

Abstract

The thesis aims to explore the involved mechanics in achieving directed transport of a particle placed on flexible surfaces excited by harmonic travelling waves. In the previous works, the particle-surface interaction modeling assumed the existence of a simple harmonic travelling wave without providing a robust paradigm for its generation in structures (thin beams and plates). However small, the wavelength contamination due to the contribution from the normal modes of the structure is inevitable, and as a result, the generated travelling wave ceases to be simple harmonic. The work presented herein is an attempt to address these gaps by explicitly considering each of the prerequisites to the particle-wave interaction. A systematic study, comprising the dynamic modelling of the actuator which imparts transverse phased excitation to structures, the passive generation of harmonic travelling waves due to such excitation, and finally, the particle-wave interaction in one and two dimensions, is attempted in the thesis. In addition, the effect of wavelength contamination on one-dimensional transport is addressed analytically using a modified form of KBM method. Mostly, the standard analytical methods for solving structural vibration problems, and occasionally, perturbation techniques, Nelder-Mead and Random Search optimization tools, are used to arrive at the results. FEM models developed in ANSYS are used to qualitatively validate some of the proposed findings, while others are substantiated using Gedanken-experiments based on analytical averaging methods. The idea of Standing Wave Ratio (SWR) minimization is proposed as a paradigm for travelling wave generation in this work. Also, it was observed that a circular plate excited by circumferential harmonic travelling waves having certain wave frequencies, causes the particle to spiral inwards towards the plate center. Surprisingly, this trajectory continues even in the regions where intermittent sticking of the particle to the plate surface is expected. The radial and tangential components of the sliding friction force is coupled by the particle kinematics and is the basis of the observed slow (average) dynamics. More importantly, the semi-analytical tools developed to analyze the particle dynamics placed in such an environment is the key contribution of this work.

Keywords: Averaging methods, Perturbation Methods, Slow dynamics, Travelling Waves, Gedanken-experiments, Harmonic Phased Excitation, Plate waves.