NUMERICAL AND EXPERIMENTAL DETECTION OF STRUCTURAL DAMAGE USING NATURAL FREQUENCY SHIFTS

By

WaelSaadyAbdEllateef Salman

A Thesis Submitted to the
Faculty of Engineering atCairo University
in partial fulfillment ofthe
requirements for the degree of

MASTER OF SCIENCE
in
Aerospace Engineering

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Under the Supervision of

Prof.Gamal Mahmoud SayedElbayoumi

Professor
Aerospace Engineering Department
Faculty of Engineering,
Cairo University

Dr. Mohammad Tawfik Abo Elsouod

Assistant Professor
Aerospace Engineering Department
Faculty Of Engineering,
Cairo University

Dr. Ahmed Mohammed RashedDesoki

Assistant Professor
Aerospace Engineering Department
Faculty Of Engineering,
Cairo University

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Approved by the Examining Committee

Prof. Dr. Gamal Mahmoud SayedElbyoumi, Thesis Main Advisor

Prof. Dr. Edward AdeebSadek, Internal Examiner

Prof. Dr.Hamdy Ahmed Ashour, External Examiner(Professor of Mechanical Engineering Department,Misr University for Science and Technology)

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Abstract

Structural health monitoring, SHM, is very important for any machine, including aircraft, since it can tell the current machine healthy state, and hence suggest the suitable action to prevent failure. We found numerous literature concerned SHM, and the great majority of them were based on detecting the damage from its induced change (shift) in the modal parameters, specifically the natural frequency. Most literature however tackled SHM theoretically, without providing clear figure about their feasibility/applicability. In this research we followed this natural-frequency-based SHM approach aiming to test and implement a real and feasible SHM system capable of detecting plate corrosion.This is the first attempt to detect corrosion damages in plates.

Firstly, the finite element, FE, model of healthy plate was prepared. Several methods for FE corrosion modeling were reviewed and one of them was chosen to model the damaged plates. The natural frequencies were calculated based on solving the eigenvalue problem of FE plate model. It was found that the shift in natural frequencies between healthy and damaged plates is very small.Therefore, two methodologies toestimate more accurately this slight natural frequency shift were introduced based on the phenomenon of beating. Both methodologies showed impressive success forundamped FE analysis.

In order to experimentally validate the SHM based on natural frequency shifts, several experiments identical to the numerical simulations were implemented. It was found that the corrosion modeling in physical plate specimens producesobservable natural frequencyshifts.The two beating-based methodologies were also experimentally verified. It was found however that one methodology succeeds while the other fails.

After that, the FE models were used to train artificial neural networks, ANN's, to obtain a SHM system capable of detecting the location and size of corrosion in thin plates. It was foundthat some types of unknown damage can be detected more accurately than others.

Based on this research, we arrived at serious conclusions as detailed in the thesis.