OPTIMIZATION OF PERFORATED DOUBLE-LAYER ABSORBERS USING SIMULATED ANNEALING

Min-Chie Chiu*, Ying-Chun Chang**, Long-Jyi Yeh**, Tian-Syung Lan***

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ABSTRACT

As noise is highly responsible for the psychological and physiological ills to workers, the noise control for enclosed manufacturing system with sound absorber becomes obligatory; besides, considering the maintenance and operation in a room, the minimal thickness of sound absorber is certainly requested, accordingly. To meet these issues, the compromising design target, ratio of sound absorption coefficient to thickness of acoustic panel, is thus proposed and applied as a researched objective, accordingly.

In this paper, the simulated annealing (SA) is utilized in the shape optimization of the double-layer sound absorption system. The paper tackles not only the theoretical derivation in a double-layer sound absorption system, but also, the presentation of the SA searching techniques. By pre-running the optimal searches of sound absorption coefficient of a single-layer absorber at the specified frequency of 350 Hz, the reliability in SA was verified. Before optimization, the accuracy of mathematic model on a single-layer sound absorber has been confirmed to be in good agreement by the experimental data. Thereafter, the exemplified case of double-layer absorber in seeking for the optimal objective function, ratio of sound absorption coefficient to thickness of acoustic panel, at the targeted 400 Hz is thus applied in the following SA optimization.

The economical and compact design of sound absorber proposed in this study surely provides a quick and optimal approach to maximize the acoustic performance at fixed total thickness and given flow resistivities of acoustic fibers by adjusting the airspace, acoustic fiber, perforated design of front plate on the perforated double-layer absorbers.

NOMENCLATURE

This paper is constructed on the basis of the following notations: c_o: sound speed (m s^{-1})
d_i: diameter of perforated hole on the i-th front plate (m)
D_o: thickness of absorber (m)
D_f: thickness of the i-th acoustic fiber (m)
f: cyclic frequency
j: \sqrt{-1}.
K_{fiber i}: complex propagation constant of the i-th acoustic fiber
K_p: complex propagation constant of the perforated front plate
K_{LX}: real part of complex K_{fiber 1}
K_{ZX}: image part of complex K_{fiber 1}
L_i: air depth of the i-layer resonator (m)
m_i: surface density of the i-th perforated front plate per 1m^2 (kg m^{-2})
N_i: hole's number on the i-th perforated front plate per 1m^2
OBJ_1: objective function (\alpha/(D_f 1 + D_f 2))
OBJ_2: objective function (\alpha)
p_i: perforated ratio of the i-th perforated front plate (%)
p_i: acoustic pressure at i (Pa)
q_i: thickness of the i-th perforated front plate (m)
R_a: acoustic flow resistivity of the first acoustic fiber (MKS rayls m^{-1})
R_b: acoustic flow resistivity of the second acoustic fiber (MKS rayls m^{-1})
R_{fiber(i)}: real part of complex Z_{fiber(i)}
\alpha: acoustic particle velocity at i (kg s^{-1})
\omega: angular frequency (rad s^{-1})
Z_i: specific normal impedance at i.
Z_{fiber(i)}: characteristic impedance of the ith acoustic fiber
Z_{p(i)}: characteristic impedance of the ith perforated front plate
X_{fiber(i)}: imaginary part of complex Z_{fiber(i)}
\alpha: sound absorption coefficient of absorber
\rho: air density (kg m^{-3})
iter_{max}: maximum iteration in SA
T_o: initial temperature
kk: cooling rate in SA