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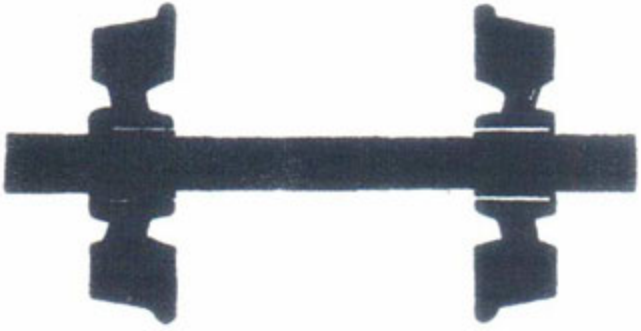

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NEW THEORETICAL PROCEDURE OF ESTIMATING THE STRESSED STATE OF SOLID-ROLLED RAILWAY WHEELS AND THEIR DESIGN IMPROVEMENT

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When developing new disigns of railway wheels, the researchers consider primarily the reliability indices both of the wheel itself, and interaction of the wheel with the railway track. The specific quantity of metal per structure, adaptability to manufacture and a number of other aspects are of major significance in the manufacture of wheels. The problem of creating optimum wheel design is actual both in the scientific and commercial plan. This calls for creating a number of optimum developments for corresponding types of rail transportation: heavy-weight freight, suburban passengor, high-speed, etc... The available at present time developments including those of the International Railway Union are still far from being perfect. In the Dnepropetrowsk Metallurgical Institute is created a scientific trend considering the wheel and rail themes in complex, i.e. their mechanical, mathematical, metallurgical and service aspects.

The investigation of stress-deformed state of various wheel elements and the wheel design as a whole called for the development of a number of calculation procedures. The most advanced one is considered to be the one based on the method of finite elements. Here we use the semi-analytical method of finite elements allowing to convert the three-dimension problem to a set of two-dimension problems by expanding the displacements, deformations and stresses by their Fourier series. Similar approach was applied by the authors both in the USSR and abroad. Nevertheless in most studies there took place a number of inaccuracies related to the presence of errors both in finite elements quantization, and in the in-

sufficient number of considered Fourier series members.

To estimate the accuracy of finite-element investigation there has been used a number of test problems for a plane disk of constant width restrained along the inner and outer contours with the possibility of their misalignment. With the help of complex variable function theory there have been obtained solutions for the disk plane deformation and flexural strain. The zero and first harmonics were considered. The comparison of finite-element solution with the test ones has allowed to optimize the parameters of the finite-element grid and to select the necessary number of Fourier series members.

There have been written out finite conditions that have allowed to take into account the wheel press-fitting on the axle, contact forces functioning in wheel-rail pair, as well as temperature fields that were determined experimentally for various regimes of applying brakes to the wheel disks. This preparing of information on wheel is done with the aid of personal computer of IBM PC AT type, the control of the geometry and quality of finite-element grid is carried out by means of machine graphics. The calculation of stresses and displacements fields is done on computer EHM-1061, and the information final processing is again personal computer-aided.

The stresses in standard wheel of the International Union of Railways, China, Germany and USSR railway have been studied. The comparison of stressed state levels with various loads acting on the wheel have been checked. Basing on the known technical solutions and theoretical modelling there have been developed a number of new designs of wheels for main-line and industrial transport. Among them the most efficient have proved to be the wheels with

so-to-say "thoroidal" and "self-relieving" disks.

For the given wheels there have been carried out test on models. With the help of tensometry the fields of deformation in various elements of wheels have been determined. The most stressed were the transient zones from the disk to the rim and from the disk to the hub. The comparison with the bench tests of the known wheel design models have shown that on the one hand they corresponded well to theoretical studies results, and on the other hand the developed designs stressed state was of lower level.

It is established that the wheels of "self-relieving" shape of the disk should have good performance in service conditions of industrial transport, especially that of the pit, where the traffic speed is as a rule not high, but there are high load on the axle. The wheel of "thoroidal" shape should function well at higher speeds in the main-line railway traffic. The design data are of patent purity and covered by the USSR authors certificates and patents of a number of leading industrially developed countries.

The described above developments have been realized in metal. The designs have proved to be adaptable to streamlined manufacture. Experimental wheel batches have been produced at the Nizhnedneprovsk Tube Works in K. Libknecht and undergone bench tests followed by trials under service conditions. The comparative train experiment proved a high serviceability of wheels of new design as compared to the used in the USSR GOST 9036-88. The efficiency of applying the developments together with the new profile of wheel rims work surface developed also at the Dnepropetrovsk Metallurgical Institute should be especially noted.

Thus the developed procedure of studies on the stressed--deformed state of wheels which includes numerical computer-aided modelling, bench modelling and full-scale deformation examination, as well as tests of wheels under service conditions have become an efficient tool for developing new wheel designs.

For further investigations we should note the necessity to develop new designs for high-speed traffic, and also seamless wheels for locomotives. The design computaions should take into considerarion the interaction dynamics with the railway bed-rail--locomotive underframe system. It is of major significance to the high-speed rail traffic. A number of developments oriented on the solution of the given problem have already been carried out.