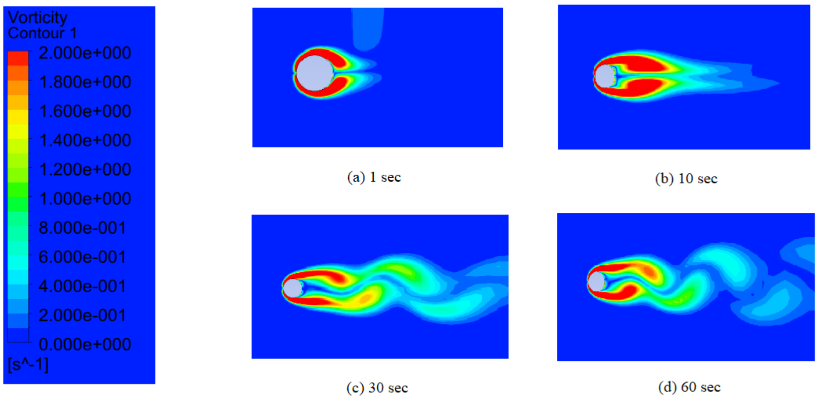

Fig.5 Evolution of the vorticity distribution for the flow past a stationary circular cylinder for Re = 120.

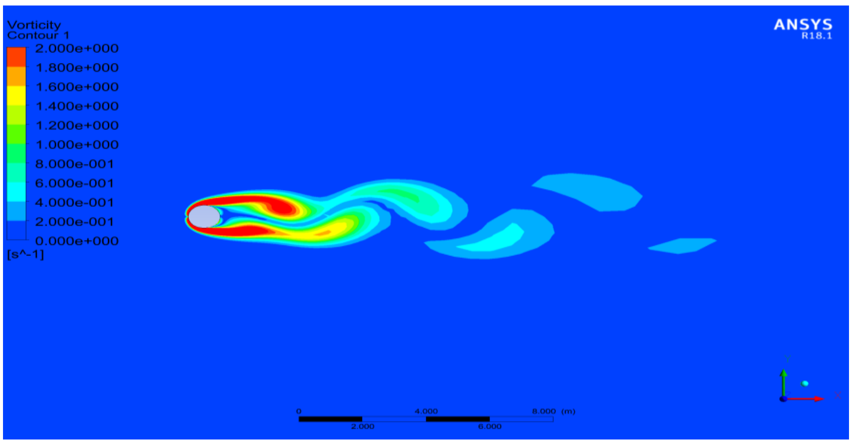

Fig.6. Vorticity distribution for the fully developed flow past stationary circular cylinder.

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to the body by shear layer which supplies circulation to the vortex. The vorticity decreases as the vortex moves away from the wake of the body.

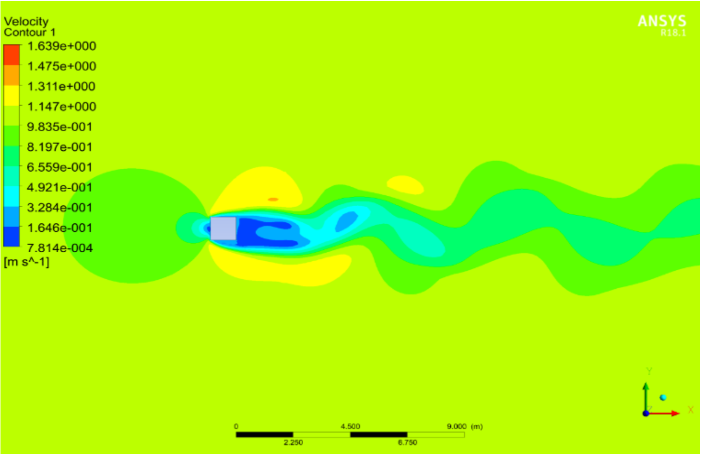

Fig.7 Velocity contour across the flow field for a fully developed flow for oscillating square prism at Re = 120.

The fluid flow in the case of oscillating circular cylinder becomes fully developed when the vortex shedding behind the wake of the cylinder becomes periodic in nature. The velocity distribution for this case when the flow is fully developed is shown in the figure 5.19.

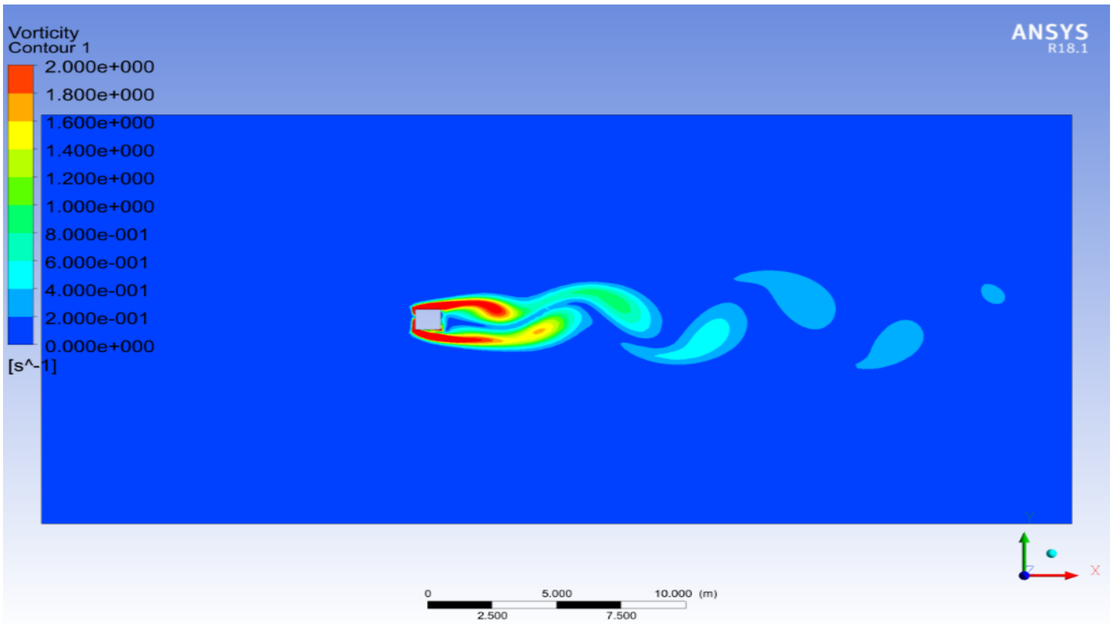

Fig.8 Vorticity distribution for the fully developed flow past oscillating square prism for Re = 120.

III. Conclusion

This paper aims to provide a comprehensive review of the wakes of the bluff bodies, including circular, triangular, square and rectangular cylinders. A wide range of Reynolds number is taken into account, comprising the laminar, subcritical, critical and supercritical flow regimes. At laminar flow regime around a circular cylinder (e.g. 1 < Re < 300), a shift in the absolute value of oblique shedding angle comes into being, particularly at Re ¼ 64–70. Strouhal number is not constant, increasing nonlinearly.

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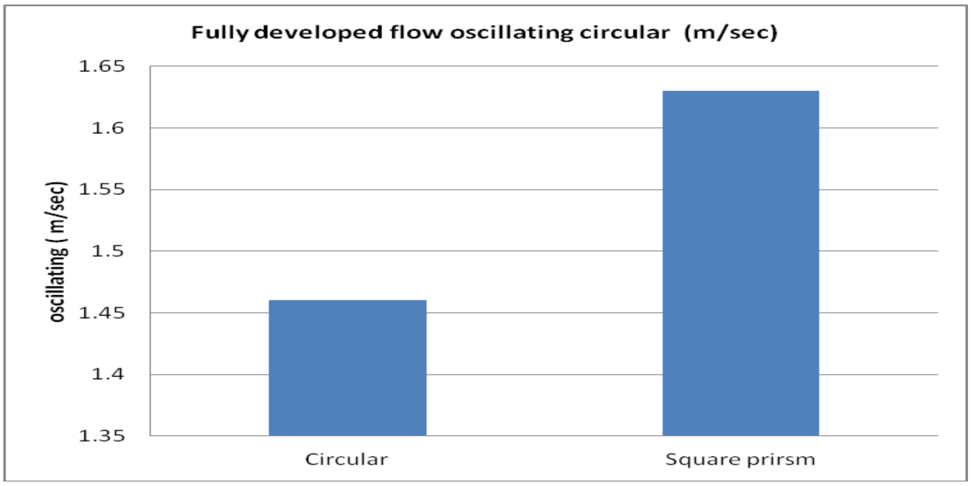

Fig.9 Fully developed flow oscillating circular (m/sec)

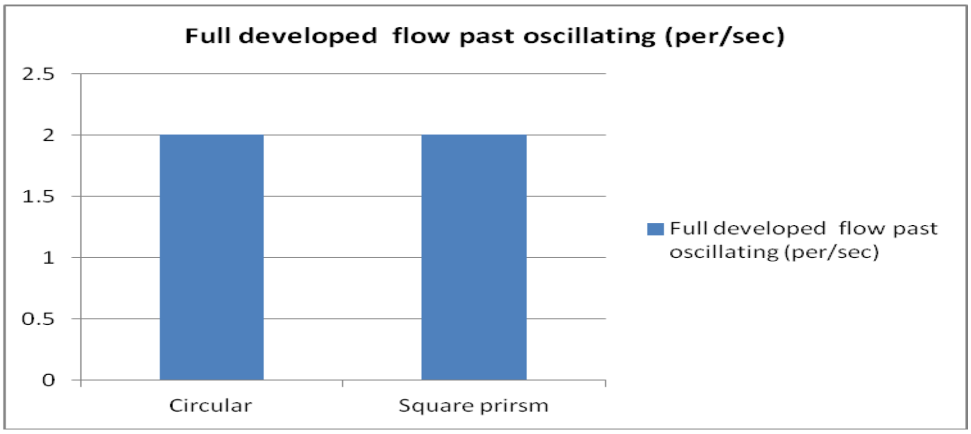

Fig.10 Full developed flow past oscillating (per/sec)

Flow over stationary circular (Wake of stationary) (Pa) A similar increase in Strouhal number is observed for other sharp-edged cylinders as well. However, there is no discontinuity in Strouhal number variations for the sharp-edged cylinders. Therefore, continuously generated vortices in the wake of the triangular and square cylinders are an advantage and can facilitate the design of the converter as compared with a circular cylinder. In addition, among the sharp-edged cylinders, a triangular cylinder can generate stronger vortice.

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