ISSN 0141-4615

RAIL ENGINEERING INTERNATIONAL

EDITION 2008
NUMBER 1

Rail grinding strategies for achieving optimum results: an inventory

Rail grinding has become a standard practice with all major railways. Its application has been discussed extensively and nobody questions its positive effects. Any maintenance activity will only achieve optimum results if deployed under optimal conditions. This requires accurate planning, well in advance, in order to minimise costs and maximise output. Rail grinding should not just be carried out when necessary or found useful. It needs to be executed strategically.

By: Dr. Wolfgang Schöch, Manager External Affairs, Speno International SA, Geneva, Switzerland.

When rail maintenance was first introduced, a rail grinding intervention was often seen as a one-off activity that was conducted independently from other track work, and even from other rail grinding activities. Nowadays, however, when rail grinding is performed to combat noise, for instance, short-pitch corrugation may be remedied and the transverse profile be corrected at the same time as well.

When the reason for rail grinding is a repetitive phenomenon - which is the rule rather than the exception - cyclical grinding interventions have to be foreseen for the future. Thus, rail grinding is no longer a one-off activity, but has become a strategic undertaking.

Rail maintenance needs to be seen as a long-term issue, as it embraces several - if not many - rail grinding interventions in the course of the service life of the rail. Whenever a rail grinding campaign is to be executed, it should be part of a specific maintenance concept. In this respect, two major questions need to be addressed:

— when should the grinding action take place?
— what should the grinding action achieve?

RAIL GRINDING ACTIONS

Basically, the following five different rail grinding actions can be distinguished:

— *grinding of new rails:* rail maintenance begins with the grinding of newly laid rails, either when a totally new railway line is built or when long sections of track are re-railed. In these cases, rails are ground to remove mill scale and surface defects that have resulted from the construction process. Also, irregularities at welds are corrected and the transverse profile is ground according to tight tolerances, in order to ensure optimal wheel/rail contact conditions. In doing so, the onset of rail surface irregularities and fatigue is delayed;

— *corrective grinding:* this rail grinding action deals with the removal of rail surface defects, such as severe corrugation (sometimes exceeding 0.5 mm), plastic deformation of the rail head (e.g. lips limiting the gauge width), or deep fatigue cracks (often more than 1.0 mm deep). Corrective grinding always requires the removal of a considerable amount of metal and a respective high number of grinding passes;

— *symptom-based grinding:* this rail grinding action entails the immediate remedying, either corrective or preventive, of a detected rail defect that exceeds pre-determined intervention thresholds. To accurately record defect severity would require regular inspections by means of measurement systems. At present, however, these only exist for corrugation. Systems to detect and measure rail surface fatigue are currently under development;

— *preventive grinding:* this rail grinding action is aimed at keeping the rail surface in a good condition before defects develop into serious problems. For instance, to control rail surface fatigue by removing small amounts of metal at regular intervals. Sometimes, it is also considered for removing corrugation at an early stage. Strictly speaking, grinding of new rails can also be regarded as a preventive action.

Preventive grinding is planned in advance. It requires only a small number of grinding passes. Often, it is executed in just a single pass;

— *cyclical grinding:* this rail grinding action, which is a preventive measure, is executed at predetermined intervals, usually after a certain tonnage borne (for instance, every 20 MGT) or after a certain time period (for instance, each year).

IMPLEMENTATION OF RAIL GRINDING STRATEGIES

For a long time, rail grinding was regarded as a somewhat exotic maintenance activity, and was planned with a limited, often very small budget. By definition, it was not regarded as an integrated part of track maintenance, nor as something that was to be planned in a strategic way.

Over the course of time, however, experience gained in practice has shown that rail grinding has far-reaching effects for the entire track structure. By removing corrugation, dynamic forces and track vibrations are reduced considerably and, thus, the track remains in a better condition over a longer time period. Also, by regular treatment of rail surface fatigue, the depths of head checks can be kept under control for a long time and, consequently, the rail does not need to be replaced prematurely, i.e. before the end of its service life.

As a consequence, the railways have developed several rail grinding strategies, embracing the planning and execution of rail grinding work, which are described hereafter.

Rail corrugation grinding

Removal of rail corrugation, both short-pitch corrugation in tangent track and in shallow curves and short waves on the low rails in sharp curves (Fig. 1), is still the main purpose of rail grinding for many railways.

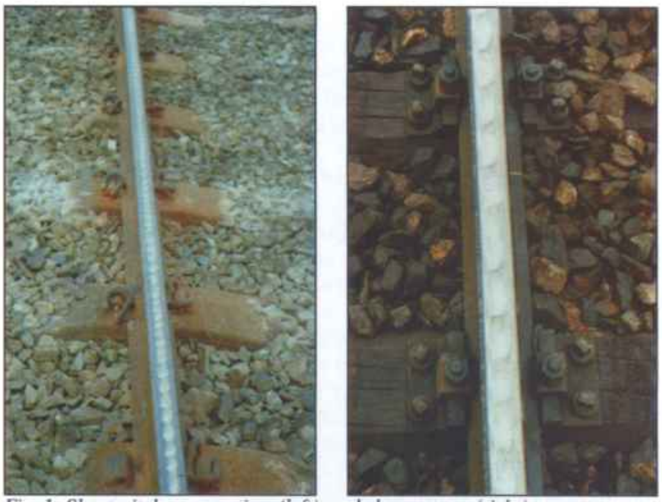


Fig. 1: Short-pitch corrugation (left) and short waves (right)

Rail corrugation can be detected by regular inspections of the railway network using, for instance, a Speno SM 775 Rail Surface Recording Vehicle (Fig. 2). The recording results thus obtained not only allow the determination of sections of track requiring rail grinding, but also enable detailed planning of the working shifts and track possession times required.

Fig. 2: Speno SM 775 Rail Surface Recording Vehicle

For short-pitch corrugation, the intervention threshold is usually set at a peak-to-peak depth of 0.05 mm as, at this level, the resulting track vibrations start to have a negative influence on the track structure. However, for the high-speed railway lines in Germany, the intervention threshold is set at just 0.03 mm, as it was found that, already at that level, fatigue cracks tend to develop in the corrugation crests. If not removed in time, they develop into severe defects, requiring a premature replacement of the rail.

Intervention thresholds for short waves on the low rails in sharp curves are set at between 0.15 mm and 0.35 mm.

Acoustic grinding

Acoustic grinding aims at combating noise due to corrugation. Corrugated rail surfaces lead to an increase in noise during the passage of trains of up to 10 dB(A). If the corrugation depth exceeds 0.03 mm, noise starts to increase. Several railways have set up particular strategies to deal with noise-sensitive areas. German Rail (DB AG), for instance, adopts a specific policy on selected routes, whereby noise levels have to be recorded at fixed intervals (every six months). If the values measured exceed the acceptance limit by 3 dB(A), acoustic grinding must be undertaken, whereby corrugation is removed.

Rail surface damage grinding

On railway lines featuring ballasted track, strong air turbulences occur under the rail vehicles, particularly when trains are passing each other. As a consequence, ballast stones are sucked up, fly around and may be crushed into the rail surface by the wheels. As a result, imprints occur, usually, with a depth of up to 0.3 mm. Some imprints may even be deeper (Fig. 3).

Fig. 3: Ballast stone imprint

The phenomenon of imprints is particularly pronounced in areas where, in winter, ice accumulates under the rail vehicles and drops off when approaching warmer areas.

On French National Railways (SNCF), for instance, it is now a common practice to annually grind the rails in such areas, whereby 0.3 mm of metal is removed, in order to eliminate the majority of the imprints and to reduce the depths of deeper ones to such an extent that they cause no harm until the campaign of the following year. At the same time, also other defects, such as rail corrugation and rail surface fatigue, are corrected.

Rail surface fatigue grinding

Rail surface fatigue, in particular the development of head checks close to the gauge corner of high rails in shallow curves, has become a major issue of concern in the past few years (Fig. 4). High-speed railway lines are particularly prone to the occurrence of head checks. But, increasingly, this phenomenon is now also being observed on conventional railway lines, which formerly were not affected by this kind of defect.

Fig. 4: Head checks in an advanced stage

For several years now, railways have been studying the phenomenon of head checks and are trying to develop appropriate counter measures. Besides the use of higher steel grades or heat-treated rails, cyclical metal removal by means of rail grinding is often recommended.

Today, specific rail grinding strategies are adopted to combat head checks. For instance, so-called anti-headcheck rail profiles have been developed by railway and infrastructure companies, e.g. SNCF, France, and ProRail, The Netherlands (Fig. 5).

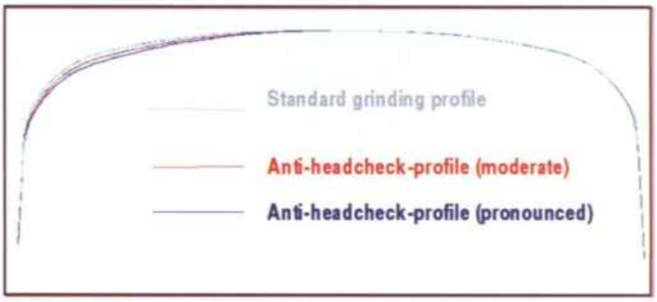


Fig. 5: Principle of anti-headcheck profiles

Since about three years now, a special rail grinding programme has been under way in The Netherlands, which is aimed at removing rail surface fatigue and keeping it under control by annual rail grinding interventions.

DB AG and Speno International are currently finalising a joint research project with respect to the treatment of head checks that will conclude with recommendations for cyclical maintenance. Frequent rail grinding interventions with small metal removal rates are proposed, as well as the application of a slightly modified transverse rail profile, in order to provide a little more clearance at the gauge side of the rail.

Special profile grinding

A yet less frequently applied rail grinding strategy is that whereby asymmetrically-shaped rail head profiles are ground. Some railways, such as Austrian Federal Railways (ÖBB) and Spanish National Railways (RENFE), have specified the grinding of asymmetric rail head profiles in sharp curves, in order to reduce lateral wear of the high rails.

On DB AG, a number of railway lines have been identified that feature a reduced track gauge, sometimes even less than 1,430 mm. New rules demanded correction. Thus, a special gauge-widening profile has been created by means of grinding that has already been applied successfully on many sections, whereby the track gauge is increased artificially by up to 2.5 mm.

On some sections of the ÖBB network, high-speed rail traffic was faced with unstable running conditions. This problem has been solved by grinding a special target profile, featuring a more convex shape that concentrates the running band in the centre of the rail head, thus ensuring a lower equivalent conicity (Fig. 6). This specific profile is now applied strategically on all tangent track on which trains are operated at speeds of more than 160 km/h.

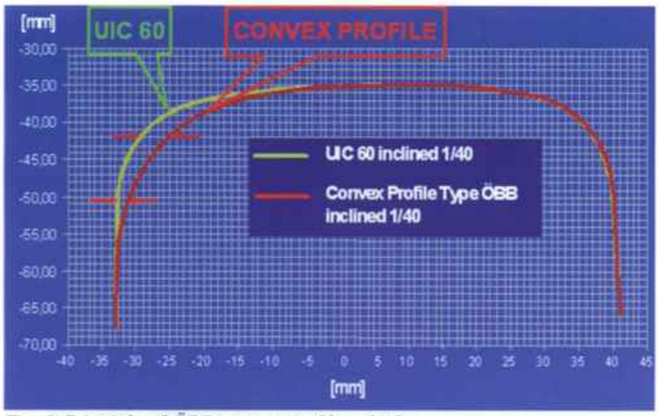


Fig. 6: Principle of ÖBB convex profile, which offers a lower equivalent conicity

Fig. 7: Speno RR 16 MS-2 Turnout Grinding Machine

Integrated grinding

On ÖBB, integrated rail grinding has been implemented, i.e. the combining of rail grinding and track tamping in a joint maintenance package. Starting from the idea that rail grinding (or not grinding) influences the track as a whole, the question was raised how rail grinding could best be integrated within the context of other track maintenance activities.

Usually, track tamping work is triggered by low track quality indices. If no tamping would be conducted, speed restrictions would have to be implemented. Rail grinding is programmed when corrugation exceeds certain intervention thresholds. However, leaving corrugation or neglecting the need to grind does not result in the implementation of speed restrictions. Consequently, it is easier to neglect rail grinding than tamping, even though corrugation, due to resulting increased track vibrations and dynamic forces, leads to a deterioration in track quality.

In practice, it has often happened that a low-quality track has been tamped without the removal of corrugation having been considered. In other cases, corrugation grinding may have been programmed without consideration of correcting a destabilised ballast bed.

With combined tamping and grinding, it is often possible to execute the work quasi-simultaneously in the same track possessions; if not, grinding follows the tamping action as soon as possible, usually within one day. As a result, the freshly tamped and stabilised track is not disturbed by vibrations resulting from corrugation. Consequently, the high track quality achieved by the tamping intervention is more durable.

Turnout grinding

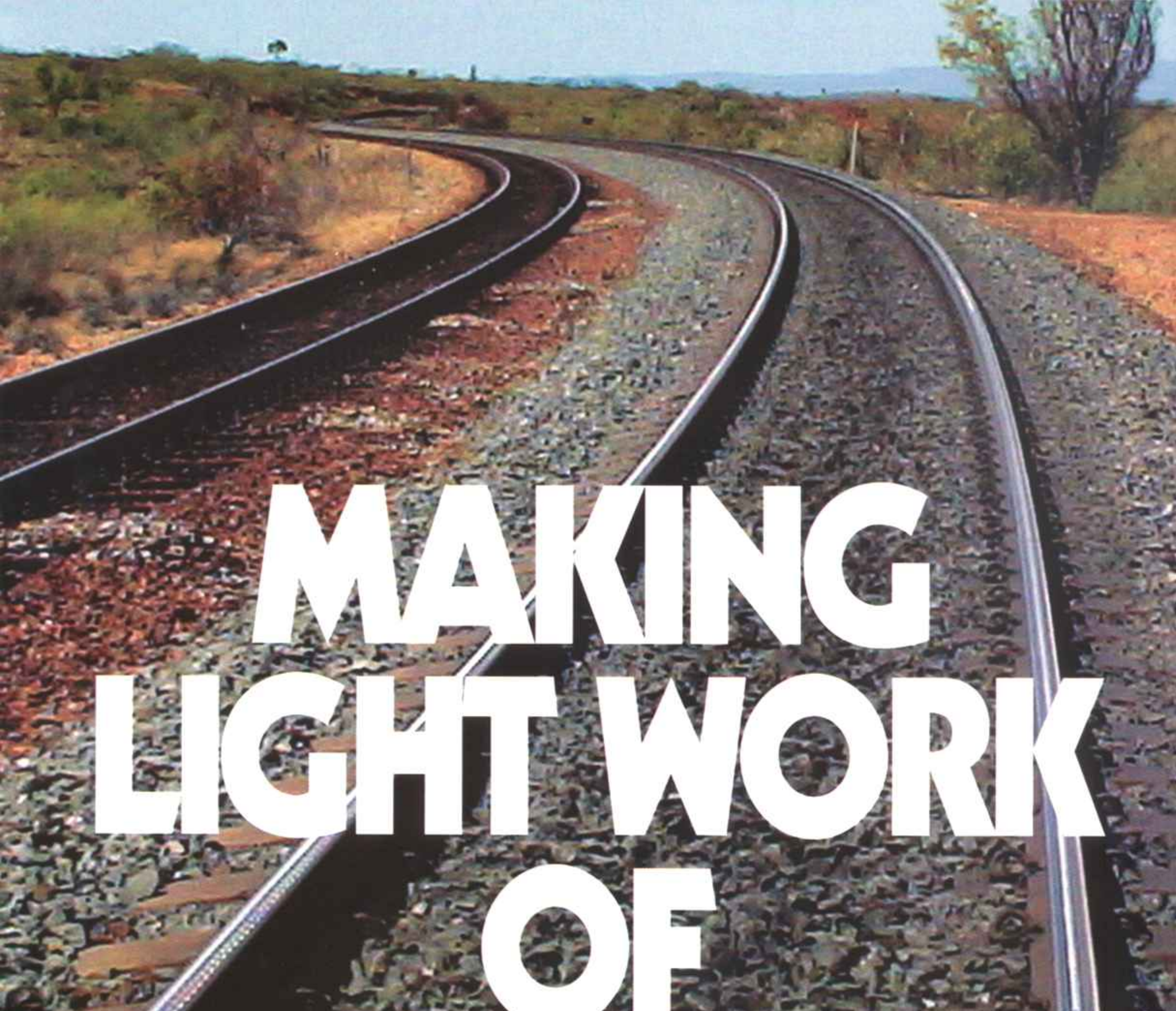
Grinding of rails in turnouts has become a standard maintenance practice on all major railways in Europe (Fig. 7).

Calculations have yielded that rail grinding is beneficial with respect to overall maintenance costs. This is particularly true for turnouts, as they are more prone to suffering from irregularities and much more expensive to maintain. Strategic grinding of rails in turnouts means that it should preferably be conducted in combination with the grinding of those in plain track, in order to ensure a continuously good rail surface throughout. Railways in Europe are starting to strategically plan rail grinding campaigns in turnouts in this manner.

CONCLUSIONS

Life-cycle costs are a heavily discussed topic with railways in Europe. As, in general, rails and other track components are costly items, it is obvious to look for good quality products at reasonable costs. But it is of the same importance to pay attention to the needs and costs of routine maintenance work.

It should not be forgotten that rail grinding has a long-term effect, resulting in an extension of the service life of the rail from 25 to 40 years. In that light, railways in Europe are increasingly looking for new ways to strategically organise rail grinding campaigns.


MAKING
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