

Amplitude reduction through energy harvesting in vortex-induced vibrations

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Abstract. In this work, an identified electrical-mechanical model is implemented to describe complex behavior, such as upper and lower branches, and the piezoelectric coupling to harvest electric power in a 1DOF cylinder exposed to a transverse flow, presenting vortex induced vibration (VIV). A classical Van der Pol model was modified to represent the variations of Strouhal number and aerodynamic damping coefficient in order to represent the experimentally observed upper and lower branches. By comparing the numerical simulation with experiments presented in the literature the proposed model was validated. Then, the effects due to the electrical coupling were analyzed in terms of electrical power generation and the suppression of high amplitude oscillations. Results demonstrate the electrical coupling contributed to reduce the amplitude of oscillation. The results of this research can be helpful in order to design efficient energy harvesters based on VIV and can assist the development of strategies to suppress vibrations.

Keywords: VIV, upper and lower branches.

Introduction

Structures with cylindrical shape are widely employed in engineering can be subjected to Vortex Induced Vibrations (VIV), consequently, to possibility of serious structural and environmental damages caused by this phenomenon. A possible approach widely employed is presented by [1]. This is adopted here with almost all the same parameters and definitions, except the Strouhal number (St) and the amplified drag coefficient (Cd). Observing the experiments of [2] it was possible note that the St is not constant in the lock-in region, especially at the lower branch region. Additionally, due to the variation of St , the Cd must be variable as described by [3]. Therefore, it was identified some empirical functions to describe those parameters. At last, in the complete model it was introduced the piezo electrical coupling to analyze the energy harvesting and its effects on the amplitude of vibrations. The results can assist in the design of safer structures and in the development of strategies to suppress vibrations by mechanical-electrical conversion into realistic structures.

Results

By comparing results from simulations with the experimental results of [2], it is possible observe that the inclusion of the identified functions provided a good agreement with the experimental results, both in terms of amplitude of oscillation and range of speed. With the inclusion of the electrical coupling, there was a reduction of the amplitude of oscillation, as seen in Fig. 1. Additionally, the harvested power obtained had a peak of 1,9 mW at the upper branch, as seen in Fig. 2.

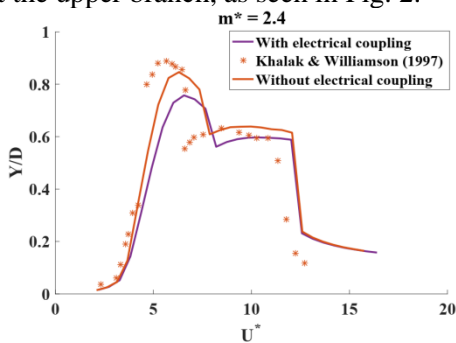


Figure 1 – Amplitude response

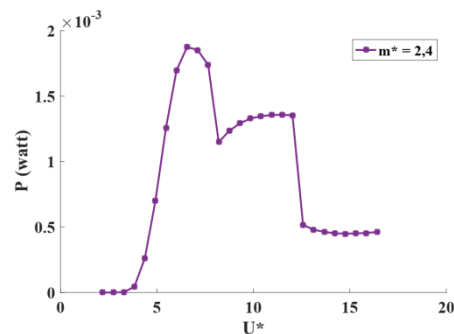


Figure 2 – Harvested power.

References

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