Study on the Dynamic Properties of a Long freight Wagon, from a Safety Point of View, when Running on a Track

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Abstract: Railway transport of goods represents a crucial part of the transport system in many countries. Currently, containers' intermodal transport has a significant ratio of goods transport and rail vehicles, i.e., freight wagons for intermodal transport across the border of countries. As it is an international transport means, freight wagons need to be designed to meet the operational conditions of all countries in which they are used. The presented research is focused on the investigation of the dynamic properties of a long freight wagon. This wagon is designed for intermodal transport, and it is equipped with two Y25 bogies. The research is performed using a scientific method based on multibody system dynamics. Output quantities in a wheel/rail contact, such as vertical wheel forces Q, lateral wheel forces Y and the derailment quotient Y/Q, are evaluated. Simulation computations are carried out in commercial multi-body software. A railway track model corresponds to a real track section. The results of the performed research showed that the load of the wagon equipped with the Y25 bogie significantly influences the dynamic properties of the wagon under operational conditions.

Keywords: Long freight wagon; Safety, Multibody system; Y25 bogie; Dynamics

1 Introduction

As in other areas, in the operations for rail vehicles, emphasis is placed on reducing the costs of operations, repairs and the maintenance of the operated vehicles, while simultaneously increasing their transport capacity. For this purpose, freight wagons for intermodal transport are designed [1-4]. The current trend, as well as the future tendencies in freight railway transport, is oriented toward using longer flat wagons for container transportation. It can be compared with the trends in road transport, where so-called "gigaliners", as well as semi-trailer chassis for containers are applied [5-8]. In intermodal railway transport, mainly 40ft containers and 20ft containers are used, at which, the ratio of the 40ft containers is increasing. These containers are transported within railways on adapted freight flat wagons [9-12]. A solved long 80ft wagon is equipped only with two bogies in comparison with an articulated six-axle wagon. The application of long flat wagons helps to reduce operational costs, running resistance, maintenance costs, and production costs. The idea of a four-axle 80ft long flat wagon (hereafter a long wagon) has already been applied in practice. The solved long wagon for intermodal container transport (Figure 1) includes fewer elements, and it has a lower self-weight, which leads to higher transport capacity. Additionally, the distance between center pivots, the height of the flat wagon body, loading capacity, and more friendly dynamic effects to a railway track thanks to the wagon body frame flexibility are other features that differentiate the solved long wagon from the others. The objective is to achieve an increased load capacity and reduced weight. It is considered that the wagon is equipped with a Y25 bogie, which represents a standard for freight wagons operated in Central and Eastern Europe.

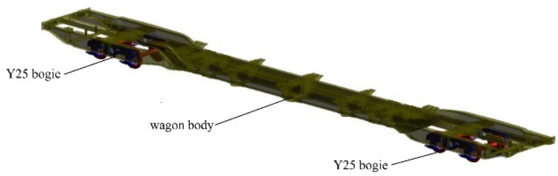


Figure 1
An illustration of the solved long wagon (a virtual model)

As it is necessary in the case of every design process, the solved long wagon is also subjected to research regarding operational properties. Safety plays a significant role in transport systems and transport infrastructure. The dynamic properties of wagons significantly affect their running safety. The approach, based on simulation computations, allows for the reduction of the costs and time needed during the development stage of a wagon. Simulation computations were also employed in the presented scientific work to research the dynamic properties of the long wagon. A multibody model (an MBS model) was created using commercial simulation software.

2 Literature Review

Research in the field of design, as well as the evaluation of dynamic properties of rail vehicles, is a subject of many scientists and researchers across many countries. It requires a constant trend of improving the safety and efficiency of rail transport. Not only all the wagons are examined, but also bogies for general and specific running modes.

The scientific work [14] is aimed at simulation analysis of a Y25 bogie. The authors created four variants of this bogie, at which point a new design of the wheelset guidance was proposed. The modes were created in the Simpack software package. The results of simulation analyses showed that a newly designed wheelset guidance with two friction Lenoir dampers and longitudinal linkages together with a torsional bar has the best results among the variants compared. However, the simulation analyses were not performed on a real track; they were only performed with a bogie, not with an entire wagon. The analyses of flat freight wagons are presented in the work [15]. There is specially designed removable equipment, which allows the transport of various kinds of containers, including 20ft and 40ft containers. Although the article is focused on a flat wagon, no mention of the dynamics when running on the railway track is made. The scientist, F. Haferkorn [16] thinks about the possibilities of high-speed freight trains in a real operation. It is proposed as a possible solution to use a Jacobs bogie for articulated flat wagons, which is in contrast with the findings presented in the introduction of this research. The authorship of the research [17] investigates negative facts that can arise during freight wagon operations, mainly longitudinal forces between buffers at emergency braking. The research does not include an investigation of a freight wagon running on a real track.

Exciting research performed by the authors N. Bosso et al. is presented in [18]. They present an application of the state-of-the-art technique, namely a digital twin, to make MBS simulations for the investigation of rail vehicle simulations easier. Although it includes modern simulation tools, the simulations were not performed for real track geometry and not for long flat freight wagons for intermodal transport of containers. N. Bosso was also a member of the research team investigating the phenomena related to freight wagons running on a track [19]. The work [20] includes an idea of the modification of a flat freight wagon by application of a basket allowing transportation of timber and containers. Despite an extensive investigation, the work does not provide a deeper view of the wagon dynamics when running on a railway track. The energy consumption of wagon running is not a negligible fact. The simulation computations with the help of MBS software are also possible to use to investigate this problem.

The authors D. Zhang et al. [21] performed the research using VI-Rail software to find a suitable position for the center of gravity of the load located on a freight wagon. Despite the interesting findings, the research has not been performed on a real railway track, allowing for the proper location of the center of gravity for a particular railway track. The article [22] is focused on exciting scientific activities of computational and experimental research of problems regarding the operation of freight wagons safety. This work does not include information about the track geometry, and, at the same time, it is not about long freight wagons. Therefore, additional information is required.

It is possible to conclude that simulation computations play an important role in the field of rail vehicle analysis. This review also shows that analyses of long freight wagons regarding their dynamics are not widely performed. It can also be stated that performing simulation analyses based on the real data of railway tracks is not a common activity among scientists and scholars. Therefore, it is worth presenting them.

3 The Main Tasks of this Research

The presented research is focused on an investigation of the dynamic properties of the long freight wagon under specific operational conditions. The main objective of the research is to provide the results of the simulation computation of the long freight wagon, which the research includes:

- Creation of the MBS model of the Y25 bogie
- Creation of the entire MBS model of the designed long freight wagon
- Creation of the railway track models for two real track sections
- Assessment of the values of the output signals of the chosen wheel/rail contact quantities, namely the vertical wheel forces *Q*, the lateral wheel forces *Y* and the derailment quotient *Y/Q*

The aim here is not to present the design solutions of the wagon but to assess the running properties under specific running conditions.

The analysis of the literature sources leads to a formulation of the following novelty of the performed research:

- The authors created the MBS model of the long freight wagon with a specific design
- The created MBS wagon is analyzed from the safety point of view of the specific railway track sections
- The simulation model includes the railway track model sections, which are set-up based on their real track geometry
- The presented values of the output quantities represent unique results, which cannot be found similarly
- The assessment of possibilities of operation of the long freight wagon on regional railway tracks, which have curves with smaller radii (the Y25 bogie has some deficiencies when running in smaller curves regarding running safety)

4 A Description of a Created Computational Model

The dynamic properties of the solved long freight wagon have been investigated using its MBS model. The Simpack software has been used for the research [14, 23, 24]. The MBS model of the Y25 bogie, as well as the entire wagon and the tracks, are described in the following subsections.

4.1 A Multibody Model of a Bogie

The Y25 bogie and its derivations are a common running gear for freight wagons operated on Central and Eastern European railway tracks [25] [26]. The Y25 bogie uses duplex coil springs between axle-boxes and a bogie frame. The wheelset base is of 1,800 mm, and the wheel diameter is 920 mm. The wagon body is connected to the bogie by a center pivot with high rigidity, and damping of the yaw movement is ensured by a pair of side-bearers [27]. The known fact about this bogie suspension system is that its load is absorbed in the vertical direction by coil springs, and the frictional force is derived by means of an inclined suspension. It is considered that the bogie has an axle load of 22.5 t. The MBS model of the bogie created in the Simpack software is shown in Figure 2. This model comes from the Y25Ls1-K bogie model, which mass is of 4.5 t and a wheel diameter is of 920 mm. Individual components of the MBS bogie model are marked, and they are as follows: 1 - wheelsets, 2 - bogie frame, 3 – axle-boxes, 4 - coil springs, 5 - side bearers, 6 - a center pivot, 7 - rails.

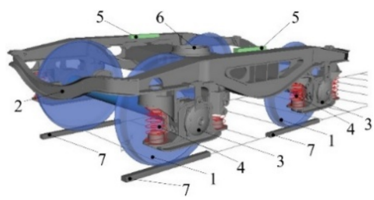
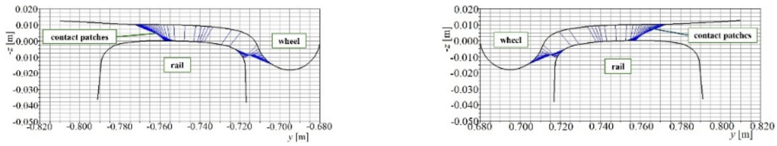


Figure 2
The Y25 bogie model created in the Simpack software

The friction damper of the bogie (also called a Lenoir link) is the key factor in creating a proper model of the bogie suspension system. The frictional forces in the used friction damper are described by Coulomb's law [15] [28]. The MBS bogie model consists of rigid bodies, including two wheelsets, four axle-boxes and one bogie frame. The wheel/rail contact model [29] [30] is an important modeling element that seriously influences the plausibility of the results. It is also defined in the bogie model. The FASTSIM algorithm was defined for the analyzed wagon bogie model. This approach is widely applied for the calculation of the wheel/rail contact forces [31-34].

The Simpack software has a built-in wheel/rail contact modeling element, which calculates the vertical wheel forces, the lateral wheel forces and the derailment quotient. It also allows the calculation of complicated tasks of wheel/rail contact, e.g., in switches, railway track transition sections, etc. [35-38]. Figure 3 depicts the geometrical couple of the wheel/rail contact. The wheel profile is S1002, and the rail profile is UIC60.



(a) (b)

Figure 3

An illustration of the wheel/rail contact points: (a) on the left side; (b) on the right side

4.2 A Model of a Long Freight Wagon

A virtual model of the long wagon consists of three subsystems: the body of the wagon, and two bogies, and this approach can be found as a standard way for evaluating wagon dynamics [39-43].

A simplified dynamic scheme of the solved freight wagon for vertical oscillation is shown in Figure 4. The wagon base was considered to be 18200 mm and the console at 4150 mm. Individual items mark the main components of the wagon model, which are as follows: 1 - wheelsets, 2 - bogies frames, 3 - a half of the wagon body, 4 - viscous-elastic coupling between wheelsets and bogies, i.e., coil duplex springs and a friction damper, 5 - viscous-elastic coupling between bogies and wagon body (a center pivot and side bearers). As seen in Figure 4, the used computational model consists of rigid bodies, which are connected by means of massless viscous-damping elements. These elements include mainly springs and dampers. The individual components are as follows: k_p is the stiffness of the primary suspension, b_p is the damping in for the friction damper used in the Y25 bogie, k_s is the stiffness of the secondary suspension and b_s is the damping of the secondary suspension. However, the term "secondary suspension" is not exact. The mass and inertia parameters of the wagon (Figure 4) are as follows: m_{b1}, m_{b2} are masses of bogie frames, $I_{b\varphi 1}$, $I_{b\varphi 2}$ are moments of inertia of the bogie frames for the lateral axes and $I_{b\psi 1}$, $I_{b\psi 2}$ are moments of inertia of the bogie frames regarding the longitudinal axes.

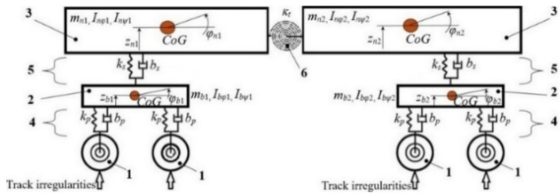


Figure 4
A simplified dynamic scheme of a long freight wagon when vertical oscillation

Side bearers of the Y25 bogie are located on the bogie frame top together with the center pivot. The center pivot has a semi-sphere shape, and it is padded with a special plastic pad with high stiffness. The rest of the marks indicate the center of gravities of individual bodies (CoG) and generalized coordinates, which are vertical movements of the bogie frames and wagon body z_{b1}, z_{b2}, z_{n1} and z_{n2}, respectively, and angular movements of these bodies φ_{b1}, φ_{b2}, φ_{n1}, φ_{n2}. It is not necessary to derive a mathematical model of the wagon. On the one hand, it would not be so easy, and on the other hand, the multibody software used derivates the computational model automatically based on the user's definitions in the software interface. In principle, the mathematical model consists of equations of motion in the known form:

$$\boldsymbol{M} \cdot \ddot{\boldsymbol{z}} + \boldsymbol{B} \cdot \dot{\boldsymbol{z}} + \boldsymbol{K} \cdot \boldsymbol{z} = \boldsymbol{Q} \quad (1)$$

where $\boldsymbol{M}$ is the mass matrix, $\boldsymbol{B}$ is the damping matrix, $\boldsymbol{K}$ is the stiffness matrix, $\ddot{\boldsymbol{z}}$, $\dot{\boldsymbol{z}}$, $\boldsymbol{z}$ is the vector of accelerations, velocities and deflections, respectively, and $\boldsymbol{Q}$ is the vector of external loads. In the case of a wagon running on a track, the $\boldsymbol{Q}$ vector usually includes the excitation forces due to track irregularities.

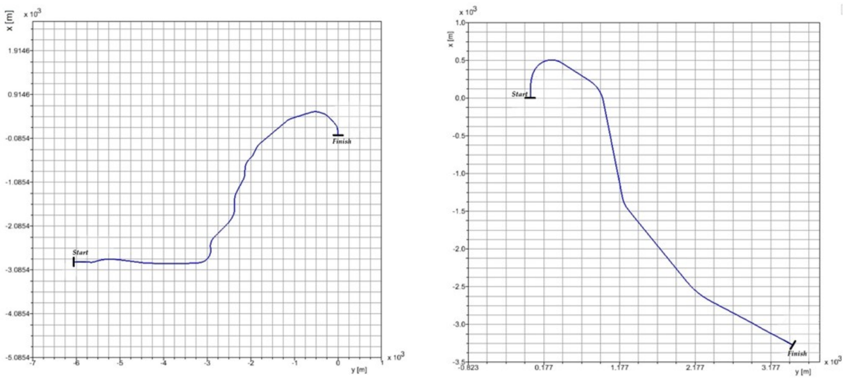
For the purposes of dynamic analysis of freight wagons running on a real track and comparison of outputs, empty and loaded wagon models were created. These load cases were considered when two containers with a length of 40 feet were loaded on the wagon. The body of the wagon is made up of two separate bodies, which in the central part are connected by a rotational link with one degree of freedom (around the x axis) and applied torsional stiffness. Figure 5a shows the wagon body of the long freight wagon in an empty state, and Figure 5b depicts the freight wagon in a fully loaded state.

(a) (b)

Figure 5
A 3D model of the long wagon model: (a) The empty state; (b) The loaded state

4.3 A Model of the Railway Track Sections

Two railway track sections have been chosen for the dynamic analysis of the solved long freight wagon. These railway track sections correspond to two real railway track sections in the Slovak Republic. These sections are as follows: the railway track between Prievidza–Chrenovec will be hereinafter Track A, and the railway track between Šurany–Úľany and Žitavou will be hereinafter Track B. Track A has the total length of 7500 m and the total length of the Track B is almost 5850 m. Figure 6a shows the horizontal geometry of Track A, and Figure 6b depicts the horizontal geometry of Track B. The running speed was set up to the average value permitted in these sections, i.e., 60 km/h.



(a) (b)

Figure 6

The geometries of the railway track in the horizontal plane: (a) the Track A; (b) the Track B

Since sections with different radii of curves and the resulting sections in transitions and ramps, as well as straight sections, occur on this track, the track is suitable for performing dynamic analyses and for assessing derailment safety. Further, the track model consisted of two rails with a UIC60 profile and a slope of 1:40. The track can be modeled with or without irregularities [44] [45]. In most cases, track irregularities are defined as the variance of values between the theoretical and real rail profile, i.e., measured irregularities of a track [46-48]. The track in the research was modelled as a rigid railway track with defined measured track irregularities. The irregularities deviations were defined with a step of 0.5 m.

5 Results of Simulation Computations

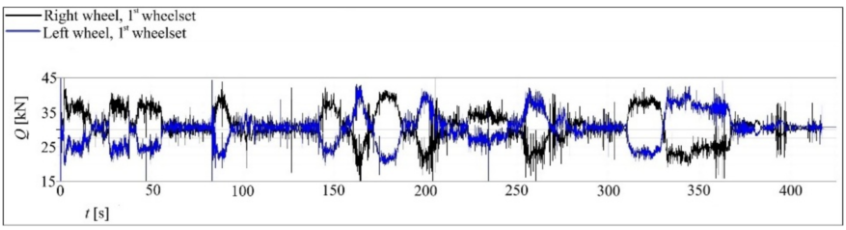
A long freight wagon is assessed in terms of dynamics using the established criteria. In Europe, there are mainly UIC (International Railway Union) regulations and also new European standards [49] [50].

The evaluation of the obtained results is focused on the assessment of three main quantities, namely vertical wheel forces Q, lateral wheel forces Y and derailment quotient Y/Q. The safety of a rail vehicle is assessed from the safety point of view. This comes from the Nadal criterion [49] [50] as follows:

$$\left(\frac{Y}{Q}\right)_{crit} = \frac{\tan(\varphi - f)}{1 + f \cdot \tan\varphi} \tag{2}$$

where φ is the wheel/rail angle contact, and f is the wheel/rail friction coefficient. The determined limit value of this ratio depends on the curve radius [49-51]. For radii $R > 250$ m, a limit value of 0.8 applies on a two-meter section, and a limit value of 1.2 applies for smaller curve radii. All the conditions that must be met by a wagon to be put into operation are listed in the relevant standards UIC 518, TSI and STN EN 14363 [49, 50, 52, 53]. It should be noted, that the results of the dynamic analyses are shown for the first wheelset in the running direction. This wheelset was chosen, because its dynamic response is crucial regarding to the evaluation of the dynamic properties of a wagon running.

The results of the dynamic analyses of the long freight wagon running on Track A are presented in Figs. 7 and 8. Figure 7 includes the waveforms of the output quantities signals for the empty state and Figure 8 for the loaded state of the wagon.



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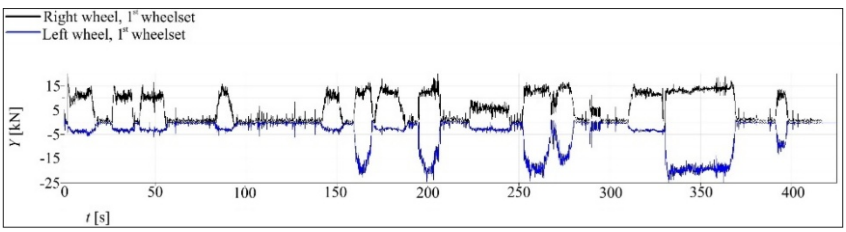

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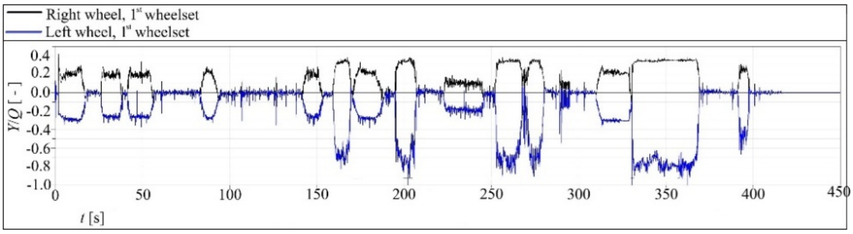
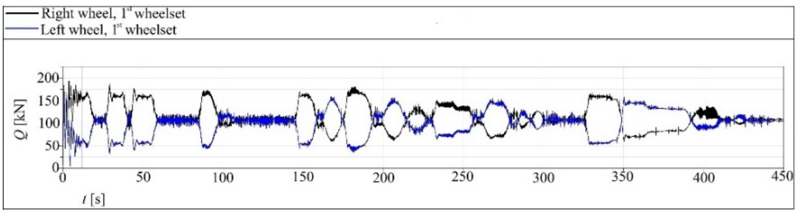


c)

Figure 7

Waveforms of the signals of the output quantities for the empty long freight wagon, Track A: (a) the vertical wheel forces *Q*, (b) the lateral wheel forces *Y*, (c) The derailment quotient *Y/Q*

Moreover, these figures consist of three graphical outputs. Part "a" belongs to the vertical wheel forces signals *Q*, part "b" for the lateral wheel forces signals *Y* and part "c" for the signals of the derailment quotient *Y/Q*. The total computation time of the simulation was 450 s. The sampling rate was chosen as 200 Hz. The waveforms of the vertical wheel forces (Figure 7a) are presented as follows: Track A includes several curves with various radii. As it can be seen, the forces increase in curves. It is caused by the centrifugal effects of the wagon running in these curves.



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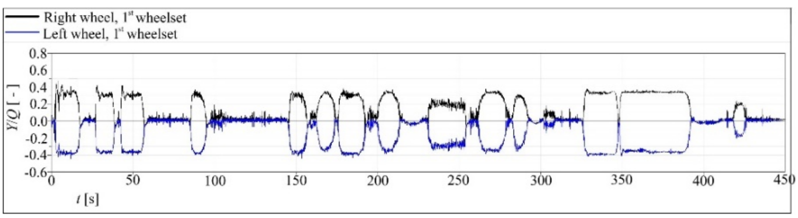

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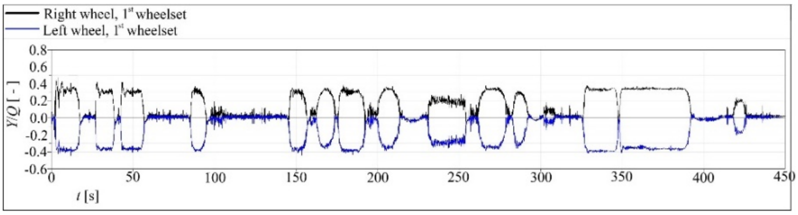


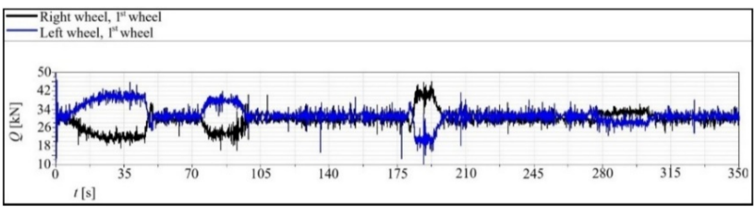
c)

Figure 8

Waveforms of the signals of the output quantities for the loaded long freight wagon, Track A: (a) the vertical wheel forces Q, (b) the lateral wheel forces Y, (c) The derailment quotient Y/Q

Further, in the straight sections, the vertical wheel force signals correspond to the gravitational load of the wagon. When the curves of the vertical wheel forces Q in the empty state are compared with the lateral wheel forces Y (Figure 7b) of with the derailment quotient Y/Q (Figure 7c), it is evident that these forces vary with high frequency ("fringed waveforms"). It is caused by track irregularities. The lateral wheel forces also increase in curves, either positive or negative values, due to the centrifugal effect of the wagon running. Indeed, these values are higher in curves with smaller curve radii. In the straight track section, the values of lateral wheel forces are sufficiently small. Finally, the derailment quotient Y/Q can be checked in Figure 7c. The objective is to compare the achieved values with the permissible value (described above in this section). It is found that the values of the Y/Q ratio exceed the permissible value of 0.8 in four curves (time intervals 190 to 210 s, 260 to 280 s and 325 to 370 s). The results of the output quantities signal for the loaded state of the wagon are presented in Figure 8. As it is identified, the waveforms of the vertical wheel forces Q have smaller amplitudes (Figure 8a). It is explained by the design of the friction damper used in the Y25 bogie. The damping force of this damper depends on the loading of the wagon. The waveforms of the lateral wheel forces signal Y correspond to the findings commented above (Figure 8b). A more interesting fact can be identified in Figure 8c, where the derailment ratio Y/Q for the load wagon is shown. The values for the loaded wagon do not exceed the maximal permissible value of 0.8, which is more favorable than the previous case of the empty wagon running.

The results of the simulation computation of the long freight wagon running on Track B are presented in Figure 9 and Figure 10.



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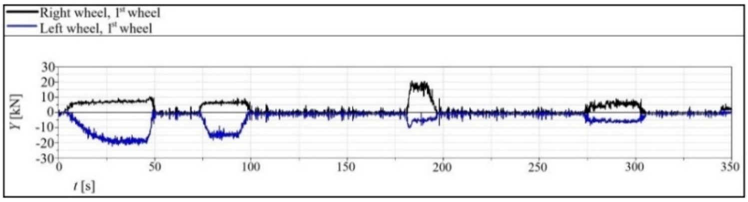

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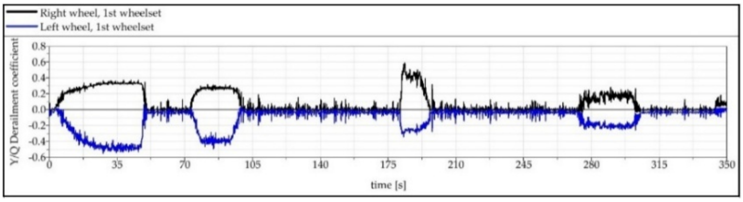
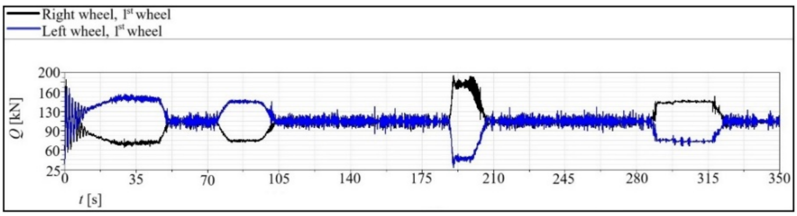


c)

Figure 9

Waveforms of the signals of the output quantities for the empty long freight wagon, Track B: (a) the vertical wheel forces Q, (b) the lateral wheel forces Y, (c) The derailment quotient Y/Q

As it can be seen in Figure 9, which includes the results for the empty wagon, the vertical wheel forces again change their values in curves due to the centrifugal effects. It is confirmed that the friction damper of the Y25 bogie of the loaded wagon has better damping effects (Figure 10a) in comparison with the empty wagon (Figure 9a). The lateral wheel forces have similar tendencies, i.e., they increase in curves, and the straight track sections have small values.



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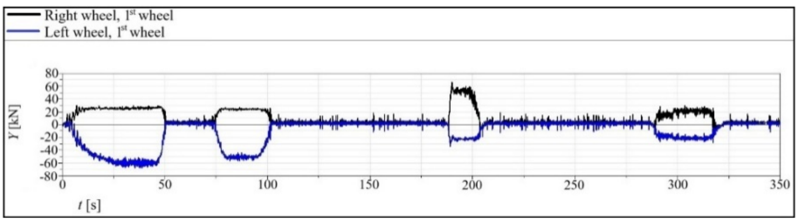

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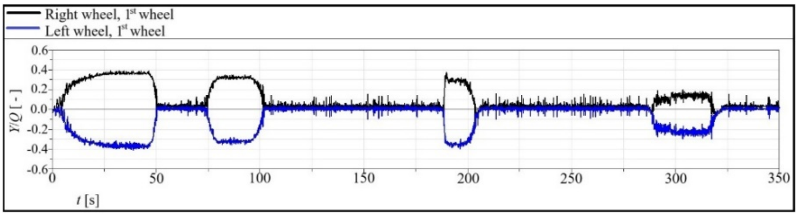

c)

Figure 10

Waveforms of the signals of the output quantities for the loaded long freight wagon, Track B: (a) the vertical wheel forces *Q*, (b) the lateral wheel forces *Y*, (c) The derailment quotient *Y*/*Q*

From the safety point of view, the assessment of the derailment ratio *Y*/*Q* is important (Figure 9c and 10c).

In the case of Track B, both empty wagon and loaded wagon run through the entire track length within the permissible derailment quotient value. It means that the freight wagon running on Track B is safe regardless of the loading conditions.

6 Findings and Discussion

The main objective of this research was to investigate the dynamic properties of long freight wagons by means of simulation computations. This was designed to assess whether the designed long freight wagon can operate not only on main railway corridors, but also on regional tracks. Simulation computations represent a robust tool to identify safety conditions without the need for expensive and time-consuming experiments. The approach of the simulation computations belongs to the scientific method to investigate the wagon dynamics and the response of the rail vehicle under operational conditions. It can even be applied as a method for commissioning rail vehicles for operation. The performed simulation computations revealed interesting facts, which helped to define a real operation of the investigated type of freight wagon on the particular railway tracks.

The values obtained for the vertical wheel force *Q*, lateral wheel forces *Y*, and the derailment quotient *Y*/*Q* are depicted in the form of graphical outputs. These values are important for the evaluation of the dynamic response of the investigated long freight wagon, and they determine the operational safety of the wagon. The assessment of the investigated freight wagon dynamics comes from the quantitative evaluation of the achieved results. Figure 7a and Figure 8a show the results of the vertical wheel forces of the empty and loaded wagon are shown. The maximal value of the vertical wheel force for the empty wagon is 43.8 kN (Figure 7a), and it is for the seventh curve (time interval of 160 s to 170 s).

The straight track section load corresponds to the gravitational force of the empty wagon, i.e., 31.75 kN. This is clearly visible for the time interval of 65 s to 80 s and further for the time interval of 115 s to 135 s. As it is considered that the center of gravity is in the longitudinal plane of the wagon, the vertical wheel forces of the right and left wheels overlap.

When we look at the results of the vertical wheel forces Q of the loaded wagon (Figure 8a), the waveforms do not have such high amplitudes. It is caused by the operational principle of the friction damper, whose damping force depends on its vertical load [28] [53]. The maximal values of the vertical wheel forces are over 200 kN, and they are detected in the first curve of the track. The gravitational load of the wheels (i.e., also of the railway track) is 115 kN in the straight track sections.

The operation of the long freight wagon on Track B shows similar tendencies regarding the waveforms of the vertical wheel forces. The maximal value for the empty wagon is 46 kN, and it is in the time interval of 180 s to 192 s (Figure 9a). Just like on Track A, the higher load of the wagon means smaller amplitudes of the vertical wheel forces and lower dynamical effects of the wagon running on the track. The maximal value of the loaded wagon running on Track B is 192 kN for the same time interval.

In principle, the lateral wheel force Y represents the lateral reaction of the wheel/rail couple to the centrifugal effects of the wagon running in curves. Of course, these forces also depend on the wagon load. Their waveforms are shown in Figure 7b and Figure 8b for Track A and in Figure 9b and Figure 10b for Track B. The highest value was detected for the loaded wagon on Track B, and it is 70 kN (the absolute value) in the first curve (Figure 10b, time interval of 25 s to 45 s)

The derailment quotient Y/Q is the most important output quantity from the safety point of view. It expresses a ratio of the safe operation of the wagon on the track under the given conditions. This value is observed along the entire tracks' sections, and it is compared with the permissible one. The maximal value of the Y/Q quotient for Track A and the empty wagon is over 0.93. This value, in combination with the curve radius, is not acceptable. When the waveform for the loaded wagon is checked, it can be seen that the maximal calculated value is lower, and it reaches the value of 0.62, which is fully acceptable.

The different situation is for Track B when the empty wagon runs through curves. The maximal value of the Y/Q ratio is 0.58 in the first curve, i.e., a time interval of 25 s to 55 s (Figure 9c). The maximal value of the Y/Q ratio for the loaded wagon is up to the value of 0.4. Therefore, it is acceptable for the wagon to be operated safely on this track.

The main limitations of the research consists in the used model. The model of wagon was created by rigid bodies. Therefore, the main prospect of the future research will focus on investigating other additional phenomena regarding modeling and simulations. There are efforts to create a flexible MBS model of the wagon. This means that the wagon body would be created as a flexible body and subsequently imported into the MBS software. It is assumed that such a model will better simulate a wagon's behavior under operational conditions. Further, the current research considered only fully loaded containers and empty containers. Although it makes sense because these load cases represent extreme loading conditions, it will be suitable to find out the limits for a minimal load of containers to ensure safe running on the tracks. Other activities will be aimed at analyses of the solved long freight wagon on other railway tracks. Moreover, there is consideration, that a flexible railway track foundation will be defined in the multibody simulations. In this way, the described limitation of the current study will be reduced and the research will better reflect actual operational conditions.

Conclusions

Computer simulation is currently a very widespread and modern way of analyzing the dynamic properties of railway vehicles. The analysis of the dynamics of wagon motion is a complex issue that uses the tools and methods of mechanics, mathematics, material engineering, and engineering technology in its solution while adhering to the principles of modern construction applied to the field of railway vehicles. Simulation calculations represent a robust way through which adequate information can be obtained for several questions arising from the increasing demands on rail transport while observing the principles and conditions belonging to technical standards before this information is obtained as a result of operation.

In this research, the running characteristics of the long freight wagon equipped with the Y25 bogie were evaluated. The evaluated parameters were the vertical wheel forces Q, the lateral wheel forces Y and the resulting important monitored criterion - derailment safety quotient Y/Q. These parameters were evaluated for an empty wagon and a loaded freight wagon, running on two selected real railway track sections. The track irregularities were also applied to the track model. The given tasks were solved, and achieved the following goals:

- The multibody model of the long freight wagon, including the multibody model of the Y25 bogie was created
- The multibody model of the real two railway track sections was created, including track irregularities
- Simulation computations of the long freight wagon were performed for empty and loaded wagon conditions
- Evaluated the selected output signals of the quantities measured in the wheel/rail contact, namely vertical wheel forces, lateral wheel forces and the derailment quotient
- An empty wagon had dangerous running properties, while running on the railway Track A in the empty state
- The rest of the examined cases were accepted for real operations

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