A Distributed Active Vibration Absorber (DAVA) for Active-Passive Vibration and Sound Radiation Control

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(Abstract)

This thesis presents a new active-passive treatment developed to reduce structural vibrations and/or their associated radiated sound. It is a contribution to the research of efficient and low cost devices that implement the advantages of active and passive noise control techniques. A theoretical model has been developed to investigate the potential of this new "active-passive distributed absorber". The model integrates new functions that make it extremely stable numerically. Using this model, a genetic algorithm has been used to optimize the shape of the active-passive distributed absorber. Prototypes have been designed and built and their potential investigated. The device subsequently developed can be described as a skin that can be mechanically and electrically tuned to reduce unwanted vibration and/or sound. It is constructed from the piezoelectric material polyvinylidene fluoride (PVDF) and thin layers of lead. The tested device is designed to weight less than 10% of the main structure and has a resonance frequency around 1000 Hz. Experiments have been conducted on a simply supported steal beam (24"x2"x1/4"). Preliminary results show that the new treatment out-performs active-passive point absorbers and conventional constrained layer damping material. The compact design and its efficiency make it suitable for many applications especially in the transportation industry. This new type of distributed absorber is totally original and represent a potential breakthrough in the field of acoustics and vibration control.

to my grandmother

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Table of Contents

List of Figures

List of Tables

List of Symbol

Upper case

A	Axial displacement coefficient (m)
B	Transversal displacement coefficient (m)
C	Shear angle coefficient or mass layer displacement coefficient (- or m)
D	Dynamic effect coefficient (rad/s)
E	Energy (J)
F	Force (N)
G_3	Electric Field (IEEE compact notation) (V/m)
H	Enthalpy density (J/m^3)
K	Stiffness (N/m)
L	Length (m)
M	Mass (Kg)
P	Order of precision for axial displacement (-)
Q	Order of precision for transversal displacement (-)
R	Order of precision for shear angle or mass layer displacement (-)
S	Order of precision for mass distribution (-)
S_1	Strain (IEEE compact notation) (m/m)
T_1	Stress (IEEE compact notation) (Pa)
U	Total displacement in the 1 direction (m)
V	Volume (m^3)
W	Total displacement in the 3 direction (m)
Y	Young modulus (Pa)
Z	Mechanical impedance (Ns/m)

Lower case

b	Beam width
c_{11}	Module of Elasticity (IEEE compact notation) (Pa)
d	Mass distribution coefficient (-)
e_{11}	Piezoelectric Stress/Charge coefficient (IEEE compact notation) (N/Vm)
f	Unknown function (-)
h	Thickness (m)
m	Index (-)

n	Index (-)
p	Index (-)
q	Index (-)
r	Index (-)
s	Index (-)
u	Displacement in the 1 direction of the beam neutral axis (m)
w	Displacement in the 3 direction of the beam neutral axis (m)
x	Coordinate in the *1* direction (m)
z	Coordinate in the *3* direction (m)

Subscripts or Superscripts

1	Axial direction
3	Transversal direction
5	Shear plane
a	Absorber
b	Beam
c	Visco-elastic layer
e	Elastic layer
k	Kinetic energy
m	Mass layer
p	Potential energy
p	Index (-)
q	Index (-)
r	Resonance
s	Structure
t	Transpose operator
z	Piezoelectric layer

Greek letters

α	Tuning ratio (-)
α_n	*Psin* coefficient (1/m)
β_n	*Psin* coefficient (-)
γ_n	*Psin* coefficient (1/m)
δ_n	*Psin* coefficient (-)
Δ	Difference operator
κ	Variational operator
$\in$	Piezoelectric material permittivity (F/m)
ρ	Density (Kg/m^3)
τ	Time (s)
ω	Angular frequency (rad/s)
ν	Poisson ratio (-)