NOVEL METHODS OF TRANSDUCTION FOR ACTIVE CONTROL OF HARMONIC SOUND RADIATED BY VIBRATING SURFACES

KYM A. BURGEMEISTER

Department of Mechanical Engineering

University of Adelaide

South Australia 5005

Submitted for the degree of Doctor of Philosophy on the 29th of February, 1996;
awarded 14th of June, 1996.

NOVEL METHODS OF TRANSDUCTION FOR ACTIVE CONTROL OF HARMONIC SOUND RADIATED BY VIBRATING SURFACES

CONTENTS

NOVEL METHODS OF TRANSDUCTION FOR ACTIVE CONTROL OF HARMONIC SOUND RADIATED BY VIBRATING SURFACES

ABSTRACT

Large electric transformers such as those used in high voltage substations radiate an annoying low frequency hum into nearby communities. Attempts have been made to actively control the noise by placing a large number of loudspeakers as control sources around noisy transformers to cancel the hum. These cancellation systems require a large number of loudspeakers to be successful due to the imposing size of the transformer structures. Thus such systems are very expensive if global noise reduction is to be achieved.

The aim of this thesis is to investigate theoretically and experimentally the use of thin perforated panels closely placed to a heavy structure (eg. a transformer) to reduce the radiation of unwanted harmonic noise. These panels can themselves be vibrated to form a control source radiating over a large surface surrounding the primary source. The problem of the equipment overheating inside the enclosure is alleviated because the holes in the panels still allow natural cooling.

An initial study is carried out to determine the resonance frequencies of perforated panels. The use of previously determined "effective" elastic properties of the panels and Finite Element

Analysis to theoretically calculate their resonance frequencies is examined.

Secondly the attenuation provided by active noise control using perforated panels as control sources is explored by use of a coupled analysis, where the primary source is assumed to influence the radiation of the perforated control panel. This analysis was found to predict poorly the amount of attenuation that could be achieved, so an uncoupled analysis is undertaken, where both the primary and control sources are assumed to radiate independently of each other. Not only does this greatly simplify the theoretical analysis but it also enables prediction of attenuation levels which are comparable to those determined experimentally. The theoretical model is reformulated to enable comparison of the sound power attenuation provided by perforated panel control sources with that of traditional acoustic and structural control sources.

Finally, the use of modal filtering of traditional acoustic error sensor signals to give transformed mode (or "power mode") sensors is examined. The independently radiating acoustic transformed modes of the panel are determined by an eigenanalysis and a theoretical analysis is presented for a farfield acoustic power sensor system to provide a direct measurement of the total radiated acoustic power. The frequency dependence of the sensor system, and the amount of global sound power attenuation that can be achieved is examined. Experimental measurements are made to verify the theoretical model and show that a sound power sensor implemented with acoustic sensors can be used in a practical active noise control system to increase the amount of attenuation that can be achieved. Alternatively the sound power sensor can be used to reduce the number of error channels required by a control system to obtain a given level of attenuation when compared to traditional error criteria. The power mode sensor analysis is then applied to the perforated panel control system, with similar results.

STATEMENT OF ORIGINALITY

To the best of my knowledge and belief all of the material presented in this thesis, except where otherwise referenced, is my own original work, and has not been presented previously for the award of any other degree or diploma in any University. If accepted for the award of the degree of Doctor of Philosophy, I consent that this thesis be made available for loan and photocopying.

Kym A. Burgemeister

ACKNOWLEDGMENTS

This research has been undertaken with the support of the Australian Electricity Supply Industry Research Board, and the Australian Research Council.

The author would like to thank Dr Colin H. Hansen and Dr Scott D. Snyder for their supervision and input, and the thesis examiners (Dr J. Stuart Bolton and Dr Scott D. Sommerfeldt) for their constructive criticism and comments. The author would also like to thank Dr Anthony C. Zander for his interest and willingness to discuss areas of the work. Experimental work could not have progressed as quickly without the swift and talented support of George Osborne and Silvio DeIeso.

The use of The South Australian Centre for Parallel Computing's CM-5 Massively Parallel Processor is also gratefully acknowledged.

Finally I would like to thank Andrew (AJ) Younghouse and Mark **H**. Davies (and later Carly-Woo Howard and Benny B. Cazzolato) for the wonderful time I have had preparing this thesis; and for realistically encouraging me to prepare it, my wife Fiona, who I love dearly.