Faculty of Mechanical Engineering

SOUND RADIATION FROM VIBRATING PLATE WITH DIFFERENT BOUNDARY CONDITIONS USING DISCRETE SOURCE TECHNIQUE

Nurain Shyafina binti Ab. Latif

Master of Science in Mechanical Engineering

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WITH DIFFERENT BOUNDARY CONDITIONS
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NURAIN SHYAFINA BINTI AB. LATIF

A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016
DECLARATION

I declare that this thesis entitled “Sound radiation from vibrating plate with different boundary conditions using discrete source technique” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .........................................

Name : .........................................

Date : .........................................

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering.

Signature : .........................................

Supervisor Name : .........................................

Date : .........................................
“To my beloved parents”
ABSTRACT

The study of sound radiation from vibrating plate is an important subject in acoustic and being widely explored throughout years. The aims of this thesis are first to develop sound radiation model from a vibrating plate using discrete elementary source for different boundary conditions such as free-free, simply-supported and clamped-clamped. Secondly, the aim is to validate the radiation efficiency model between the proposed method and the experimental data. Analytical models of the sound radiation a rectangular plate are often based on simply supported edges for its mathematical convenience. Models for other boundary conditions also exist, but mostly these employ rather complicated analytical calculations.

This study presents a mathematical model of the radiation efficiency for a baffled plate using a discrete elementary source model. The plate velocity from each element on the plate has been determined from Finite Element Analysis (FEA) then was inserted into MATLAB for radiation efficiency calculation. The model requires only the knowledge of the spatial distribution vibration velocity of the panel and hence, the surface velocity can be calculated conveniently by using the established mobility equations for different boundary conditions. The model from FEA has validated with theoretical model. After the validation, which the model from FEA shows good agreement with the theoretical model, then the radiation efficiency can be determined using velocity data from FEA modeling. For validation, the experiment was done in small chamber and reverberation chamber. The sound power was measured using reciprocal technique because of its convenient (time efficient, less cost) compared to direct method which needs the use of shaker. The experimental results are presented for free-free and clamped-clamped boundary conditions which show reasonable agreement with the predicted results. On the basis of the results of this research, it can be concluded that the clamped-clamped boundary condition has the highest radiation efficiency compared to free-free and simply-supported boundary conditions. The model to calculate the radiation efficiency from vibrating plate using discrete elementary source has been successfully modeled and validated with the experimental data.
ABSTRAK

ACKNOWLEDGEMENTS

In the name of Allah, The Beneficent, The Merciful

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Also not to forget staff in the Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka and Faculty of Engineering and Built Environment of Universiti Ke-bangsaan Malaysia, Bangi which their names are too numerous to mention, who help me
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LIST OF ABBREVIATIONS

FEA  Finite Element Analysis
FFT  Fast Fourier Transform
SPL  Sound Pressure Level
kHz  kilo Hertz
CAD  Computer Aided Design
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<th>Physical Constant</th>
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<td>Speed of sound</td>
<td>$c_o = 343 \text{ ms}^{-1}$</td>
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<td>Density of the air</td>
<td>$\rho = 1.2 \text{ kgm}^{-3}$</td>
</tr>
<tr>
<td>Density of aluminium</td>
<td>$\rho_{al} = 2700 \text{ kgm}^{-3}$</td>
</tr>
<tr>
<td>Poisson’s ratio of aluminium</td>
<td>$\nu = 0.334$</td>
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<tr>
<td>Young’s Modulus of aluminium</td>
<td>$E = 7.1 \times 10^{10} \text{ Nm}^{-2}$</td>
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LIST OF SYMBOL

\(a\) Length of panel
\(b\) Width of panel
\(E\) Young’s modulus
\(F\) Force
\(h\) Thickness of plate
\(i, j = \sqrt{-1}\) Imaginary unit
\(I\) The second mass moment inertia of the structure
\(k\) Acoustic wavenumber
\(M\) Total mass of panel
\(m\) Odd modes
\(n\) Even modes
\(\text{Re}\) Real part
\(v\) Velocity
\(v_p\) Plate velocity
\(W\) Radiated power
\(Y_p\) Point mobility
\(Y_t\) Transfer mobility
\(\langle v^2 \rangle\) Spatial average of mean-squared velocity

\(\omega\) Angular frequency or natural frequency
\(\rho\) Density
\(\eta\) Damping loss factor
\(\nu\) Poisson’s ratio
\(\varphi\) Relative phase
\(\lambda\) Wavelength
\(\phi, \theta\) Phase
\(\mu\) Mean

xx
\( \sigma \)  Sound radiation

\( \Phi \)  Normalised mode shape
LIST OF PUBLICATIONS

Proceedings


