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Semi-active control of jacket platforms under wave loads considering fluid-structure interaction

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A B S T R A C T

Jacket platforms are among the most used offshore platforms for energy extraction from seabed and are prone to failure caused by the inherent dynamic nature of wave loads. Therefore, vibration control of these structures with the goal of enhancing efficiency and preventing structural damage is of outmost importance. In current work, semi-active control of the Ressalat jacket platform using a large-scale magnetorheological (MR) damper with fuzzy logic controller is investigated with the aid of the computationally efficient modified endurance wave analysis (MEWA), considering waves with return periods of 2, 5, 10, 20, 50 and 100 years. The effect of number of dampers, fluid-structure interaction, added mass effects and actuator saturation has been simultaneously implemented in the current study. A total of six performance indices based on maximum and root mean square (RMS) of responses (inter-story displacement, velocity and acceleration) are used to assess the efficiency of the control method for waves with different intensities and return periods. Results of current analyses provide a comprehensive overview of the performance of the MR damper for the semi-active control of the Ressalat jacket platform under different wave loads with different return periods and show an acceptable performance for all the considered wave loads, with the goal of enhanced safety and increased service life.

1. Introduction

Fixed based platforms have been used since the 1890s for natural resource explorations, among which jacket platforms are the most well-known (Graff, 1981). These structures are subjected to different dynamic loadings during their service life such as wave loading, wind, ice, sea currents and earthquakes, which can lead to structural failure of different components of the platform, as well as creating problematic serviceability issues (Graff, 1981). Among the aforementioned dynamic forces, wave loading and the resulting vibrations play an important role in the performance and service life of these platforms, and in regions with minor seismic activity such as the Persian Gulf, the predominant design load is the wave force. Therefore, vibration control can play an important role in the proper performance of these structures, and therefore, potentially increase their service life.

The application of these control devices for vibration mitigation in oil rigs dates back to 1979, where Vandiver and Mitome (1979) used the idea of tuned liquid damper (TLD) and the concept of liquid turbulence in tanks to alter the period of vibration and damping of platforms. Over the years, researchers have used various passive control devices to control the vibrations of offshore platforms, including the tuned mass damper (TMD) (Abdel-Rohman, 1996), viscoelastic damper (Lee, 1997), viscous damper (Ding, 2001), friction damper (Patil and Jangid, 2005) and base isolation (Ou et al., 2007). Some studies have identified some drawbacks of using these control systems for platforms. For example, Patil and Jangid (2005), and Golafshani and Gholizad (2009) presented some of the limitations of using friction and viscous dampers in these structures. Zhang et al. (2017) concluded that in general, the use of base isolation is not always a practical solution for vibration control of platforms. Despite the popularity and simplicity of passive control, their poor performance under excitations with a wideband frequency and also limited efficiency in vibration mitigation warrants the need for other control strategies such as active or semi-active (Enferadi et al., 2019).

Active control devices require the use of an external power, sensors, and actuators. Given they usually have a feedback system, they result in lower weight of the damper, attenuates at a wider vibration frequency,

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