Advances in Computational Design, *Vol. 5, No. 3 (2020) 209-231*
DOI: https://doi.org/10.12989/acd.2020.5.3.209

An investigation of non-linear optimization methods on composite structures under vibration and buckling loads

Mustafa Akbulut[1a], Abdulhamit Sarac[2b] and Ahmet H. Ertas*[3]

[1]TUBITAK Marmara Research Center, Kocaeli 41400, Turkey
[2]TUBITAK National Metrology Institute, Kocaeli 41400, Turkey
[3]Department of Mechanical Engineering, Faculty of Engineering & Natural Sciences, Bursa Technical University, Bursa 16330, Turkey

(Received January 8, 2020, Revised April 10, 2020, Accepted April 24, 2020)

Abstract. In order to evaluate the performance of three heuristic optimization algorithms, namely, simulated annealing (SA), genetic algorithm (GA) and particle swarm optimization (PSO) for optimal stacking sequence of laminated composite plates with respect to critical buckling load and non-dimensional natural frequencies, a multi-objective optimization procedure is developed using the weighted summation method. Classical lamination theory and first order shear deformation theory are employed for critical buckling load and natural frequency computations respectively. The analytical critical buckling load and finite element calculation schemes for natural frequencies are validated through the results obtained from literature. The comparative study takes into consideration solution and computational time parameters of the three algorithms in the statistical evaluation scheme. The results indicate that particle swarm optimization (PSO) considerably outperforms the remaining two methods for the special problem considered in the study.

Keywords: Benchmarking; Heuristic optimization algorithms; structural optimization; laminated composites; buckling load; fundamental frequencies

1. Introduction

In many engineering fields, fiber reinforced plastic composite plates are employed, and the demand for their use especially in aerospace industry is continuously rising. In aircraft industry where high specific strength and low cost are desired, the structural parts such as wings, ailerons, and tails are made of high-tech fiber-reinforced plastic composites and all these structures are subject to heavy operational conditions including buckling and vibration. In special cases both design parameters should be considered in the same problem, which may be formulated as a multi-objective optimization procedure in order to find out the fittest design configurations.

For the solution of multi-objective optimization problems dealing with high number of

*Corresponding author, Associate Professor, E-mail: ahmeth.ertas@btu.edu.tr
[a] Ph.D., E-mail: mustafaakbulut2002@hotmail.com
[b] Ph.D., E-mail: ahamitsarac@gmail.com

http://www.techno-press.org/?journal=acd&subpage=7 ISSN: 2383-8477 (Print), 2466-0523 (Online)

Ncr	*critical load*
ω	*natural frequency*
D_{ij}	*bending stiffness*
$\{\Theta\}$	*vibration mode shape*
w	*transverse deflection*
θ	*orientation angles*
λ_b	*minimum critical load*
λ	*weighted ratios for critical load*
u_0	*mid-plane displacements in x directions*
ξ	*weighted ratios for natural freq.*
v_0	*mid-plane displacements in y directions*
X_i	*swarm vector*
w_0	*mid-plane displacements in z directions*
V_i	*velocity vector*
ϕ_x	*the rotations of transverse normal about x- axes*
B_i	*best position vector*
ϕ_y	*the rotations of transverse normal about y- axes*
w_p	*inertia weight*
A_{ij}	*laminate stiffness*
c_1, c_2	*positive acceleration constants*
B_{ij}	*laminate stiffness*
r_1, r_2	*random numbers*
W	*virtual work*
T_j	*temperature parameter*
K	*linear stiffness matrix*
f_t	*current cost*
E	*elasticity modulus*
f_h	*highest cost*
ρ	*density*
υ	*Poisson's ratio*