Passively enhanced vortex-induced vibration response of side-by-side cylinders in turbulent flow

by Salman Masood

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Introduction

Passive VIV (vortex-induced vibration) enhancement is one of the main focuses in the development of VIVACE (vortex-induced vibration of aquatic clean energy) because no energy input is needed to achieve it. The proposed method is placing stationary upstream cylinders in front of vibrating SBS cylinders to enhance the VIV responses. The passive enhancement of VIV responses is investigated in the varying upstream diameters.

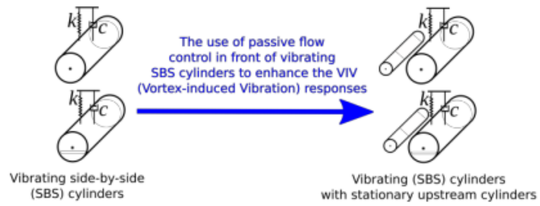

Figure 1: Stationary cylinders in front of vibrating side-by-side cylinders

Description of the flow visualization method

The present study utilized an in-house solver named TIGER-C, which employed Direct-Forcing Immersed Boundary (DFIB) and Large Eddy Simulation (LES) for the numerical simulation. The numerical solutions were processed in the Tecplot 360 EX to extract the 3-D flow structure. The Q-criterion was used to present the vortex structure, and then the spanwise vorticity was selected for coloring purposes.

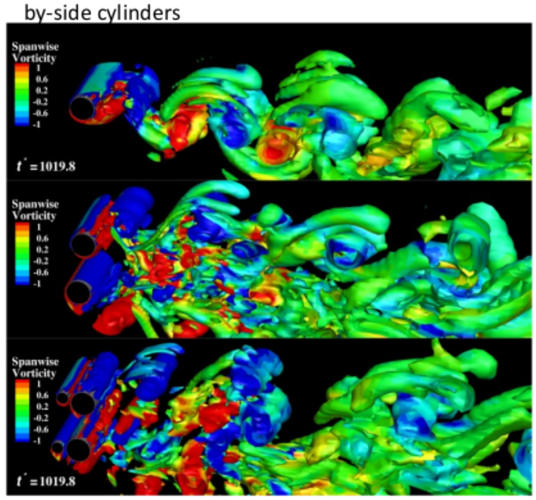

Figure 2: Vibrating cylinders with different configurations

Physical insight and conclusions

The positive and negative spanwise vortices are shed from the VIV simulation of a vibrating single cylinder, as shown in Fig. 2. This pattern is known as the 2-S vortex-shedding mode. The fluid flow through the gap of vibrating side-by-side cylinders results in a more chaotic wake. The spanwise vortices from both vibrating cylinders merge immediately after release. When the stationary cylinders are placed in front of vibrating SBS cylinders, the wake pattern becomes different, as shown in the flow visualization. Due to the strong influence of the wake in a vortex-induced vibration phenomenon, the presence of those stationary cylinders leads the vibrating structures to vibrate in a different response, as presented in Fig. 3. The larger upstream spacing allows the formation of positive and negative vortices behind the stationary cylinders. Further, those vortices are released and interact with the vibrating cylinders. Although the larger spacing ratio does not change the wake pattern, in fact, the appearance of upstream wake interaction still enhances the amplitude of vibrating side-by-side cylinders.

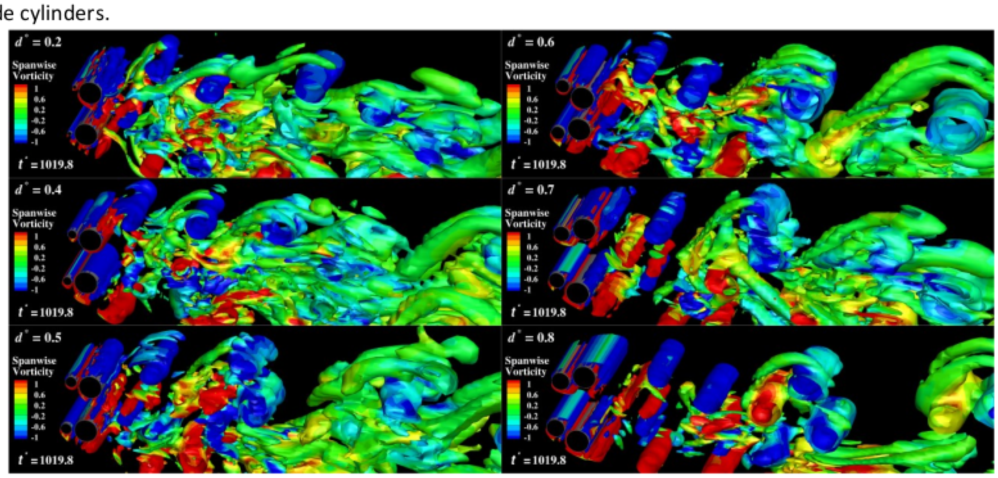

Figure 3: Instantaneous flow field of vibrating side-by-side cylinders with different upstream diameters

Reference:

Irawan, Y. H., Raza, S. A., & Chern, M. (2023). Passively enhanced VIV responses of side-by-side cylinders at moderate Reynolds number. Applied Ocean Research, 138(July), 103668. https://doi.org/10.1016/j.apor.2023.103668

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