Curve Squeal Project of UIC

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Introduction

The Curve Squeal Project is carried out by the International Union of Railways (UIC). The objective of the project is to develop practical measures which can be applied by the railways in order to reduce squeal noise. This paper focuses on the results of the first phase of the project and the steps to be undertaken in the 2nd phase.

The ongoing problem Squeal Noise

Noise arising from curve squeal is still a non solved problem. Many research projects have been carried out in the last years with the goal to provide a fundamental understanding of the phenomena and the parameters for the generation of squeal noise. For the railways, UIC started under the management of ERRI in 2002 a three-phase project. Its final product is planned to be an overall problem-oriented guideline which covers different problems and offers applicable solutions against squeal noise.

The objective of the first phase was to survey the extent of the problem within the railways, to compile a „Toolbox of solutions", to develop further a model of squeal noise and to integrate it into a software which can be connected to the actual railway noise calculation software TWINS, as well as to create an inventory of suitable rig tests for validation of model results and test of effectiveness of solutions [1].

Extent of the problem

Curve Squeal is the tonal, high frequency noise which is about 10-30 dB higher than rolling noise. This noise may occur when a vehicle passes a small-radius curve. This noise does not occur permanently and can not be predicted for 100%. There exist no official regulations regarding squeal noise, accordingly squeal noise is not included in official noise calculation models and is not integrated in noise mapping (with the exception of the German Schall03). Therefore neither railways nor authorities are aware of the number and the location of the curves and the annoyance potential of squeal noise for a network. Squealing curves do get attention when complaints from passengers or nearby inhabitants exceed a certain limit or when maintenance engineers become aware of the problem.

A standardised questionnaire was sent out to the railways and its findings extrapolated. It showed, that about 10% of the inhabitants disturbed by rolling noise in Europe are disturbed by curve squeal noise as well, which equals about 1.5 Mio. The extrapolation concerning railway clients showed that about 7% of railway passengers using daily the services are exposed to curve squeal noise [2].

Toolbox of existing measures

In order to compile existing measures for reduction of squeal noise an extensive literature and internet research was carried out. The following type of measures were compiled and described in detail [3]:

- Wheel-based measures (ring dampers, constrained layer dampers and resilient wheels).
- Track-based measures (rail dampers)
- Lubricants and friction modifiers
- Coatings
- Asymmetric rail profile
- Steerable axles
- Further measures have been compiled, but were not further considered: Train speed adaptation, shielding, adaptation of curve radius.

It was nearly impossible to compare the measures concerning their effectiveness against squeal noise, as comparable measurement data did not exist. Squeal noise has to be treated in terms of the level of occurrence and the level of noise, and for most cases the level of occurrence was not evaluated. Such an instrument is still missing.

Some of the measures are still very theoretical and do not receive much confidence from the railways in terms of costs, environmental concerns, technical feasibility and safety.

Model Development

Observations indicate that the highest squeal noise is usually generated by the leading inner wheel of a four wheeled bogie or two axle-vehicle. This noise has been associated with stick-slip lateral motion at the contact between the wheel tread and the rail, referred to here as „squeal due to lateral creepage". A theoretical model for curve squeal has previously been developed by TNO [4]. This model is based on excitation by unstable lateral creepage. As a part of phase 1 this model – a new calculation model named SLYNX - was linked to TWINS 3.0 [5, 6].

	Theoretical development	Preliminary model	Test rig validation
Lateral creepage	TNO	TNO	TNO
Longitudinal creepa	Phase 1	Phase 1	
Spin creepage	Phase 1	Phase 1	
Flange contact	Phase 1		

Figure 1: Modelling carried out in phase 1

The contact between the wheel flange and the rail, which occurs at the leading outer wheel in sharp curves, has generally been found to reduce the likelihood of stick-slip squeal at this wheel. However it is thought that flange contact may generate a different form of squeal noise, which can be a source of considerable annoyance. ISVR developed the model of TNO by including longitudinal and spin creepage into the model and to account for flange contact (see Figure 1). In the framework of this project it was possible to develop a model for the excitation of curve squeal that includes lateral, longitudinal and spin creepage terms [7] (see figure 1).

Inventory of Test Rigs

Rig testing has two objectives: The assessment of the effectiveness of treatments for curve squeal noise and the gathering of data for the validation and extension of the theoretical model of curve squeal noise.

Nine different types of rigs were reviewed and three were analysed in detail [8]: the TNO test rig in Delft, the DB test rig in Brandenburg-Kirchmöser, and the DB Roller Rig in Munich. The TNO 1:3 scaled test-rig and the RaSSP rig allow detailed investigations of the wheel/rail contact under well-defined and well-controlled conditions. The Roller Rig facility in Munich comes closest to reality (tests possible which are very much the same as on a real track). Due to the fact that the rig is shut down this year, further investigation is no longer possible.

Next Steps

The second phase of the project started this year. Some measures will be tested on test rigs as well as on several curves networks in France, UK and Switzerland. Priority is given to improve the level of confidence in the selected measures concerning environmental performance, costs and safety. A preliminary design manual for selected measures will be produced at the end of this phase.

As not all measures in the tool box can be tested a selection must be made. Budget restrictions are one of the most important factor defining the selection.

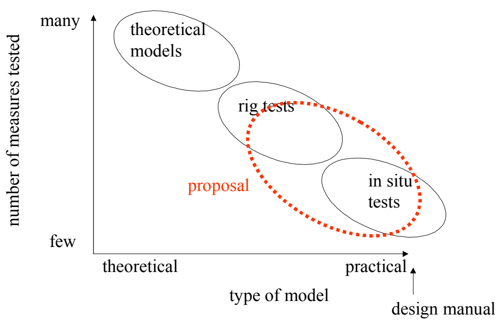

Figure 2: Range of selected measures [9]

Within this restriction varying factors are the number of measures that can be tested and extent of testing, e.g. more measures mean less in depth testing and vice versa. In general rig testing will be less expensive per measure, however the confidence level is not as high as in situ tests. Out of these variables, the optimum combination must be found. This, however, is difficult, due to a lack of experience.

The options are shown graphically in Figure 2:

The selection of measures was made according to a variety of criteria, which led to a program with the following steps [9]:

1) To develop standard measurement protocols for rig tests and field tests.

2) On the TNO rig a large number of parameters and friction modifiers are measured.

3) Field tests with friction modifiers in Switzerland, France and UK.

4) Final rig tests on 1:1 DB rig based on open questions from point 3.

Tests and measurements are planned to be carried out in summer 2004, final results are expected for 2005.

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