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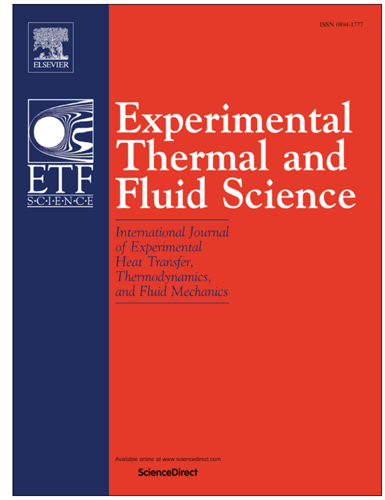

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Wen-Li Chen, Xiang-Wei Min, Dong-Lai Gao, An-Xin Guo, Hui Li

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Experimental investigation of aerodynamic forces and flow structures of bionic cylinders based on harbor seal vibrissa

Wen-Li Chen [a, b*], Xiang-Wei Min [a, b], Dong-Lai Gao [a, b], An-Xin Guo [a, b], Hui Li [a, b]

[a] *Key Lab of Smart Prevention and Mitigation for Civil Engineering Disasters of the Ministry of Industry and Information, Harbin Institute of Technology, Harbin, 150090, China*

[b] *Key Lab of Structures Dynamic Behavior and Control of the Ministry of Education, Harbin Institute of Technology, Harbin, 150090, China*

* *Corresponding author*

Abstract: In the present study, we investigated a new type of non-uniform surface cylinder based on a harbor seal vibrissa to reduce aerodynamic forces and suppress vortex shedding. Three vibrissa-based bionic cylinder models (i.e., models #1, #2, and #3) with different undulation wavelengths were manufactured and tested in a wind tunnel. The wind tunnel experiments were conducted at a Reynolds number of $Re \approx$ 50000 based on the hydrodynamic diameter (D_h) and incoming airflow speed. The control effects on the aerodynamic forces and flow structures around the bionic cylinders were studied and compared with those of a baseline circular cylinder. In addition to measuring the surface pressure distributions using an array of digital pressure transducers, a high frequency force balance was used to determine the aerodynamic forces acting on the test models. Moreover, a digital particle image velocimetry (PIV) system was utilized to quantify the stream-wise flow structure and span-wise flow field to assess the effectiveness of the bionic cylinder models. The results revealed that a bionic non-uniform surface distribution could reduce the mean drag and suppress the fluctuating lift to a certain extent. Bionic cylinder model #2, which had a wavelength of two minor axes, worked best among the three models, and it was found to achieve a drag reduction of 15% and a maximum fluctuating lift suppression of 58% when the angle of the incoming airflow was 0°. The PIV results indicated that the non-uniform surface structure would disrupt the consistency of span-wise flow and decrease the span-wise correlation in the near wake of the test models, which could decrease the turbulent kinetic energy, mean drag, and fluctuating lift of the test models.

Keywords: cylinder, non-uniform surface, passive control, span-wise, PIV.