Abstract

The present work focuses on developing an effective damage assessment algorithm for composite structures utilizing swarm based optimization techniques from the changes of vibration responses. The leading varieties of damages occur in composite structures are fiber breakage, matrix cracking, delamination, etc. Fiber breakage, matrix cracking can be detected using failure theories. However, those failure theories can not detect presence of delaminations in composite structures. Therefore, vibration based inverse technique has been used here to assess the delamination damages in composite beams and plates like structures. Natural frequencies and modeshapes have been used as damage indicators. They are used to construct objective functions, which have been minimized to achieve the damage scenarios.

The minimization of objective function has been done utilizing swarm based optimization techniques. Each optimization technique has their own advantages and disadvantages. Therefore, proper optimization algorithm must be selected to build a successful inverse damage assessment algorithm. This has been achieved by performing a comparative study among ten well-known swarm based algorithms in terms of their performance in assessing damages in a few isotropic structures (beam and space truss). Teaching-learning-based optimization (TLBO) is found to be the most suitable among ten algorithms in assessing damages in isotropic structures in noisy and noise free environment.

However, instead of choosing only TLBO, four best algorithms from the study of isotropic structures have been selected to assess delamination damages in composite beams. The other three algorithms are unified particle swarm optimization (UPSO), scout UPSO (UPSO_Scout), grey wolf optimization (GWO). Delamination has been modelled using layerwise theory. Natural frequencies and modeshapes have been used as damage indicators. Two- stage method has been developed for assessing the damages. In the first stage modeshape curvature is used

to get a tentative idea about the in-plane location of the damage. In the second stage optimization algorithm has been used to assess the damages more accurately. Three different approaches have been developed for the second stage, they are: Binary-Decimal-Continuous-Approach (BDCA), Random Continuous Approach (RCA) and Mixed Approach (MA). Among these three approaches MA found to the best in terms of convergence speed and accuracy. Among four optimization algorithms UPSO and UPSO_Scout have shown similar effective performance, while the other two have failed to perform consistently. So, MA-UPSO (MUPSO) has been extended to assess delaminations in composite plates in noisy and noise free environment. Experimental validation of RCA-UPSO and MA-UPSO have also been performed for delamination assessment of composite beams. The outcome is found quite encouraging.

Keywords: Damage assessment, Inverse problem, Swarm based optimization, Composite structures, Unified particle swarm optimization, Layerwise theory, Delamination, Vibration response, .