

Vector Evaluated and Objective Switching Approaches of Artificial Bee Colony Algorithm (ABC) for Multi-Objective Design Optimization of Composite Plate Structures

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ABSTRACT

In this paper, a generic methodology based on swarm algorithms using Artificial Bee Colony (ABC) algorithm is proposed for combined cost and weight optimization of laminated composite structures. Two approaches, namely Vector Evaluated Design Optimization (VEDO) and Objective Switching Design Optimization (OSDO), have been used for solving constrained multi-objective optimization problems. The ply orientations, number of layers, and thickness of each lamina are chosen as the primary optimization variables. Classical lamination theory is used to obtain the global and local stresses for a plate subjected to transverse loading configurations, such as line load and hydrostatic load. Strength of the composite plate is validated using different failure criteria—Failure Mechanism based failure criterion, Maximum stress failure criterion, Tsai-Hill Failure criterion and the Tsai-Wu failure criterion. The design optimization is carried for both variable stacking sequences as well as standard stacking schemes and a comparative study of the different design configurations evolved is presented. Performance of Artificial Bee Colony (ABC) is compared with Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) for both VEDO and OSDO approaches. The results show ABC yielding a better optimal design than PSO and GA.

Keywords: *Artificial Bee Colony Algorithm (ABC), Failure Criteria, Laminated Composite Plate, Multi-Objective Optimization, Objective Switching Design Optimization (OSDO), Structural Optimization, Vector Evaluated Design Optimization (VEDO)*

DOI: 10.4018/jamc.2011070101

INTRODUCTION

Extensive Research in behaviour of living systems has provided scientists with powerful methods for designing optimization algorithms. Such algorithms use ideas inspired from the nature. The basic idea behind developing these techniques is to simulate the natural phenomena such as flocking behaviour of birds, ants, etc., seeking a path between their colony and a source of food, simulating living systems and their evolution, immunology and observed immune functions. These algorithms thus operate on a set of individuals rendering population or swarm based methodologies. Swarm intelligence is characterized by some features, where every individual is self-autonomous and can obtain local information, and interact with their geographical neighbours. Complex group behaviour emerges from the interactions of individuals who exhibit simple behaviours by themselves.

Inspired by the behaviour of a bee, Karaboga introduced Artificial Bee Colony (ABC) technique for optimizing numerical functions and real-world problems (Karaboga, 2005). In addition, for achieving good performance on a wide spectrum of problems, such techniques tend to exhibit a high degree of flexibility and robustness (Karaboga & Basturk, 2007). ABC is a population based stochastic optimization technique which incorporates a flexible and well-balanced mechanism to accommodate the global and local exploration and exploitation abilities within a short computation time. Artificial Bee Colony (ABC) optimization technique has been used in variety of scientific and engineering applications over the past few years. A modified ABC algorithm which can solve constrained optimization problems is developed by Karaboga and Basturk (2008). In this study, performance of ABC is compared with differential evolution (DE) and particle swarm optimization (PSO) algorithms by considering linear, quadratic and non linear objective functions and found that ABC performs better in all the cases considered.

An ABC algorithm to determine the sectionalizing switch to be operated in order to solve the distribution system loss minimization problem is implemented by Srinivasa et al. (2008). They found ABC to be advantageous in terms of its global search capability and computational capability on comparison with GA, DE and simulated annealing (SA). A modified ABC algorithm to adapt to the grid computing environment and applied it to optimize the equilibrium of confined plasma in a nuclear fusion device is developed by (Antonio et al., 2010). Work on optimization aspects of a multi-pass milling operation using Artificial Bee Colony (ABC) algorithm is presented by Venkat Rao and Pawar (2010). The objective considered is minimization of production time (i.e., maximization of production rate) subjected to various constraints of arbor strength, arbor deflection, and cutting power. Study shows that ABC is good in converging to an optimal solution in terms of process parameters like depth of cut, cutting speed, feed and number of passes with good local as well as global search capability.

Clustering analysis has become an important method in identifying homogeneous group of objects which gather as a group (cluster). ABC algorithm for data clustering on classification problems and performance of the algorithm is compared with particle Swarm optimization (PSO) and nine classification techniques are employed by Karaboga and Oztruk (2011). The study depicts that an improved classification is obtained in case of ABC and also it can be applied for multivariate data clustering.

ABC algorithm is successfully adopted for the classification of acoustic emission signal by Omkar et al. (2009). They have presented that an improved classification can be achieved for the complex acoustic emission data set using ABC. Although the above literature studies showcase extensive use of ABC in different engineering domains, not much work is reported on the design optimization of composite structures.

In order to achieve an efficient design that fulfils the design criteria and the difficulty to select the values out of a large set of constrained

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