Dynamics of string lattices, vibrating near obstacles

Vladimir Astashev, Vitaly Krupenin

Mechanical Engineering Research Institute RAS
4, M. Kharitonyevskiy Pereulok, 101990 Moscow, Russian Federation
v_astashev@mail.ru ; krupeninster@gmail.com

Abstract

Lattice structures are prevalent in a wide range of modern engineering and construction industries. An important subclass of such systems is flat (2D) lattices. They define the design of a number of mountain, screening and sorting machines; they are involved in modeling of numerous 2D-objects - membranes, plates, panels, and other building structures. Furthermore, using such lattices, it is possible to analyze wave propagation in meta-materials, composite materials with periodic reinforcement, crystals, as well as nanostructured surface and near-surface layers of constructional materials. This list can be substantially continued.

However, for a variety of reasons, the dynamic analysis of lattice structures is unpopular, while the works, relating to the dynamics of lattice structures with the account of the impacts of their points, being rare.

By the string lattice we mean two systems of mutually perpendicular inertialless elastic strings which form rectangular cells with absolutely rigid point bodies at their vertices (points). String lattices with massive points appear to be natural 2D-generalization of the well-known “string with beads" model which played a significant role in the theory of oscillations.

The paper presents the results of the investigation of string lattices with rectangular cells, the points of which collide with fixed limiters. The investigation was based on analytical methods of the theory of vibro-impact systems grounded on frequency-time analysis of periodic vibro-impact processes, as well as experimental methods using modern vibration measuring equipment.

The main object of study is in-phase standing waves, called clumps. When these waves are realized in the forced oscillation regime, in a number of frequency ranges the standing waves are set, which is characterized by simultaneous collisions of all lattice points. The main dynamic effects, typical for the classical shock oscillator, are inherent in such regimes. The amplitude-frequency characteristics of the claps are constructed. At the same time, complex modes of motion, including those with disordered character, were discovered and described.

In several theoretical considerations Newton's hypothesis was rejected for describing collisions. Realistic models for energy losses mechanisms during impacts were used.

Also studied were lattices with triangular (centered hexagonal) cells. In the long-wave approximation, they are compared with lattices with square cells.