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Intelligent Active Force Control of a Helicopter Seat Suspension using Iterative Learning Algorithm

Samaneh Ahmadi,Mohammad Gohari*
Faculty of Mechanical Engineering
Arak University of Technology
Arak,Iran
*moh-gohari@arakut.ac.ir, moh.gohari@gmail.com

Mona Tahmasebi
Agricultural Engineering Research Department, Markazi Agricultural and Natural Resources Research and Education Center
Agricultural Research, Education and Extension Organization (AREEO), Arak, Iran

***Abstract*—Thehigh level of noise and vibrations inhelicopters is not preventable and happens through flight operations. This high level of vibrations can produce uneasiness and may affectaircrew performance and their health. Correspondingly, their concentration on flight operation and decision making is strongly depended to comfort ability. Therefore, vibration attenuation can improve flight control, and aircrews feel better conditions. In this study, the helicopter structure was modeled in ANSYS software and natural frequencies have been obtained. The seat suspension and pilot body were modeled by Lumped modeling method. The active force control (AFC) scheme hybridized by Iterative learning (IL) to determine the estimated mass called AFCILwas used in helicopter seat suspension system to reduce the vibrations transmitted to the pilot body. The simulation was performed with sinusoidal and random disturbance signals and results demonstrated in both the time and frequency domains. Attained results were compared with the passive system, PID controller and AFCANN schemes. The AFCIL scheme had superior performance in pilot head displacement reduction compared to the classical PID controller. The results of the AFCIL and the AFCANN were similar together while AFCIL results were marginally superior to AFCANN.**

Keywords*—Active seat suspension; active force control; helicopter seat suspension; iterative learning algorithm; artificial neural network

I. Introduction

The high level of noise and vibration in helicopters is not avoidable and occurs during flight.This high level of vibrations transmitted to the aircrew body can cause discomfort and may affect their health and interfere withtheir concentration on flight operation and decision makingduring missions.Long time of flight with body vibration can produce damages in the spine, neck pain and back pain [1]."These problems will be increased when additional instruments, such as the Head-Up Display (HUD) and Night Vision Goggle (NVG) system, are integrated onto helicopter pilot helmets in military operations"[2].Therefore reduction of vibration levels transmitted to the aircrew body is essential. Choi and Wereley analytically evaluated the biodynamic response mitigation to sinusoidal and shock loads using semi-active Magneto-Rheological (MR) seat suspension system [3]. Also Hiemenz etal. developed a MR seat suspension system for helicopter seat damping control[4]. The semi-active suspension systems had a good vibration isolation performance in the high frequency range but increase the level of vibrations in low frequency range.Chen et al. designed and developed an active seat suspension systemthat used anAdaptive Control Law [5,2]. Moreover, active force control (AFC) was added to conventional PID in helicopter seat suspension hybridized to Artificial Neural Network called AFCANN [6]. In that study simulation showed that pilot head displacement reduction was notable by AFC.Active suspension system, had a good vibration isolation performance. Also in these systems no increase in vibration levels in low frequency range was observed. Current research aims to use Iterative Learning Algorithm (IL) in AFC scheme in order to achieve more effective vibration isolation performance.

II. Helicopter Structure Analysis in ANSYS

The helicopter structure was modeled in ANSYS software (Fig .1). The natural frequencies of helicopter structure were obtained.The natural frequencies are listed in TABLE I for first twenty modes.

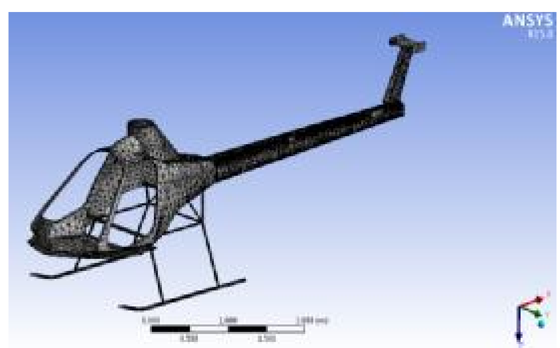

Fig.1.Modeling helicopter in ANSYS software

As can be seen in TABLE Ithe first sixth modes are Rigid Body Modes.Consequently,there is not any deformation on helicopter body, while after sixth mode, body deformation is initiated.