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An Analysis about the State of Stress in a Railway Axle

The paper deals with a finite element analysis about the state of stress and deformation in a driving railway axle or shaft. The stress - displacement analysis has been performed with the Algor and Ansys softwares ,two powerful finite element analysis tools.There were especially analyzed the freeting areas between the axle and the driving gear or the rolling wheels and the contact areas between the rolling wheels and the rail.

1.Introduction

A classical calculus consider the driving wheelset axle of a railway vehicle as a primary shaft subjected on bending and torsion. In order to perform a quasi-static calculus, only the forces acting in certain points are needed The equivalent stresses and the displacements are usually multiplied by coefficients recommended by railway authorities ,because of safety reasons.

2. The finite element analysis

At first,the stress - displacement analysis has been performed with the Algor software,[8].The wheelset has been modelled by using the Superdraw II modulus. As a rotational three-dimensional body,the outline surface has been obtained by repeated rotational copy out of the boundary outline around the central axys OX, ,[1]. The automated meshing process of the outline surface has been performed by using the Merlin modulus. The outline surface has been meshed by 5527 surface finite elements.After that,a 3D automated meshing of the body of the axle has been performed by using the advanced automatic mesh engine Hexagen. The wheelset axle has been meshed by 26094 "brick" (8 nodes) elements.

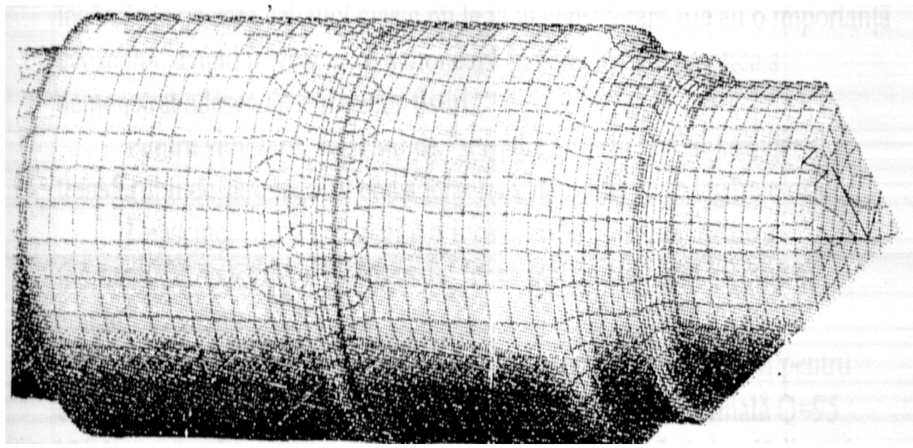

Figure 1. The meshing procedure of the wheelset

The proping on conditions have been simulated by using special boundary elements, taking into account the elasticity and the stiffness of the wheels on the vertical direction.In order to simulate the loading it is necessary to specify:

-pointed forces in the nodes

-uniformly distributed forces in the fretting contact areas between the rolling wheels or driving gear and the axle

Elastic"beam" elements has been considered in the fretting areas, so their elastic behaviour is in accordance with the linear characteristic of springs, ,[6]:

$$F=kz\ , \qquad (1)$$

where:

F-the normal force

k-the elastic constant of the spring

z-the elongation

Taking into account the fretting geometrical conditions as well as the stiffness and the elasticity of the bodies in contact,there is possible to calculate the contact forces in the above mentioned areas. Moreover,different stiffnesses in the supports has been considered in order to simulate the hunting motion and the loading transfer.There has been considered the rated value of the driving torque, so the finite element analysis has been performed for running conditions.

Afterwards,it has to specify the following typical parameters:the Young`s modulus,the Poisson`s ratio,the density,the thermal dilatation coefficient,the shearing modulus,the temperature.There are presented in figures 2 respectively 3 the state of traction-compression stresses in the plane XOZ respectively the absolute displacements caused by the pressing loading on the wheelset axle in the proping on supports:

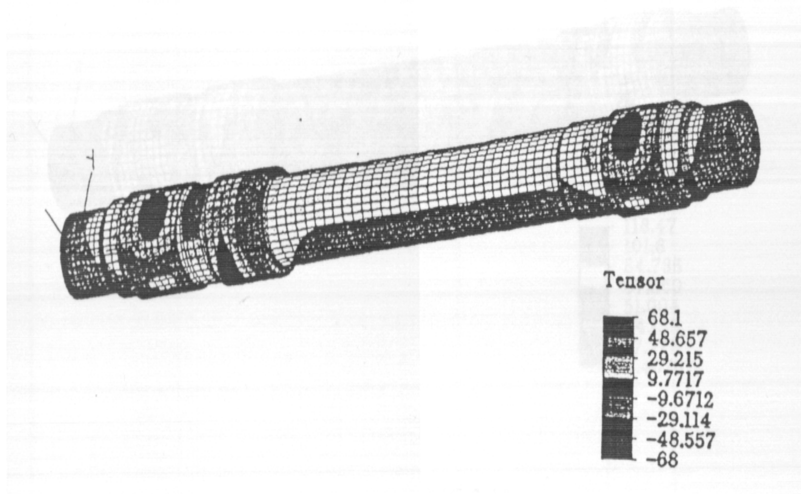

Figure 2. Traction-compression stresses in the plane XOZ caused only by fretting

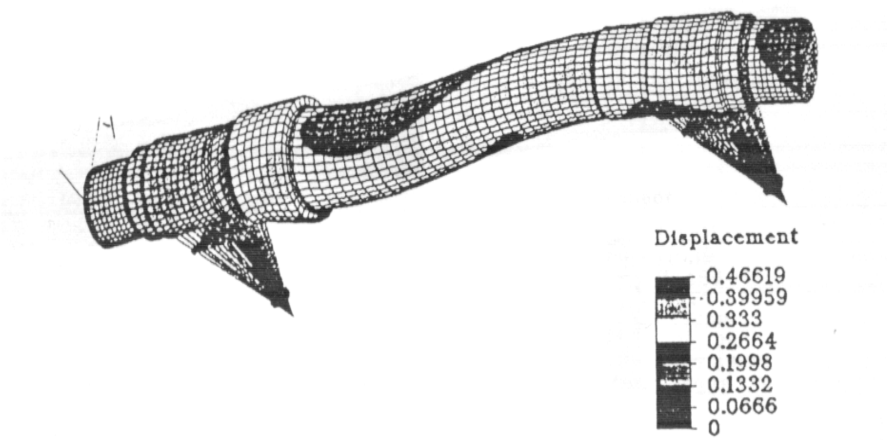

Figure 3. Absolute displacements caused only by pressing loading

There are presented in figures 4 respectively 5 the state of Von Mises stresses respectively shearing stresses in the plane XOZ caused by the total nominal load.The axle has been loaded with vertical(Q=950 kN) and horizontal forces on the proping on supports and with the nominal torque, vertical force and pressing loading in the fretting areas. A similar analysis has been performed for a 10 times nominal torque value, when the stick-slip phenomenon occurs.

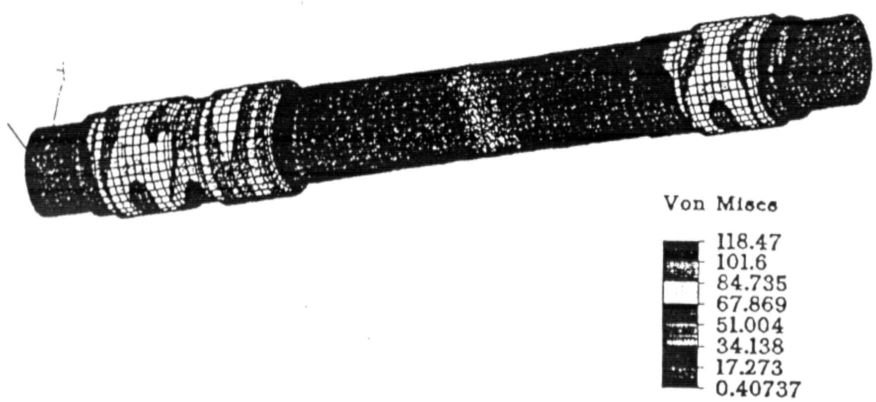

Figure 4. The Von Mises stresses caused by the total nominal load

The finite element analysis offer the opportunity to obtain comprehensive information and data regarding the behaviour of wheelset axle subjected under complex loading conditions.The post-processing modulus Sview has been used in order to obtain the results,as maps of equal stresses or displacements.

The multiplying (safety) coefficients recommended by the railway literature and the U.I.C. (Unione Interantionale de Carrozzi) files are in a perfect agreement with the location of the most stresed areas in the shaft.Especially the results in the fretting areas between the driving gear and the body of the axle (where theoretically stresses and torques did not reach their maximum values) is very covenient to be investigated with the above mentioned procedure.

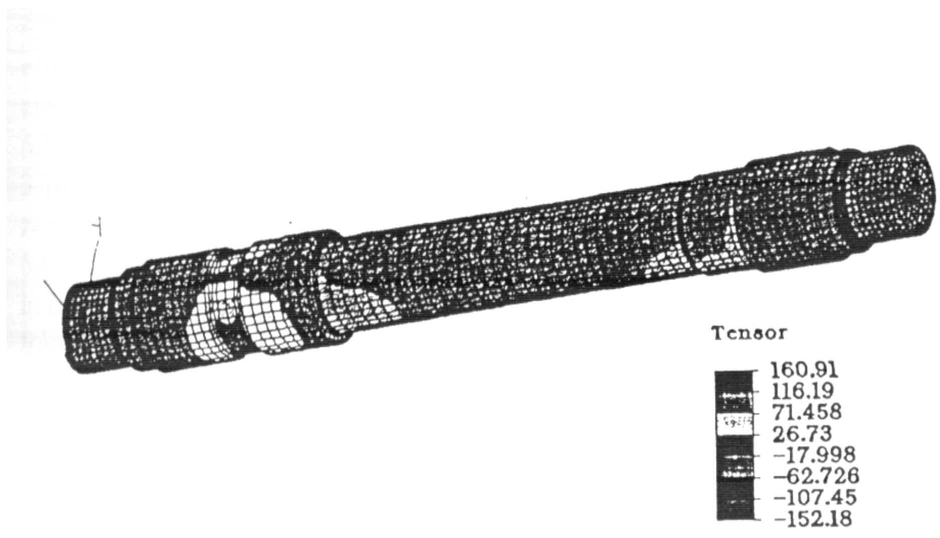

Figure 5. The shearing stresses caused by the total nominal load
Case when loading transfer is of $\Delta Q=0,6kN$

3.Conclusions

On the basis on the numerical simulations,the following conclusions can be drawn:

-The finite element analysis ascertain the wheelset areas where high stress concentrations occurs.These areas are located in the near proximity of the fretting zones of the wheels as well of the driven gear on the axle.In the contact areas between the wheels and the rail,the high stress values may caused a plastic deformation.

-There are post-processed the real values of equivalent stresses and displacements.So,a multiplying operation,because of safety reason,there is not required.

-The presence of the fretting zones may conduce to an important decreasing of the life-time in working conditions.Moreover,there is possible that these influence to be more important in comparison with the effect of the stress concentrations.

-A time-history analysis for different quasi-static or dynamic conditions there is also possible to perform according to the above mentioned procedure.

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