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MODELLING OF REANALIZING BEHAVIOUR OF BOGIES OF TRAIN JZ 412/416

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Abstract: *Modelling of products using CAD/CAE tools provides at the same time working on more engineering tasks. In earlier time, this process infolded only through creation and usage of prototype. Complex identification of behaviour of bogies of EM train is based on static and dynamic calculation applying method of finite elements*

Key words: *modeling, railnjay vehicle, analyzing, FEA.*

1. INTRODUCTION

Perennial electromotive JZ 412/416 train exploitation showed that improvement of some subsystems of bogies was necessary. The justification of improvement could be seen only if the models of framework show compatibility to phenomena that are present in exploitation or examination. According to the results from analysing of EMV prototype and according to the perennial exploitation, we decided to establish “Plan of examination…” [1], that involves analyses of phenomena of possible cases of functional requirements such as load and response adjusted to permissive limit of carrier structure of bogies. CAD/CAE pack KOMIPS [2] is used in analysis.

1.1 Usage of CAD in product modelling

The development of CAD/CAE systems resulted into “model” forming as a product related to the computer, and that is how the term “computer modelling” (that we use for describing these activities) developed. Original CAD is used for automatisation of the tasks that are conceptually simple but intensive. It was later possible to create two-dimensional and three-dimensional wire (cable) models that reflected more real image on the screen. The final result was limited to drawing and relation to NC machines.

CAD systems developed from the instruments for drawing to the instruments for computer modelling. They allow creating of models on the computer, so that research can be carried out on them, instead of making physical models. The latest CAD models support detailed and better modelling of products.

1.2 Modelling

According to the systematisation of activities, applying of method of final elements of modelling is carried out within the first step. Modelling presents complex process of mapping of physical model into computer model by application of idealization. Physical model with its geometry and load requirements (struts and loads), assumed class, and distribution of displacement, deformation and tension of the model presents departure base of the process of mapping. Modelling is accomplished throughout choice of type, number and the size of final elements for discretization, number of grades of knot, load conditions as well as throughout implementation of idealization and simplification. Number of grades of the final element defines possible (assumed) movements and deformations in coordinate system of elements (local) and model (global).

One very important moment in supporting girder modelling on which the engineer should count, should be emphasised. It is the classification of supporting elements. That means that it is necessary to choose the corresponding finite element for right modelling as far as supporting structure and distribution of load within that structure is concerned.

According to the relation of dimensions of supporting elements between its supporting or binding with other elements, the classification is made: long girder-pole; girder; short girder; very thin disc and shell; thin disc and shell; thick disc; centre.

Very important experiences that the author acquired in a perennial numerical analysis and experimental verification of rail train have shown that it is necessary to discretize models of bogies by [3] elements of girder or disc.

2. COMPLEX IDENTIFICATION OF CONSTRUCTION BEHAVIOUR

Specific estimation allows better knowledge of behaviour of construction. Collateral stress for all types of finite elements can be estimated by Hank-Misses hypothesis for elements and global knots. Elements of analysis that are known thanks to course of moving, distribution of membrane and flexible stress, distribution of energy of deformation and kinetic and potential energies of structure that enable very effective identification of behaviour of construction. Distribution of behaviour of elements is expressed in percentages and according to the chosen group of elements.

2.1 The course of movement and distribution of stress

Determination of the course of movement and distribution of the stress of construction from the place of its taking to the supporter (from the source to the pit) presents the base of understanding of behaviour of construction [4]. Namely, the stress moves while the drag is at its lowest point (the course - line of the biggest stiffness. As example we can take moving of water through canal that have different cross section that takes place from the same point. Water will distribute itself in stationary condition according to the size of canal (cross section). The more water will go into canal. By dynamic filling of canal the water will go in the biggest canal first.

2.2 Distribution of membrane and flexible stress

This distribution is present for finite elements of girded and disc. We find weak (flexibility is present) and good places (only membrane stress present) as well as places with low stress. Distribution shows the way how modifications should be carried out in order to minimize negative influence of flexibility and better distribution of load. If model has flexible stress, it is possible to apply of numbers of grades to three translations or application of simpler finite element (for example, membranes instead of discs, pole instead of girded).

2.3 Distribution of normal and tangential stress

This distribution is also present at the finite element of disc and girded. We find weak (present at tangential stress) and good places (present only normal stress) as well as places with a low stress degree. Normal and tangential stress are not put into gear because they have no connection in elastic host. The presence of tangential stress has negative influence on the precision. It is necessary to have more models to reach the convergence and vice versa.

2.4 Distribution of energy of deformation

Equation of balance of potential energy of deformation and the work of external force can be presented by multiplication of the basic statistical equation with vector of moving.

(1) $$\{\delta\}^{T}[K]\{\delta\} = \{\delta\}^{T}\{F\} \equiv E_d \, .$$

Energy of deformation of finite element

(2) $$E_d = \{\delta_{sr}\}_e^T \left[\overline{k_{rs}}\right]_e \{\delta_{sr}\}_e,$$ where is:

$\{\delta_{sr}\}_e$ -Belonging global vector of moving

$\left[\overline{k_{rs}}\right]_e$ -Global matrix of stiffness of element

Equivalence of the sum of all energies of deformation of elements and the work of external forces shows that the model is good, concerning limited conditions. Distribution of energy of deformation to the groups of elements (parts of structure) shows to the place where the stress is, that is which parts of structure transfer and which take the load. The sensitivity of model to some modifications can be also defined on that way.

2.5 Distribution of kinetic and potential energy to the main form of swinging

By multiplication of dynamic equivalence from the left side with matrix with its own vectors, we can get the equivalence of balance (equality) of potential and kinetic energy:

(3) $[\mu]^T \cdot [K] \cdot [\mu] = [\mu]^T \cdot [M] \cdot [\mu] \cdot \{\lambda\}$

Kinetic e_k^r and potential e_p^r energy of the finite element and the whole structure E^r on the r-main form is:

(4) $e_k^r = \omega_r^2 \{\mu_{sr}\}_e^T [m]_e \{\mu_{sr}\}_e$,

(5) $e_p^r = \{\mu_{sr}\}_e^T \left[\overline{k_{rs}}\right]_e \{\mu_{sr}\}_e$,

(6) $$E^r = E_k^r = E_p^r = \omega_r^2 \{\mu_r\}^T [M] \{\mu_r\} = \\ = \{\mu_r\}^T [K] \{\mu_r\}$$

Where is ω_r -proper frequency, $\{\mu_r\}$ proper vector and $\{\mu_{sr}\}_e$ - belonging r-proper vector of elements. The change of square of proper frequency reanalysis- without another calculation:

(7) $\dfrac{\Delta\omega_r^2}{\omega_r^2} = \dfrac{\alpha_e \cdot e_p^r - \beta_e \cdot e_k^r}{E^r}$, where are

α_e, β_e - Measurement that define modification of e-element

All stated distributions, along with the fact that enable complex identification of behaviour of construction, also define needed modifications on a construction, and by introducing them the behaviour of construction in exploitation should be better.

2.6 The main forms of swinging and own frequency

The main forms of swinging (free non-attenuate swinging) have the forms of deformations of models under the imagined load. The worst behaviour of construction can be noticed at the first form of swinging and so on successively. Construction has very good dynamic behaviour if the first frequency is high and if the space between frequencies is big. It is possible if the construction is generated from maximal stiffness and minimal mass. The proper frequency is proportional $\sqrt{k/m}$. Solution of compulsive swinging in frequent place presents frequent characteristics of load structure.

3. TYPICAL RESULTS OF ANALYSIS [5]

In the text the characteristic models of bogies have been shown, in order to find the most proper solution of behavior of construction.

According to the appearance of concentration of the stress on the skeleton of bogies, model 5. presents the combination of model structure (skeleton) and girded (cradle, primer and secondary suspension, brake rod, draw bar). On the Fig. 6 the image of deformation and stress is shown.

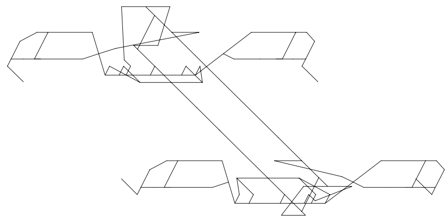

Fig 1. Model of girded with bogie

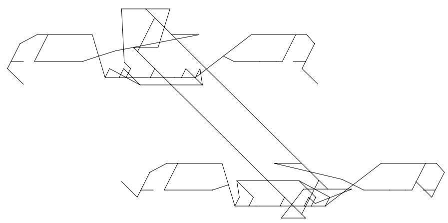

Fig 2. Base without brake rod

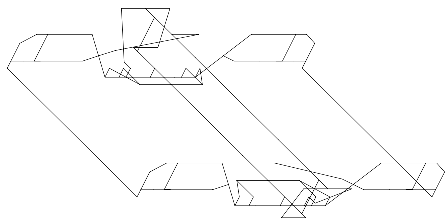

Fig 3. Base with brake rod and end-loading relation

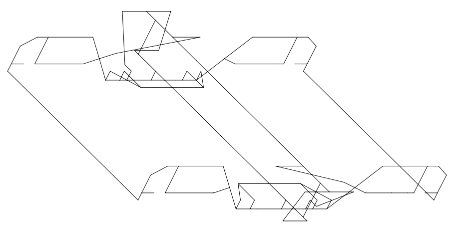

Fig 4. Base with end-loading relation, without brake rod

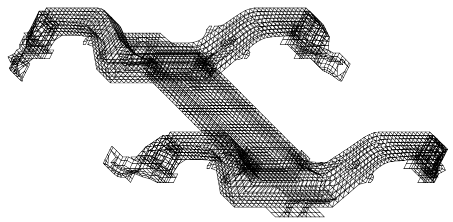

Fig 5. Combined model of base, skeleton modelled by plates

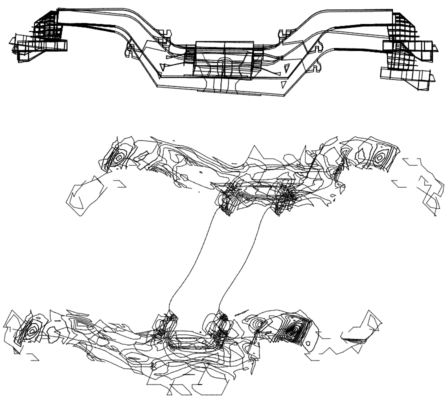

Fig 6. Deformations and izo-stress lines

4. CONCLUSION

According to the stated criteria of identification, variant with most proper bogie behavior correspond to the model 3. That is a model with retained brake rod and merged end-loading relation. Detailed values of results will be published in some of next works.

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МОДЕЛИРАНЕ НА РЕАНАЛИЗИРАНО ПОВЕДЕНИЕ НА ТАЛИГИТЕ НА ВЛАК JZ 412/416

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Резюме: *Моделирането на продукти, използващи CAD/CAE, осигурява работа едновременно по повече инженерни задачи. Преди този процес този процес се е извършвал само чрез създаване и използване на прототип. Комплексното определяне на поведението на талигите на електрически мотрисен влак се основава на статично и динамично изчисляване, ката се използва метода на крайните елементи.*

***Ключови думи*:** *моделиране, железопътно возило, анализ, метод на крайните елементи.*