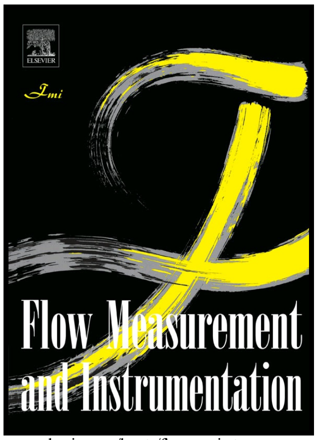

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Vortex-meter Design: The Influence of Shedding-body Geometry on Shedding Characteristics

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Abstract

The periodic vortex shedding from bluff bodies may be used in flow metering applications. However, because the bluff-body is highly confined (typically in a pipe) the shed vortices may interact with the pipe wall; causing an undesirable non-linear behaviour. An experimental investigation has been conducted; examining the vortex-shedding characteristics of highly confined bluff-bodies in pipe flow, at high Reynolds number ($Re_D = 4.4 \times 10^4$ to 4.4×10^5). The bluff-bodies were comprised of a forebody and tail; both of which affected the primary-shedding characteristics. The shedders typically produced two unsteady modes: Mode-I was associated with the vortex shedding and mode-II resulted from a separation of the pipe-wall boundary layer. The mode-I behaviour allowed two classes of shedder to be defined: long-tails and short-tails. Modes I and II interacted, particularly for long-tailed geometries. When the length-scale of mode-II exceeded 0.8κ (where κ is the physical scale of the primary shedding vortex), mode-II disrupted mode-I, as the mode-frequency ratio (f_{II}/f_I) approached an integer value. The coupling of modes I and II caused mode-I to deviate from its preferred Strouhal number. When the deviation exceeded 25-30%, mode-I locked on to the mode-II frequency. This did not happen for short-tailed geometries, as the length-scale of mode-I was always dominant. Mode-coupling for short-tails occurred only when the mode frequencies were equal.

Keywords: bluff-body, vortex-meter, splitter-plate, frequency-characteristic, vortex-shedding, compressible

1. Introduction

Vortex-flow-meters are used in a wide variety of industrial applications owing to their robust nature [1]. Generically, the vortex-flow-meter consists of a bluff-body with a characteristic dimension (typically the height or maximum thickness) denoted d, mounted in a pipe or duct of diameter D. Most commercially available designs operate with high blockage ratios ($d/D \approx 0.3$ [1]) to maintain a good signal-to-noise ratio. The flow through a vortex-meter may hence be considered as a highly confined bluff-body flow; i.e. one in which the blockage of the body is significant (unlike many fundamental bluff-body studies).

In the *classical* picture of vortex shedding from a bluff-body, the shedding frequency is proportional to the flow velocity when the flow Reynolds number is approximately in the range 10^3 to 10^5. The non-dimensional frequency (Strouhal number, St) of the shedding is therefore constant. Although several works e.g. [2, 3] show a slight decrease in St as Reynolds number increases beyond $Re_d \approx 10^4$. Although, as with most classical works on the subject of bluff-body wake shedding, these works exclusively consider low blockage ratio bodies d/D $O(0.01)$.

For highly-confined bluff-body flows, the geometry of the shedding device can influence the linearity of the meter; even at high Reynolds numbers. In addition, the vortex street produced by the bluff-body may interact with the walls resulting in "non-classical" behaviour. It is necessary to rigorously characterise the influence of the various geometric parameters of the bluff-body on the nature of the vortex-shedding to facilitate the efficient design of such metering devices. This knowledge will enable the vortex-meter designer to avoid geometries which produce non-linear or discontinuous shedding characteristics. It also enables geometric parameters to be selected to provide a balance between meter range and sensitivity, whilst minimising total pressure loss and spectral noise.

Venugopal *et al.* [4] have investigated geometric

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