A Structural-based Interpretation of the Strouhal-Reynolds Number Relationship

PEDRAM ROUSHAN, X.L. WU, University of Pittsburgh, SOFT-MATTER TEAM — We propose a new Strouhal-Reynolds number relationship for shedding of vortices from circular cylinders. This new relationship is motivated by the observations that (i) for a fixed mean velocity $U$, the vortex street travels at a constant velocity $v_{st}=cU$ independent of the rod diameter $D$, and (ii) the spatial periodicity $\lambda$ of the street is linearly proportional to $D$ with $\lambda = \lambda_0 + \alpha D$, where $c$, $\lambda_0$ and $\alpha$ are constants. It follows that the non-dimensional frequency or the Strouhal number $St(=fD/U)$ should scale with the Reynolds number $Re$ as $St=1/(A+B/Re)$, where $A$ and $B$ are functions of $\lambda_0$, $\alpha$, and $c$. For the laminar wake, our result outperforms the classical relation, proposed by Lord Rayleigh, while it is comparable to other postulated relations in terms of accuracy in fitting experimental data. More significantly it describes remarkably well the two-dimensional (2D) film experiments over a broad range of $Re$ ($10<Re<3,000$), where vortex shedding is unaffected by 3D instabilities encountered in all 3D measurements. We note that while the new relation converges to the classical result in the limit of a large $Re$, the $1/Re$ expansion, required for such a convergence, is not in general valid as originally proposed by Rayleigh.

Pedram Roushan
University of Pittsburgh

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