Design and realization of a vortex induced vibration converter

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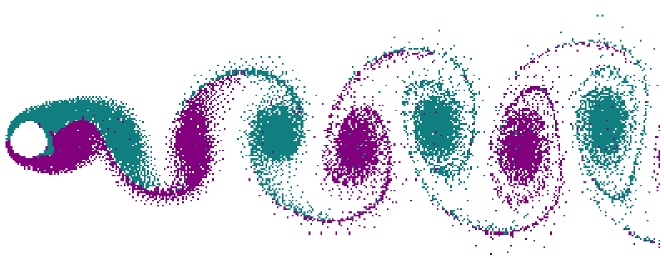
Content

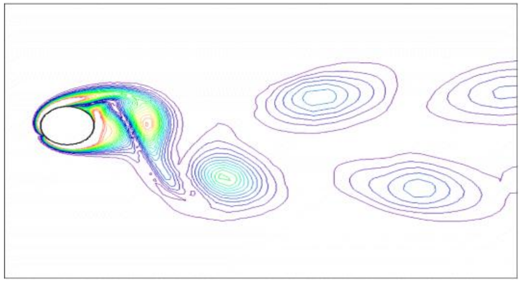
INTRODUCTION

Vortex induced vibrations

- When a fluid flows past a structure, such as a cylinder or a bluff body, alternating low-pressure vortices form on either side. This phenomenon is known as *vortex shedding*.
- These vortices generate oscillating forces in a direction transverse to the flow.
- When the vortex shedding frequency approaches the natural frequency of the structure, the body begins to oscillate with a large amplitude. This motion becomes synchronized with the vortex shedding frequency and continues with significantly large amplitudes over a range of flow velocities..



Karman vortex street created by a stationary cylinder



Vortex induced vibration of an oscillating cylinder

INTRODUCTION

Vortex Induced Vibration (VIV) converters

- They enhance the vortex shedding phenomenon to generate electrical or mechanical energy over a wide range of flow velocities.

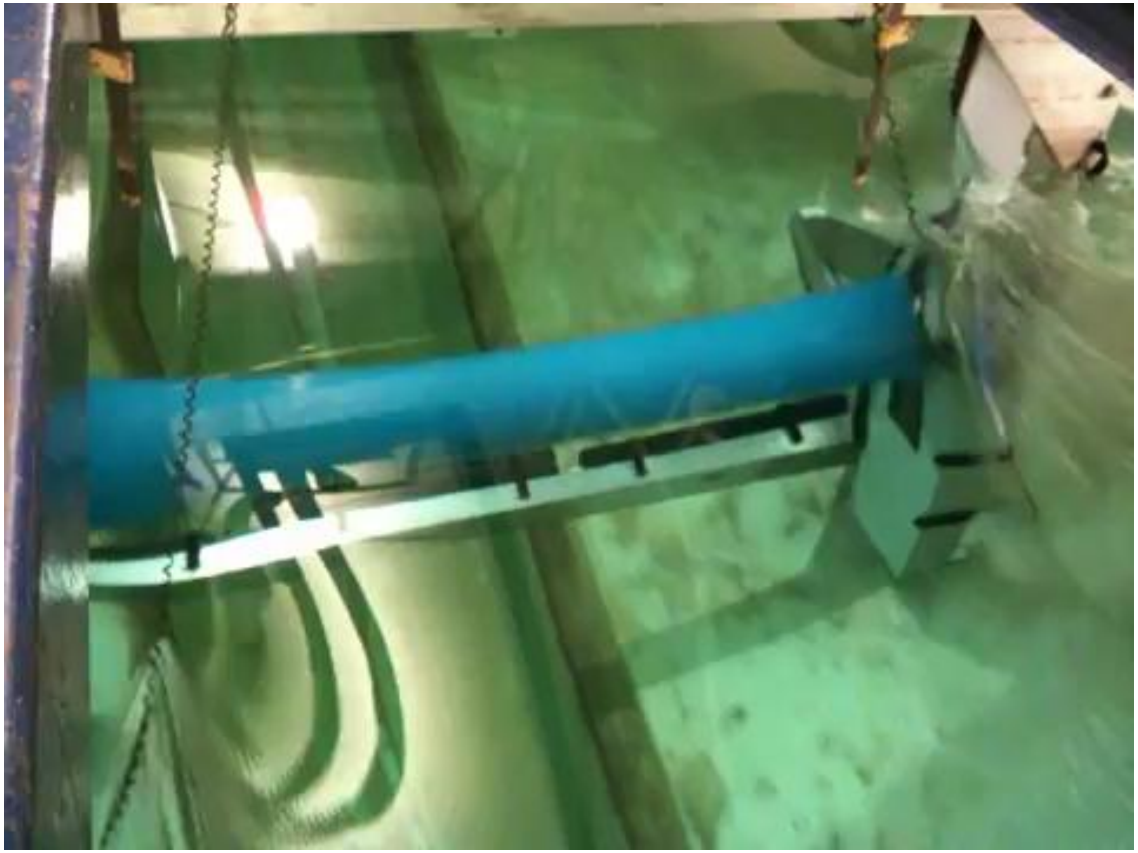
  This technology harnesses abundant energy from ocean and river currents.

  The VIVACE (Vortex Induced Vibration Aquatic Clean Energy) converter, a type of VIV converter, was invented in 2008 by Prof. M. Bernitsas at the University of Michigan.

Advantages

- Due to the vortex synchronization this has wide optimal operational window. Can efficiently operate in low velocity currents (0.25 – 2.5 m/s)
- Scalability and adaptability
- Comparably low cost

INTRODUCTION



Aim

- Develop a robust mathematical model to analyze the performance of vortex induced vibration converter and validate it using a lab prototype.
- Study the possible efficiency improvements to the system.

OBJECTIVES

- Obtain a conceptual understanding of the working principles of the VIVACE converter and its models.
- Develop a mathematical model and simulate the system's performance.
- Design and simulate a VIVACE lab prototype.
- Validate the mathematical model using the prototype.
- Study key areas for improvement, including:
  - The vortex synchronization region,
  - Determining optimum damping based on flow conditions, and
  - Exploring possible improvements in the power take-off system.

METHODOLOGY

- Learn about the hydrodynamic behavior of fluid flow around a cylinder, non-linear vibrations, and power take-off systems.
- Conduct a literature review on VIVACE converter models.
- Review existing mathematical models and develop a suitable model to simulate system performance using MATLAB/Python.
- Design a lab-scale prototype of the VIVACE converter using SOLIDWORKS. The scaling will be determined based on the capacity of the Fluid Mechanics Laboratory.
- The design will then be simulated using ANSYS/OpenFOAM.
- Fabrication and testing will be conducted using laboratory facilities.

TIMELINE

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Finalizing the project topic																														
Project proposal presentation submission																														
Literature review about vortex induced vibration and VIVACE converter models																														
Literature review about non linear vibrations																														
Literature review about power take-off systems																														
Understaning of existing mathematical models																														
Mid Video Presentation and viva																														
Develop a mathematical model for VIVACE																														
Design and simulation of the scaled-lab prototype																														
Demonstration																														
Lab prototype fabrication (without generator)																														
Lab. Testing I																														
Implementation of the generator																														
Study possible improvements to the system																														
Lab. Testing II																														
Final Evaluations																														

REFERENCES

1. Bernitsas, M., Mortimer, E., Cooley, M., Director, M., Device, H. and Workshop, M. (2011). *The VIVACE Converter Enhancing Flow Induced Motions to Harness Hydrokinetic Energy in an Environmentally Compatible Way*. [online] Available at: https://www.nrel.gov/docs/fy12osti/51421-09.pdf.
2. Bernitsas, M.M., Raghavan, K., Y. Ben-Simon and E. Oliver Garcia (2006). VIVACE (Vortex Induced Vibration Aquatic Clean Energy): A New Concept in Generation of Clean and Renewable Energy From Fluid Flow. doi: https://doi.org/10.1115/omae2006-92645.
3. Rostami, A.B. and Armandei, M. (2017). Renewable energy harvesting by vortex-induced motions: Review and benchmarking of technologies. Renewable and Sustainable Energy Reviews, 70, pp.193–214. doi: https://doi.org/10.1016/j.rser.2016.11.202.

THANK YOU