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Spatial Vibration of Cargo Cars in Computer Modelling with the Account of Their Inertia Properties

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Abstract

The papers describes some methods for more exact computation of the freight wagon's inertial characteristics, that is necessary for performing more exact computer simulation of the railway vehicle dynamics. Comparison of the simulation results with the test data shows the appropriate coincidence between them that confirms the mathematical model's adequacy.
KEY WORDS: *freight wagon's, inertial characteristics, computer simulation, railway vehicle dynamics.*

1. Introduction

When studying the dynamic qualities of rail vehicles and especially freight cars, an important part at generation of initial conditions necessary for mathematical and computer simulation play mass, geometrical, inertial characteristics. Though the parameters named above are connected among themselves in one way or another, inertial characteristics attract particular interest. All the more these dimensions directly participate in formation of dynamic parameters of vehicles under study [1 - 6].

In case of freight cars it is necessary to consider similar characteristics of the cargo (whether it is bulk or tare cargo) except inertial characteristics of the car [5]. This research is devoted to specification of definition methods of inertial characteristics of a car body and cargo for further use of these data in computer simulation of a car dynamics.

The primary goal of the dynamic characteristics of rail vehicles' research lies in defining of optimum values of their parameters (geometric dimensions, mass, inflexibility, etc.) at which undesirable oscillations and dynamic forces in rolling stock designs are minimized. It was preceded with solving of the task of the oscillation processes research of a car and its separate parts, criteria finding for a smoothness of movement estimation, stability against derailment, turn-over and lift of a car. The equations describing these processes include geometric and mass characteristics, and also inertial characteristics in explicit or implicit form. Hence, these parameters influence the oscillation process inevitably arising at operation of a rolling stock [2, 7].

2. Testing procedures

A model of any rail vehicle in calculations is represented in the form of concentrated mass connected by spring linkages and various oscillation dampers. In many cases to each of these mass the inertial characteristics expressed by polar or equatorial moments of inertia of any vehicle's element are given. At designing of new unit of a rolling stock these characteristics are initial in valuations of a car and rail force interaction [6].

Operation of freight cars is accompanied by shock influences at shunting operations, in train operation, with application of highly efficient cargo-handling gear. Thereof damageability of cars, number and volume of unplanned types of repair and accident risk increase. Calculations on shocks of structural assembly and elements at a design stage allow to estimate not only durability, but also reliability, and one of the most important calculations is definition of inflexibility characteristics of each structural element [4].

The increase in capacity of locomotives and brake facilities of rolling stock, load-carrying capacity of cars, mass, lengths and speeds of train movement, an intensification of shunting operations (noncompliance of cars' impact velocity) have led to increase in forces acting on a rolling stock and, as consequence, to occurrence of emergencies and contingencies. At calculations of longitudinal forces acting on cars and leading to emergencies, mass, geometric and inertial characteristics of separate elements also are used in a train dynamics [3].

A major contribution to this study was made by Professor Victor Danovich [8, 9]. Under his guidance theoretical research of dynamic parameters of certain types of cars has been carried out. These results are represented in papers on freight cars and locomotives with participation of professor Anisimov P. [10], professor Manashkin L. [3, 4, 11, 12], professor Myamlin S. [5, 13 - 16], Litvin V. [5, 17], Neduzha L. [5, 18], Shvets (Malysheva) A. [5, 19].

Inertial characteristics have been defined according to the fundamental laws of theoretical mechanics, in particular to its "Dynamics" section [20].

A car body as well as freight is represented in the form of separate body, each has its mass, dimensions and initial position in the chosen coordinate system.

Moments of inertia with respect to principle central axis of inertia are defined for each body as for unladen (for definition of dynamic parameters of an empty car), and for laden – body weight (container with freight) and a center of mass height of laden and unladen body above a bolster plane lean against a spring set. Geometric moments of inertia of each body and the area in longitudinal vertical plane and in transverse vertical plane are also defined.

After calculation initial data are formed.

The resulted inertial characteristics have been used for definition of dynamic parameters of cars. The parameters which estimate dynamic qualities of a car were the following:

- vertical and horizontal dynamics factors on sprung and unsprung parts of a car, and also on interaction forces;
- vertical and horizontal lateral accelerations of plates;
- lateral and directing forces, edge stresses;
- mutual moving of car bodies;
- wheels' wear factors;
- derailment stability factor.

Research of the given problem can be conducted by the method of mathematical simulation of freight car's spatial oscillations with a help of a software package «Wagon Dynamics (Single Wagon) 10.12.2007» [7, 21] based on Normative documents (Direction on inspection, examination and make up of wheelset) [22].

Up-to-date programming techniques have been used in the program design, in particular, an object-oriented approach to three-dimensional model of railway vehicles making. It allowed to make models almost of all types of railway vehicles without changing of the basic programs' texts. Application of an object-oriented programming methods demanded introduction of concepts "object" of vehicle and "connection". Object is any undeformed element of vehicle's design with known mass and moments of inertia with respect to its principle axis. Connection is a deformation element of a vehicle's design, weightless, used for damping of objects' relative movements. The set of connections in the program is wide enough, but can be extended if necessary depending on structural component used.

The process of the vehicle's mathematical model development is reduced to creation of an objects and connections array, setting up of their parameters and communication settings by which dynamic quality parameters of a vehicle are calculated. Convenient user interface allows to carry out these actions even by nonexpert in the three-dimensional dynamics of railway vehicle field.

For the behaviour analysis of railway vehicles in different conditions (i.e. at different types of railway track imperfections) various types of vertical and horizontal roughnesses are offered. Roughnesses can be set in the form of the determined and-or casual processes [7, 21].

For study of sensitivity of vehicles' dynamic parameters to changes of objects' inertial parameters or to changes of connections' parameters, apart from above-listed, the user can set so-called anomalies of objects or connections before calculations, types of objects and connections cannot be changed, but it is possible to change their parameters.

A longitudinal profile, a railway track plan and a roll surface profile of wheelset are considered at vehicle's movement simulation.

For performance of vehicle's movement simulation the following parameters are chosen: vehicle's model, movement district, vehicle's wheelset profile.

The following parameters are set: speed variation range, results registration step, district length where simulation of a train movement and of some other parameters will be executed (Fig. 1).

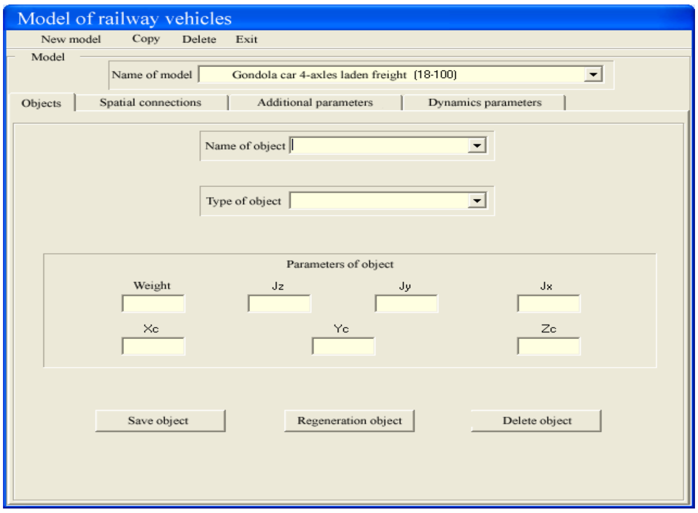

Fig. 1 The car parameters panel

Parameters of a car objects are set in the first bookmark, spatial connections between objects - in the second, additional parameters - in the third, and connections defining calculation of dynamic parameters of a car - in the fourth.

There is also an additional bookmark for the set of anomalies of objects and connections (Fig. 2).

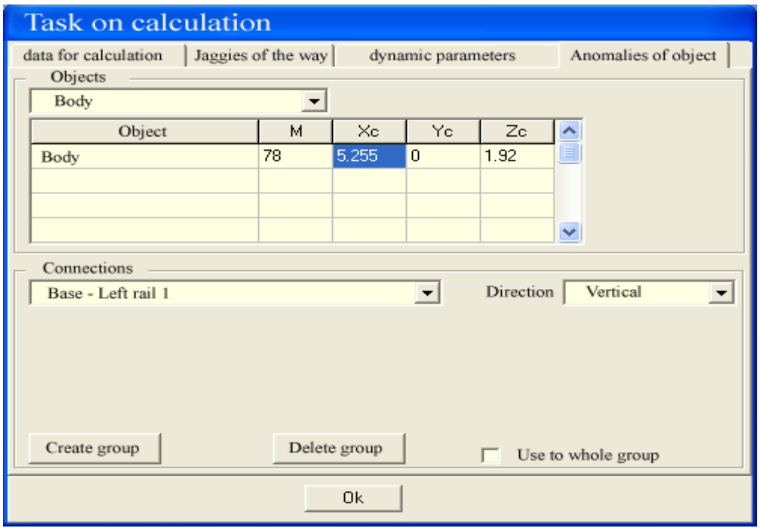

Fig. 2 Anomalies of objects set panel

Anomalies of objects or connections are changed values of the chosen parameters (for objects they are inertial parameters and center of mass coordinates, for connections they are connection parameters) in comparison with preset values in the model (Fig. 3).

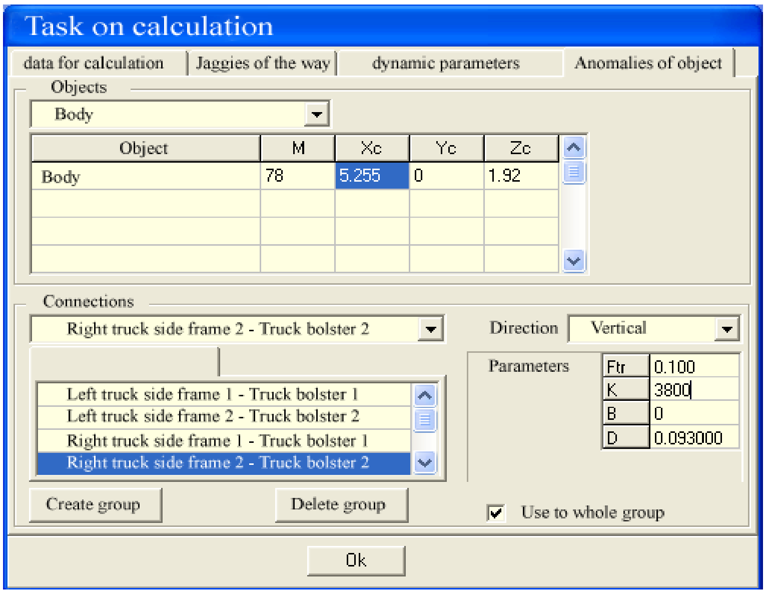

Fig. 3 Anomalies of connections set panel

For the set of objects anomalies (for example, car bodies) you should choose the needed object from the list and change values of its parameters.

For change of parameters it is necessary to choose the needed direction of connection and change the necessary parameters in the Table of parameters. The flag «Apply to all group» means that after changes the parameters of all group will be identical. If this flag is switched off it is possible to set different values of parameters for each connection of group.

If necessary it is possible to create several groups of connections and to change parameters of connections of each group, but one connection should enter only one group.

By results of calculations it is possible to make comparison of dynamic parameters of different types of freight cars to results of experimental research.

3. Conclusions

Thus, addition of mathematical models of spatial oscillations with initial data with specified inertial characteristics of cars elements and freights allows to approach results of calculations to a real condition of objects and, thereby, to improve reliability of mathematical simulation.

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