Influence of Design Parameters on Vehicle Track Dynamic Loading

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ABSTRACT

The paper describes possible design of vehicle track computation model and basic testing step of dynamic loading simulation of the track. The computational model is built for computational simulating system MSC. ADAMS, Tracked Vehicle Toolkit. Computational model intended for MSC computational system is built from two basic parts. They are geometrical and contact computational parts of model. Geometrical computational model consists of basic parts of vehicle undercarriage movable parts. Contact computational model consists of impact and frictional forces system. The full model consists of all parts of real vehicle undercarriage design. The aim of the simulating calculation is the determination of change influence of specific vehicle track constructive parameters on changes of examined qualities of the vehicle track link. The computing result sample comes out as one of many possible cases. The influence of changes of driving sprocket diameter values on the needed torque changes of driving sprocket is displayed in the article. Further research plans are described in the article as well.

Keywords: tracked vehicles, track, dynamical loading.

1. INTRODUCTION

The paper describes design of computational model of the vehicle track and undercarriage of the track vehicle. The paper is introducing possible modeling method of selected type of vehicle track and some results of simulating computer modeling of dynamic loading of vehicle track by vehicle running [1].

The work described in this article has been performed in order to solve the requirement for analyzing the problem of bad course holding of specific track vehicle when driven at a speed exceeding 65 km.h^{-1}. It is possible to find out the reasons of this effect and propose possibilities of its elimination. It would be useful to propose possible design changes, that would make safe improvement maximum vehicle speed at the same time.

One way of solution of this problem is using of mathematical computer simulation [2] and [3]. The mathematical model of examined object must be built and powerful computing system must be available [4] and [5]. The mathematical model described in this article is built for modelling in computational system MSC.ADAMS.AVT [1] and [6].

The main aim of the work is to create composition of a computational model not only of the vehicle track but also the general vehicle undercarriage dynamic properties. The practical use of such effort could be represented by possibility of general use of given mathematical model for computational experiments leading to essential information on individual undercarriage parts behaviour during vehicle ride.

Main task of the work now is to define main possibilities of track vehicle course holding improvement by simultaneous increase of maximum speed vehicle. As a first step, the simulation is used for collecting of undercarriage design parameters under influence of different vehicle course holding conditions and increasing maximum speed. The basic simulating calculations are done already it this part of work. The purpose of these preliminary simulations is to monitor the influence of changes in supporting axes reaction forces in relation with changes of track links weight and initial tension of track. Such changes can influence vehicle course holding. It is well known that design parameters have relevant influence on dynamic loading of some undercarriage parts. The complete calculation of this influence is subject of the second part presented work.

Following part of the work is focused on determination of possible changes of sprocket wheel torque in relation with changes of sprocket diameter. According to torque required on driving wheel (absorbed to override the resistance of the vehicle track), it is possible to determine next parameters of undercarriage design, that are greatly affecting maximum vehicle speed.

2. COMPUTATIONAL MODEL DESCRIPTION

The computational system MSC.ADAMS.AVT, version 8.0 is used for the computational modelling. This system can be used for the analysis of kinetic and dynamic characteristics of the modelling mechanic system and its animation. Computational model intended for MSC computational system is built from two basic parts. They are geometrical and contact computational parts of model [6].

2.1 Geometrical part of computational model

Geometrical computational model consists of basic parts of vehicle undercarriage movable parts.

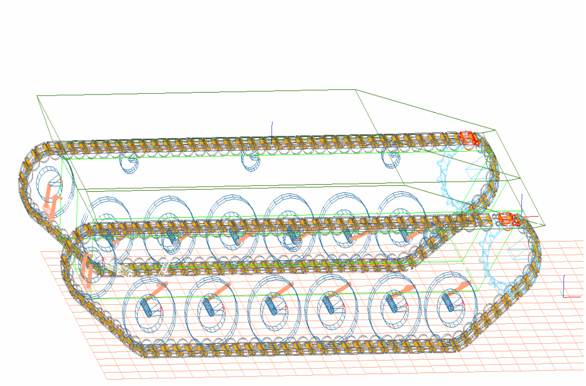


Fig.1: Geometrical part of computational model

The model consists of road wheels (Fig. 1), supporting rollers, driving sprocket (Fig. 2) idle wheel and track line on which individual track links are connected by couplings (Fig. 3). The parts are defined by components with right geometrical shape. The critical aspect at this point is to keep flat contact.

The main parts of the track link are: the body with two guiding detents and two connected eyes with pins, couplings, and retaining screws [7]. There are 84 track links on each track.

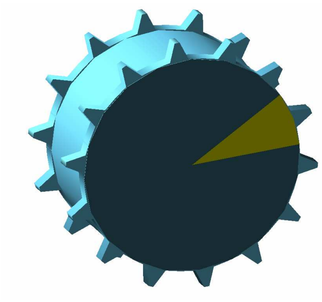


Fig. 2: Geometrical model of sprocket wheel

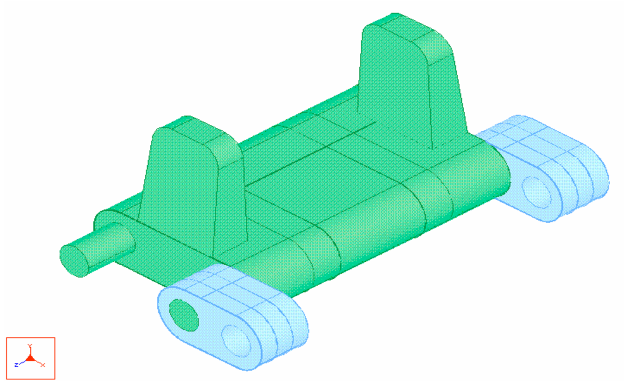


Fig. 3: Geometrical model of track link and connecting clip

Axel arms, torsion bars and shock absorbers are defined as simplified shape components, such as without contact components. This type of components is generated from offer of universal track vehicles undercarriage components. They are defined by input data as basic design dimensions, weight, moment of inertia, stiffness, absorbing and number of parts.

2.2 Contact part of computational model

Contact computational model consists of impact and frictional forces system [6]. To guarantee the highest accuracy and practicality, the impact and frictional forces of individual undercarriage parts are defined in such way [9], that the whole model resembles the reality as much as possible. These contact forces are described in Adams System by impact force Eq. (1):

$$F = -k`(q - q_0)^n - cq` \qquad (1)$$

Where: $q-q_0$..penetration of bodies in contact,
k - contact stiffness,
c – damping coefficient,
q` - sliding velocity of bodies in contact,
n - stiffness force exponent

Contact model is described by characteristic of influence sliding velocity on friction coefficient (Fig.:3), [8] and [9] as well:

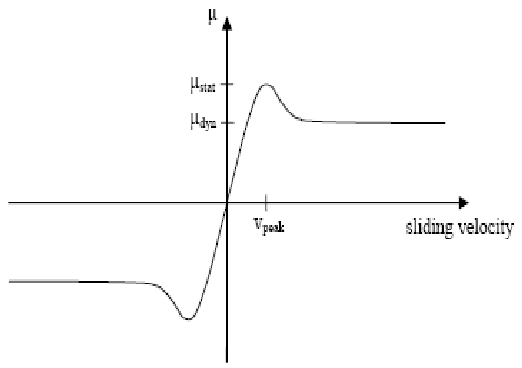


Fig. 3: Course of friction coefficient

Where: μ_{stat} - static friction coefficient,
μ_{dyn} - dynamic friction coefficient

3. SIMULATING CALCULATION DESCRIPTION

The aim of the simulating calculation is the determination of change influence of specific vehicle track constructive parameters (curve track geometry or track preloading) on changes of examined qualities of the vehicle track link (reaction force against motion, minimal track link speed and medium track speed). These are determined especially by intensity changes of the reaction force of the carrying elements of track links bodies.

The conditions of the track loading in these calculations can be described clear. The specific vehicle track parameters will be determined gradually with changes during which it will be possible to reach sufficient result changes of the examined quantities of the track qualities. These examination of quantities could be carried out and their basic influences could be determined.

It is evident that the results of simulation computations have proven the assumption that by means of changes in constructional parameters of undercarriage parts it is possible to improve dynamic behaviour of some parts of track vehicle undercarriage and optimise dynamic properties of the vehicle in motion.

4. IMPLEMENTATION OF SIMULATING CALCULATIONS

Simulating calculation is quantifying the influence of driving sprocket diameter change on needed torque of driving sprocket.
The input data and information for driving sprocket diameter influence quantifying:

- vehicle velocity - 40 km/h
- horizontal plane - 0°
- geometry of model - Fig.1
- models-ADAMS/AVT diameter R1, R2, R3
- start velocity - 11.11 m/s
- geometry of vehicle - real design parameters.

Three types of driving sprockets were considered:

Driving sprocket 1 – R1 with 13 catch detents

Driving sprocket 2 – R2 with 14 catch detents – real design

Driving sprocket 3 – R3 with 15 catch detents.

5. RESULTS OF SIMULATING CALCULATIONS

Simulation calculations were realized with use of computation model displayed in Fig. 1.
Fig 4 shows the printout of the results of aforementioned model. The influence of changes of driving sprocket diameter values on the needed torque changes of driving sprocket is displayed.

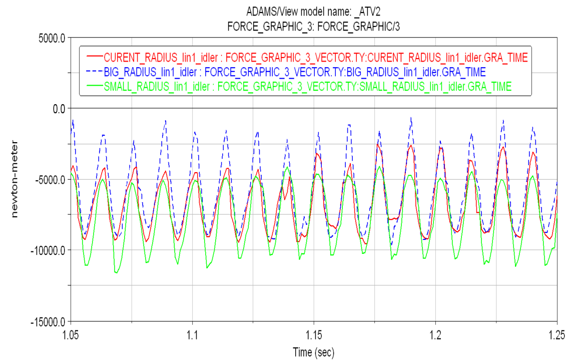
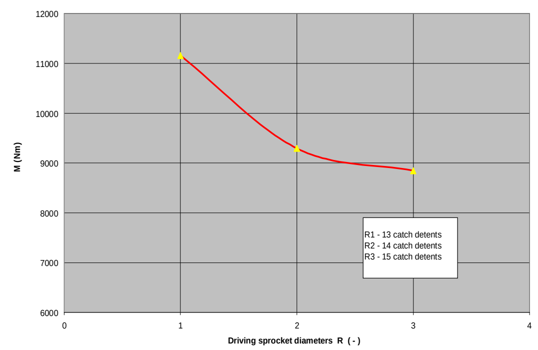


Fig. 4: The values of needed torque of driving sprocket

Significant variation of needed torque values (affected by changes of sprocket diameter) can be seen.

Graph 1: Course of needed torque moment values on driving sprocket diameter



As can be seen in Graph No.1, reduction of driving sprocket diameter for about 15.5 % causes improvement of needed torque value from 9 320 Nm to 11 220 Nm. It represents approx. 20.6 %. increase of driving sprocket diameter for approx.15.5 % causes reducing of needed torque value from 9 320 Nm to 8 880 Nm , which is about 4.5 %. It is possible to say that there is a big influence of changes in driving sprocket diameter on driving sprocket needed torque. This parameter influences vehicle course holding and improves maximum speed of the vehicle. It seems to be very promising and important to perform the full analysis of this phenomenon (influence of this design parameter) in the future. The results of previously performed basic simulating calculations shown the big influences of changes in reaction forces supporting rollers axes on changes of track links weight and initial tension of track. It is clear that this design parameters have big influence on dynamic loading of some undercarriage parts and therefore a maximum speed of vehicle. The same influence of changes of needed torque on sprocket wheel in relation with changes of driving sprocket diameter were approved as well. This parameter influences vehicle course holding and improves maximum speed of the vehicle. This phenomenon will be the subject of our forthcoming research when full calculation will be performed.

6. FURTHER RESEARCH PLANS

Application of second-rate simulation collection will be performed hereafter to assemble of approximation relation y_o of influence monitored parameters R_x, , F_{pr}, k_p a m_x,

1. Composite plan simulations assembly for 4 parameters (Fig.: 5), [10].

The composite plan for simulation of 4 parameters

Simulation number	R_x	F_{pr}	k_p	m
1	R_1	F_{pr1}	k_{p1}	m_1
2	R_3	F_{pr1}	k_{p3}	m_1
3	R_1	F_{pr3}	k_{p1}	m_3
4	R_3	F_{pr3}	k_{p3}	m_3
5	R_1	F_{pr1}	k_{p1}	m_1
6	R_3	F_{pr1}	k_{p1}	m_1
7	R_1	F_{pr3}	k_{p3}	m_1
8	R_3	F_{pr3}	k_{p1}	m_3
9	R_1	F_{pr1}	k_{p3}	m_3
10	R_3	F_{pr1}	k_{p1}	m_1
11	R_1	F_{pr3}	k_{p1}	m_1
12	R_3	F_{pr3}	k_{p3}	m_1
13	R_1	F_{pr1}	k_{p1}	m_3
14	R_3	F_{pr1}	k_{p3}	m_3
15	R_1	F_{pr3}	k_{p1}	m_1
16	R_2	F_{pr2}	k_{p2}	m_1
17	R_2	F_{pr2}	k_{p2}	m_3
18	R_2	F_{pr2}	k_{p2}	m_1
19	R_2	F_{pr2}	k_{p1}	m_2
20	R_2	F_{pr2}	k_{p3}	m_2
21	R_2	F_{pr1}	k_{p2}	m_2
22	R_2	F_{pr3}	k_{p2}	m_2
23	R_1	F_{pr2}	k_{p2}	m_2
24	R_3	F_{pr2}	k_{p2}	m_2

Fig. 5: Composite plan of simulations for 4 parameters

2. Implementation of 24 simulating calculations according to composite plan.

3. Assesment of regression function

Pursuant to known recourse model common dependence regarding variable Eq. (2) it can be put together approximation relation of regression capacity as Eq. (3). Regression quadratic model regarding variable:

$$y = \beta_0 + \sum_{j=1}^{n} \beta_j x_j + \sum_{j=1}^{n} \beta_{jj'} x^2_j + \sum_{j<j'}^{n} \sum_{j'}^{n} \beta_{jj'} x_j x_{j'} + \varepsilon \quad (2)$$

Where: β - regression coefficient,
x_j - monitored parameter,
n - number of parameters

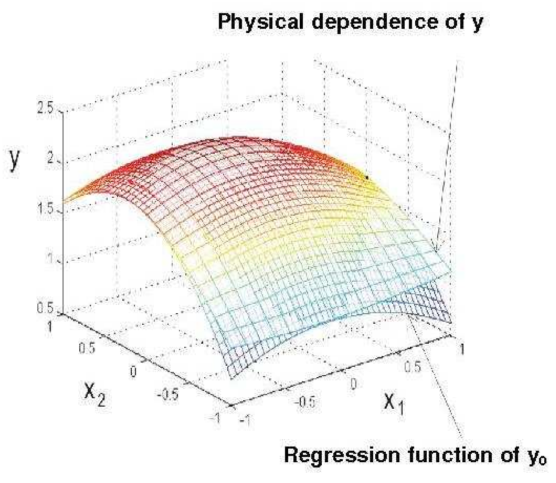
The form of approximation equation:

$$y_0 = \beta_0 + \beta_1 R + \beta_2 F_{pr} + \beta_3 k_p + \beta_4 m + \beta_5 R^2 + \beta_6 F^2_{pr} + \beta_7 k^2_p + \beta_8 m^2 + \beta_9 R \cdot F_{pr} + \beta_{10} R \cdot k_p + \beta_{11} R \cdot m + \beta_{12} k_p \cdot F_{pr} + \beta_{13} m \cdot F_{pr} + \beta_{14} k_p \cdot m + \beta_{15} R \cdot F_{pr} + \beta_{16} m \cdot R \cdot k_p + \beta_{17} m \cdot R \cdot F_{pr} + \beta_{18} m \cdot k_p F_{pr} + \beta_{19} m \cdot F_{pr} \cdot k_p \cdot R + \varepsilon \quad (3)$$

Where: β - regression coefficient,
R - monitored parameter (diameter of driving wheel)
F - monitored parameter (initial tension force of track)
k – monitored parameter (track geometry)
m - monitored parameter (track link weight)
n - number of parameters

4. Final verification of mathematical model

Final verification is provided by comparison of physical dependence value y obtained from measurement and regression function y_o in consonant point (Fig. 6).



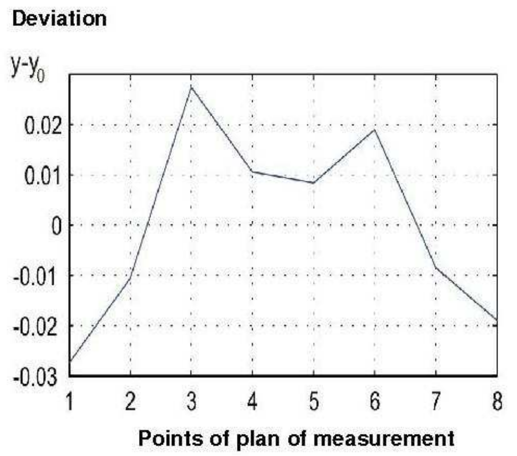


Fig.6: Comparison of physical dependence y and regression function y_0

7. CONCLUSION

The paper describes one of the possible ways of creating the computational model of real track vehicle movement mechanism in software environment MSC.ADAMS.AVT. Vehicle track design and recommendation for upgrading mathematical model is emphasised. The objective is to create computation simulation for the purpose of finding the basic information on track component parts and undercarriage performance of moving vehicle.

They was perform simulating calculations already sooner. They follow clouts changes reaction force values on axes of supporting rollers depending on changes weight track link, changes of track radius and sizing changes initial tension track. Their results approve, that influence of changes of track radius, initial tension and track link weight, on changes of reaction forces on supporting rollers of undercarriage influence they have and they have such character, that fit with them behind-go in the future. It ratify here again publicize results of simulating calculations of influence changes driving and tensive wheels on needed driving wheel twist moment. We have order of design value of undercarriage, which affected the size of dynamic loading of vehicle chassis parts evidently by movement.

It is obvious from the contents of the article that the research conducted and described up to now is an introduction to problems of vehicle track dynamic properties modelling, which seems to be the only viable way of track dynamic properties analysis of moving vehicle. On the grounds of the analysis outcome it will be possible to state which constructional changes will lead to objective accomplishment. This objective can be defined as a track vehicle directional improvement at simultaneous maximum speed increase, simulated apart from other factors, not only by track construction, but also by the whole track kinetic and suspension track vehicle undercarriage mechanism.

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