Wheel set Integrated Design and Effective Maintenance

Type EU-funded FP6 research project - Contract number TST4-CT-2005-516196

Project website http://www.widem.org

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ERRAC evaluation ?

Keywords Railway, wheel set, loads, design, materials, NDT

Summary
The economic efficiency and competitiveness of the rail transportation mode depends on the safety, availability and maintenance of its individual highly loaded structure components, such as railway wheel sets.
Background
The idea of starting this project was stimulated by the application of the new European
design standards. As the verification of full-scale fatigue limits of wheels and axles
becomes mandatory, testing methods and interpretation methods of the results were
either not defined or not generally consistent throughout European laboratories.

The technical information that can be found in the new European standards comes from
the previous UIC norms: for example, in the case of axles, it is based on the so-called
A1N steel grade, which was extensively tested in the 1970s by SNCF laboratories. Over
the past years, these norms were proven to be safe when using this kind of steel grade.
In the last 20 years, many new vehicles were put into service achieving higher and higher
speeds, and vehicle weight reduction became necessary for the majority of European train
manufacturers.

In Italy, during the 1980s, the former Fiat Ferroviaria, together with Lucchini, started to
use an alloy steel grade (30NiCrMoV12) for the new axle of the first Italian tilting train. In
this case, design methods based on the manufacturer’s internal experience were used to
handle this material and the applied design was proven to be safe by years of service.

The new European standards enable the use of materials different from E1N, but not
much of the recently gained experience, and knowledge in using new materials and in
designing new advanced vehicles, were considered when writing these norms. For the
reasons mentioned above, it becomes difficult for today’s designers to define more
precise load spectra and material characteristics, which can be accepted by an authority
responsible for approving the qualification of a new component.

Objectives
Combining inputs from reliable service measurement of wheel–rail forces carried out by
means of an innovatively instrumented wheel set and an extensive assessment of actual
material properties, an endurance strength design concept will be developed and validated
through a comprehensive testing programme on full-scale wheelset prototypes. A flexible
numerical tool is also proposed as an upgrading of existing knowledge. Additionally, the
project will develop and evaluate alternative NOT (non-destructive testing) techniques
that allow a greatly increased detection probability and a size estimation of cracks to set
up a schedule for NOT periodic inspection. The research work will lead to the definition of
wheelset design procedures and maintenance methods to be implemented into existing
standards for a quick and easy optimisation of the process.
The WIDEM project has developed an innovative measuring wheelset using up-to-date wireless data processing and transmission technology. A dynamic calibration is being carried out by using a unique roller rig on which a running condition near to reality can be performed.

Test campaign measuring loads on two different kind of vehicles – the high-speed tilting train (the Czech Pendolino from Alstom) and the 30 axle-tonne freight vehicles from MTAB travelling across Sweden.

Definition of a rigorous methodology to test the fatigue resistance of full-scale axles and wheels.

Research on fretting fatigue phenomena, which takes place under axle seats, by taking into account seats and section transition geometry, press fit pressure and axle/hub slip.

Creation and validation of an innovative methodology to design and validate wheelsets. This methodology is based on load spectra and S-N curve for the material in the full-scale condition.

A new wheelset maintenance strategy based on more accurately defined inspection periods by taking into account the actual probability of NDT equipment to detect defects and cracks of defined dimensions, and full-scale crack propagation tests performed on axles.

At this stage a new real-time measurement methodology of wheel-rail contact forces based on the acquisition of axle deformations having a bandwidth of about 70Hz has been developed. The development of a standard procedure for processing load (or stress) measurements will allow the computation of a wheelset design mission profile.

The innovatively instrumented wheelset developed in WP1 has been mounted on a Czech Pendolino vehicle and will be used to determine the load spectra. Specific measurements will be made by running on switches and turnouts.

The possibility of combining full-scale experimental fatigue tests resulting from a current testing campaign together with a FEM model representing the actual longitudinal stresses and micro-slips between hub and seat can enable the definition of design criteria against fretting fatigue. This work is presently under progress for A1N, A4T and 30NiCrMoV12 steel grades.

Full scale tests are being carried out on the Lucchini test rigs to find the fatigue limit at 10^7 cycles for different diameter ratios with the aim of validating the above described fretting fatigue model and of defining the ‘D/d border’. Below this value, cracks will appear on the axle seat; above this value, cracks will appear on the body fillet. Such a value will increase with the fatigue resistance of the steel grade so that it will be appropriate to define the optimal D/d for each kind of material.

Different inspection methods are being applied on both fatigue tested axles and real in-service cracked axles to find the probability of inspection related to crack or defect dimension.
Inspection intervals: significant work has been completed in deriving crack growth rate parameters under both plane and rotating bending conditions.

**Additional details**

- **Total cost:** 3,766,500 €
- **EU contribution:** 1,949,900 €
- **Duration:** 01.01.2005 – 31.12.2007