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Computation of quasi-periodic localised vibrations in nonlinear cyclic and symmetric structures using harmonic balance methods

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Abstract

In this paper we develop a fully numerical approach to compute quasi-periodic vibrations bifurcating from nonlinear periodic states in cyclic and symmetric structures. The focus is on localised oscillations arising from modulationally unstable travelling waves induced by strong external excitations. The computational strategy is based on the periodic and quasi-periodic harmonic balance methods together with an arc-length continuation scheme. Due to the presence of multiple localised states, a new method to switch from periodic to quasi-periodic states is proposed. The algorithm is applied to two different minimal models for bladed disks vibrating in large amplitudes regimes. In the first case, each sector of the bladed disk is modelled by a single degree of freedom, while in the second application a second degree of freedom is included to account for the disk inertia. In both cases the algorithm has identified and tracked multiple quasi-periodic localised states travelling around the structure in the form of dissipative solitons.

Keywords: Energy localisation, harmonic balance methods, cyclic structures, quasi-periodic vibrations

1. Introduction

The emergence of localised vibrations in cyclic and symmetric structures is an important phenomenon due to potential problems induced by high cycle fatigue. Mechanical components with cyclic symmetry are very common in the aerospace industry, where e.g. bladed disks of aircraft engines [1], space antennas [2] and reflectors [3] are usually composed of ideally identical substructures

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