Intelligent PID Controller Tuned by Bacterial Foraging Optimization Algorithm for Vibration Suppression of Horizontal Flexible Structure

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***Abstract*—Flexible structure offers various advantages such as being lightweight, efficient, quick system response and low energy consumption. However, this structure produces too much vibration which leads to system failure. To overcome this drawback, this project developed an intelligent vibration controller based on Bacterial Foraging Optimization (BFO) and incorporated into a Proportional-Integral-Derivative (PID) controller. BFO is a metaheuristic approach categorized as an evolutionary algorithm recently developed, and a nature-inspired optimization algorithm. BFO has been successfully applied to solve some engineering problems due to its simplicity and ease of implementation. Therefore, by introducing BFO to the PID controller, the desired parameters to control vibration experienced by a horizontal flexible plate can be easily found. The performance of the intelligent PID controller was compared to the conventional tuning method known as Ziegler-Nichols (ZN). It was noticed that the PID controller tuned by BFO successfully outperformed the PID controller tuned by ZN by achieving a high attenuation at the first mode of vibration of 44.65 dB as compared to the latter which was only attenuated at the first mode of vibration at 12.8 dB. The developed PID controller was also able to maintain a good performance level even when this system was introduced to multiple sinusoidal disturbance.**

Keywords—Horizontal flexible plate, PID controller, Bacterial foraging optimization algorithm, Active vibration control, intelligence controller

I. Introduction

Flexible structure is widely used in engineering applications such as the construction of bridge decks, satellite panels, electronic circuit board design, solar panels, winglet part in the airplane and automotive parts in various industries. Flexible structure consists of plates, shells, beams and frames which gives many advantages such as being lightweight, low energy consumption, safer operation, faster system response and reduced maintenance requirements. However, when subjected to disruptive forces such as external vibrations, the flexible flat thin plates are easily altered. Thus, this undesirable vibration needs to be removed to maintain the performance of the system. Recently, many researchers have had their attention drawn to replace such structures with flexible plate structure as it offers some advantages such as being lightweight, minimum power consumption, small actuator criteria and low rigidity specifications [1,2].

To suppress unwanted vibrations, researchers have come up with many vibration control techniques such as passive, semi-active and active [3-5]. Passive vibration control (PVC) was extensively by many researchers to suppress the excessive vibration on the structure. However, it does experience some limitations due to its heavy structure. Then, in the early 1930s, Lueg introduced active vibration control (AVC) to tackle the limitations of PVC [6].

AVC became prominent among earlier researchers as it was able to address the shortcomings of PVC. Various research were conducted to study AVC in a system. Wang and Mak (2017) investigated the use of a portable active vibration control on a moving raft to regulate time-varying disturbances [7]. On the other hand, Liu (2019) proposed prototypes of wind tunnels using an active damping vibration control system [8]. Proportional-Integral-Derivative (PID) controller has been used to provide an appropriate parameter to suppress external disturbances. Previously, the well-known loop tuning approach for adjusting PID parameters, commonly known as the ZN tuning rules, was devised by John G. Ziegler and Nathaniel B. Nichols in 1942. This technique has been widely used in various industrial applications and has been effectively applied into feedback control systems [9].

However, when applied to industrial facilities, the ZN formula still has problems to determine the parameter gains of a PID controller. Currently, many researchers have considered the uses of optimization algorithms to tune the parameters of PID controller, for instance the Artificial Bee Colony (ABC) Algorithm, particle swarm optimization (PSO) Algorithm, Genetic Algorithm (GA), Bio-Inspired Algorithm, Reactive Evolutionary Algorithms and Bacterial Foraging Optimization (BFO) Algorithm [10]. Recently, BFO has received remarkable attention among researchers due to its simplicity and fast convergence in problem solving. Inspired by its simplicity, this study aims to develop an intelligence PID controller tuned by the BFO Algorithm for vibration suppression of a horizontal flexible plate structure and the performance is to be compared to the Ziegler-Nichols tuning method, a more traditional tuning technique.