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Experimental Investigation of Passive Flow Control on Bluff Bodies

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Abstract

Flow control techniques are broadly classified into two types 1.passive control 2.active control. Present paper discuss about the experimental investigation of flow control using passive method on bluff body. Authors also explains about the various flow control techniques used in bluff body aerodynamics. Experimental setup consists of L m span and diameter d of cylinder model. The next model is having strip of cross section 0.01d dia is placed on the cylinder along the span wise distance with equal polar distance around 30^o. both the models were kept between four walls in a Reynolds number ranging from 10000 to 15000. The results show that the C_p values changes according to the changes in cylinder roughness.

Keywords: Active flow control, Passive control, bluff body.

Introduction

Most of the physical structures like mountain, trees are bluff bodies. Even bluff bodies take place in many building structures like stay cables and chimes. We can classify the bluff body into streamline body by its characteristic length to diameter ratio. Due to its unique nature of response with airflow, it may subject to uneven flow pattern around it. The researchers continue their efforts towards finding the flow properties of bluff bodies in low speeds after the first accident Tacoma Narrows Bridge, which collapsed in 1940 due to low speed instability problems. During the construction of the bridge, it was experience series of vertical motions in specific time interval. So the designers considered to use stringers for control the oscillatory motion. Two inclined cable as pair, stays that connected the main cables to the bridge deck at mid-span. These remained in place until the collapse, but were also ineffective at reducing the oscillations. The structure was equipped with hydraulic buffers installed between the towers and the floor system of the deck to damp longitudinal motion of the main span. The effectiveness of the hydraulic dampers was nullified, however, because the seals of the units were damaged when the bridge was sand-blasted before being painted. To drill holes in the lateral girders and along the deck so that the air flow could circulate through them to reduce aerodynamic vertical loads. This was suggested by Professor Farquhar son and his students. With this long historical background and the present studies on low speed aerodynamics studies over bluff bodies is having unique place in research field. This paper explains the fundamentals of flow control techniques over bluff bodies and how passive control can control the flow over a cylinder.

The marine applications of bluff bodies such as pipelines, risers, offshore platform support legs are broadly discussed [1,2]. The experimental investigation on Reynolds number based bluff bodies and the prediction of vortices separates from bluff body is explained [3]. These periodically moving vortices through the downstream form self-excited oscillations are known as von Karman Vortex Street [2]. The separation and prediction of flow region development of laminar to turbulent is happens between 1000 to 20000 Re is known as subcritical [4]. The flow after Re 20000 is fully turbulent [5]. There are several experimental and computational studies has been made for flow over cylinder to determine subcritical [6]. The computation study on blowing from four slots located on the circumference of the cylinder with a velocity magnitude of 50% of the free stream velocity yields a drag reduction of 23% compared to the uncontrolled case [7].

Experimental Arrangements

A. Model description

Two model has been adopted in this experiment. One is normal bluff body and another one is modified bluff body with variable roughness. The bluff body model used in this research is cylinder with diameter of‘d’. The second model is cylinder with same dia ‘d’, but the roughness is vary. In second model the extended strips of cross section 0.1d X 0.1d is fixed on the cylinder at the location of $2d^o$.

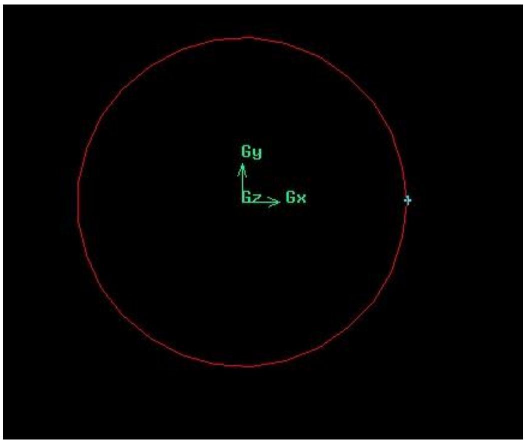

Figure 1: Cylinder with diameter 'd'

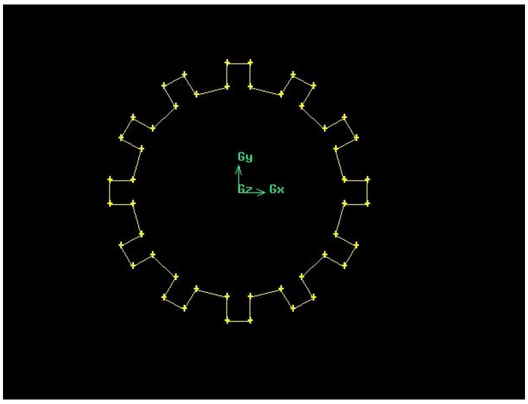

Figure 2: Cylinder With Extended Strip of 0.1d X 0.1d

B. Windtunnel description

Figure 3: Wind tunnel layout 10d X 10d X 40d

The blow down tunnel with cross section of 20d X 20d X 40d is used to measure the pressure distribution over cylinder model.

Experimental Procedure

The cylinder model has been kept between two walls and the desired Renumber flow was generated using standard RPM control of the wind tunnel.

C. *Calibration of windtunnel*

Wind tunnel Contraction ratio – 7:1

Equations used:

$P+1/2\rho v^2=\text{constant}$

$P_0+1/2\rho v_0{}^2=P\infty+1/2\rho_\infty V_\infty{}^2$

$P_0=P_\infty+1/2\ \rho_\infty V_\infty{}^2$

$V_\infty=2\sqrt{2}\ \rho m*g*h/\ \rho a$

Static manometer reading = $1.2*10^{-2}$ m

Density of alcohol inside inclined manometer = 775 kg/m^3

Constants used:

Density of methanol=791 kg/m^3

Density of air=1.226 kg/m^3

S. No	Rpm	Manometer reading in cm	Velocity m/s
1	500	7	21.95~22

D. *Smooth cylinder Experiment*

Figure 4: Smooth Cylinder At Test Rig

The smooth cylinder is fixed on the test rig with the help of fixtures available in wind tunnel. The rpm was chosen as 500 RPM.

E. Variable roughness cylinder

Figure 4: Roughness Cylinder At Test Rig

The variable roughness cylinder is fixed on the test rig with the help of fixtures available in wind tunnel. The rpm was chosen as 500 RPM.

F. Results

The results are obtained from the manometer available with the wind tunnel. The variation of C_p along the characteristics length of the cylinder is measured using the manometer arrangements available in the cylinder. Redline shows the value of C_p of cylinder without roughness. Blue line shows the values of cylinder with roughness.

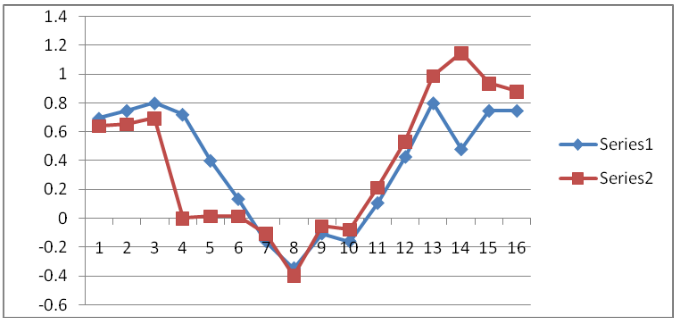

Figure 5: C_p Variation on Two Different Roughness Cylinder

Results and Discussions

The variation of C_p along the characteristics length is shown that the roughness is one of the parameter in bluff bodies that could define the flow properties. Here, the bluff body flow drag profile is depends on skin friction rather than pressure loss. So we can use roughness to control the drag characteristics in bluff bodies.

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