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THE ANALYSIS OF FINITE ELEMENTS MESH GENERATION FOR DIFFERENT RAILWAY WHEELS

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1. Introduction

Finite Element Method is the most popular method of the structural and thermal calculations of the rail wheel sets. It allows to analyze the wheels with their complicated geometry, which are given up technological loads, thermal loads, concentrated forces, initial displacement, gravitational and centrifugal loads. Usage of finite elements method on approximate calculating procedures causes receiving mistake results.

One of the stages in creating analytical model FEM is creation finite elements mesh. Suitable division of physical model of the object into finite elements has a great influence on accuracy of obtained results [1]. Authors of this work would like to pay an attention on imperfection of the automatic creation of finite elements mesh in programmes which are used to analyze FEM for example in systems: Femap/Nastran, Ansys and Cosmos. Authors also would like to present results of their experiences in creation finite elements mesh using FEM models of railway wheel sets.

2. Subject of the work

Authors of this work made a complex calculations of the series of the wheels in railway wheel sets. Methodology of creation analytical model (geometrical, physical, FEM model) which is accepted and obtained results of numerical calculations will be presented on the example of the railway wheel which is produced in Czech Republic according to technical documentation FWG302.0.02.001.007 (Fig.1a), and used up railway wheel which is produced in Russia in according to technical documentation ГОСТ 9036-88 (Fig.1b). First stage of these calculations was creation of geometrical model of the wheel. Software Auto CAD 2002 was used for it. Next step of the creating analytical model was creation of flat four-nodal elements finite mesh, type shell on the half of wheel cross-section. Automatic generators of the mesh was used in the first approximation which were included in Femap/Nastran, Ansys and Cosmos systems mentioned above.

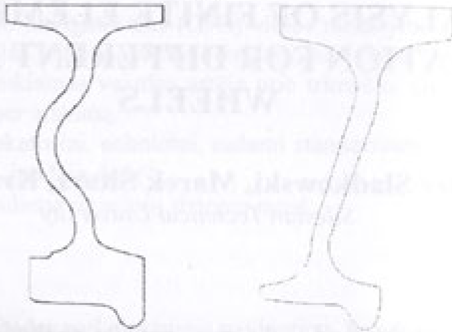

Fig.1. Shape of half of the railway wheel cross-section:
a. FWG302.0.02.001.007, b. ГОСТ 9036-88 (used)

The only one condition which was imposed on generators of the networks and it was length of the finite element edge. The length of the finite element edge was selected so as to number of elements was six in the direction of wheel disk cross-section. Authors in former re research had realized an optimisation of the elements in the transverse direction of disc cross-section. The criterion of optimisation was precision of the calculations [1, 2]. Numerical calculations and analytical was compared.

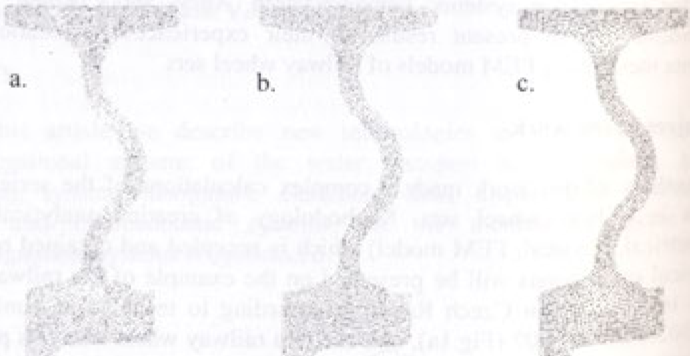

Fig.2. Flat finite elements mesh, automatically generated by programmes:
a. Femap/Nastran, b. Cosmos, c. Ansys

On the basis of number of nodes in flat model FEM (Fig.2) of the half wheel cross-section we was able to estimate number of degrees of freedom in spatial FEM model (Fig.4c). The number of degrees of freedom in spatial FEM model in every case oscillated round 590.000 it is not difficult to notice that numerical calculations of such a great model are time-consuming and demand high classed hardware. That is the reason why it is necessary to create analytical model with lesser number of degrees of freedom which would fulfill at the same time requirement connected to precision of numerical calculations. Therefore next step of Authors of this work was change of conditions enforced to automatic generators of the finite elements mesh. The number of finite elements was determined generated on every typical section and on arcs which determine a half of the railway wheel cross-section. However mesh which was generated did not satisfy the Authors. The number of degrees of freedom in spatial model of the wheel was essentially decreased to 160.000 but many finite elements appeared, but its shape made reservations of Authors. The number of finite elements in transverse direction of the disk did not correspond with these which Authors assumed. The number of finite elements in the transverse direction of disc cross-section did not correspond to assumption which Authors had made and it was from 2 to 4. This could be the reason why imprecise results appeared [1]. Moreover there were places with too much of concentration or rarefaction in finite elements mesh and also asymmetric appeared in division into finite elements of the wheel symmetric finite elements. Particularly it can be seen on wheel hub section. Mesh which were generated by all three programmes looked very similarly and included similar mistakes.

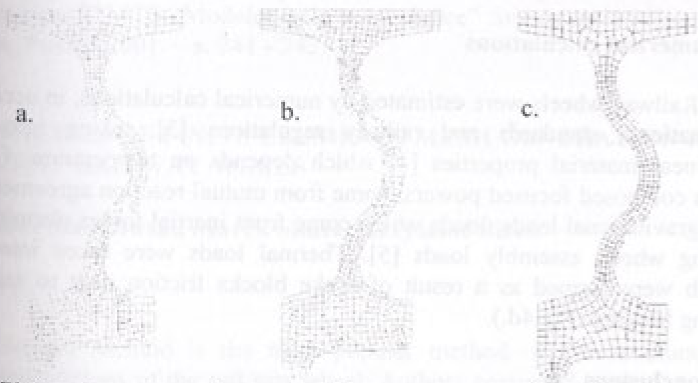

Fig. 3. Finite elements mesh generated by programmes after defined the number of elements on the border of half of wheel cross-section: a. Femap/Nastram, b. Cosmos, c. Ansys

Next step made by Authors to improve the finite elements mesh was introducing an auxiliary lines on half of wheel cross-section (Fig.4a). It allowed to obtain finite elements mesh with satisfactory size, shape and symmetry (Fig.4b). Flat finite elements mesh was used to generate spatial wheel model (Fig.4c). Spatial model was created by using spatial eight-nodal elements type: solid. Number of degrees of freedom of spatial wheel model was 160.000 which allowed to considerably reduce time of calculations and lower requirements for hardware in relation to first variant of creation the finite elements mesh.

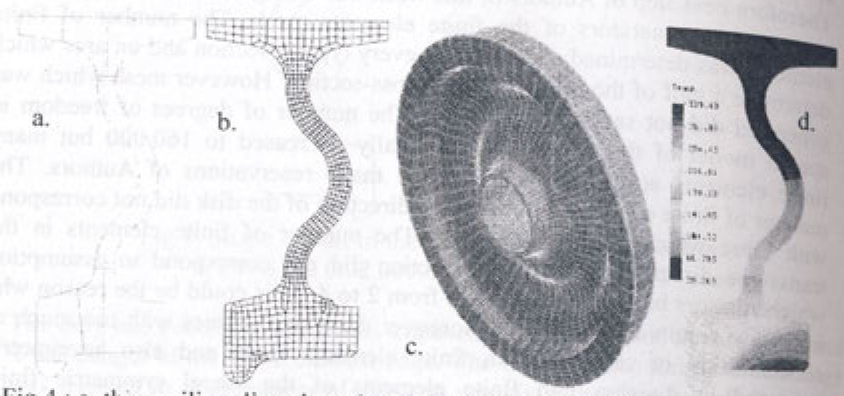

Fig.4.: a. the auxiliary lines introduced on wheel cross-section,
b. flat finite elements mesh,
c. spatial finite elements mesh,
d. stress map come from thermal loads,

3. Numerical calculations

Railway wheels were estimated by numerical calculations, in according to international standards and railway regulations [3], taking into account nonlinear material properties [4] which depends on temperature. On wheel loads composed focused powers, come from mutual reaction agreement wheel-rail, gravitational loads, loads which come from inertial forces, forming during rolling wheel, assembly loads [5]. Thermal loads were taken into account which were formed as a result of brake blocks friction near to railway car during braking (Fig.4d.).

4. Conclusions

Authors presented generation finite elements mesh methodic by using different software, basing on finite elements method (Femap/Nastran, Ansys, Cosmos). It was proved, that modules for automatic generation finite elements mesh software mentioned above fulfilled wrongly their role, in case of generation railway wheels mesh. Problem expressed in this way allows to realize semi – automatic generation of mesh, which will ensure suitable precision of the numerical calculations. The usage of submitted approach managed to make numerical calculations for many wheels with wide scale of loads.

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