Ain Shams University
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Simulation of Sound Propagation through Ducts

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B.Sc. Mechanical Design and Production Engineering

Submitted in Partial fulfillment of the requirements of the degree of Master of Science in Mechanical Engineering

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Declaration

The contents of this work are the result of original research and have not been submitted for a similar or higher degree to any other university or institution.

This thesis is the result of my own work and all sources used in it have been furthermore acknowledged.

The work included in this thesis was carried out, at the Sound and Vibration Laboratory (SVLab), Design and Production Engineering Department, Faculty of Engineering, Ain Shams University.

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Committee

The undersigned certify that they have read and recommended to the Faculty of Engineering, Ain Shams University the acceptance of the thesis entitled "*On the Simulation of Sound Propagation through Ducts*", submitted by Sara Mohamed Elsaadany, in partial fulfillment of the requirements of the degree of masters of science in Mechanical Engineering.

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Foreword

Sound propagation in duct systems is an important field. Mainly when trying to prevent the sound propagation to reach openings. To control such a problem during the engineering phase, computational methods should become available, which can predict the behavior of sound propagation through the entire system and effect of the noise on the environment.

The aim of this work is to develop computational tools in order to achieve better description of sound propagation through fluid conveying ducts required for engineering purposes.
These computational tools will handle untouched issues in the field of sound propagation in duct systems.

The work in this research is categorized into two categories.
The first category includes the computation of flow distribution through different paths in order to correctly estimate the change in the impedance of the network elements and to model the convective effects.
While the second category includes

1- Studying the gas properties variation with different conditions.
2- Calculation of the acoustic pressure outside the system.
3- Adding active standardized acoustic sources to the system such as
    - Saw tooth waves
    - Rectangular waves
4- Finding an algorithm to automatically generate multi-port elements based on the segmentation approach.
5- Play time domain signal of a pressure calculated at a certain node using the computer sound card. This time domain signal is constructed using the inverse Fourier Transform of the frequency spectrum.

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Symbol	Description
p	Acoustic pressure (Pa).
q	Particle Volume velocity (m/s)
P_s	Static Pressure (Pa)
P	Stagnation Pressure (Pa)
h_e	Head losses (m)
ρ	Density (kg/m^3)
g	Gravitational acceleration (m^2/s)
v	Velocity (m/s)
R_f	Flow Resistance (kg/s^2)
k_e	Loss coefficient
L	Length (m)
D	Diameter (m)
f	Friction factor
A	Area (m^2)
Re	Reynold's number
μ	Dynamic viscosity (Ns/m^2)
θ	Cone angle (deg)
H	Height (m)
n_c	Number of cells per square inch
σ_s	Permeability (m^2)
C_D	Orifice discharge coefficient
M	Mach number
σ	Perforate porosity
T	Transfer matrix
z	Height above the datum (m)
τ	Shear stress on the pipe wall N/m^2
Φ	Specific flow resistance per unit thickness $kg/m.s^2$
aug	Augmentation factor for catalytic converter
h	Thickness (m)
TL	Transmission loss (dB)
NR	Noise reduction (dB)
IL	Insertion loss (dB)
K	Wave number
f	Frequency (Hz)
c	Speed of sound (m/s)
λ	Wave length (m)
ω	Angular velocity (rad/s)

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