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# Mobile rail machining in tracks and switches by means of rotational planing

***Presentation of the operating principle, performance parameters and work results of a new rail machining technology used in the rotational planer D-HOB 2500.***

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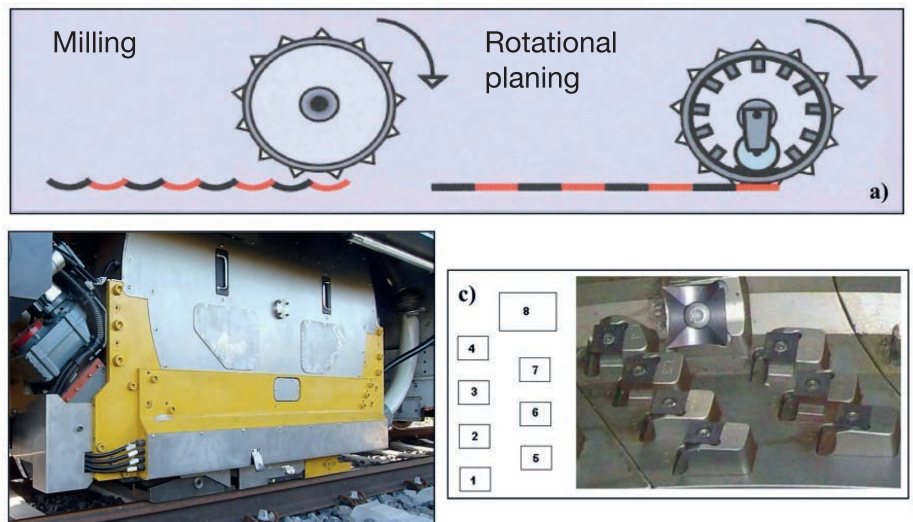
Until recently, grinding, milling and planing were the only technologies available for machining rails in track [1]. Since the end of 2012, another technology has been in use, the **rotational planing**. It was first presented to the public during the InnoTrans 2012 fair in Berlin. With the introduction of the **rotational planing** technology, Schweerbau GmbH & Co. KG once again demonstrated its commitment to innovation in mobile rail treatment. The **rotational planer D-HOB 2500** incorporating the new technology was build by Mevert Maschinenbau GmbH, Lauenhagen (technique) and Gleisbaumechanik Brandenburg/H. GmbH, Kirchmöser (vehicle engineering).

**Rotational planing** is innovative in two ways: the combination of milling and planing into a single technique and the advances as regards the tools used for the machining. Both milling and planing contributed their specific characteristics. Milling achieves a high amount of metal removal, produces an exact transverse profile of the rail head, requires a large diameter of the milling unit and achieves the desired final result in one or possibly two passes. Planing offers the advantage of a very high metal removal and – apart from a precise transverse profile – a very accurate longitudinal profile of the rail head even without subsequent treatment. The new technology successfully combines the advantages of the two methods while eliminating disadvantages such as the restriction of both methods to predetermined fixed target profiles and the fact that planing occasionally interferes with the clearance. The rail is treated in a synchronous machining operation. A first characteristic feature of this technology is that each of the tools, which can be positioned independently, performs a rotating movement that is superimposed by a short-time uniform movement parallel to the running surface of the rail. A second feature is that the target profiles to be achieved can be continuously changed during the **rotational planing** process and that these changes can be made independently for either rail (Fig. 1). The **D-HOB** working unit has a diameter of 1,400 mm and carries 32 cartridges. In each of these cartridges, seven straight plane blades and one curved blade are attached. As a whole, they describe the target contour of the rail head transverse profile to be produced. The machining of the rail head extends from Z-14 on the gauge side to Y+14 on the field side and then gradually decreases tangentially. This way, the rail head contour relevant for the running of the vehicles is covered completely. Especially the second innovation permits for the first time a continuous machining of solid profiles and the profiles of switch blades. The working speed is 300 to 1,500 m/h. The lateral scanning of the rail is made either on the gauge side or the field side. The machine has one working direction. Chips are sucked off immediately at the **rotational planing** tool and are conveyed into a chip container through vacuum lines. The planing process does not generate any sparks or dust. The tools are arranged so as to be within the loading gauge. No track switching and signalling equipment must be removed.




Photos: Hartleben

**Fig. 1: Rotational planing** – a new rail treatment technology. a) mode of action; b) **Rotational planing** unit; c) **Rotational planing** tools

## Introduction of the rotational planing technology with the rotational planer D-HOB 2500

### Description of the machine

The **D-HOB 2500** is a conventional-design vehicle with two two-axle bogies and short couplers and has a length of 11,340 mm. Vehicle envelope, axle loads and driving power were designed to allow working on the railway network of Deutsche Bahn (DB) as well as on various metro networks such as LUL London. The **rotational planer** is operated as a stand-alone machine complemented by a control module and a chips module (Fig. 2). It is structured into a drive compartment (diesel-electric unit), a control compartment (electrical cabinets and control systems) and the **rotational planer** compartment including chip suction system. The machine has an own working traction drive (15 km/h) and can be towed at a maximum speed of 100 km/h. The machine-specific track geometry constraints for the deployment of the **rotational planer** are as follows: working radius ≥ 30 m, rail cant (superelevation) ≤ 180 mm and gradient ≤ 70 ‰. Both in transport and in working position, all machine components of the **rotational planer** are within the rolling stock construction gauge G1 (German Ordinance on Railway Construction and Operation EBO, § 22, Annex 7) (Table 1). Hence, the **rotational planer** can be deployed without any constraints or special considerations related to the distances to the operated neighbouring track. The **D-HOB 2500** does not generate any air pollution. The diesel engine is permanently operated with a particulate filter removing


**Fig. 2: Rotational planer D-HOB 2500** (in the middle), control module and chips module
a) mainline version
b) metro version

| | Rotational Planer D-HOB 2500 | Control module | Chips module |
|---|---|---|---|
| Length (mm) | 11,340 | 9,080 | 8,440 |
| Width (mm) | 2,540 | 2,600 | 2,450 |
| Height (mm) | 2,833 | 3,910 | 2,850 |
| Weight (t) | 47 | 16 | 16 (23) |
| Number of axles | 4 | 2 | 2 |
| Number of bogies | 2 | – | – |
| Axle load (t) | 11.7 | 8.0 | 8.0 (11.5) |
| Engine power (kW) | 354 | – | – |
| Travel speed, trailed (km/h) | 100 | 100 | 100 |
| Min. negotiable radius (m) | 30 | 80 | 30 |
| Clearance gauge | G1(UIC505-1) and RATP, LUL | G1(UIC505-1) | G1(UIC505-1) and RATP, LUL |
| Diesel fuel tank (l) | 1,500 l | – | – |
| Number of **D-HOB** working units | 2 units, Ø 1400 mm | – | – |
| Working speed (m/h) | | | |
| – Planing (m/h) | 300-1500 | – | – |
| – Site travel (km/h) | 15 | | |
| Min. working radius (m) | 35 | 80 | 35 |
| Max. gradient (‰) | 70 | 40 | 70 |

**Table 1:** Technical parameters of the **D-HOB 2500** and the control and chips modules

99.9 % of the particulate matter contained in the exhaust gas. The **D-HOB 2500** has been approved by the German Railway Authority EBA. DB issued the authorization to work on 15 November 2012. Since 25 March 2013, the machine may also be used on high-speed lines of up to 300 km/h, which also reflects the appreciation of the demonstrated high quality of the work. The key units of this machine configuration are the **D-HOB** and the chips module. The control module can also be substituted by a combined drive and control module. The space required for operating the control of the **D-HOB** merely comprises the space for a 12“ notebook and a 21“ monitor.

## Mode of operation

To bring the machining units of the **rotational planer** into operating position, the units are lowered by about 200 mm from their transport position. Then the units move about 150 mm transversely to the longitudinal axis of the rail to the outside and afterwards directly descend onto the rail head. Setting-up the **D-HOB 2500** from travelling to operating position and vice versa takes about 3 minutes. While the work is in progress, the position of the machining units to the rail does not change. Commencement and termination of the milling/planing process are controlled via a ramp. Should the track being worked on have conductor rails, these must be de-energized. The quality of the work performed is documented with measurements of the transverse profile and the longitudinal profile of the rail head and measurements of the metal removal.

## Operating conditions and performance

Preferably, the **D-HOB 2500** is deployed for removing rolling contact fatigue defects and geometrical defects in the longitudinal and transverse profiles of the rail head of any sizes.

Near surface rail defects are currently the most frequent rail defects in railway networks [2]. They comprise rolling contact fatigue defects, periodic defects in the longitudinal profile of the rail head, defects in the transverse profile contour of the rail head and other defects in the running surface of the rail. Particular attention is paid to rolling contact fatigue defects. While defects in the longitudinal and transverse profiles of the rail head increase the maintenance expenses for trackage and vehicles, impair the travelling comfort for the passengers, and result in higher levels of noise and vibration affecting the lineside residents, there is a direct relationship between rolling contact fatigue defects and ensuring the operational safety. Rolling contact fatigue defects comprise head checks (the most widespread defect), squat, Belgrospis (a network of cracks on the crests of corrugated high-speed lines, named after the engineers Belz, Grohmann and Spiegel who first detected them) and others.

Head checks have been known as a rail defect for about 15 to 20 years. The conditions and mechanisms of their formation have been thoroughly investigated, their growth and development stages are increasingly well understood and can be quantified. The technical information TM 2011-276 [3] issued by Deutsche Bahn defines how to deal with them. Whether or not it will at some time be possible to prevent the very formation of head checks is still an open question. Hence, the only solution is to correct these defects in a targeted way and at the right time.

The machining of rails for acoustic reasons and the machining of new rails are further applications. The rectification of defects and the performance of the above stated tasks can be made both in tracks and in switches. The machine can also be used in tunnels, on bridges, in tracks with side contact rails and in residential areas. There are no limitations on working on sections with track switching and signalling equipment, check rails, or track covering. The final performance depends on the size and the kind of the rail defect. The cutting depth of the **D-HOB 2500** can be adjusted within a range of 0.2 to 1.0 mm (running surface) and 0.2 to 2.0 mm (running edge). This metal removal is achieved in a single pass at the mentioned **rotational planing** speed of 300 to 1,500 m/h.

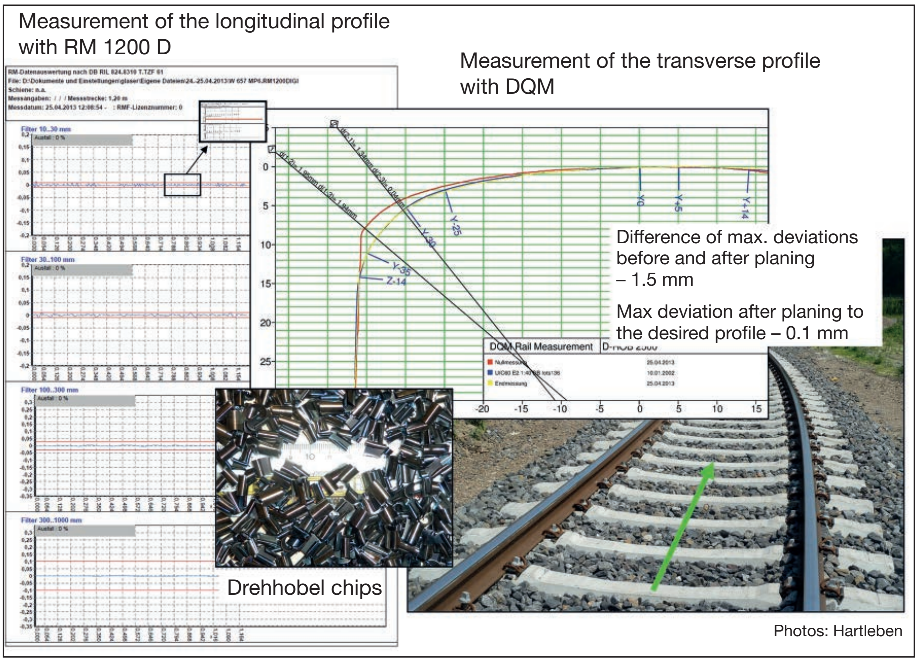



**Fig.3:** Measurement of the transverse and longitudinal profiles of the rail head after the rail treatment with the **D-HOB 2500**.

## Machining results accomplished with the D-HOB 2500

### Machining accuracy

The adjustable, yet fixed positioning of the plane blades ensures that a transverse profile of the rail head can be produced with utmost accuracy based on a specified contour (Fig. 3). The requirements of the European norm 13241-3:2012 are safely met. The deviations from the desired values of the rail head transverse profile are as little as ± 0.1 mm, with ± 0.2 mm being permissible on lines with v ≤ 280 km/h (DB). If the client so requests, the plane blades are positioned such that the target profile is always undercut. The maximum deviation from the target profile is within the range from Y-25 to Y-30 and then gradually decreases to 0 towards the running edge (Z-14) and the tangential point (Y+5 in case of 60E2 1:40). To prevent or delay the formation of head checks, the Anti Head Check profile was introduced in Germany which provides for undercutting the transverse profile by 0.4 mm. This successfully shifts the wheel/rail contact area towards the middle of the rail. At the same time, the wheel/rail contact area is extended and as a result the tensions in the running surface of the rail are reduced. That profile is, however, only required for the outside rail of a curved track which is primarily prone to develop head checks. The challenge to produce different profiles for the inside rail and the outside rail at the same time, with high precision and with a continuous transition from one to the other profile can be very well met with the flexibly adjustable tools. With the **rotational planing** technique, the longitudinal profile of the rail head can be produced with an accuracy of ± 0.01 mm over the wavelength ranges 10 to 30 mm and 30 to 100 mm. That again is well within the requirements of the stringent EU norm.

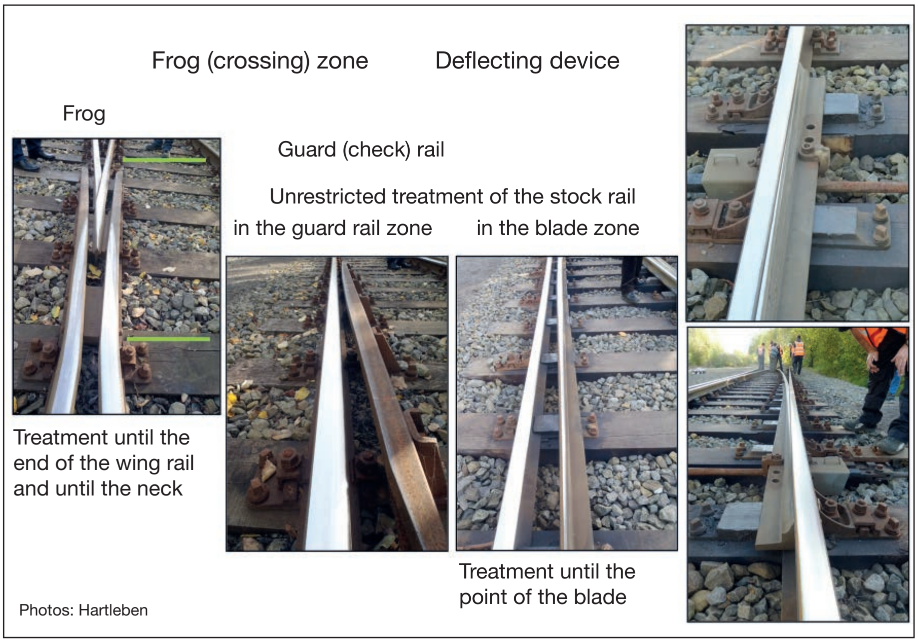



**Fig. 4:** Switch treated with the **D-HOB 2500**

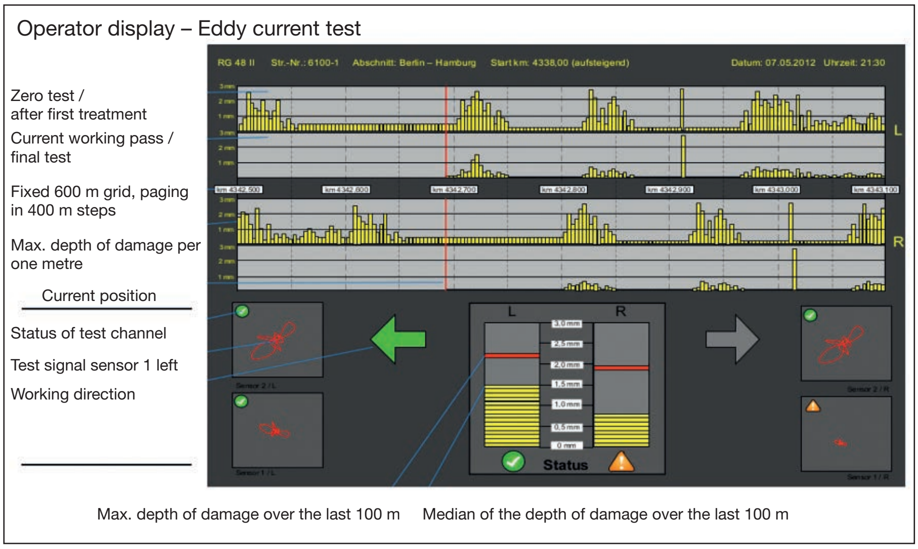



**Fig. 5:** Operator display of the eddy current tester Elotrain SBM 1.5 (schematic diagram)

For the wavelength ranges 100 to 300 mm and 300 to 1000 mm, the values are clearly below the permissible limits. In the majority of cases, the results are ± 0.010 mm (permitted: ± 0.015 mm) and ± 0.05 mm (permitted ± 0,075 mm), respectively. Thanks to the use of plane blades that are temporarily guided in parallel to the running surface, the achieved roughness of 3 to 5 µm is likewise safely below the limit of 10 µm.

## Planing of switches

For the first time, an almost complete machining of switches was achieved (Fig. 4). This is neither possible with milling nor with planing. Only the frog, the area from the end of the wing rail to the neck, is left out. This is the only area where subsequent manual work is carried out. No manual treatment is required in the switch blade area. Unlike switch grinders, the machine always covers the range from Z-14 (or to a limited degree from Z-10) to Y+14. For machining the contacting blade, this was initially raised, as required by the guideline DB-Ril 824.4016, to prevent contact of the planing tool with the stock rail. After a design change of the planing tool, this is no longer necessary. This design change also made it possible to machine switches of high-speed lines without any restrictions, since raising the blades on these switches is excluded for various reasons. Since **rotational planing** does not generate any dust or sparks, it is not necessary to cover the pawl locks and rollers and clean them after completion of the **rotational planing** process. Neither is it necessary to lubricate slide chairs during or after the planing or clean the zones of insulated joints and track switching and signalling equipment. While grinding requires several passes, planing usually makes do with only one or two machining passes. All that saves time and makes **rotational planing** an extremely efficient rail treatment technology. Planing is controlled by software programs that are stored on the machine computer and called up by the operator. These programs differ depending on whether a single switch is to be treated or two switches are to be treated together, depending on whether the main or the diverging track is to be treated, and depending on the direction of working (from the beginning of the turnout towards the heel of the turnout (facing-point movement) or in opposite direction (trailing-point movement). At the commencement of the work, characteristic points are marked with little magnetic plates in the switch which are important for the alternate use of the inside and outside copying of the planing tool.

Also a joint preliminary survey of the switches by the client and the contractor contributes to a high efficiency in the treatment of switches. Such surveys comprise the determination of the geometric circumstances, the inspection of the material damage at the switch, the subsequent definition of the machining lengths A, B and C from the beginning of the turnout and the heel of the turnout, the derivation of construction management requirements and the separate determination of the machining time for the main track and the diverging track. Especially when defining the machining lengths, it is important that those areas that for technological reasons cannot be machined by the track treatment equipment are covered by the switch treatment equipment.

## Proof of absence of head checks on treated rails

An analogy to the grinding and milling machines and the planing machine, also the **D-HOB 2500** is currently equipped with eddy current testing equipment. The testing system, developed by Rohmann GmbH of Frankenthal and Mevert Maschinenbau GmbH of Lauenhagen with input from Schweerbau, comprises:

- one sensor carrier per rail
- two testing sensors per sensor carrier
- an industrial eddy current tester type Elotest PL500
- a data server PC
- a terminal PC with visualization software
- a printer.

The sensor carriers can be lowered and raised during the machining pass. They independently position themselves, are guided at the running edge, and are suitable for use in switches. Tests are made 9.2 mm and 17.9 mm from the running edge. The maximum testing speed is 20 km/h. The testing equipment is calibrated every working day based on the specifications by the client.

The visualization software generates both a display for the operator and a test record. The operator display has a fixed window arrangement (Fig. 5). At the start of a shift, data such as machine ID, line code number, track section from – to, starting position, ascending or descending kilometrage are entered into the header. Date and starting time are generated automatically.

The test results are displayed separately for the left and the right rail in the bar graphs below the header. In the upper section, the zero-test results (i.e. the results of a survey of the actual situation prior to the start of the treatment) are shown, in the bottom section – with the final machining pass – the results of the final test. The online evaluation covers rail sections of a length of 1 m each.

After completion of the treatment job, usually defined as “required metal removal in the middle of the rail while achieving the desired contour of the transverse profile of the rail head”, it is possible to page through the entire testing section on the monitor. The client’s employee supervising the rail treatment then determines whether treatment of the next section can be commenced or if there are any remaining rail defects that have to be removed first. The test record includes the information in the header, the maximum depth of defects for each metre of rail before and after the rail treatment and the kilometrage data. In addition, plausibility information is shown and a legend of the displays is indicated. The plausibility display is required to identify a potential failure of the testing signal and to exclude defect situations that cannot be evaluated (more than 150 incipient cracks per metre of rail).

Following the usual displays of track diagnostics measurements, the selected scale is 1:5,000. With this scale, 1,400 m of track can be shown in an A4 format, and at a width of 0.2 mm, the shown maximum defect per 1 m of rail is still easily legible. For clarity, the depths of the damage are classified and represented in different colours following the practice used by the DB diagnostics vehicle.

## Summary

The **rotational planer D-HOB 2500** is used to treat the rail head of rails in track to eliminate rail defects that have developed during the operation of the track. The longitudinal and transverse profiles of the rail head are produced at a high level of accuracy. **Rotational planing** is a technology that combines milling and planing. The rail head transverse profile can be modified in a targeted way during the machining pass. This for the first time allows the treatment of complete switches by a machine. The process does not interfere with the required clearance and does not generate any sparks or dust. The D-HOB machine has been in operation since November 2012. Its technical parameters allow its deployment on railways and metros alike. This innovative technology has two key benefits: on the one hand, it allows planing the rail head transverse profile with a continuously changing target contour, which for the first time permits mobile planing of switches. On the other hand, the superposition of milling and planing achieves a further improvement in the quality of the longitudinal rail head profile.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## Summary

**Mobile rail machining in tracks and points by means of rotation planing**

With the aim to eliminate track default which have formed during operations, a new rail machining technology, the rotation planing, the rail head of tracks in track facilities are machined with the D-HOB 2500. This will produce the longitudinal and transverse rail head profile. Rotation planing is a technology which combines milling and planing. The transverse rail head profile can be changed during machining in a targeted way. This allows for the first time to treat points by mechanical means. The procedure works without profiles, sparks and dust. The D-HOB has been in operation since November 2012. Its technical parameters allow for operation on railways as well as metros.



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