INVESTIGATION OF DYNAMIC CHARACTERISTICS OF GONDOLA CARS ON PERSPECTIVE BOGIES

Purpose. In this paper, it is necessary to examine the dynamic properties of the gondola car with bogies, model 18-1711 when it moves on straight and curved sections of a track. Methodology. The calculations were performed using the object-oriented programming on the program "Dynamics of Rail Vehicles" ("DYNRAIL" Myamlin S.V. registered 20.03.2003). Mathematical models of a gondola car and bogies 18-100 and 18-711 were created for the calculations. Findings. Dynamic performances comparison of the gondola car with bogies 18-1711 and the gondola car with bogies 18-100, obtained by calculation method was carried out. Originality. Firstly calculations in order to determine the dynamic properties of the gondola car with bogies 18-1711 when it moves on straight and curved sections of track were performed. At the same time an assessment of the dynamic characteristics of the gondola car was made. The following dynamic standards were determined: the coefficient of vertical dynamics (Cdv), the coefficient of horizontal dynamics (Cdh), and the safety factor against derailment (SFd). Track irregularities in vertical and horizontal transverse planes were assigned as perturbations. They should be so that the dynamic indexes of the widely used in operation gondola car on bogies model 18-100 keep in admissible range of speeds up to 80km / h for the empty gondola car and at speeds up to 90km / h for the loaded gondola cars. Practical value. As a result of the calculations and comparisons of their results, we have findings that the use of bogies with bilinear characteristic of the central suspension will improve the dynamic performances of gondola cars, currently operating on bogies, model 18-100. And by improving the dynamic performances it is possible to increase the permissible speeds of these cars motion.

Keywords: dynamic qualities of gondola car; bogie of the model 18-1711; dynamic performances of gondola car

Introduction

The design of cars improvement and increase of train speeds requires solution of a question concerning safety in operating, reliability of rolling stock and a track. In seeking to resolve such matter the important factor is operations on modernization of existing ones and creation of new structures of a truck. Dynamic and strength qualities of cars in general depend on their workability.

These requirements were the basis for the development of a new freight bogie, model 18-1711 with increased axle load [3, 7].

The bogie 18-1711 is a three-element structure consisting of two side frames and a bolster. In the bogie the central bilinear suspension and friction wedge-type shock absorbers of spatial actions were implemented.

One of the bogie 18-1711 features is the presence of elastic coupling between the side frames and wheel sets implementing through the herringbone absorber that works in all three planes. Therefore, the bogie 18-1711 can be considered as having two stages of suspension.

Purpose

The aim of this work is the dynamic properties research of the gondola car with bogies, model 18-1711 when it moves on straight and curved sections of a track and their comparison with the dynamic qualities of the gondola car with bogies, model 18-100. Results comparison of such calculations will determine the direction of scientific research in order to improve the dynamic qualities of gondola cars.

Methodology

A mathematical model of bogies, model 18-1711 was built in this study. The dynamic characteris-
Dynamics of the gondola car in empty and loaded state, when it is installed on these trucks were determined too [1, 2].

Dynamic properties determination of gondola cars with bogies 18-1711 was performed during its movement on straight and curved sections of a track. At the same time the dynamic characteristics evaluation of the gondola cars was carried out according to the following regulatory dynamic parameters: coefficient of vertical dynamics (Cvd), the coefficient of horizontal dynamics (Cdh), the safety factor against derailment (SFd) [4, 5].

For the calculations a typical gondola car with the following inertia characteristics was chosen (table 1).

Table 1

<table>
<thead>
<tr>
<th>Object</th>
<th>Weight [t]</th>
<th>Moments of inertia [t · m²]</th>
<th>Coordinates of the center of mass [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Jz</td>
<td>Jy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basis</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bogie 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left rail 1</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right rail 1</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wheelset 1</td>
<td>1,37</td>
<td>1</td>
<td>0,1</td>
</tr>
<tr>
<td>Left rail 2</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right rail 2</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wheelset 2</td>
<td>1,37</td>
<td>1</td>
<td>0,1</td>
</tr>
<tr>
<td>The left side frame 1</td>
<td>0,68</td>
<td>0,22</td>
<td>0,22</td>
</tr>
<tr>
<td>The right side frame 1</td>
<td>0,68</td>
<td>0,22</td>
<td>0,22</td>
</tr>
<tr>
<td>Bogie-bolster 1</td>
<td>0,45</td>
<td>0,3</td>
<td>0,05</td>
</tr>
<tr>
<td>Bodie 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left rail 3</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right rail 3</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wheelset 3</td>
<td>1,37</td>
<td>1</td>
<td>0,1</td>
</tr>
<tr>
<td>Left rail 4</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right rail 4</td>
<td>0,5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wheelset 4</td>
<td>1,37</td>
<td>1</td>
<td>0,1</td>
</tr>
<tr>
<td>The left side frame 2</td>
<td>0,68</td>
<td>0,22</td>
<td>0,22</td>
</tr>
<tr>
<td>The right side frame 2</td>
<td>0,68</td>
<td>0,22</td>
<td>0,22</td>
</tr>
<tr>
<td>Bogiebolster 2</td>
<td>0,45</td>
<td>0,3</td>
<td>0,05</td>
</tr>
</tbody>
</table>

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Fig. 1. Dependence graphs of the dynamic parameters of the empty gondola car on the speed movement (Direct):

- \(a\) – coefficients of the vertical dynamics;
- \(b\) – coefficients of the horizontal dynamics;
- \(c\) – the safety factor
Fig. 2. Dependence graphs of the dynamic parameters of the empty gondola car on the speed movement (Curve 600 m):

- a – coefficients of vertical dynamics;
- b – coefficients of the horizontal dynamics;
- c – the safety factor
Fig. 3. Dependence graphs of the dynamic parameters of the empty gondola car on the speed movement (Curve 300 m):  
\( a \) – coefficients of vertical dynamics;  
\( b \) – coefficients of the horizontal dynamics;  
\( c \) – the safety factor
Fig. 4. Dependence graphs of the dynamic parameters of the loaded gondola car on the speed movement (Direct):

\( a \) – coefficients of vertical dynamics; \( b \) – coefficients of the horizontal dynamics; \( c \) – the safety factor.
Fig. 5. Dynamic indexes of the loaded gondola car (Curve 600 m)

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Фіг. 6. Залежність гідографів динамічних параметрів гондоли вагона від швидкості руху (Крива 600 м): 

а – коефіцієнти вертикальної динаміки; 
б – коефіцієнти горизонтальної динаміки; 
в – західний коефіцієнт

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Maximum permissible values of determined dynamic parameters for gondola cars with bogies having over axle box suspension are presented in the Table 2.

**Table 2**

<table>
<thead>
<tr>
<th>Index value</th>
<th>Empty</th>
<th>Loaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of vertical dynamics ($C_{dv}$)</td>
<td>0,95</td>
<td>0,8</td>
</tr>
<tr>
<td>Frame strength (fs)</td>
<td>0,4</td>
<td>0,38</td>
</tr>
<tr>
<td>Safety factor (SF)</td>
<td>1,4</td>
<td>1,4</td>
</tr>
</tbody>
</table>

The calculations were performed using the object-oriented programming on the program "Dynamics of Rail Vehicles" ("DYNRAIL" Myamlin S. V. registered 20.03.2003). Mathematical models of a gondola car and bogies 18-100 and 18-711 were created for the calculations [6, 8, 9].

In order to compare the obtained results calculations were performed for gondola cars on bogies of the typical model 18-100 and new bogie 18-1711.

Track irregularities in vertical and horizontal transverse planes were assigned as perturbations. They should be so that the dynamic indexes, of the widely used in operation gondola cars on bogies, model 18-100 keep in admissible range of speeds up to 80 km/h for the empty gondola car and at speeds up to 90 km/h for the loaded gondola cars.

Next, movement simulation of empty and loaded cars on straight and curved section of a track with middle (600 m) and small (300 m) radii with the above mentioned irregularities of tracks was carried out. The results of these calculations will be used as reference values for comparison of them with the results for the gondola car on the bogies, model 18-1711 [10-14].

**Findings**

In all the figures the results for cars on bogies 18-100 are shown by the line with a triangular marker and for cars on bogies 18-1711 – by the line with rhomboid markers.

Analysis of the results obtained during the research let us make the following conclusions:

1. The use of the spring grouping bogie with a bilinear characteristic in the central stage of suspension has improved dynamic performances of described gondola cars.

2. To a large extent dynamic performances of empty gondola cars have improved in comparison with loaded. This explains the fact that the static deflection of spring grouping in the empty gondola car is on a section characteristic with less rigidity. Dynamic performances of loaded gondola cars on bogies, model 18-1711, were improved too, though to a lesser extent.

Improving the dynamic performances is more evident in the modeling of freight gondola cars motion on a straight section of the track than at motion on curve of medium and small radii. This is due to the fact that the dynamic performances of gondola cars during motion on curves are largely determined by the centrifugal forces that operate on cars.

**Originality and practical value**

Firstly calculations to determine the dynamic performances of gondola cars with bogies, model 18-1711 during its motion on straight and curved sections of the track were carried out. At the same time the assessment of dynamic characteristics of a gondola car was made and the following regulatory dynamic performances were identified: the coefficient of the vertical dynamics ($C_{dv}$), the coefficient of horizontal dynamics ($C_{dh}$), and the stability factor against derailment ($SF_d$). The use of bogies with bilinear characteristic of the central suspension will improve the dynamic performances of gondola cars, currently operating on bogies, model 18-100. And by improving the dynamic performances it may increase the permissible speed of these cars.

**Conclusions**

Analysis of the calculations results and comparison of dynamic parameters of the gondola car with bogies 18-1711 and the gondola car with bogies 18-100 shows that the bilinear characteristic of the central suspension of freight car bogie has a positive effect on its dynamic performances both during motion on a straight sector and in the curved sections of the track. Besides the dynamic performances improvements are more pronounced in the gondola car in empty state. Thus, the use of bogies 18-1711 with bilinear characteristic of the central suspension for gondola cars will enable to...
increase the maximum permissible motion speeds in unloaded state, which is very actual for modern railway transportsations.

LIST OF REFERENCE LINKS


8. Свидетельство о регистрации авторского права на произведение № 7305. Компьютерная программа «Dynamics of Rail Vehicles» («DYNRAIL») / С. В. Myamlin; зарег. 20.03.2003. – 1 с.


ИССЛЕДОВАНИЕ ДИНАМИЧЕСКИХ ХАРАКТЕРИСТИК ПОЛУВАГОНОВ НА ПЕРСПЕКТИВНЫХ ТЕЛЕЖКАХ

Цель. В работе необходимо исследовать динамические качества полувагона с тележками модели 18-1711 при его движении по прямолинейным и криволинейным участкам пути. Методика. Расчеты производились с помощью объектно-ориентированного программирования на программе «Dynamics of Rail Vehicles» («DYNRAIL») Мяmlin С. В. зарегистрирован 20.03.2003 г.). Для расчетов были созданы математические модели полувагона и тележек 18-100 и 18-1711. Результаты. Выполнено сравнение динамических показателей полувагона с тележками 18-1711 и полувагона с тележками 18-100, полученных расчетным путем. Научная новизна. Впервые выполнены расчеты по определению динамических качеств полувагона с тележками 18-1711 при его движении по прямолинейным и криволинейным участкам пути. При этом была выполнена оценка динамических характеристик полувагона и определены следующие нормативные динамические показатели: коэффициент вертикальной динамики (Кв), коэффициент горизонтальной динамики (Кдг), коэффициент устойчивости от схода колес с рельсов (Кч). В качестве возмущений были заданы геометрические неровности пути в вертикальной и горизонтальной поперечной плоскостях, такие, чтобы динамические показатели широко использовались в эксплуатации полувагона на тележках модели 18-100 укладывались в допустимый диапазон при скоростях движения до 80 км/ч для порожнего полувагона и при скоростях до 90 км/ч для груженного полувагона. Практическая значимость. В результате проведенных расчетов и сравнения их результатов было установлено, что применение тележек с биенелийной характеристикой центрального подвешивания позволит улучшить динамические показатели полувагонов, эксплуатируемых в настоящее время на тележках модели 18-100. И за счет улучшения динамических показателей возможно увеличение допустимых скоростей движения этих вагонов.

Ключевые слова: динамические качества полувагона; тележка модели 18-1171; динамические показатели полувагона

REFERENCES
1. Bubnov V.M., Myamlin S.V., Mankevich N.B. vozdeystviye na put gruzovykh vagonov na teleshkakh modeli 18-1711 s raznoy konstruktsiyey klinia ressornogo podvshivaniya | Impact on the track of freight cars on

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2. Kovalenko A.V. Silovoye vzaimodeystviye puti i gruzovogo vagona s uprugimi svyazami kolesnykh par s ramoy telezhki. Avtoreferat Diss. [Force interaction of a track and a freight car with elastic constraints of wheelsets with a bogie frame. Author’s abstract]. Moscow, VNIIZhT Publ., 2006. 28 c.


