Optimal Placement of Actuator for Vibration Suppression Based on Intelligent PID Controller

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***Abstract* — Many attempts have been proposed by the previous researchers due to reduce the undesired vibration by considering several control strategies. The simplest way in reducing the vibration is to build more rigid structure so that less vibration will be produced. Nevertheless, this strategy is usually not applicable since the structures are need high power consumption and limitation in operation speed. Furthermore, it becomes a growing trend among the industries to use light weight of mechanical structure known as flexible plate. However, the critical problem faced by the industries is vibration on the structure that can lead to structural damage. Hence, this research presents the optimal placement of actuator and sensor on the experimental rig for vibration cancelation of the flexible plate structure based on intelligent PID controller. The PID controller tuned by artificial bee colony (ABC) algorithm was used to control the undesired vibration on the structure. The robustness of developed controller was validated by varying the position of actuator on the experimental rig. It was indicated that point A2 leads to the good attenuation level by achieving highest attenuation value at the first mode of vibration with 28.83 dB which is equivalent to 21.62 % attenuation, after the introduction of vibration control.**

Keywords — flexible plate, active vibration control, artificial bee colony, PID controller, placement actuator

I. INTRODUCTION

In recent times, the characteristics offered by the flexible plate structure such as lightweight, faster response, less power consumption and less bulky design have received significant considerations by the industries to apply its advantages into their engineering applications [1-4]. Nevertheless, the vibration of the flexible plate structure is a critical problem faced by the industries, particularly in the airport baggage transport conveyor, micro hand surgery system and semiconductor manufacturing industry which have a light weight characteristic and relatively low damping for the fundamental and initial models [5].

This drawback is often a limiting factor in the structure performance that can lead to the instability, fatigue and structural damages [6]. Moreover, the frequency associated with this structure is commonly low which makes the nodes vibration control become an important issue for the light flexible structures [7]. Many attempts have been proposed by the researchers in order to reduce the vibration by considering several control strategies. The simplest strategy in reducing the vibration is to build more rigid structure so that less vibration will be produced.

Nevertheless, this strategy is usually not applicable. Passive control strategy has also been approached by applying passive materials like vibration damper and dynamic observer. However, this method is only applicable for high frequencies range, but not working well for low frequency range. Moreover, in meeting the demand of engineering applications, many industries are putting efforts to keep the structural weight as low as possible, thus making the passive solutions nonviable [8].

In fact, an active vibration control (AVC) method is more efficient, reliable and flexible in controlling the unwanted vibration of flexible structure. The potential of active vibration has been received remarkable attention from the researchers due to many applications that demand for effective vibration suppression especially in the aerospace structure, flexible robotic arms and micro mechanical systems. AVC is a method to reduce the amplitude of the unwanted vibration by introducing the secondary sources of vibration to the dynamical system [9].

The key to achieve high attenuation level at the first mode of vibration is by determining the exact position of actuators on the flexible plate structure. Therefore, this study presents the effect of location of an actuator on the horizontal flexible plate structure using active vibration control technique by employing artificial bee colony algorithm (ABC) for parameter estimation of PID controller.

II. PID CONTROLLER TUNED BY ABC ALGORITHM

ABC algorithm is a swarm based on metaheuristic algorithm that was introduced by Karaboga in 2005 for optimizing numerical problems and inspired by intelligent foraging behavior of honey bees. In this research, ABC algorithm was used to find the optimum value of PID parameters due to achieve the best attenuation level in suppressing the unwanted vibration of the horizontal flexible plate system. Details about artificial bee colony algorithm has been described in this publication [5]. The objective function of the optimization used to tune the PID controller is formulated based on the mean square error (MSE) of horizontal flexible plate system. The PID-ABC controller is implemented in the closed-loop controller using MATLAB/Simulink environment software. Fig. 1 shows the schematic diagram of PID-ABC controller.

The procedure of ABC algorithm in tuning the PID parameters can be summarized as follows:

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