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Brief communication

Effect of shear-layer thickness on the Strouhal–Reynolds number relationship for bluff-body wakes

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Abstract

In a previous paper, we provided a rationale for the empirically observed St–Re number relationship for vortex shedding in bluff-body wakes. This rationale derives from a mechanism of vortex formation observed in numerical simulations coupled with an estimate of the terms in the vorticity transport equation based on this mechanism. Adopting the typical size of the body D as the characteristic length scale resulted in a rationale which matches the traditional $1/\mathrm{Re}$-fit. Here, we propose to adopt the thickness of the separated shear layers as the length scale which governs the diffusion of vorticity during the vortex-formation process instead of D. Thus, providing a new rationale matching Williamson–Brown's $1/\sqrt{\mathrm{Re}}$-fit, which has one order of magnitude less error than the traditional fits in terms of $1/\mathrm{Re}$.

Keywords: Vortex streets; Separated flows; Vortex dynamics

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1. Introduction

During the past five decades, there have been extensive measurements which yielded different coefficients for the Strouhal–Reynolds number relationship for the laminar regime of vortex shedding in bluff-body wakes. Those fits generally follow the lead of Roshko (1954), who plotted the parameter $\mathrm{Ro} = \mathrm{St}\,\mathrm{Re} = fD^2/\nu$ (where f is the shedding frequency and D the characteristic length of the body) versus Re. Ro is now known as the Roshko number. Roshko (1954) found a linear least-squares fit for the Ro–Re plot, which gives a St–Re relationship in terms of $1/\mathrm{Re}$,

$$\mathrm{St} = A - B/\mathrm{Re}. \tag{1}$$

Following Roshko's work, many curves of the St–Re relation were published, often showing little agreement between them, and a controversy started about the nature and place of the several jump discontinuities in the data that were observed. This long-running debate was largely resolved by Williamson (1988a) who found that manipulating the end boundary conditions to enforce parallel shedding, the resulting St–Re curve can be made continuous throughout the laminar range ($49 < \mathrm{Re} < 178$). It is now believed that this universal parallel-shedding curve represents measurements for purely two-dimensional vortex shedding (Williamson, 1989).

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