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Vortex Shedding from Elongated Rectangular Plates at Low Reynolds Numbers

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ABSTRACT

Vortex excitation from rectangular elongated plates when the length parallel to the flow (c) is much greater than the height perpendicular to the flow (t) has been investigated experimentally by Nakamara and co-authors [1, 2]. They concluded that vortex shedding from elongated flat plates with square leading and trailing edges is dominated by the impinging-shear-layer instability, when a single separated shear layer can be unstable in the presence of a sharp downstream corner [3].

Transition in vortex shedding from the Kárman type to the impinging-shear-layer instability has been observed when the Reynolds number was increased from 200 to 300 [1]. Experimental data show that on short plates ($c/t < 3$) the flow separates at the leading edge corner and the shear layers interact directly, without reattaching to the plate's surface, thus forming a regular vortex street. On longer plates ($c/t > 3$), the shear layers are reattached upstream of the trailing edge and form a separation bubble which grows and may divide, depending on the chord-thickness ratio (c/t). These bubbles are convected toward the trailing edge (Fig. 1). For Reynolds numbers of $Re > 300$, experimental results show that the Strouhal

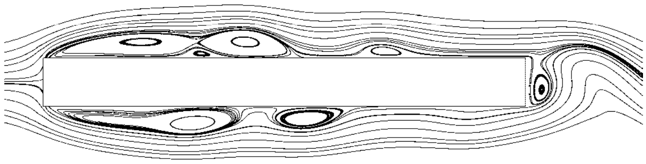

Figure 1: Streamlines, c/t=10, Re=300

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number $St(c)$, based on the chord length, increases stepwise with c/t increasing from 3 to 12, viz.

$$St(c) = \frac{fc}{U} = 0.55m \tag{1}$$

where, f, U are the vortex shedding frequency and the free-stream velocity, respectively, and m is the number of vortices (bubbles). Recently, Hourigan et al. [4] found that the trailing-edge shedding plays an important role in the stepwise behavior of the Strouhal number.

We have performed numerical simulations of flows around rectangular plates for chord-thickness ratio varying from 3 to 12 and Reynolds numbers of 200 and 300 based on the plate's thickness. Our simulations confirm that the dominant vortex shedding frequency, f, normalized by the cord length c and the free-stream velocity U (in other words, the Strouhal number $St(c) = fc/U$) displays the stepwise behavior with increasing a chord-thickness ratio c/t (Fig. 2).

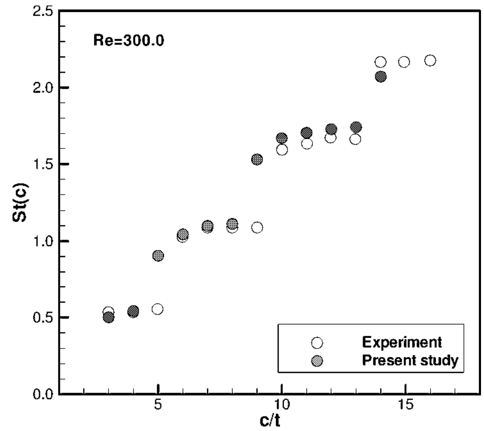

Figure 2: $St(c)$ vs. c/t, $Re = 300$

References

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