Информационные системы и технологии

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A.P. Timohin[1], D.I. Konotop[2], V.P. Zinchenko[2], Ph. D.

Providing tire stiffness tests in LMS Virtual.Lab-Imagine.Lab AMESim co-simulation

Рассмотрено создание струнной модели растяжения шины и проведено ее испытание на жесткость. Главный акцент сделан на возможности использования данных для струнной модели из программы ABAQUS и на проведении совместного моделирования с помощью программы Imagine.Lab AMESim, которая обеспечивает настройку представленную модель. Выполнено сравнение результатов проведенного моделирования с результатами реальных тестов.

Tire stretched string model creating and stiffness tests performance are discussed. Main emphasis is put on the possibility of using data of string modal decomposition (string eigen forms and eigen frequencies) obtained from ABAQUS and co-simulation with Imagine.Lab AMESim which provide tuning of represented model. Also comparison of virtual simulated tests with real tests is performed.

Ключевые слова: *tire stretched string model, stiffness tests, ABAQUS, Imagine.Lab AMESim, co-simulation, shimmy, TNO MF-Tire, MF-SWIFT.*

Introduction

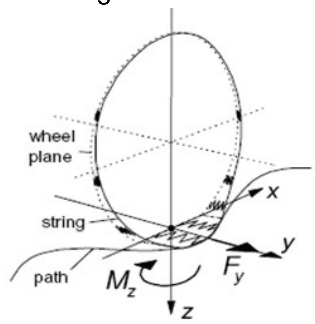
In the case of studying of landing gear dynamical stability (shimmy investigating), values of tire stiffness parameters is critically important information. Usually, precision theoretical prediction of these parameters is not possible or is very complicated calculation challenge, because tire is strongly nonlinear multi-componential object. There are a set of mathematical models of tire behavior [1 – 5] but all of them are require natural tire stiffness tests to obtain a set of parameters. In general full cycle of stiffness tests is performed on dynamical stage of vehicle development. But what can be done if in different reasons tests performance is impossible?

There are a set of software packages which can help researchers model tire dynamical behavior. Complex LMS Virtual.Lab & Imagine.Lab AMESim allows using a lot of tire mathematical models like Magic tire, TNO MF-Tire, MF-SWIFT e. t. c. but tuning of these models is the difficult task, requires of knowing a lot of tire parameters. In real work engineers don't have a full set of needles parameters. The only one stiffness parameter of tire is taken from the supplier - vertical force-displacement diagram.

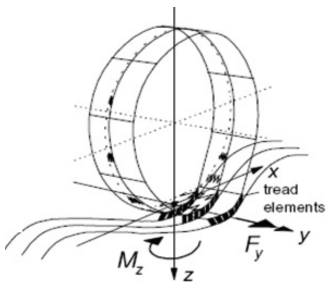
The main goal of this work is manual creating tire stretched string finite-element model [4, 5], tuning and validating it with single parameter data - static vertical force-displacement diagram which is standard data from tire supplier and obtaining other needles stiffness parameters of tire from virtual stiffness test.

1. Tire model representation

Schematic representation of classic stretched string tire model and model of tire which will be discussed are shown in fig. 1.



a



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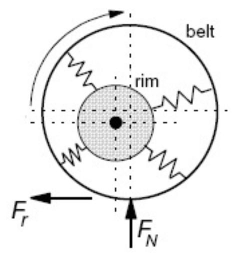

c

Fig. 1. The classic single string (*a*) and multi string models (*b*) of tire and tire model which is discussed in this research (*c*)

The main idea of this model is representation of interaction of path and flexible circle line which connected to rigid rim by spring system. Detailed mathematical description for this model is described by H.B. Pacejka in [4]. In this work constructing, tuning and simulation of tire string model are described.

2. Virtual tire stiffness test

The virtual model of experimental stand was created in CATIA V5 than transformed into virtual mechanism in Virual.Lab. Stand geometrical representation is showed in fig. 2.

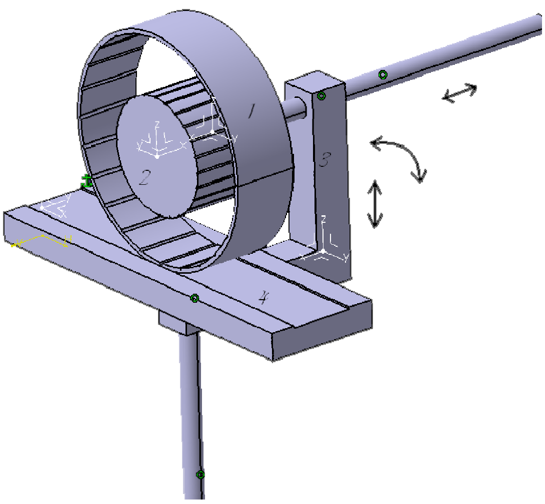

Fig. 2. Experimental stand

The stand consists of: 1- flexible string which rigidly (mutual string-ground geometrical intersection is forbidden) and with friction (mutual displacements in contact zone are forbidden) interacts with fixed ground 4, rigid rim 2 has single translational DOF relative to lever 3 to simulate lateral slip, lever 3 has two DOF - translational and rotational relative to ground 4 to simulate vertical compression and yaw. To take into account flexibility of string, modal analysis with software package ABAQUS was provided and resulting data of string modal decomposition (string eigen forms and eigen frequencies) were imported into Virtual.Lab. Six Eigen forms for stretched string are represented in fig 3.

The model of string system which connects the flexible string with rigid rim Imagine.Lab AMESim is used. Scheme of co-simulation of Virtual.Lab and Imagine.Lab models is represented in fig. 4.

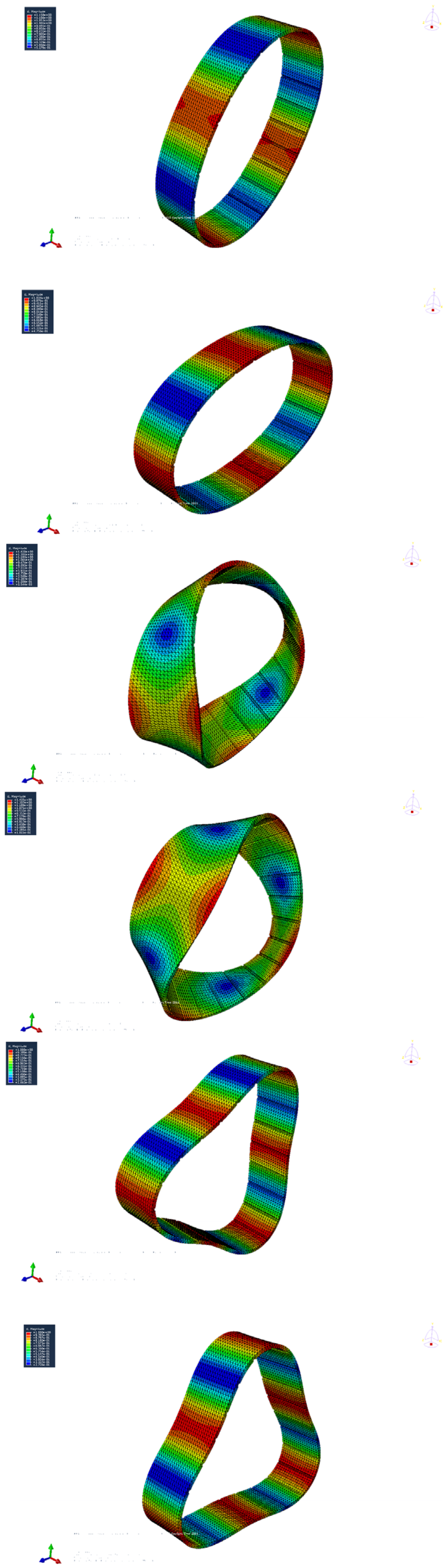

Fig. 3. Six eigenforms for flexible string

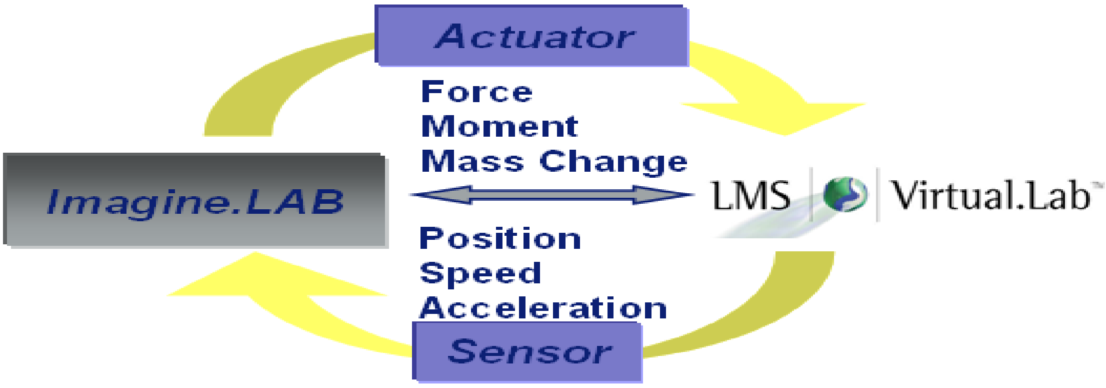

Fig. 4. Scheme of co-simulation of Virtual.Lab and Imagine.Lab models

There is a system of slots on the string and rigid rim which can be seen on fig. 1. These slots form the system of reference points to Imagine.Lab. In each point sensor and actuator are placed. Point on string and appropriate point on rigid rim form the spring - sensors obtains relative distance between points and send them to Imagine.Lab, after that reaction force value from Imagine.Lab is applied to actuators in these points.

Tire model tuning is performed in Imagine. Lab by changing spring parameters - dependencies between points relative displacement and reaction force.

3. Stiffness test results

Obtaining of vertical static force-displacement diagram is represented in fig. 5.

Comparison of resulting diagram with real test result is shown in fig.6.

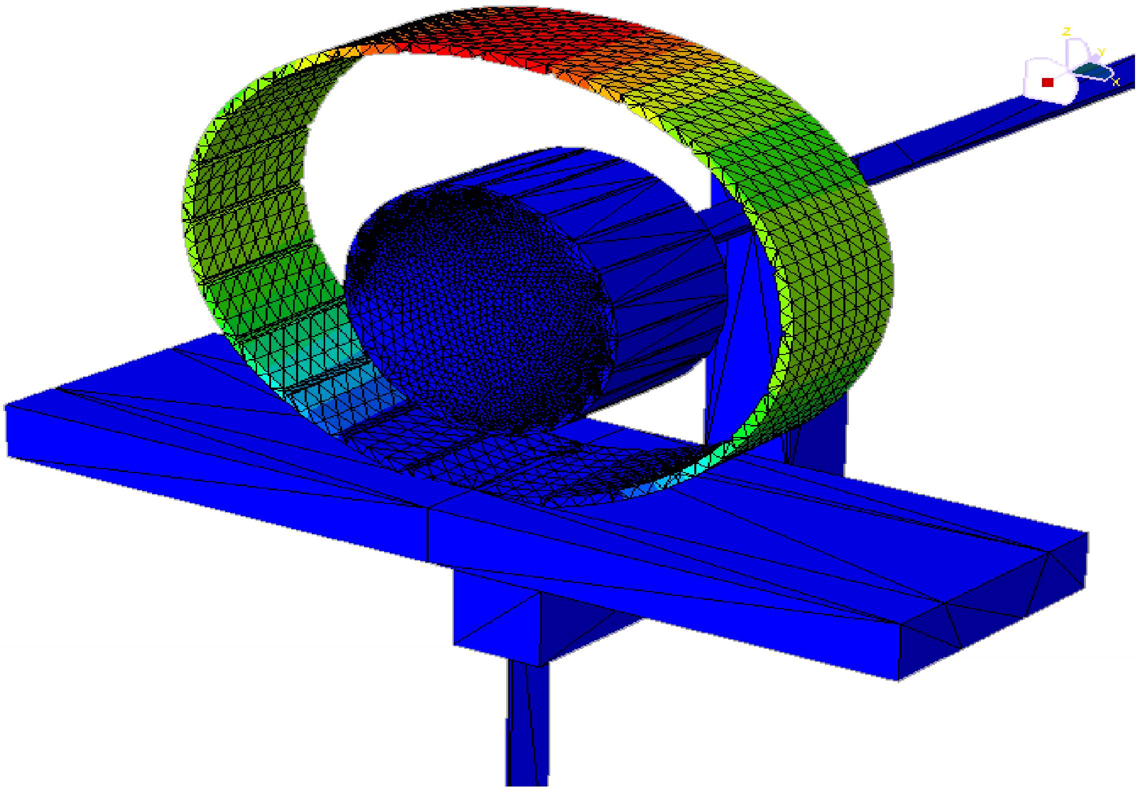

Fig. 5. Tyre vertical compression simulation

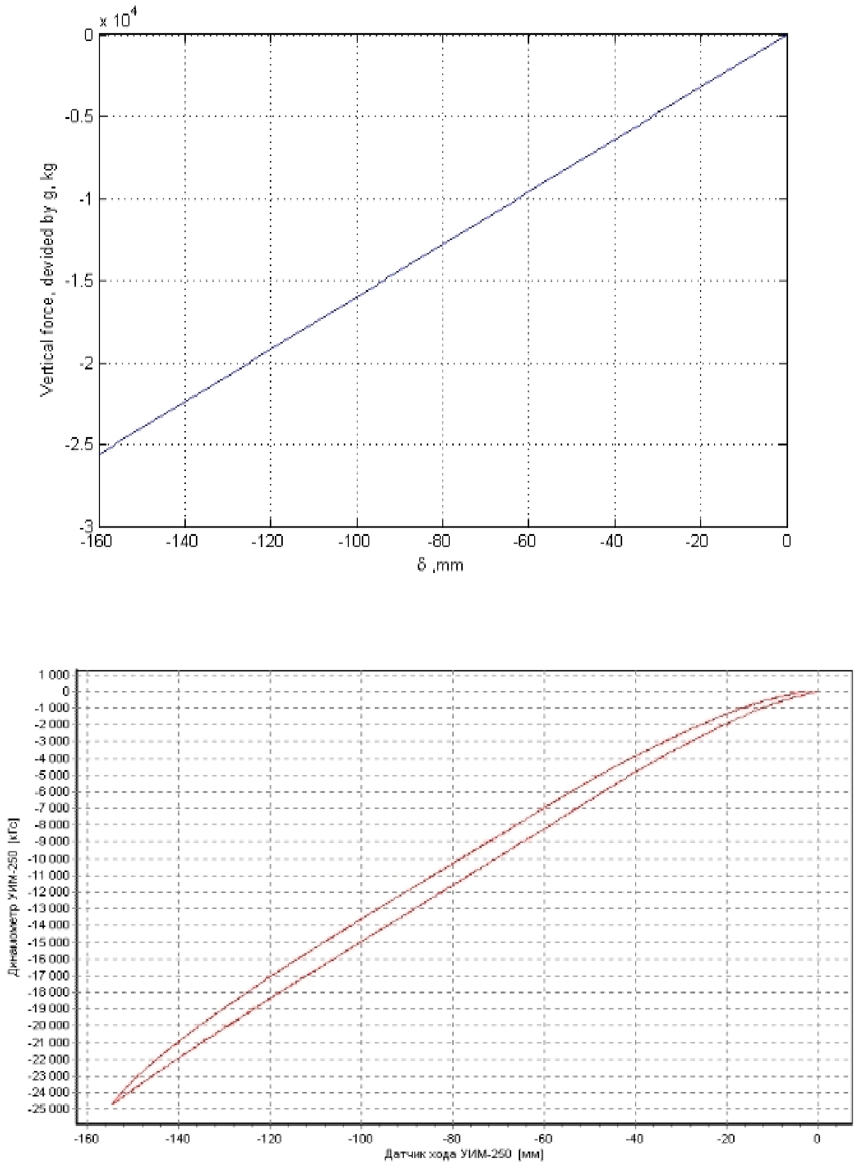

Fig. 6. Simulated data and real data of tire vertical compression

Obtaining of lateral static force-displacement diagram is represented in fig. 7.

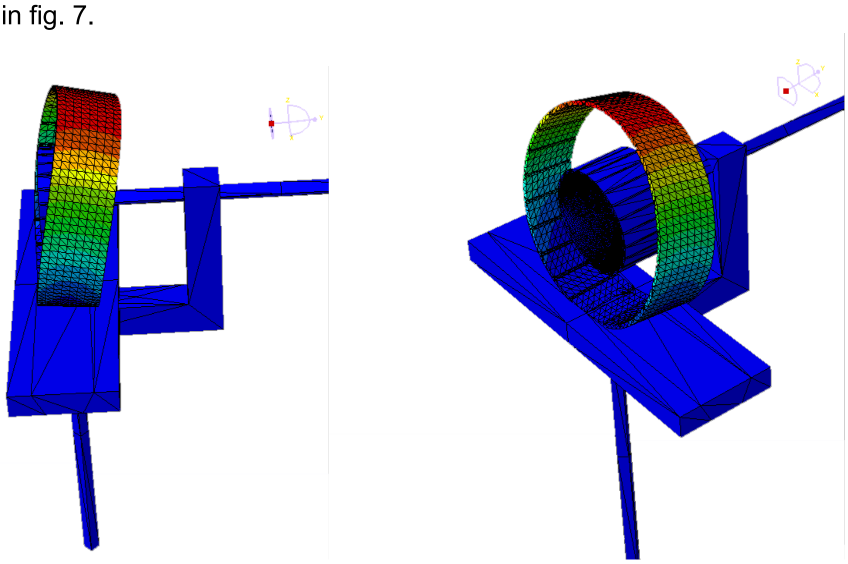

Fig. 7. Tire lateral slip simulation

Comparison of resulting diagram with real test result is shown in fig.8.

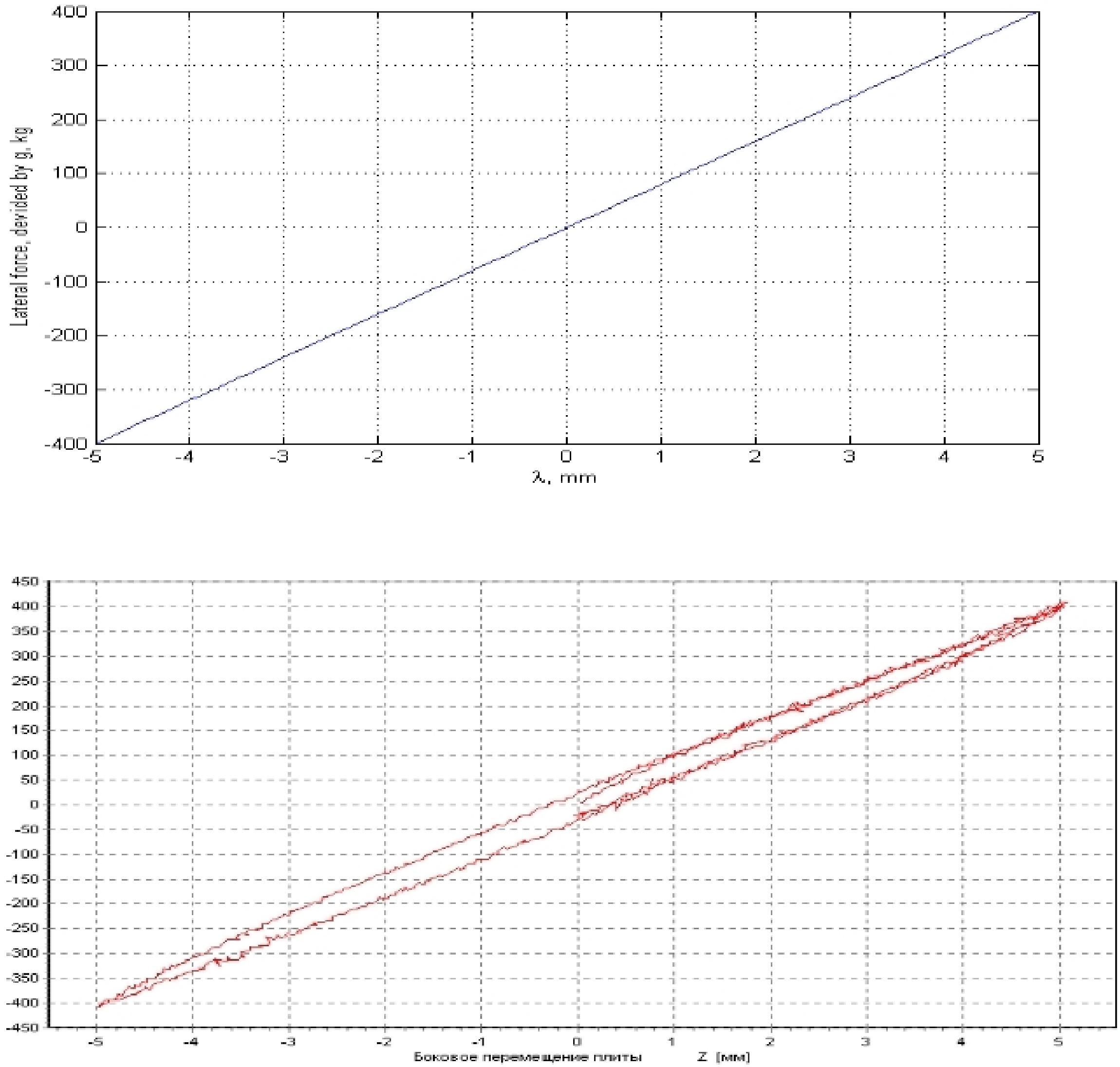

Fig. 8. Simulated data and real data of tire lateral slip

Obtaining of yaw static force-displacement diagram is represented in fig.9.

Comparison of resulting diagram with real test result is shown in fig.10.

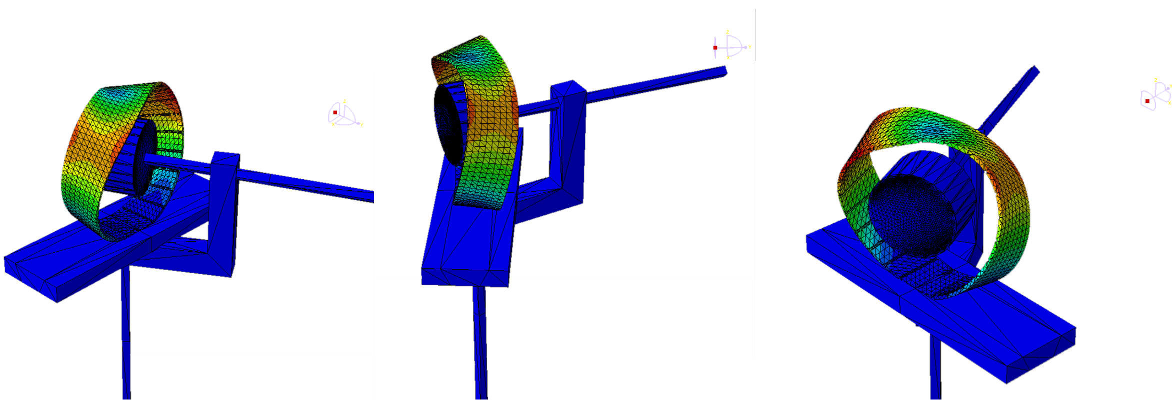

Figure 9. Tire yaw simulation

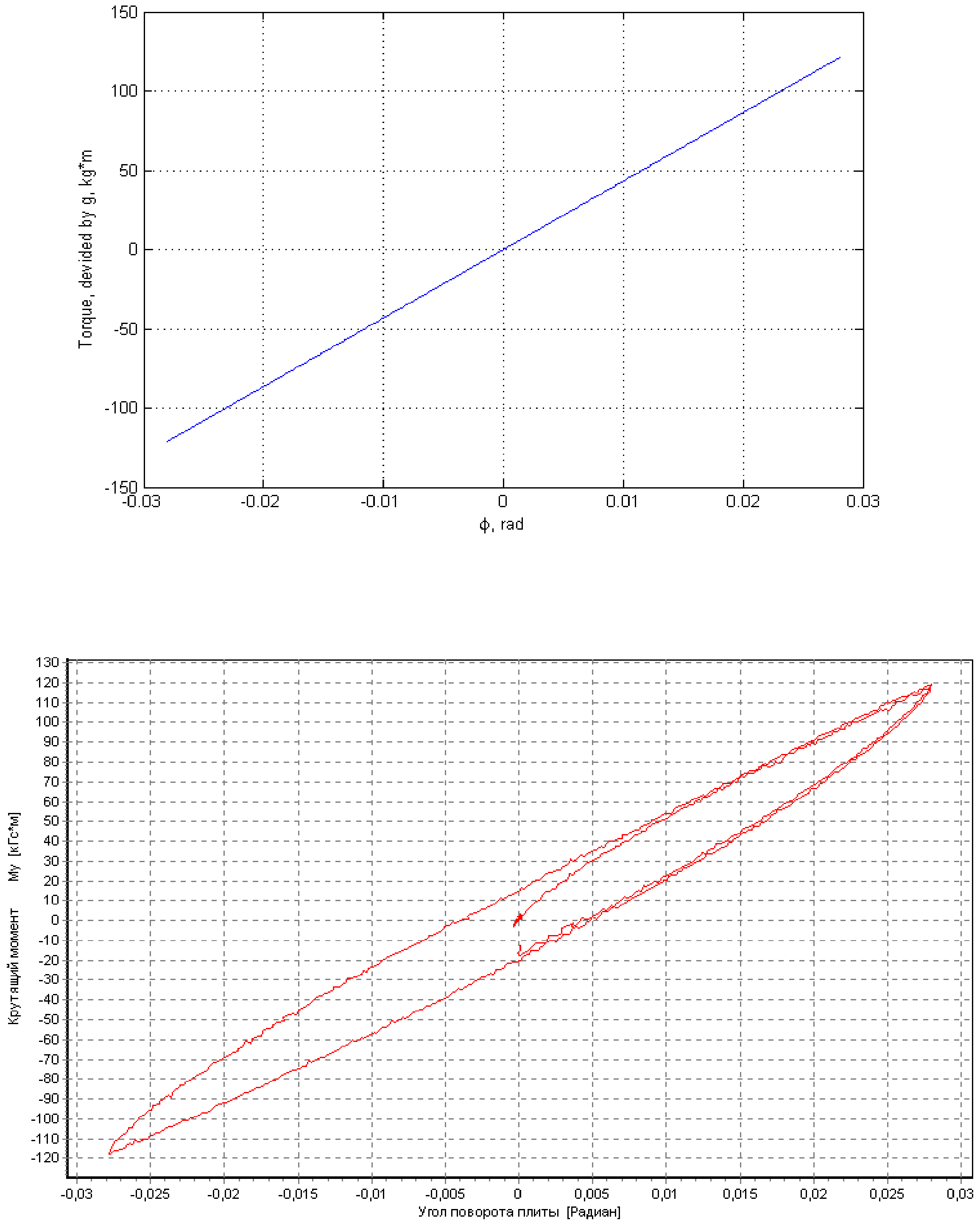

Fig. 10. Simulated data and real data of tire yaw

Conclusions

1. Stretched string tire model has confirmed it's high dynamical quality again. Created FEM virtual tire model based on stretched string principal can be simply tuned and doesn't need knowing any input parameter besides vertical force-displacement diagram. Performed virtual stiffness tests show good correlation of virtual tests data with real-life tests data.

2. It must be emphasize that LMS software complex Virtual.Lab & Imagine.Lab AMESim allows engineers and researchers using width spectrum of capabilities for fast and simple investigating complicated physical processes. Native interface from CATIA V5 makes Virtual.Lab useful and powerful aid habitual for designers and eliminates necessary of CAD models converting. Shortcomings of this package is absence of native FEM solver and CFD simulation possibilities. But opened interface

allows using a lot other name software for resolving these tasks in co-simulation mode (simultaneous simulation for example ABAQUS\CFD-Virtual.Lab co-simulation for fluid-structure interaction like flutter).

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[1] *Национальный Университет им. Т.Г. Шевченко*
[2] *Национальный технический университет Украины «Киевский политехнический институт»*

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