Passive vibration mitigation of a crane's payload under parametric excitation

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Abstract. This paper presents passive vibrations mitigation strategies of a parametrically excited pendulum. In the context of a crane's payload dynamic behaviour. Dynamics of a hanging crane payload is typically described by a lumped-mass pendulum model. Currently, there are various active control strategies to mitigate the swinging motion of the payload. However, there are very scarce passive mitigation techniques for this problem. The proposed technique involves the utilization of Pendulum Dynamic Vibration Absorbers (PDVA), hinged to the original payload. The PDVA properties can be properly adjusted to absorb the vibrations of the main system. Implementation of these strategies leads to the study of a double pendulum system. The paper presents numerical results of the proposed PDVA system that demonstrate the efficiency of the proposed method.

Introduction

Cranes remain an indispensable tool for heavy lifting in the construction sector as well as loading and unloading various cargos and goods from/to ships or lorries. Cranes are actively used on ships and helicopters to conduct launch and recovery or rescue operations, which are the integral part of their daily routine. In fact, 35% of worldwide weather conditions have sea state 3 and higher. These adverse conditions lead to almost 50% of launch and recovery operations to a halt, either suspended or aborted [1]. Moreover, the development of unmanned boats and ships in recent years has been at the focal centre of many countries, where the on-board manual supervision of critical processes and activities is impossible. Thus, such activities in unmanned vessels will have to be controlled and supervised remotely. This constraint requires auxillary video monitoring systems, multiple sensors, data transmission units and other equipment to provide enough information about the ongoing and planned activities. Development of autonomous systems, including ROVs and UAVs has substantially increased the dependence on and role of cranes as well as their capabilities of performing routine operations remotely or completely autonomously. This is a highly challenging task, since nowadays all cranes operations are physically supervised by a crane operator, who heavily relies on his/her experience, knowledge and ability to adequately perceive the surrounding environment, including wind gusts, existing and/or suddenly appearing static or moving obstacles, current position and velocity of the payload, etc. The situation aggravates substantially if the crane is positioned on a ship, operating in sea, where the roll, pitch and heavy motions of the ship are directly transmitted to the motion of the crane and crane's boom, exciting parametric vibrations [2],[3],[4].

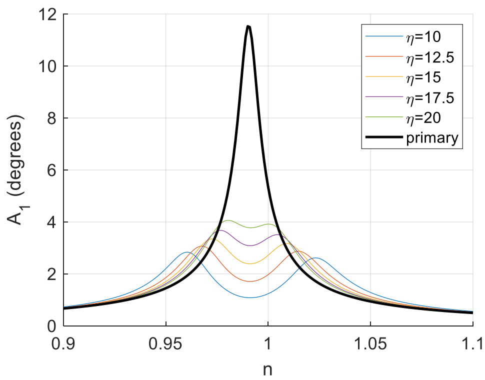

Figure 1. Vibration attenuation at various lengths of the crane payload and comparison with original primary response (solid line)

Results and Discussion

Passive vibration attenuation of a crane's payload with a Pendulum Dynamic Vibration Absorber (PDVA) is presented in this paper. The paper focuses on base-induced vibrations which lead to parametric excitation of the payload. It is shown (see Figure 1 for example) that the introduction of a compound pendulum leads to easily adjustable properties of the PDVA that allow effective mitigation of parametric vibrations,

References

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