The UIC-project Noise Impact of Composite Brake Blocks (Nicobb)

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Introduction

In some countries the railway freight traffic experienced in the last years an economic revival with a continuous growth of the absolute tonnage as well as a relative increase of the market shares compared with the other modes of transport. In other countries, freight transport shift from road to rail is an objective. However, the parallel increase of environmental noise endangers this economic development and obliges the stakeholders to find new technical solutions capable of reducing the railway noise with particular emphasis on rolling noise from freight traffic. Since the adoption of the TSI Noise by the European commission, all new freight wagons taken into operation have to fulfil very stringent noise limits, making the use of composite brake shoes of the type K essential.

The K-blocks preserve the wheel treads during braking, so that the wheel roughness and as a matter of fact the rolling noise can be considerably reduced in comparison with cast iron blocks braked wheels. On the other hand, the coefficient of friction of K-blocks is much higher than that of cast iron blocks, which requires a major modification of the brake systems (rods, cylinders…). This leads to considerable costs for the retrofit of existing freight wagons.

For all these reasons UIC supports the development of new composite brake blocks of type LL in order to combine the positive effect of K-blocks on wheel treads with the coefficient of friction of cast iron shoes. This opens the opportunity to substitute cast iron blocks by LL-blocks with less effort in comparison to K-blocks, hence making LL-Blocks very attractive for the retrofitting of existing cars. Up to now the effort was focussed on the technical development of new blocks and only a few projects investigated the acoustic properties of LL-blocks. This is due to the fact that acoustic measurements generally require field tests, which are very time and money consuming. Thus there is a need of simplifying the acoustic validation procedure to encourage manufacturers to develop new products.

The project Nicobb (acronym for Noise Impact of Composite Brake Blocks) is a UIC project carried out by SNCF and Deutsche Bahn. It aims at developing a testing procedure for the validation of low roughness levels retained by new composite brake blocks (LL or K) as a low-cost alternative to expensive field tests.

This procedure shall consist of two steps:

1. Generation of a wheel roughness typical for a particular brake block on a test rig
2. Application of a transfer function to assess the radiated rolling noise spectrum from wheel roughness

The development of this transfer function is a central part of the NICOBB project.

Figure 1 illustrates the structure of the Nicobb project.

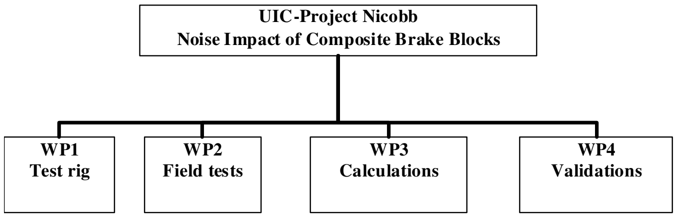

Figure 1: Structure of the Nicobb project

Field tests

Work package two dealt with the field tests and aimed at checking the noise reduction potential of LL-Blocks compared with K and cast iron (CI) blocks under type testing conditions i.e. on a TSI+ reference track [1]. Another objective of this WP was to collect a complete set of data (track and vehicle conditions) for different types of brake blocks, which can be used as input for the activities carried out in the other WPs especially for the validation of the software tool.

The test train was composed of 9 freight wagons of the type Habbiins 14, 4-axle sliding-wall wagons, taken from normal service (see Figure 2). For each type of investigated brake block (K, LL and CI) three wagons were provided.

Figure 2: Habbiins wagons passing by the test site

The test runs were carried out on the TSI reference track maintained by DB Systemtechnik on the conventional line Augsburg-Donauwörth. Prior to the test runs, measurements of rail roughness and track decay rates according to the new European standards prEN 15610 [2] and EN 15461 confirmed the TSI conformity of the track section. Before the beginning of the runs, the roughness of each wheel, main focus of the project, was measured with a special measuring device (see Figure 2 and Figure 35).

The pass by noise levels of each group of wagons illustrated in Table 1, show that the noise emission levels of the K- and LL-wagons were comparable at both test speeds and more than 13 dB(A) lower than the pass by noise levels of the cast iron braked wagons. The wagons with composite brake blocks fulfilled the TSI-limits for new and retrofit wagons (≤82 dB(A) at 80 km/h).

Speed km/h	$L_{pAeq,tp}$ in dB(A)		
	CI	K	LL
80	94	80	81
120	100	87	87

Table 1: Pass by noise levels measured under TSI conditions

A comparison with a data base of wheel roughness results carried out to check the representativeness of the pass by noise results showed that the roughness levels measured on the CI-wheels were in-line with former tests whereas the K- and LL-block braked wheel treads were smoother than expected. However this comparison relies on a thin database since very few wheel roughness data of composite block braked wheels are available at the moment.

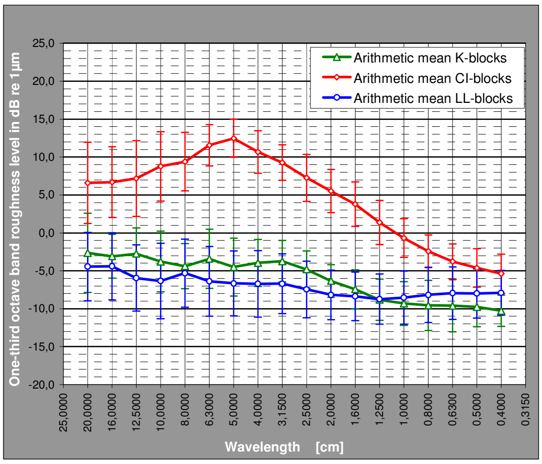

Figure 3: Averaged one-third octave band roughness spectra of K-, LL- and CI- block braked wheels measured during field tests**.**

Test rigs

Work package one dealt with the test rigs investigations and aimed at checking the ability of a test bench to generate for a particular brake block a wheel roughness representative of normal service.

A literature research showed that former attempts to generate wheel roughness at test bench failed because the grinding effect produced at the wheel-rail contact could not be reproduced. Therefore the design department of SNCF test center AEF (Agence d'Essais Ferroviaire) developed a roller mounted on a UIC-compatible clamp aiming at simulating the wheel-rail contact (see Figure 4).

This roller, applied in place of the brake blocks within the course of the braking sequence, was thought to condition the wheel treads in a representative way. However the experience showed that the rollers produced facets and cracks on the wheel treads without influencing the roughness significantly. As a consequence this matter was not followed up.

Figure 4: CAD-drawing of the roller applied on a wheel

Due to the different coefficient of friction occurring while braking with K-blocks on the one hand and with LL- or CI-blocks on the other hand, two different braking programs were used to condition the wheel treads. They were derived from actual braking sequences recorded on a SBB-CFF wagon equipped with a stand-alone recorder during three months, between Italia and Switzerland on the St Gothard route. This program is called “basic braking cycle” and is made of round 500 brakings (stop and gradual braking) and simulates approximately 8.000 km of one wagon life. The applied forces are different according to the brake block type (K or LL). A cycle consists in a mix of stop, slowing down and jagged (sawtooth) brakings from different initial speeds. The sequence includes the simulation of three different vehicle conditions: wagon loaded, half loaded and unloaded. In order to monitor the roughness growth, wheel roughness measurements were carried out approximately every 2.000 km (see Figure 5).

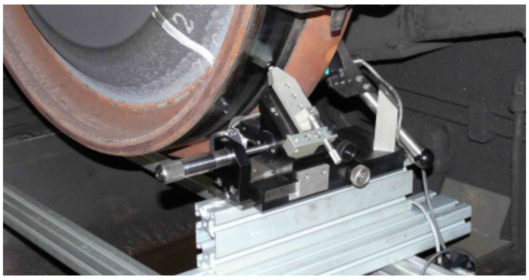

Figure 5: Roughness measuring device RM1435 mounted at the DB dynamometer

SNCF investigated different brake programmes configurations and applied them to three types of brake blocks: Cast iron, K-block Becorit 929-1 (organic) and LL-block IB 116* (organic) at the AEF test rig. Then the reproducibility of the method was checked at the dynamometer of DB Systemtechnik in Minden, where three types of block were tested: the Becorit 929-1, the IB116* as well as a sintered LL-block of the type Cosid 952.

The analysis of the roughness spectra measured at each test rig and at field test showed that, in the case of the composite blocks, the roughness spectra conditioned at the dynamometers are in agreement with experience of field tests. For the two types of composite blocks measured at both SNCF and DB dynamometers a satisfying reproducibility was achieved (see roughness spectra of organic LL-blocks in Figure 6).

A few issues found during the investigations may affect the accuracy of the method and therefore restrict the applicability of the procedure. The very high roughness levels usually observed on cast iron braked wheels could not be reproduced at the test rig. This is not really critical since the project focuses on composite blocks to which the method shall be applied in the future but affect the accuracy of the method while assessing bad blocks acoustically speaking. Furthermore a crossed comparison of the wheel roughness measuring devices of DB Systemtechnik and SNCF showed that due to the absence of a standardised procedure, the different algorithms used to process the roughness data may affect the roughness spectra in the short wavelength domain.

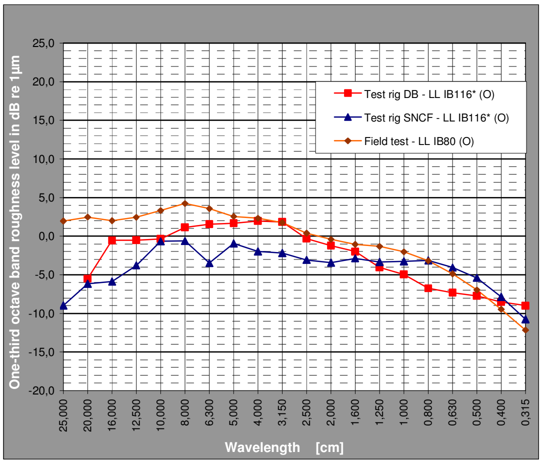

Figure 6: Wheel roughness spectra as function of wavelength measured at DB (red line) and SNCF (blue line) test rigs at the end of the brake programme vs. roughness levels measured at field test during the UIC project RP32 (brown line); all the wheels braked with organic LL-blocks; each measurement carried out by a different team with a different device.

Calculations and validations

Within these WP an easy-to-handle engineering prediction tool was developed by SNCF. The model is derived from the Track Wheel Interaction Noise Software (TWINS) and is based on the assumption that the total pass by noise of a railway vehicle can be considered as the sum of the track and vehicle contributions plus the wheel-rail combined roughness under consideration of the contact filter as illustrated in equation (1) (see also [3]).

$$L_P(total) = (L_H(track) \oplus L_H(Vehicle)) + (L_r^{rail} \oplus L_r^{wheel}) + C_{filter} \quad (1)$$

The prerequisite for the application of the Nicobb-tool is the availability of a full set of measurements performed under TSI conditions including wheel and rail roughness, track decay rates as well as pass by noise for a given vehicle configuration. The software allows then to predict the noise emission that would be obtained on the same track with the same vehicle equipped with a different brake block by substituting the wheel roughness measured at field tests for the roughness measured at rig test with the new brake block.

A further option of the tool extends the domain of application to the track parameters by considering the vertical and lateral track decay rates as input parameters. Thus it allows predicting the noise emission on tracks having different properties, for instance a TSI compliant track if the original measurements were carried out on a non compliant track. The latter option is however less precise, only applicable to vehicles which don't present other sound sources than rolling noise, requires competent knowledge of track dynamic characteristics and is therefore designed for advanced users.

At the moment, the final validation of the tool has to be achieved.

Conclusions

The Nicobb project aimed at developing a new methodology to allow a low-cost assessment of composite brake blocks on the basis of test rig investigations. For this purpose a braking programme has been defined and applied successfully to several types of composite blocks at the brake dynamometers of SNCF AEF and DB Systemtechnik. In the case of the investigated composite blocks, the wheel roughness spectra measured at the end of the braking sequences were representative of normal service and in some measure reproducible. However very few roughness data of composite-block braked wheels are available at this time.

An engineering easy-to-handle calculation tool able to predict the noise emission based on the roughness spectra measured at test rig was developed and partly tested. The final validation of the tool has still to be achieved.

Field tests conducted with a freight train equipped with K-, LL- and CI-blocks showed that the composite block-braked wagons fulfilled the TSI Noise limits for new and retrofit wagons.

One can conclude that the brake block assessment procedure developed within the Nicobb project is promising for future developments of composite blocks. However it is necessary to extend the database of roughness measurement results both from field and rig tests to validate the method and to get a statistical assessment of its accuracy.

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