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Delivering maintenance efficiencies

A simple approach to rail head repairs

DEFECTS Aluminothermic welding offers a convenient way to repair isolated flat defects on the rail surface, maintaining the integrity of the rail and avoiding the need to insert short plug sections.

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Rail defects come in many different types and sizes and can emerge at any stage during the life of a rail. They can range from a single isolated defect to a problem that affects a long length of rail. Whilst problems extending over a long section will require extensive treatment or complete replacement of a defective rail, small localised defects can be tackled in isolation.

Individual defects are often repaired by building up the rail head using metal-arc welding, or by cutting out the fault and inserting a 'plug' section. But this creates two new joints in the rail, and railways are looking for cheaper and simpler repair methods.

The use of aluminothermic welding to repair an isolated rail head defect is not new. About 50 years ago Elektro-Thermit developed a build-up welding method based on the Thermit technology used for joining rails. Although the process did not become established at that time, we believe it is now time to revisit the technique.

The Thermit Head Repair process has been developed for repair of more-or-less flat defects on the running surface of flat-bottomed rails, such as squats, shelling, spalling or wheel burns. The process can easily be adapted for worn rails or rail profiles with different head heights. At this stage THR is mainly envisaged for the European market, but it should become available more widely within the next few years once the necessary approval processes and track tests have been undertaken.

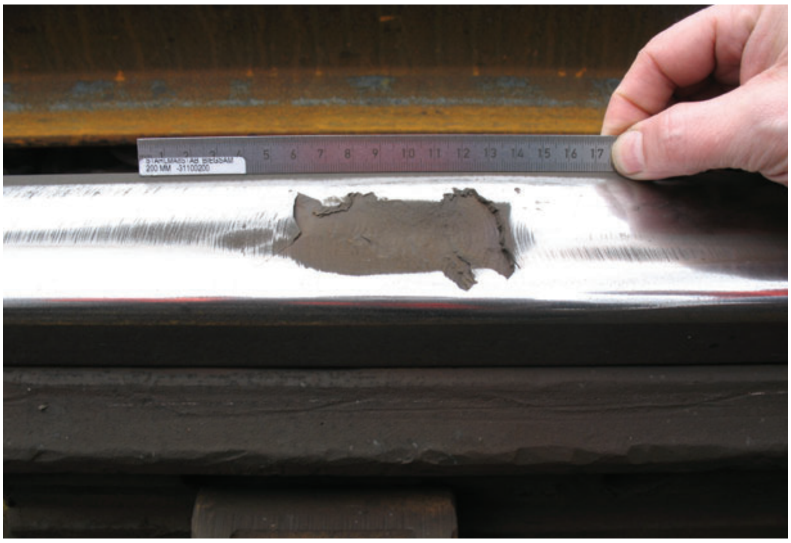

Fig 1. Squats are typical rail defects that can be repaired by using the THR process.

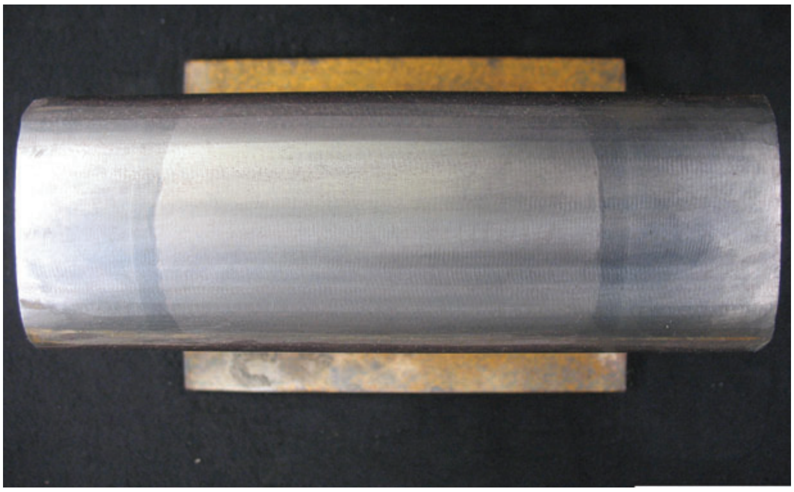

Fig 2. Running surface of finished THR weld after etching.

Cut and fill

As with any spot repair, the first step is to make an estimate of the dimensions, perhaps using hand-held ultrasonic testing methods to determine more accurately the exact size and position of the defect. The complete defect is then removed by grinding, milling or using a cutting torch. The cut in the rail is based on an arc of a circle, with a maximum depth of 25 mm at the centre and a maximum length of 75 mm along the running surface, extending across the width of the railhead.

When it comes to filling the hole, most of the steps used in conventional aluminothermic welding, such as weld execution, shearing and grinding are applied. The main difference with THR is that there is no gap between the two rail ends. A second factor is the need to provide some form of central lift under the weld in order to avoid any dipping of the weld as a result of thermal

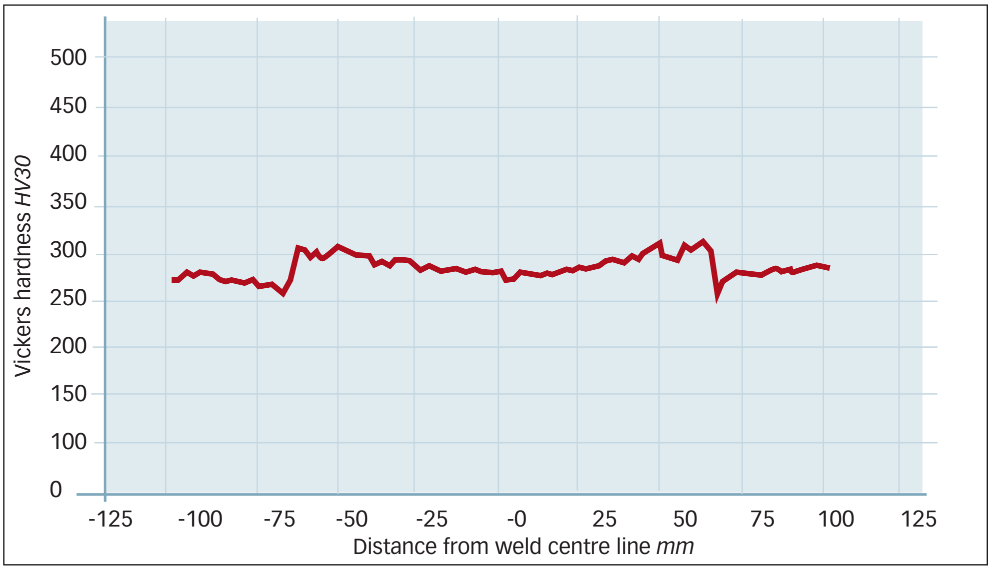

Fig 3. Hardness profile of THR weld measured in the longitudinal direction of the weld (rail grade R260).

shrinkage. If necessary the rail foot can be counterheated directly under the weld to reduce the effect of thermal shrinkage and maintain a correct vertical alignment.

After final grinding, the finished THR weld will have a similar external appearance to the original rail (Fig 2). No collar is formed under the railhead, whilst the web and rail foot remain unaffected. In fact, it is possible to install two THR welds right next to each other or adjacent to an existing aluminothermic weld.

Weld properties

The hardness and chemical composition of the weld metal are determined by the Thermit portion grade, which can be specified to ensure the best possible match with the properties of each grade of rail steel. Fig 3 shows a typical hardness profile of a THR weld, with a small heat-affected zone. In terms of hardness distribution, the properties of a THR weld are very similar to those of a standard aluminothermic weld. As the Thermit technology allows the chemical composition to be adjusted to meet local requirements, this is not a critical factor.

Although standard for aluminothermic welding, slow bend tests are not really applicable to a THR weld. As the repair does not disturb the continuity of the web or rail foot, the strength of the original rail remains largely unaltered; thus the test is effectively testing the rail steel and not the weld. During slow bend tests with a R260 grade rail to 60E1 profile, we observed a deflection of up to 40 mm at a maximum load of more than 1 700 kN. The test was stopped at this point, and the weld did not fracture. So breaking load and deflection are not critical. Indeed, the high deflection values that can be achieved are a very good indication of the robustness of this repair method.

Fatigue properties

The same points also apply to fatigue testing, which is used to assess the quality of Thermit welds on a laboratory scale, although the real conditions in track cannot be easily reproduced. Tensile stresses generated in the foot of the rail are usually responsible for the initiation of a fatigue crack during testing, but such cracking is not relevant when assessing a head repair weld.

More significant are the microstructure and fusion properties of the head weld, and how the THR process ensures sufficient fusion between the weld metal and the rail. Fig 4 shows the longitudinal section of a fusion zone and the size of the excavation. The fusion line and the boundary between the heat-affected zone and the unaffected rail steel are highlighted. Considering the size of the initial excavation, it can be seen clearly that sufficient fusion has been achieved between the rail and weld metal. Furthermore, there is only a narrow heat-affected zone on the running surface.

Even if the complete defect had not been removed, the THR process would still improve safety as much of the defective material would have been cleared away.

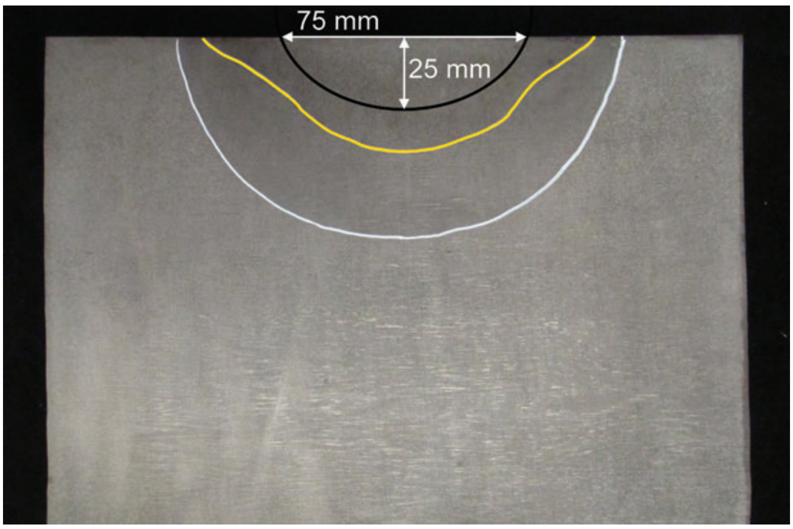

Fig 4. Longitudinal section of a THR weld, showing the fusion zone and heat-affected zone, as well as the dimensions of the initial excavation.

Ease of use

Building on the robustness and widespread use of the aluminothermic process, the THR technique offers railhead repair with similar or improved properties and similar behaviour to a stand and wide-gap Thermit weld. Qualified track maintenance staff already familiar with conventional aluminothermic rail welding, can easily be trained to undertake the THR process, minimising the need for specialist training.

As the localised repair method does not compromise the integrity of the rail, the longitudinal stresses are unaffected. So unlike a plug repair, there is no need to re-neutralise the track stresses following the work.