Grinding programme COMBINES noise reduction and preventative maintenance

Use of a ballastless track design on HSL-Zuid meant that there was a risk of exceeding the legal limits for noise emissions, which are based on conventional ballasted track. The problem is being countered with a carefully-tailored maintenance programme that combines acoustic and preventative grinding

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LINKING Amsterdam with the Belgian border, the HSL-Zuid high speed line was tested during February and March at speeds in excess of 300 km/h.

The Thalys test train, its interior bristling with measuring equipment, yielded a large volume of data. This included noise measurements that were of special interest to technicians from M+P Consulting Engineers, Speno International and BAM Rail, three companies which have worked together to develop a rail maintenance strategy for the line.

M+P is an engineering consultancy specialising in sound and vibration, Speno is a Swiss company well-known for its expertise in rail grinding, and BAM Rail is a construction firm forming part of the Infraspeed consortium that was commissioned by the Dutch government to design, build, finance and maintain the line from 2006 to 2031.

Most of the 100 km line uses Rheda 2000 ballastless track (RG 4.05 p201). The Rheda system was adapted to suit the Dutch conditions (Rheda 2000 NL) and consists of prefabricated sleepers anchored in a reinforced concrete slab poured on site. This produces a very rigid and strong trackform which was laid as double track over 80 route-km; the sections of ballastless track include 16 high speed turnouts. In addition, there are 40 km of track, mainly consisting of connections to the rest of the Dutch network and the link to the Belgian network, which were laid on a conventional ballast bed.

The Rheda 2000 design offers major advantages in terms of durability, maintenance options and passenger comfort, but the decision to use it meant that the legal limits for noise emissions, which are based on the use of ballasted track, were in danger of being exceeded. To tackle this problem, BAM Rail and M+P worked with Speno in an extensive study to develop a cost-effective method of preventing the extra noise emissions.

Noise mitigation at source

Acoustic grinding smoothes out irregularities in the contact surface between the rail and the wheel, reducing noise caused by the rolling contact. Consequently, the noise produced is effectively cut off at the source.

The rail is ground for the first time during track construction, removing the mill scale and imperfect surface left after the metal is rolled and any irregularities that may have occurred during construction. After this initial grinding, the rail is in good condition for future maintenance. Grinding at this stage is done in such a way as to meet the acoustic requirements. Rail roughness is the criterion used to determine whether the rail is acoustically sound.

Once the line becomes operational, the rail is ground to keep it in optimal condition; this is common on Dutch and other European railways.

Grinding will also be carried out to reduce rolling noise; this process will be extensively used on HSL-Zuid. To date, acoustic grinding has not been used on such a large scale anywhere else in the world – more than 80 km of double track will be maintained in this way.

It is especially unusual as acoustic grinding has been fully integrated into the traditional grinding process, which is used to counteract the effects of incipient cracks caused by normal rail wear and to prevent them wherever possible. To facilitate this, BAM Rail and M+P have set up an integrated grinding and evaluation programme.

The grinding is handled by Speno, which has developed a special technique for HSL-Zuid which it will continue to fine-tune in the future.

The noise produced and the mechanical condition of the entire rail section on

Fitted with ERTMS and instrumented by Siemens, this Thalys trainset seen south of Rotterdam is being used for pre-comissioning testing on HSL-Zuid at up to 330 km/h
Photo: Peter Honig

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The direct method of measuring rail roughness produces very accurate results, but only on a short section of track.

the high speed line are checked periodically using a track inspection train.

These periodic checks of noise levels and rail condition will prevent the rails from being ground unnecessarily. They will also ensure that rails which are in poor acoustic or mechanical condition between two scheduled grinding times will not cause environmental or safety problems. Compared to performing separate operations for acoustic grinding and preventative grinding, the integrated grinding process offers a cost reduction of at least 50%.

Shared expertise used to develop grinding programme

Three companies were involved in developing the rail maintenance programme for HSL-Zuid: BAM Rail, Speno International and M+P Consulting Engineers, which works on and researches railway noise issues with sister company Müller-BBM. BAM Rail, the operating arm of the construction company Royal BAM Group, provides maintenance and construction services to the Dutch railway market. BAM Rail and Speno International are responsible for all grinding performed on the Dutch network, and their combined knowledge and experience were used in developing the maintenance programme for HSL-Zuid.

Grinding trains on HSL-Zuid operate from two maintenance yards at Lage Zwaluwe and Hoofddorp. The Netherlands sets high standards for the environmental aspects of rail grinding, requiring the near-complete removal of all grinding residues; this requirement is met by the 48-stone grinding trains that operate on HSL-Zuid.

Speno International became involved in developing a method of grinding to reduce rolling noise on both conventional and high speed track in the early 1990s. This led to the development of special machines and tools for this type of work, with systematic and rigorous methods of implementation.

In most cases, conventional grinding of rail corrugation succeeds in reducing noise emissions. Acoustic grinding carried out in accordance with prEN ISO 3095 contributes a further reduction of around 3 dB(A). For high speed lines, grinding methods that are now being developed and refined will permit a further reduction of noise emissions by 5 dB(A) in the centimetric roughness spectrum and below.

Grinding to cut noise

To mitigate the rolling noise effectively, the roughness of the rail should be reduced at certain wavelengths corresponding to acoustic frequencies that dominate the noise spectrum. Reducing the long wavelengths in rail roughness will reduce the low-frequency noise, whereas reducing the fine roughness will reduce the higher frequencies.

Vehicle speed is a relevant parameter in translating roughness wavelengths into acoustic frequencies – as speed rises, roughness with a certain wavelength will produce noise at an increasing frequency. For the specific application of rail grinding on HSL-Zuid, the rail roughness is reduced for wavelengths between 10 mm and 250 mm.

The Dutch Noise Calculation Scheme for railway noise (RMVR '96) is the legal basis for the calculation of the effect of noise reduction measures for HSL-Zuid. The future Calculation Scheme includes a new procedure to convert a rail roughness reduction into a noise reduction. This procedure states that a reduction of the rail roughness in comparison with the defined Dutch average rail roughness constitutes a noise reduction at the source. This direct relationship between roughness level and noise implies that a rail roughness spectrum can be defined that provides the required noise reduction.

Measuring the grinding result

As the rail roughness reduction can be directly translated into a noise reduction, it is vital to be able to measure and monitor rail roughness on the high speed line.

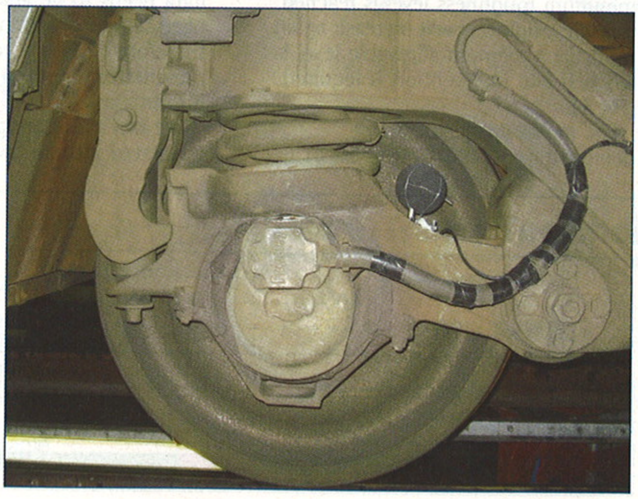
Either direct or indirect methods can be used to measure rail roughness. The direct method measures rail roughness by recording the displacement of a transducer that is moved along the rail (left). This produces very accurate results, but it only measures the roughness on a short section of the track. In the indirect method, vibrations or sound from a train wheel running on the rail are recorded and translated back into roughness levels for that specific rail. This provides measurements for a longer section of track, but it is more sensitive to disturbance and is likely to be less accurate.

On HSL-Zuid the rail roughness needs to be monitored over a long length of track to a high degree of accuracy. M+P therefore developed a combined direct and indirect rail roughness measurement method, as well as a special indirect measurement system known as ARRoW. This consists of a combination of vibration sensors and four measurement microphones, coupled with data analysis software and a GPS system for position and speed logging. The ARRoW measurements are calibrated with direct measurements. This achieves the best of both worlds – the accuracy of the direct method and the measurement speed of the indirect method. The combined technique (below) was deployed during the Thalys test runs earlier this year.

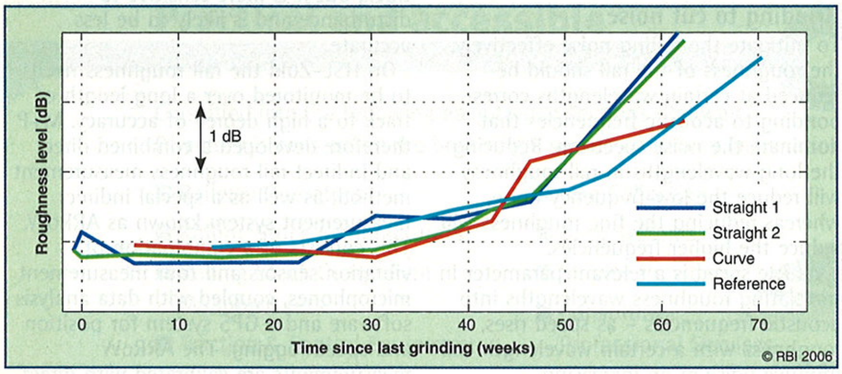
Whole-life grinding

The rail roughness level is not a static parameter that is maintained throughout the lifetime of the rail. Roughness increases as the rail is used due to simple wear and depends, among other factors, on the total tonnage that passes over the track. It also depends on the types of wheel used on the track and the roughness levels of the wheels. Because of the non-static roughness level, a certain average noise reduction by grinding is achieved by maintaining the rail at a certain average level of rail roughness.

At the start of the project, only



The ARRoW system developed to measure rail roughness on HSL-Zuid combines sensors and microphones on the Thalys trainset with GPS logging of speed and location



ABOVE: *Fig 1. Direct roughness development over time, as recorded using the mbbmRM1200 measurement device*

TOP: *A Speno 48-stone grinding machine at work on HSL-Zuid* Photo: Peter Honig

qualitative data was available on the lifetime development of the roughness. M+P and BAM Rail accordingly carried out a rail grinding monitoring experiment on a piece of track which was subjected to acoustic grinding by Speno. Rail roughness measurements were then taken on a regular basis for more than a year.

The monitoring revealed that grinding reduces the roughness to a certain level and that roughness will decrease further just after grinding until a certain minimum level is achieved. After the minimum roughness level is reached, the rail roughness will increase again until the maximum allowable level is reached and intervention is required (Fig 1).

The monitoring experiment demonstrated the effectiveness of the measure and gave the M+P and BAM engineers enough insight to choose grinding as the noise mitigation method for the Rheda 2000 track design, to integrate the acoustic grinding into the cyclic grinding programme and to develop a cost-effective rail grinding maintenance programme.

Monitoring programme

Monitoring rail roughness during operation of HSL-Zuid is needed to provide information about the exact development of roughness and to identify the moment when the maximum roughness level is reached and more acoustic grinding needs to be scheduled. Moreover, the regulatory authorities are informed about the noise reduction being achieved by rail grinding.

After measurements with the ARRoW monitoring system, a huge amount of data needs to be analysed to extract the necessary information. BAM and M+P therefore devised a calculation and presentation method for the monitoring information.

The raw monitoring results are translated into an 'average acoustic track quality' number ($C_{b,\,c,\,t\text{-avg}}$) and then presented using a colour scheme which is explained in Fig 2.

The segments where grinding should be scheduled are clearly identified by the red colour. Failing segments are completely red, and local deviations within a segment are indicated by the red hatching. The segments where the acoustic condition is good are indicated by the green colours. The light green sections denote segments where grinding will be required in the near future.

The method of presentation is intentionally kept simple so all parties involved can immediately see the acoustic quality of the track, even if they do not have the necessary technical background to interpret the figures. ■

Le programme de meulage associe réduction de bruit et entretien préventif

Aux Pays-Bas, l'emploi du concept de voie sans ballast Rheda 2000 sur la ligne à grande vitesse HSL-Zuid signifiait qu'il y avait un risque de franchissement des seuils légaux en matière d'émissions de bruit, mais cela sera contré grâce à un programme de maintenance soigneusement élaboré sur mesures, combinant un meulage à la fois pour des motifs acoustiques et des motifs préventifs. Les mesures de bruit réalisées lors d'essais à grande vitesse avec une rame Thalys ont été utilisées pour définir et développer la stratégie d'entretien de la ligne

Schleifprogramm kombiniert Lärmverminderung mit präventivem Unterhalt

Der Einsatz des schotterlosen Oberbaus Rheda 2000 auf der HSL-Zuid Hochgeschwindigkeitslinie in den Niederlanden bedeutete, dass die Gefahr bestand, die gesetzlichen Lärm-Emissionslimiten zu überschreiten. Dies wird abgewendet, durch ein sorgfältig zusammengestelltes Unterhaltsprogramm, welches akustisches und präventatives Schleifen kombiniert. Lärmmessungen von Hochgeschwindigkeitstests mit einer Thalys-Komposition wurden zur Definition und Entwicklung der Unterhaltsstrategie dieser Linie verwendet

El programa de amolado combina la reducción de ruidos y el mantenimiento preventivo

La utilización del diseño de vía sin balasto Rheda 2000 en la línea de alta velocidad HSL-Zuid en los Países Bajos supuso el riesgo de que se excedieran los límites legales de emisiones acústicas, pero esto se está siendo contrarrestado con un programa de mantenimiento meticulosamente confeccionado que combina el amoldado acústico y preventivo. Las mediciones de ruido que se obtuvieron de los controles de alta velocidad con un tren Thalys se utilizaron para definir y desarrollar la estrategia de mantenimiento de los carriles

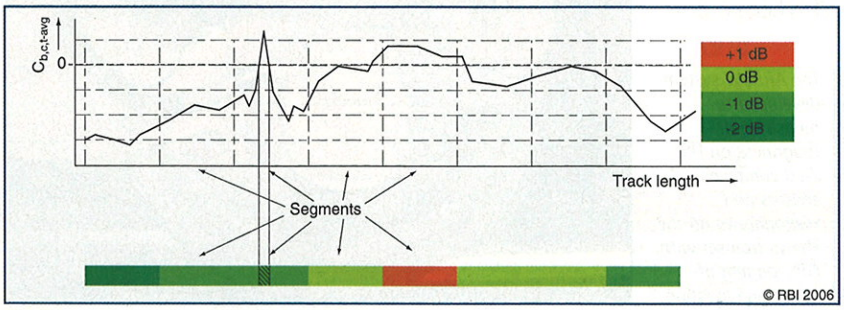


Fig 2. Indirect roughness measurements taken using the ARRoW system are presented as coloured bars for easy interpretation