UNIVERSITI PUTRA MALAYSIA

NUMERICAL MODELING AND MINIMIZATION OF ENCLOSURE INTERIOR NOISE USING LOCAL ACTIVE SOUND CONTROL

SAMIRA MOHAMADY

Numerical Modeling and Minimization of Enclosure Interior Noise using Local Active Sound Control

By

SAMIRA MOHAMADY

Thesis Submitted to the School of Graduate Studies, **University Putra Malaysia**, in Fulfilment of the Requirements for the Degree of Master of Science

August 2010

Dedicated

To

My dearest parents

For their extensively love

and

Their endless care

Abstract of thesis presented to the senate of University Putra Malaysia in fulfillment of the requirement of the degree of Master Science

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ABSTRACT

Chairman: Raja Mohd Kamil b. Raja Ahmad, PhD

Faculty: Engineering

Low frequency noise has detrimental effects on human's physiology and psychology. To reduce low frequency noise, active control of sound is more effective compared to passive sound absorbers. Reduction of low frequency noise in structures like vehicle cabin and room in a house is therefore important. These structures can be modeled as a three dimensional (3D) enclosure with a flexible boundary structure on one of its side. In this thesis minimization of sound pressure in an enclosure with five rigid walls and a flexible plate on its top side using local active noise control technique was investigated. The acoustic environment of the enclosure was modeled using the finite element method. COMSOL© MULTIPHYSICS software which provides structural and acoustical modules was used to create finite element model of the enclosure. Modal analysis of this system was performed and the eigenfrequencies were compared against those obtained in related analytical and experimental works. In order to verify the finite element modeling procedure,

convergence analysis of the system was performed. The eigenfrequencies of the finite element model were compared with the ones obtained for analytical and experimental models and the mean absolute error of 5.8 % and 4.3 % were achieved respectively. Local control method has been used to design the controller in reducing the interior sound pressure field at two observer locations. The estimated noise reduction was assessed by calculating the estimated sound potential energy in the enclosure with and without controller. An average of 140.4 dB reduction in estimate potential energy in low frequency range has been obtained. Reduction of sound pressure at each observer position is around 60 dB. This implies that local active control of sound can be used in reducing sound pressure level at desired observer locations within the enclosure.

Sari tesis dipersembahkan kepada senat bagi University Putra Malaysia dalam perlaksanaan syarat-syarat darjah bagi Master Sains

PEMODELAN BERANGKA DAN PENGURANGAN HINGAR DI DALAM MEDAN TERTUTUP MENGGUNAKAN KAWALAN BUNGI AKTIF SETEMPAT

Oleh

SAMIRA MOHAMADY

Ogos 2010

Pengerusi: Raja Mohd Kamil b. Raja Ahmad, PhD

Fakulti: Kejuruteraan

Hingar berfrekuensi rendah mempunyai kesan yang akan menjejaskan fisiologi dan psikologi manusia. Di dalam pengurangan hingar frekuensi rendah, kawalan aktif bunyi adalah lebih berkesan berbanding dengan penyerap bunyi yang pasif. Pengurangan hingar frekuensi rendah dalam struktur-struktur seperti kabin kenderaan dan bilik dalam sebuah rumah adalah penting. Struktur-struktur ini boleh dimodelkan untuk dijadikan sebagai satu ruang tertutup tiga dimensi (3D) dengan sempadan struktur yang fleksibel pada salah satu sisinya. Dalam tesis ini kajian mengenai keberkesanan mengawal bunyi dalam sesebuah kawasan dengan lima dinding tegar dan satu plat boleh lentur pada sisi atas menggunakan teknik kawalan hingar aktif setempat telah dijalankan. Persekitaran akustik kawalan dimodelkan dengan menggunakan kaedah unsur terhingga. Perisian COMSOL©

MULTIPHYSICS yang menyediakan modul-modul struktur dan akustik digunakan bagi mencipta model elemen terhingga bagi ruang tertutup tersebut. Analisis modal sistem ini dijalankan dan frekuensi eigen dibandingkan dengan nilai yang diperolehi daripada kerja eksperimen dan analisis yang sedia ada. Dalam mengesahkan model elemen terhingga, prosedur analisis penumpuan mesh bagi sistem telah dijalankan bagi mendapatkan bilangan elemen yang terbaik bagi model tersebut.. Dalam membandingkan frekuensi eigen antara model elemen terhingga dan analitikal, begitu juga dengan model elemen terhingga dengan eksperimen. Min ralat mutlak 5.8 % dan 4.3 % telah diperolehi secara langsung. Kaedah kawalan setempat telah digunakan untuk mengurankan tekanan bunyi pedalaman di kedua-dua lokasi pemerhati. Pengurangan hingar telah ditaksirkan dengan pengiraan tenaga keupayaan bunyi dianggarkan dalam kawalan dan tanpa kawalan. Purata 140.4 pengurangan dB Penurunan tekanan suara pada setiap posisi pemerhati adalah sekitar 60 dB.dalam tenaga keupayaan dianggarkan di dua lokasi-lokasi pemerhati telah diperolehi. Ini menandakan kawalan aktif setempat itu boleh digunakan untuk mengurangkan tekanan bunyi di mana-mana lokasi pemerhati yang berada di dalam ruang tertutup.

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I certify that an Examination Committee has met on to conduct the final examination of Samira Mohamady on her Master of Science thesis entitled "Modeling and control of interior noise in an enclosure using local active control of sound" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Chairman)

Examiner 1:
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Examiner 2:
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Examiner 3:
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(External Examiner)

_____

Bujang Kim Huat, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Raja Mohd Kamil bin Raja Ahmad, PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Chairman)

Rizal bin Zahari , PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Internal Member)

Nawal Aswan bin Abdul Jalil , PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Internal Member)

Allahyar Montazeri, PhD
Lecturer
Faculty of Electrical Engineering
Iran University of Science and Techlonogy
(External Member)

_____

HASANAH MOHD GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: December 2010

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at University Putra Malaysia or other institutions.

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SAMIRA MOHAMADY

Date: August 2010

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