Abstract: The present application relates to a process and device (38) for treating rails (20) in order to improve their durability, the process comprising adding a metal surface material to the rail (20) by the process of friction surfacing. Optionally the rail (20) may be heated prior to adding the surfacing material and optionally a starter plate may be used to increase the temperature of the surfacing material prior to contact with the rail (20). The device (30) comprises: an application mechanism (36), preferably pivotally mounted, adapted to rotate or oscillate a surfacing material, and capable of providing an axial force of at least 5kN and a movement mechanism adapted to move the application mechanism! linearly. The device (30) weighs less than 500kg, preferably less than 250kg and is portable and may be used on site. Preferred embodiments include a heating element adapted to heat the substrate prior to the friction surfacing. The invention provides a convenient method and device (30) for increasing the durability of rails (20), increases the safety of workers who may not need to exit a repair locomotive, and reduces track maintenance time, so the track may be put into operation more quickly.
This invention relates to an improved process and device for treating rails for railway tracks. The safety of rails upon which trains run is an important consideration in the rail industry. Damage to track may occur by railway wheels skidding on the track and "burning" a local area, stones being crushed on a track and also in areas proximate to butt joins, where the heat used when adjoining the track has softened a portion of the rail in close proximity.

One particular problem with rails is known as gauge corner cracking which is a phenomenon which often occurs at the curves of railway tracks - a series of small cracks appear on the rails and can propagate throughout the rail. It is thought that some fatal train crashes were a result of rail failure due to gauge cracking.

In practice rails may be removed and replaced periodically, which requires a temporary shut down of the railway track causing loss of revenues, inconvenience to passengers and delay in deliveries using the railway. Moreover for workers removing and replacing the rails, a danger persists of collision with trains still operating on adjacent railway lines.

According to the present invention there is provided a process for treating rails in order to improve their durability, the process comprising adding a metal surfacing material to the rail by the process of friction surfacing.

The friction surfacing process normally comprises rotating or oscillating a solid surfacing material, typically in the shape of a rod, whilst in contact with the rail, applying a pressure between the solid surfacing material and
the rail, the pressure sufficient to cause a temperature increase in the surfacing material, to plasticise it and create a layer of surfacing material on the rail.

Previous attempts to weld portions of rail to improve their durability have not proven successful. Arc welding was attempted, but a large portion of the rail must be heated in order to prevent cracking. Thus it has surprisingly been found that rails for railway tracks may be treated to improve their durability by a specific welding process known as friction surfacing.

Durability includes, but is not limited to, wear resistance.

Typically the pressure is at least 1kN, preferably more than 5kN, preferably more than 15kN. Preferably less than 50kN, preferably around 25kN.

Notably the surfacing material preferably does not melt but merely plasticises. Preferably therefore the surfacing material is heated to a temperature of around 60 - 80% of its melting temperature in Kelvin, that is preferably no higher than 80%.

Preferably the process includes moving the surfacing material and rail with respect to each other in addition to the rotation/oscillation of the surfacing material. Thus the surfacing material and rail normally move linearly with respect to each other. This can be any linear direction and is used to spread the surfacing material over a larger area than the contact point of the surfacing material and the rail.
The process according to the present invention can conveniently provide a layer of surfacing material on a rail of a railway track.

The metal surfacing material is preferably an austenitic steel. Suitable materials include manganese cast iron steels such as Hatfield steel; and austenitic cobalt alloys such as Stellite 6.

For certain embodiments, the process may be performed *in situ* that is where the rail remains part of the railway track during the process. Such embodiments are preferred where the damage to the rail is relatively minor, such as "burning" caused by trains skidding thereover, or damage caused by crushed stones or softening caused by welding and heating operations in close proximity that result in local excessive wear of the rail.

Surprisingly it has been found that the present invention can also prevent, delay, repair or mitigate surface cracking especially early stage gauge corner cracking.

For other embodiments therefore, the more serious damage, such as gauge corner cracking, is preferably prevented or at least delayed by pre-treatment of the rail before it is put into use, that is, the rail is pre-treated with the layer of surfacing material, especially at its gauge corner, to reinforce that area and prevent or at least delay the onset of gauge corner cracking.

Rails which have suffered early stage gauge corner cracking may be repaired, normally *ex-situ*, using the process of the present invention.

Thus the invention provides a process to repair or mitigate surface cracking especially gauge corner cracking comprising adding a metal surfacing material to the rail by the process of friction surfacing.
Moreover mitigating the gauge cracking in a rail improves the durability of the rail, in accordance with the first aspect of the invention.

Early stage gauge corner cracking is where the cracks are less than 2.5mm deep, preferably less than 2mm deep.

For certain embodiments, the rail may be pre-heated prior to undergoing friction surfacing. Preferably the heating is applied by induction heating. Typically the temperature of pre-heating is in the range of 300 - 400 °C, preferably 350 °C.

The pre-heating can reduce embrittlement or over-hardening caused by the friction surfacing process. For certain embodiments, the surfacing material may be heated directly.

Preferably the area to be heated is less than 1,800mm², normally less than 1000 mm², especially less than 600 mm².

For certain preferred embodiments, a starter plate may be provided between the surfacing material and the rail. This allows the rotating/oscillating surfacing material to heat up to a sufficient temperature to plasticise without penetrating the rail.

The starter plate is typically from 1 to 12mm thick, preferably 3 - 10mm, especially 6 - 8mm. The surfacing material typically travels through the starter plate, somewhat akin to a drill, and gradually warms up to a temperature sufficient to cause the surfacing material to plasticise.
Preferably the surfacing material is pressed onto an edge of the starter plate. For such preferred embodiments, the rotating/oscillating surfacing material may be moved linearly without removing contact with the starter plate or substrate, thus maintaining the temperature of, and pressure on, the surfacing material and therefore its plastic properties at that temperature.

The process of friction surfacing can then continue as described above.

Preferably the friction surfacing results in a layer of surfacing material on the surface of the track of up to 1.5mm, preferably up to 1mm, especially around 0.5mm.

The present invention is particularly suited to areas proximate to butt joins in railways. These have been softened due to the heat treatment during formation of the butt weld and often result in a dip in the track. Such areas are normally less than 10x10cm, typically less than 5x5 cm especially around 3cm x 3cm.

According to a further aspect of the present invention there is provided a device for friction surfacing a rail, the device comprising:
- an application mechanism adapted to rotate or oscillate a surfacing material, and capable of providing an axial force of at least 1kN;
- a movement mechanism adapted to move the application mechanism linearly

wherein the device weighs less than 500kg.

With such a relatively low weight, the friction surfacing machine is portable and may be used to repair rails of railway tracks in situ. The device can be lifted and positioned on a rail track if necessary using a small hand
operated crane. Thus preferably the device can be mounted on rails or a railway track. Indeed preferably the weight of the device is less than 250kg.

Alternatively the device may be attached to the underside of an existing rail track maintenance locomotive such as the one know as a "Tamper" which is a locomotive performing routine maintenance operations such as stabilising the ballast under the track sleepers and ensuring that the rails are properly aligned. For such embodiments the safety of workers is improved since there is no requirement to be out of the locomotive in the proximity of the track and so removes the danger of other trains on adjacent tracks colliding with workers.

Preferably the axial force of the application mechanism is hydraulically powered. A hydraulic power unit is normally a separate unit which is connected to the device before use. The hydraulic power unit typically weights less than 250kg and so is also easily transported and deployed with a small crane.

Preferably therefore the invention provides an apparatus for friction surfacing a rail, the apparatus comprising a device as described herein and a hydraulic power unit.

In alternative embodiments, a locomotive, such as a maintenance locomotive, may be used to provide hydraulic or electric power to the device.

Preferably the application mechanism is adapted to rotate the surfacing material.
Preferably the device comprises heating mechanism. Preferably, in use, the heating mechanism heats a portion of a substrate prior to said portion being contacted with the surfacing material.

Preferably the heating mechanism is an induction heating mechanism.

Preferably the application mechanism is capable of exerting an axial force of more than 5kN, preferably more than 15kN. Preferably less than 50kN, preferably around 25kN.

Preferably the application mechanism is pivotally mounted.

Preferably the device comprises an attachment mechanism, such as clamps, for attachment to a rail to be treated.

Sensors may be provided to determine the linear and/or angular position of the application mechanism with respect to the rail.

The terminology "rail" or "rails" as used herein means railway track rails.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a perspective view showing the process of friction surfacing;

Fig. 2 is a perspective view showing a rail which has suffered gauge cracking;

Fig. 3 is a first embodiment of an apparatus in accordance with one aspect of the present invention and a rail;

Fig. 4 is a second embodiment of an apparatus in accordance with one aspect of the present invention and a rail;
Fig. 5 is a third embodiment of an apparatus in accordance with one aspect of the present invention and a rail;

Fig. 6 is a diagrammatic view showing a process according to a further aspect of the present invention;

Fig. 7 is an upper perspective view of the Fig. 6 apparatus; and

Fig. 8 is an end view of a fourth embodiment of the present invention.

Fig. 1 shows a process for friction surfacing a rail. A rod 10 made from a suitable surfacing material is rotated and pressed against a substrate 12 at a force and speed sufficient to cause the rod to plasticise. The substrate can then be moved linearly and the rod is maintained in contact with the substrate thus depositing a layer 14 of surfacing material onto the surface of the substrate 12.

Fig. 2 shows a rail which has suffered from cracking - gauge corner cracking 22 has occurred on the gauge corner 24 of the rail 20.

Fig. 3 shows a first embodiment of an apparatus for friction surfacing a rail 20. The apparatus comprises attachment claws 32a & 32b, a drive mechanism 36 for rotating a rod (not shown) and a pivoting platform 38, mounting the drive mechanism 36. The drive mechanism is hydraulically activated via a hydraulic connector 37. The drive mechanism can alternatively be electrically activated with an electric motor and gearbox or an air motor.

In use, the drive mechanism 36 of the apparatus 30 rotates the rod. The drive mechanism may be tilted by the pivoting platform 38 and moved along the rail in order to align the rod with the area of the rail to be treated. The rod is then pressed against the rail 20. The friction of the contact
between the rod and the rail 30 causes the rod to plasticise and coat the rail. The rotating rod can then be moved along (or around) the rail to surface an area thereof. For this embodiment, the surfacing parameters are:

- maximum torque: 60Nm
- axial welding force: 25kN
- reaction forces in and perpendicular to the welding direction: 2.5kN
- travelling speed: 0.5m/min

The surfacing material is 316 Stainless Steel comprising austenitic steels of the 18% Cr 8% Ni type. Alternative surfacing materials include other hard wear resistant materials such as work hardening steels containing 12% to 14% manganese, known as "Hatfield Steel".

A second embodiment 40 of the apparatus is shown in Fig. 4. The apparatus 40 comprises similar features to the apparatus 30 and like parts will not be described. As can be seen, the apparatus 40 comprises parallel screws 39a, 39b along which the drive mechanism 46 may be moved. The Fig. 4 embodiment functions in the same way as the Fig. 3 embodiment.

Fig. 5 shows a further embodiment 70 which functions in the same way as the Fig. 4 embodiment - the apparatus comprises attachment claws 62a & 62b for attachment to a rail 60 or other substrate; a friction surfacing machine or drive mechanism 66 for rotating a rod 61 (which is to be applied to the rail 60), a pivotable platform 68 mounting the drive mechanism 66 and parallel screws 69a, 69b for moving the drive mechanism 66 linearly.
An induction heating coil 72 is also mounted on the parallel screws 69a & 69b which are in turn provided on the pivoting platform 68. Thus in use, the heating coil 72 and the drive mechanism 66 move together either linearly along parallel screws 69a & 69b, or pivot around the rail 60. The coil 72 and drive mechanism 66 are arranged such that during linear movement, the coil 72 will pre-heat a portion of the rail 60 prior to surfacing that area with the rod 61. The preheat temperature achieved using the induction coil is up to 400 °C.

Additionally the apparatus 70 comprises a clamping mechanism 63a & 63b for attaching the claws 62a & 62b to the rail 60. The clamping mechanisms 63a & 63b are hydraulically activated and suitable hydraulic connections 65a, 65b are provided.

Figs. 6 and 7 show a further embodiment. In this embodiment, a starter plate 50 is provided above a substrate 52 (such as a rail). The inventors have found that for certain embodiments of the invention used with very hard materials, are too slow to plasticise and the rod of surfacing material is pushed some way into the substrate (typically 5 mm), acting like a drill, before it will plasticise. On certain occasions this will mean that the surfacing material has penetrated further into the substrate than is ideal. This sometimes causes the equipment to be damaged when the lateral movement starts because the tip of the rod tends to remain in the hole it has formed in the substrate causing bending stresses on the shaft of the drive mechanism.

As shown in Fig. 6 and 7, the metal starter plate 50 of 6 mm thickness is attached at the starting point. The rotating rod of surfacing material is forced down with the centre of the rod in line with the edge of the plate. In this way the tip of the rod is plasticised before it reaches the surface of the
substrate and lateral movement can then be started. Moreover as it is pressed down on the edge of the starter plate the rod can be moved linearly away from the starter plate without removing contact of the rod with the starter plate/substrate.

Thus in use, the rod is rotated and pressed into the starter plate to build up the heat. The rod moves through the starter plate, building up heat as it moves. When the rod is of sufficient temperature (and pressure) to plasticise and surface the substrate, it can be moved linearly and the surfacing process continued as described above.

Adjacent layers of surfacing material may be applied in this way to provide a wider layer.

Fig. 8 shows an end view of a further embodiment of the invention. The fourth embodiment comprises a friction surfacing machine 86 mounted on a pivoting platform and linear drive mechanism such as those shown in any one of the first three embodiments, for example the screw drives 69a, 69b of Fig. 5. The fourth embodiment also comprises a first sensor 82 for determining the distance between the friction surfacing machine 86 and the surface of a rail 80, especially a gauge corner 81 of the rail 80, and a second sensor 84 for determining the angular position of the friction welding machine 86 relative to the rail 80. With such sensors, the fourth embodiment is particularly adept at friction surfacing around the gauge corner of the rail, instead of along the rail in the direction of the rail axis. The sensors of the fourth embodiment may be incorporated into any one of the previous embodiments.

The first sensor may be a LIPS sensor, such as those obtainable from Positek Ltd, Cheltenham, United Kingdom, or an optical device, such as
those obtainable from RS-Components Ltd, Corby, United Kingdom. The second sensor may be an encoder which is normally a wheel on the friction surfacing machine 86 turning against a stationary frame thus providing information on the angular position of the friction surfacing machine 86. A suitable encoder may be obtained from RS-Components, supra. Alternatively the second sensor may be a clinometer which is an electronic level which can detect the angular orientation of the machine 86. A suitable clinometer may be obtained from Inertial Aerosystems UK Ltd, Thorpe, United Kingdom.

Whilst the rod of friction surfacing material is pressed against the rail by the friction surfacing machine 86, such as by the action of a hydraulically controlled piston, the fourth embodiment also comprises a motorised slide or actuator (not shown) to move the friction surfacing material towards and away from the rail 80, ie essentially the same axial direction as that when the rod is pressed against the rail. This allows the movement of the rod of friction surfacing material to be manipulated more easily, especially given the shape of the rail. The rod may be positioned close to the surface of the rail 80 by the motorised slide and then contacted and pressed against the rail 80 by action of the piston.

The motorised slide or actuator may be a lead screw powered by either a hydraulic motor or an electric motor and gearbox. Alternatively a hydraulic ram could provide the motion.

A control system 88 is connected to and processes signals from the sensors 82, 84 and in turn controls the positioning of the friction surfacing machine 86 so that the target area, such as the curved gauge corner 81 portion of the rail 80, is followed. In alternative embodiments, the profile of the rail head can be programmed into the control system 88.
A number of benefits may be realised from certain embodiments of the present invention. Rails may be reinforced or repaired to reduce their susceptibility to gauge corner cracking, thus reducing the amount of maintenance required on the rail track and in turn reducing expensive downtime of the track. Moreover damage to the rails may be conveniently repaired *in-situ* since the devices described herein are portable. This also reduces track downtime. Safety is increased as certain embodiments do not require workers to be on the track; the associated bureaucracy for such risks can also be avoided.

Improvements and modifications may be made without departing from the invention.
Claims

1. A process for treating rails in order to improve their durability, the process comprising adding a metal surfacing material to the rail by the process of friction surfacing.

2. A process as claimed in claim 1, wherein the friction surfacing process comprises rotating or oscillating a solid surfacing material whilst in contact with the rail, applying a pressure between the solid surfacing material and the rail, the pressure sufficient to cause a temperature and pressure increase in the surfacing material, to plasticise it and create a layer of surfacing material on the rail.

3. A process as claimed in claim 2, wherein the pressure is at least 1kN, preferably more than 5kN, especially more than 15kN.

4. A process as claimed in any preceding claim, wherein the surfacing material is heated to a temperature of from 60% up to 80% of its melting temperature measured in Kelvin.

5. A process as claimed in any preceding claim, including moving the surfacing material and rail linearly with respect to each other.

6. A process as claimed in any preceding claim, comprising repairing or mitigating surface cracking especially gauge corner cracking, wherein the surface cracks are less than 2.5mm deep.

7. A process as claimed in any preceding claim, wherein the rail is pre-heated to more than 300 °C prior to undergoing friction surfacing.
8. A process as claimed in claim 7, wherein the area to be heated is less than 1,800 mm², normally less than 1000 mm², especially less than 600 mm².

9. A process as claimed in any preceding claim, wherein a starter plate is provided between the surfacing material and the rail and the solid surfacing material is rotated or oscillated on the starting material prior to contact with the rail.

10. A process as claimed in any preceding claim, wherein the friction surfacing results in a layer of surfacing material on the surface of the track of up to 1.5 mm, preferably up to 1 mm, especially around 0.5 mm.

11. A process as claimed in any preceding claim, which is applied to areas proximate to butt joins in rails.

12. A device for friction surfacing a rail comprising:
- an application mechanism adapted to rotate or oscillate a surfacing material, and capable of providing an axial force of at least 1 kN;
- a movement mechanism adapted to move the application mechanism linearly;
wherein the device weighs less than 500 kg.

13. A device as claimed in claim 12, wherein the axial force of the application mechanism is hydraulically powered.

14. A device as claimed in claim 12 or 13, comprising a heating mechanism.
15. A device as claimed in any one of claims 12 to 14, wherein the application mechanism is pivotally mounted.

16. A device as claimed in any one of claims 12 to 15, comprising an attachment mechanism for attachment to a rail.
Fig. 3
Fig. 8
**INTERNATIONAL SEARCH REPORT**

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 2002/125216 A1 (J. SAURON ET AL) 12 September 2002 (2002-09-12)</td>
<td>1-8, 10-12, 14-16</td>
</tr>
<tr>
<td>A</td>
<td>paragraphs [0001], [0002], [0051] - [0054], [0059], [0063] - [0077], [0091] - [0096], [0105] - [0111], [0120] - [0126]; figures</td>
<td>9</td>
</tr>
<tr>
<td>Y</td>
<td>GB 2 270 864 A (THE WELDING INSTITUTE) 30 March 1994 (1994-03-30) page 10, lines 1-27; figure 5a</td>
<td>1-8, 10-12, 14-16</td>
</tr>
<tr>
<td>Y</td>
<td>GB 446 111 A (CR. DEGLON ET ALL) 24 April 1936 (1936-04-24) page 1, lines 28-59; figure 1</td>
<td>7,8,14</td>
</tr>
</tbody>
</table>

* Further documents are listed in the continuation of Box C

See patent family annex

---

**Date of the actual completion of the international search**

3 December 2008

**Date of mailing of the International search report**

15/12/2008

**Name and mailing address of the ISA/Authorized officer**

European Patent Office
P B 5818 Patentlaan 2
NL-2280 HV RUISWijk
Tel (+31-70) 340-2040,
Fax (+31-70) 340-3016

Jeggy, Thierry
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>JP 05 169292 A (RAILWAY TECHNICAL RES INST) 9 July 1993 (1993-07-09) abstract; figures</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>FR 2 661 698 A (REPCORAIL SARL; L. PETIGNOT ET AL) 8 November 1991 (1991-11-08) page 1, line 34 - page 3, line 21; figure 1</td>
<td>12, 13, 15, 16</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN 1313155 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 60116981 T2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 1145793 T3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2256183 T3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2806337 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HK 1040952 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PT 1145793 T</td>
</tr>
<tr>
<td>GB 2270864 A</td>
<td>30-03-1994</td>
<td>NONE</td>
</tr>
<tr>
<td>GB 446111 A</td>
<td>24-04-1936</td>
<td>NONE</td>
</tr>
<tr>
<td>FR 2661698 A</td>
<td>08-11-1991</td>
<td>NONE</td>
</tr>
<tr>
<td>US 6237835 B1</td>
<td>29-05-2001</td>
<td>NONE</td>
</tr>
</tbody>
</table>