# Vibrations of a rolling tyre

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## Abstract

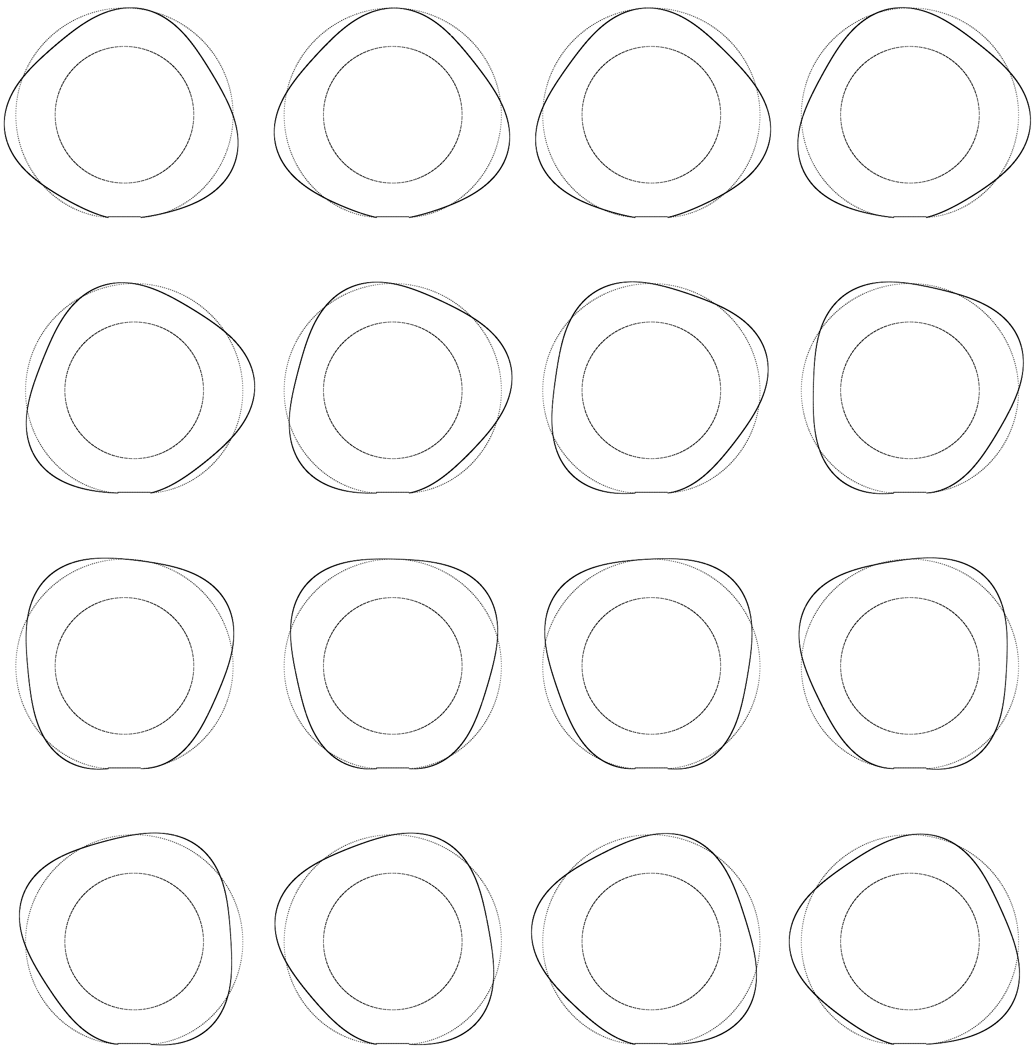

Figure 1: The rotation of the second MS of a loaded rotating tyre (the angular velocity $\Omega = 175$ rad$\cdot$s$^{-1}$, the NF $\nu = 94.93$ Hz).

Current problems of investigating the dynamics require an implementation of fast calculating models. Therefore, the problem of constructing models, which are capable of both simulating complex dynamic processes with reasonable accuracy and not requiring significant computational resources, is very important. There are two approaches: model approach and phenomenological approach. Within the phenomenological approach, the relations characterising the dependence of forces and moments applied to the wheel disc on the parameters of motion are empirical. The internal structure of the deformable periphery and the details of interaction are not usually considered. Thus, the object of study is represented

in the form of a "black box" which can be viewed solely in terms of its input and output characteristics. On this approach a number of modern researches are based. In contrast to the phenomenological approach, a model approach is used here. This approach allows mathematical description of a deformable periphery [1, 2, 3, 4, 5, 6]. That is, we propose a possible mathematical model of radial tyre.

We investigate vibrations of an unloaded and loaded tyre rolling at constant speed without slipping in the contact area. A previously proposed analytical model of a reinforced tyre is considered. The surface of the tyre is represented by flexible tread, combined with parts of two tori (sidewalls of the tyre). The elastic sidewalls are described by the Mooney-Rivlin model of incompressible rubber. The tread is reinforced with inextensible cords. In the undeformed state, the tread is represented by a circular cylinder. The contact between the wheel and the ground plane occurs by the part of the tread.

The natural frequencies (NF) are determined numerically and mode shapes (MS) are determined analytically for loaded rotating tyre (Figure 1). The results were compared with experiments for the non-rotating tyre. In the case of loaded rotating tyre, the increasing of the angular velocity of rotation implies that NF decrease. Moreover, a phenomenon of frequency loci veering is visible here: NF as functions of angular velocity approach each other and then veer away instead of crossing. The MS interact in veering region and, as a result, interchange.

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