Structural and Multidisciplinary Optimization
https://doi.org/10.1007/s00158-020-02839-2

INDUSTRIAL APPLICATION PAPER

Enhancement of travel range of electrostatically driven fixed-fixed microbeam in static and dynamic mode using mutated particle swarm optimization

R. R. Trivedi[1] · D. N. Pawaskar[1] · R. P. Shimpi[2]

Received: 26 February 2020 / Revised: 27 October 2020 / Accepted: 23 December 2020

Abstract

Particle swarm optimization (PSO) is a substantially exercised technique for optimizing structural design problems. One major snag of particle swarm optimization is a possibility of premature convergence, observed in the specific cases where global optimum is encircled by the solutions having higher objective function values. These territories are unexplored and swarm can fall into local optimum. The present work proposes to suggest one of the variants of the PSO algorithm to enhance the reliability. In the proposed algorithm, during each iteration, few particles will be chosen to follow worst solution, this would enable to perform exploration and exploitation of design space simultaneously. Hence, the probability of not getting caught into local optima gets augmented which gives better assurance to the achieved solution. The mutated particle swarm optimization (MPSO) is efficaciously employed for shape optimization of electrostatically driven fixed-fixed microbeams to augment the static and dynamic travel range. The geometry of fixed-fixed microbeams is optimized using continuous, smooth, parametric functions of width and thickness. For structural analysis, Rayleigh–Ritz energy method is utilized to compute the static and dynamic pull-in parameters. Nonlinear design constraints of engineering interest are implemented through penalty approach. Using modified particle swarm optimization, width and thickness profiles of fixed-fixed microbeams that result in maximum pull-in displacement have been obtained. Augmented pull-in parameters for optimized geometry of microbeams have been endorsed using 3-D finite element analysis. The optimization parameters reveal maximum rise in the static pull-in displacement by 41.25% and dynamic pull-in displacement by 39.15% of fixed-fixed microbeam compared to referential prismatic microbeam. Efficacy of mutated particle swarm optimization is emphasized through 18 representative cases. Mutated particle swarm optimization converges in around 20% of time in comparison with the hybrid simulated annealing, without getting trapped into local minimum in all the test cases.

Keywords Mutated particle swarm optimization · MEMS · Electrostatic microbeams · Pull-in instability

1 Introduction

1.1 Introduction to particle swarm optimization

Particle swarm optimization (PSO) was originated by Kennedy and Eberhart in 1995, which miniatures social behavior of fish schooling or bird flocking in search of food (Kennedy and Eberhart 1995; Hu et al. 2003). The term particle forms the basic part of the swarm and is not having any mass and volume but having its own velocity and acceleration (Kennedy et al. 2001). In PSO, procedure begins with an arbitary set of candidate solutions and looks for optimum value by updating generations. Particles'

Responsible Editor: Mehmet Polat Saka

Part of this work is published in the conference proceedings of WCSMO-10,2010.

✉ D. N. Pawaskar
pawaskar@iitb.ac.in

[1] Department of Mechanical Engineering, Indian Institute of Technology Bombay, Mumbai 400076, India

[2] Department of Aerospace Engineering, Indian Institute of Technology Bombay, Mumbai 400076, India

Published online: 10 February 2021