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Impact of three axle boxes bogie to the tram behavior when passing curved track

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Abstract

Ride of vehicles along curved track is a serious technical problem, which for the long term requires attention of vehicle engineers as well as track designers. It is especially interesting to observe behavior of tram cars passing a curved track, because they should be able to pass arcs up to 17 meter radius. Ride of a vehicle along such strongly curved track is nowadays accompanied by significant wear in rail-wheel contact, increased bogie and track stress and by generation of noise. One of the key causes of this unfavorable phenomenon is an increase of slip velocities in rail-wheel contact. This paper is based on simulation analysis, which compares different ways of minimizing slip velocities and thus mitigating the impacts of passing vehicles on the track as well as on the car itself. Bogies with and without wheelset steer possibility were analyzed. Both bogies were also analyzed with wheel profiles of different delta R function course.

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Keywords: Creep velocities in wheel - rail contact; simulation analysis; passing of vehicle trough transition curves; wheelset steering mechanism

1. Introduction

Ride of a vehicle along curved track is an actual technical problem, which requires special attention. Especially in environment of urban lines, track arcs with small radius are used. Ride of vehicles along such curved track causes

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significant strain of track as well as the tram's bogie. Ride of vehicles along such strongly curved track is nowadays accompanied by significant wear in rail-wheel contact, increased bogie and track stress and by generation of noise. The main causes of this negative phenomenon are increased angles of attack and slip velocities in the rail-wheel contact. Nowadays, to decrease wear and especially noise, special equipment for lubricating the side of rails is installed in track before track sections of small radius. However, such lubricated rail tends to absorb dust from the environment. In this manner the lubricant loses its qualities and through the effects of solid dust particles, the lubricant changes into an abrasive paste. Also from the ecological point of view, this solution cannot be considered as satisfactory in long - term.

Slip in the wheel-rail contact during ride takes place in longitudinal as well as in lateral direction. Slip in longitudinal direction, except applying of traction and braking force, is caused especially by different length of rails situated on the inner and outer side of the track curve. If the wheelset is represented by one rigid body, the rail length difference can be partially compensated by suitable wheel profile geometry in relation to the rail profile geometry used. However, for this compensation, certain conditions in the form of sufficient track free channel width must be fulfilled. A major disadvantage of a wide track free channel is that bogies without a steering wheelset possibility tend to pass such curves in jammed position. Widening of the track free channel makes it possible for them to significantly divert their position from the one suitable for ride in track curve. This causes increase in slip velocities in lateral direction.

Slip in lateral direction is caused mainly by ride of a wheelset along curved track in other than radial position. Therefore, it is necessary for the bogie frame design to allow displacement of bearing boxes in lateral direction in a way, which makes it possible to reach the radial position of a wheelset. However, decreasing the stiffness of bearing boxes suspension in longitudinal direction is not a sufficient solution, as it would result in additional deviation of the wheelsets from the correct position. Therefore, it is necessary to define the position of bearing boxes using special mechanism for setting the wheelset position.

Presently, bogies allowing independent rotation of wheels situated on one axle can be seen. In this way, the slip velocity in longitudinal direction can be significantly decreased. However, independent rotation of wheels causes significant decrease of the bogie's ability to take the centered position in straight track. This phenomenon affects the safety of ride in a negative way.

2. Creating of computational model of vehicle

One way how to obtain detailed overview of the vehicle behavior is simulation of the vehicle model in calculation software. Based on definition of the input parameters describing vehicle properties, for example joints kinematics, flexible binding parameters, rail-wheel contact geometry and a many other, the vehicle response to wheelset steering and wheel profile geometry can be obtained.

The goal of this dynamical analysis was to compare the influence of wheel profile and wheelsets steering on creep velocities in the wheel-rail contact. Creep velocities are strongly influenced by bogie design. To obtain as reliable results as possible, model of the whole vehicle was created. Vehicle parameters are similar to T3 tramcar.

To compare the influence of wheel profile geometry, wheel profiles E-99-00 and KP-1 were chosen. They significantly differ in running surface conicity and thus by delta r function as well. The delta r function of wheel profiles can be seen in Fig. 1. Rail profile geometry NT1 was used for all of the analyzed cases.

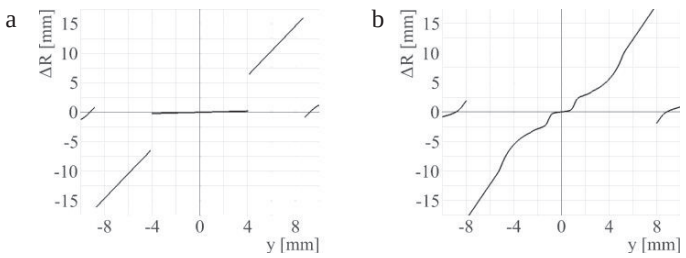

Fig. 1. Delta R function course a) for profile E-99-00 b) for profile KP-1