TRANSBALTICA-03

4-osios tarptautinės konferencijos, įvykusios Vilniuje 2003 m. balandžio 10–11 d., MOKSLINIŲ PRANEŠIMŲ RINKINYS

4-th International Conference, which was held in Vilnius in April 10–11, 2003, PROCEEDINGS

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Vilnius „Technika“ 2003

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Modelling of contact for a wheel – rail pair

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Contact interaction for a wheel - rail pair is considered. Modelling is carried out by means of a finite element method. Problems of generation of FE grids for the solution of contact problems are discussed. As an example interaction of a new wheel with a profile of GOST 9036-88 with new rail R65 is considered.

1. Introduction

Contact interaction between a wheel and a rail is a basis of movement of rail vehicles. The durability and reliability of wheels and rails, and also traffic safety depends on improvement of this process. It is known, that the contact zone is a place in which there are rather interesting physical phenomena. It is possible to attribute to them microslip, various kinds of wear, plastic deformation, etc. Despite of rather big number of the authors research in this problem during tens of years, a question of the mathematical description of physics of contact interaction in a wheel – rail pair on a macro level is not solved and actual.

The main problem here is made that the effective solution of problems of contact interaction, unfortunately, is not offered yet. The most part of solutions is based on Hertz theory which can be applicable only with very serious assumptions. It is known, that assumptions of Hertz theory are requirements of smoothness of interacting surfaces. They are modelled by half-spaces. For real wheels if interaction with rail occurs in a zone of a circle of driving, such assumptions can be insignificant still. However if there is a flange contact Hertz theory is inapplicable in the pure state.

It is necessary to note works of J.J. Kalker [1], K.L. Johnson [2], A.D. de Pater [3] and other authors who aspired to depart classical statement, to take into account tangential stresses and slip. Attempt of improvement of statement on the basis of Hertz theory has been made also in work [4]. Nevertheless, within the framework of these works the form of contact zones should be elliptic or close to these. The researches submitted in the book [5], speak that it not always so. In particular, the form of a contact patch can come nearer to rectangular with the rounded corners.

The most perspective modern method of researches for the solution of contact problems can be FEM.

2. Problems of FE grid generation for the solution of contact problems

The solution of contact problems with help of FEM is the well-known approach and a number of universal packages of applied programs is realized with algorithms of the solution of contact problems. For this purpose in such packages special nonlinear modules, and also additional types of elements by means of which contact algorithms are realized should be stipulated.

For example, in package MSC.VisualNASTRAN for Windows for the solution of contact problems are used Slide Line elements. It is special type of finite elements which sense consists in the following. Nodes belonging to both contacting bodies for which it is offered if they will contact are allocated, at deformation to be on one line. It is obvious, that such restriction is rather rigid and not always feasible. Most likely it causes purchase by firm MSC of package MARC. It has no so essential restrictions on a relative positioning of contact nodes.

The analysis of work with various packages has shown, that the optimal is preparation of initial geometry of objects (profiles of sections of a wheel and a rail) by means of any CAD package, for example, AutoCAD. The received graphic object in an open format is imported to package VisualNASTRAN where it is created FE model of interacting bodies. Here it is necessary to note at once, that use of standard generators of a grid is inadmissible. The grid cannot be broken in regular intervals. For considered three-dimensional problems the total amount of nodes should not exceed 10 thousand. It is caused by that nonlinear problems, and contact problems concern to nonlinear, are solved in comparison with linear on the order and sometimes and more longer.

The following algorithm has been offered. From three-dimensional geometrical models of a wheel and a rail geometrical objects such as “a contact surface” have been allocated. For them uniform enough fine discretization of a FE grid is established. For other parts of objects the uniform considerably integrated discretization was used. Advantages of the grids generator of package VisualNASTRAN have allowed to unit these inconsistent requirements and to create comprehensible FE model which is submitted on fig. 1.

Then the created model was exported to a format which was accessible to reading to package MSC.MARC and accordingly read with its help. Assignment of contact boundary conditions it was made already in this program. The received results could be analyzed both with help MARC, and with help VisualNASTRAN. Here again quite obvious became, that more or less uniform splitting into finite elements in a contact zone it is not enough. On fig. 2 the result of calculation for the model shown above is resulted. Distribution of contact normal nodal forces is shown. As we see from the resulted figure, the contact zone in general is not present. There are the separate groups of contact nodes located chaotically enough, that completely contradicts common sense.

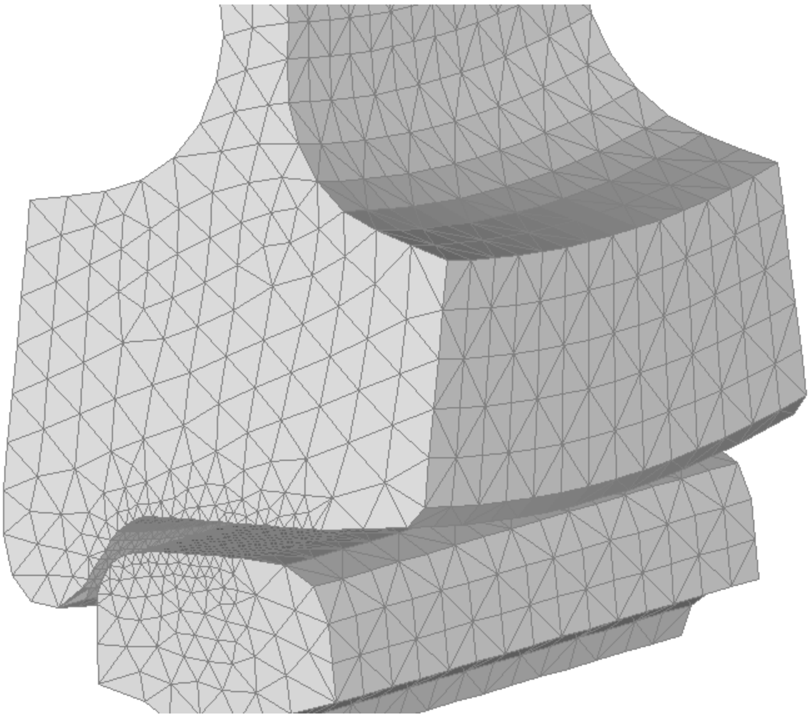

Fig. 1. FE model interacting wheel and rail

The analysis of results has led to the following conclusions. Principal cause of the erroneous solution is imperfection of grids of a wheel and a rail. For them additional restrictions should be used. First, grids should be mutually coordinated, so that contacting nodes at deformation of a wheel and a rail or rolling wheels on a rail coincided or that possible discrepancy was minimal. Second, the elements following a contact layer should be similar on structure, i.e. there should not be sharp transformations of a FE grid in a near contact zone. If in a contact layer elements quadrangular same should be and in a near contact areas, and it is desirable, that their size was still kept.

The specified postulates have been used at creation new FE grids for a wheel and a rail. In particular, the following technique is used. The graphic file which contains not only profiles of a wheel and a rail, but also allocated near contact zones is initially created. Then in VisualNASTRAN regular FE grids are created for near contact zones coordinated among themselves. Then grids of other parts of a wheel and a rail are under construction and "are sewed" among themselves on border of near contact zones.

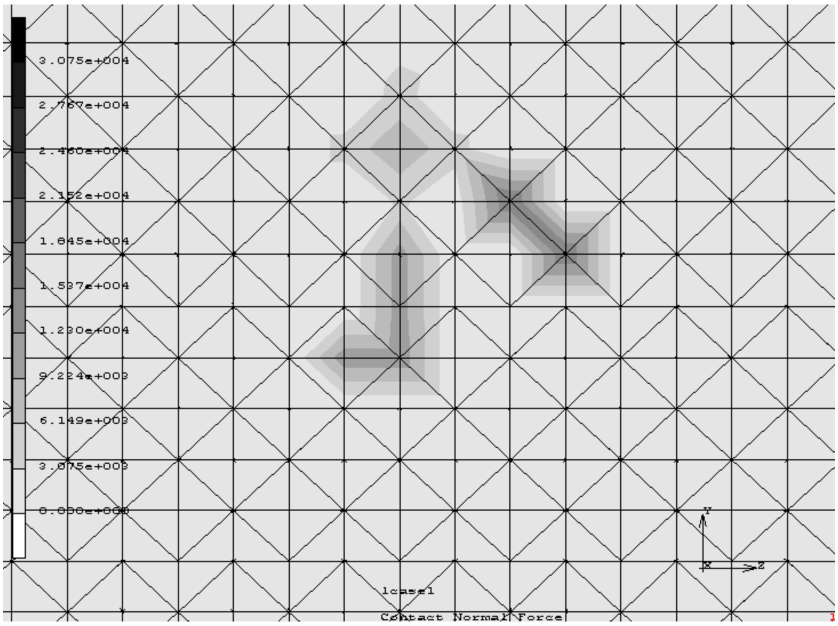

Fig. 2. Distribution of contact normal nodal forces

The specified constructions are carried out in two-dimensional model. On fig. 3 such model for considered wheels and a rail is resulted. As an example have been taken a wheel with a profile of GOST 9036-88 and rail R65 stacked with canting 1:20.

Then flat FE grids of a wheel and a rail will be transformed in spatial by means of transformations EXTRUDE and REVOLVE. On borders created FE objects boundary conditions should be set. The optimal would be to solve preliminary a problem about deformation separately wheels and a rail under action of contact forces. To allocate areas which further it is planned to use for the solution of contact problems. And displacements of this border to set as boundary conditions in displacements for a considered contact problem.

3. Results of researches

The specified algorithm has been in part realized and on fig. 4 distributions of displacements in a contacting wheel and rail are submitted. The given results are received after import of results of calculation package Visual-NASTRAN.

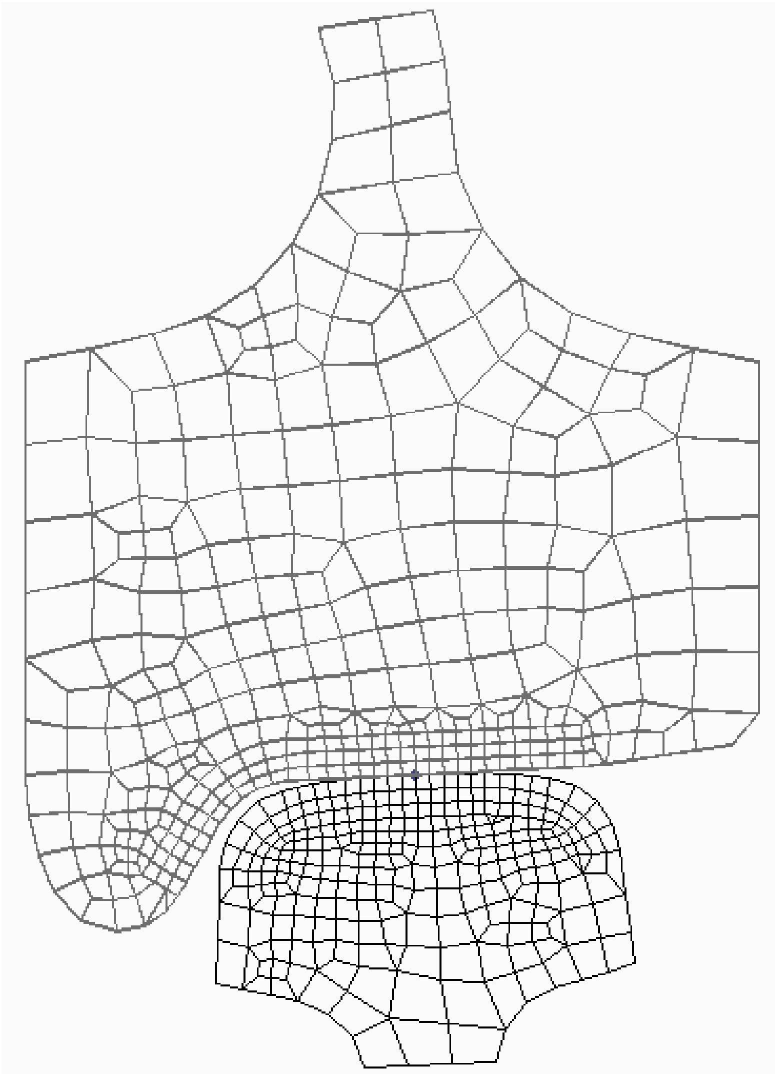

Fig. 3. Finite element discretization of a wheel and a rail in view of the coordination of contact nodes

It is quite obvious, that it is possible to judge correctness of the received solution with the greatest confidence on distribution of contact stresses or their analogue - contact nodal forces. Such distribution is submitted on fig. 5. It fully complies with classical representations.

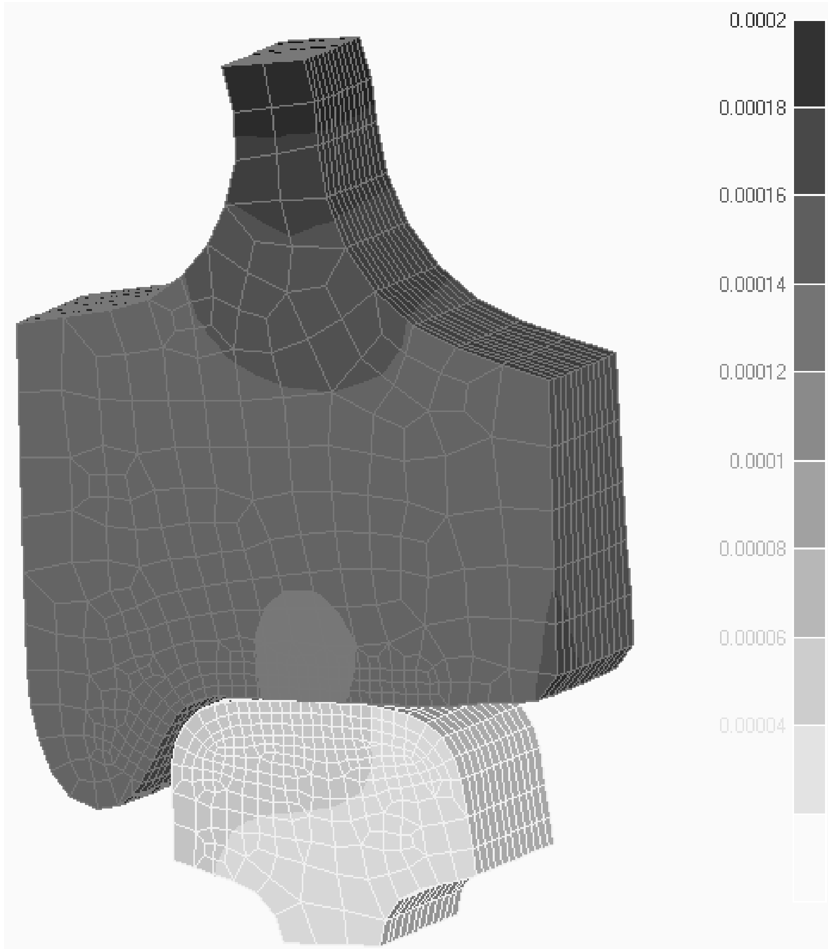

Fig. 4. Distribution of total displacement in a contacting wheel and rail

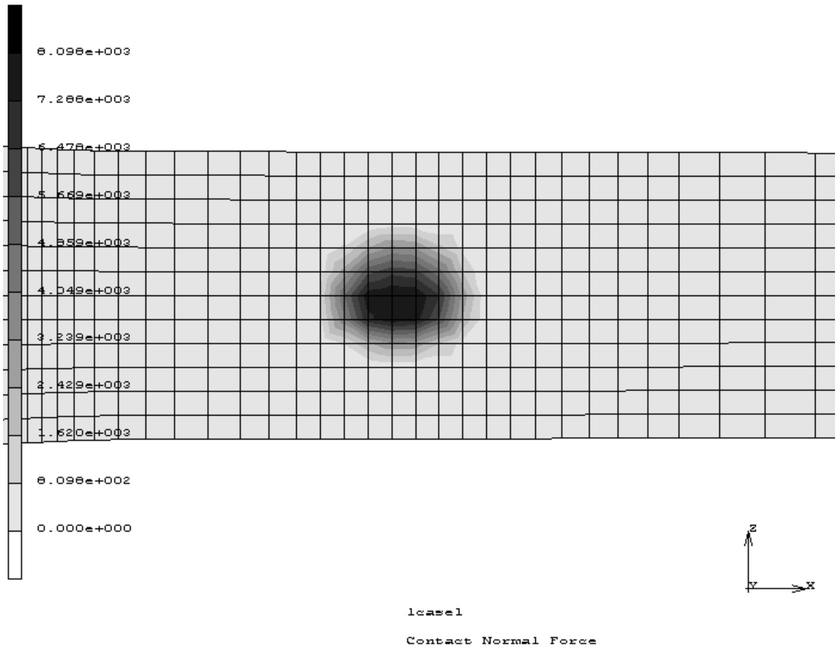

Fig. 5. Distribution of contact nodal normal forces for the specified model

4. Conclusions

The algorithm of the solution of contact problems is offered with help FEM. The specified algorithm can be effective for the analysis of contact between a wheel and a rail for difficult nonhertzian cases of contact, for example, presence of several contact zones or nonzero angles of attack wheels.

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