Case Study of Vortex-induced Motions (VIM) on a Monocolumn Platform Applying the Hilbert-Huang Transform Method

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ABSTRACT

Vortex-Induced Motion (VIM) is a highly non-linear and non-stationary dynamic phenomenon which is very important for offshore platforms, such as the MPSO (Monocolumn Production, Storage and Offloading System). An important particularity of the VIM is the amplitude and period modulation signal, which makes it difficult, perhaps not accurate, to analyze the data by using the Fourier transform. An analysis procedure addressing this matter was developed based on the Hilbert-Huang transform method (HHT). A case study of VIM of a MPSO applying a previously developed procedure is presented. Then, the usual spectral analysis method, Fourier transform method, was compared with the HHT applied on experimental data carried out from VIM tests on MPSO. The results were compared to draw some additional conclusions. The HHT is applied to the VIM phenomenon, aiming to disclose some hidden dynamic characteristics, such as the time modulation and jumps of multi-branched response frequencies. The experimental results for the MPSO compared by means of the two analysis methods consider different headings, drafts, and external damping conditions. The comparison between the methods made clear the larger non-stationary behavior in the motions in the in-line direction, in which the differences were up to 20% in some cases; on the other hand, the results for motions in the transverse direction showed to be similar.

KEY WORDS: vortex-induced motions (VIM), fluid-structure interaction, model tests, monocolumn platform, Hilbert-Huang transform method, spectral analysis

INTRODUCTION

As outlined previously, vortex-induced motion (VIM) has shown to be a very important issue to be considered in the design and analysis of some offshore platforms such as spars and MPSOs (Monocolumn Production, Storage and Offloading System), since the phenomenon may severely impact the fatigue life of risers, see for example Huang et al. (2003), Bai et al. (2004), Smith et al. (2004) and Sagrilo et al. (2009). Hence, more research must be performed in order to better predict the response of the system.

One of the aspects that make VIM such a complex and an interesting topic is its non-linear and non-stationary characteristics. As a result, traditional analysis techniques based on Fourier transform analysis can become inaccurate.

An alternative analysis is presented based on the so-called Hilbert-Huang transform method (HHT), which was not developed to study VIM, but can easily be adapted for it. This type of analysis was firstly introduced to vortex-induced vibration (VIV) studies by Pesce, et al. (2006) and to VIM studies by Fujarra, et al. (2007) and later by Gonçalves et al. (2010a). The method is based on the fact that, differently from the Fourier transform analysis, HHT does not require stationary and linear behavior in the system. Consequently, the distribution of energy in the spectrum is more precise in the latter. The analysis methodology of VIM on a MPSO applying HHT presented by Gonçalves, et al. (2010a) is now applied to reanalyze the experimental results in Fujarra et al. (2009). Those previously results were obtained from towing tank experiments of a small-scale model of a MPSO (MonoBR) in order to study VIM applying the traditional analysis (Fourier transform).

In the next section, for the sake of better understanding, the