In Situ Rail Head Rectification on British Railways

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The economic climate that led to the development of a system of in situ rail head rectification by planing, the history of its development, and the equipment used are described. Included are comments on how rail planing forms an integral part of the overall strategy adopted by British Railways for the maintenance of rail head geometry.

Ever-increasing economic pressures demand that the use of track components be optimized. On heavy curves it had been the practice to transpose or turn rails when a side on the high rail had reached unacceptable levels. Little attention was paid to the low rail. With the widespread use of continuously welded rail, turning was no longer an option, but transposition of rails was. As line speeds increased it was soon discovered that transposed rails gave an unacceptably poor ride because of bogie instability.

The "new" high rail clearly exhibited a flattened crown radius and often displayed mushrooming; this was caused when slow-speed traffic transferred a significant proportion of its weight to the low rail before transposition. Mushrooming or lipping can also lead to the formation of stress cracks, which ultimately cause failure of the rail.

The attractiveness of reusing rails rather than purchasing new ones led British Railways to develop a process by which to reprofile the head of rails in situ and gain, as it were, a second life for them. This permitted rails to be transposed on the same site or to be relocated on another route, that is, to cascade from a primary to a secondary line where speeds might still be high (in excess of 75 mph) but axle loads and gross tonnage lower.

Locating a reprofiling machine in a depot was an alternative, but it would have incurred substantially higher rail transport and handling costs.

DEVELOPMENT HISTORY

The British Railways network is made up of some 20,000 route km. Because of the legacy of a piecemeal construction history and many geographical features (which presented railway construction pioneers with barriers that tested their ingenuity), much of this network is on curves.

With one notable exception, namely, the London-to-Bristol route, all the main routes have their fair share of significant curves, and, in order to cut overall trip times and remain competitive with other transport modes, railway engineers designed these curves to the tightest possible standards.

British Railways is a mixed-traffic network. It attempts to cater to the widest possible range of traffic including, at one extreme, high-speed passenger trains going up to 200 km/hr and, on the other, short-wheelbase freight wagons with a maximum speed of 45 km/hr. The maximum permitted axle load is 25 tonnes with a speed limit of 96 km/hr, but freightliners (bogie container-carrying wagons) with a maximum axle load of 22 tonnes are permitted to go 120 km/hr.

Therefore for all main lines curve design is a difficult compromise, but inevitably both high and low rails will experience substantial forces that cause side wear and flattening and mushrooming.

It was realized that on curves where rails had been transposed, the flattened head crown radius was producing an unacceptably poor ride. This led to prohibition of rail transposition on all but the slowest-running lines.

The result was the generation of rails that were ultimately worn to unacceptable limits. If reprofiled, they could have been reused, because they still contained a substantial amount of metal, but without such a process, these rails were fit only for scrap, a waste of a potential asset.

In 1978 Plasser and Theurer offered a machine that reprofiled the back edge of the low rail to facilitate transposing (Figure 1). It was designed to treat a maximum of 50 percent of the head width, and the cutting sequence was as follows: first cut—one cutter at 45 degrees; second cut—two cutters, one at 15 degrees and the other at 75 degrees; third cut—a clean-up profiler.

FIGURE 1 General view of production machine.

British Railways Board, Paddington Station, London W21FT, England.

Trials began in 1979, and it was soon realized that it would be beneficial to adjust the cutters. The new arrangement was as follows: first cut—one cutter at 45 degrees; second cut—two cutters, at 30 degrees and 60 degrees; third cut—gage corner radius profiler.

The profiles thus achieved were disappointing, giving an equivalent conicity of between 0.3 and 0.45. The target was set at 0.213, which was achieved by a worn wheel set of a Mark II passenger coach relative to the standard British Railways 113A flat-bottomed rail.

This machine was able to plane at 55 to 60 m/min, and the life of each cutting tool was 1.3 to 1.5 km. The cutting tools were designed for easy changing and adjustment, and the operators soon learned that the cutters became very hot during planing. The swarf generated was also red hot, and clearly, even when it had cooled sufficiently to be handled, it was unpleasant material to load and dispose of. If left on the ballast, it presented a major hazard to track maintenance staff and any electrical equipment. A trolley equipped with four magnets was soon added to the planing machine to handle this problem (Figure 2).

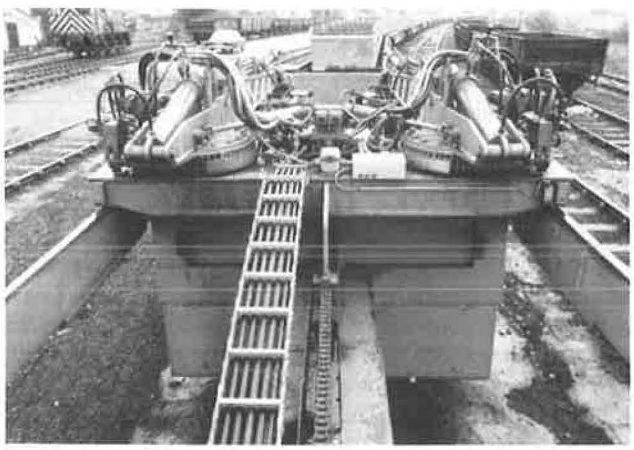

FIGURE 2 Earlier swarf collector.

New trials in 1980 involved planing the whole head in 8 and 10 passes. The results this time achieved an equivalent conicity of better than 0.213, even though the cutters had been set for a rail inclined at 1 in 40 rather than the British Railways standard of 1 in 20. It is interesting to note that at this site the rails were also corrugated and that the planing successfully removed all trace of the corrugations.

Further developments involving various ideas for swarf collection followed, because the magnet arrangement was slow and less than effective (Figure 3). Great care had to be exercised near signal equipment to avoid damage leading to signal failure. A vacuum cleaner was considered but rejected. A continuous magnetic loading system was preferred, and amendments to facilitate discharge of swarf from the collection hopper followed (Figure 4).

As experience was accumulated, other problems came to light. Some welds caused the cutting tools to shatter because of the sudden change in hardness.

The program of trials continued in 1981 using the following cutting sequence:

1. Middle of rail shoulder,
2. 45 degree chamfer on gage corner,
3. Deeper cut than in step 2,
4. 25 and 67 degrees on gage corner,
5. Just inboard from cut 1,
6. Just inboard from cut 5,
7. Center of rail head, and
8. Radius cutter on gage corner.

The results showed that if the planing sequence is interrupted and trains are permitted to run over the rails at an intermediate stage, no temporary speed restriction is required.

FIGURE 3 Loading swarf.

FIGURE 4 Later type of swarf collector.

The success of this extended development sequence led to the placing of an order for four machines in 1982. The major difference from the prototype concerned the swarf collector. A twin rotating magnetic-drawn system plus conveyors replaced the four magnets supported by jibs. A ballast profile plate was also adopted to avoid the swarf's being trapped by uneven ballast.

Since 1984 these machines have formed an important part of the British Railways rail rectification regime; their prime purpose is to reprofile lipped and mushroomed rails so that they can be transposed or relocated (Figures 5 and 6). Corrugation removal is not the primary function of these machines, although they will successfully eliminate head defects

FIGURE 5 General view of reprofiled rail.

FIGURE 6 Reprofiled rail with gage.

of that type. British Railways employs four Speno grinding machines for the removal of corrugations and recently has begun some reprofiling with the latest grinding machine. This, however, is to improve the quality of ride over those rails that are not to be removed from the track.

MACHINE SPECIFICATION

The Plasser rail planing machine (PPM-100) is based on the standard 07 chassis. It is a self-propelled unit capable of running at a sustained speed of 80 km/hr up gradients of 1 in 500. It can negotiate a curve of 80-m radius and can work on track curved to 100-m radius.

It is designed for British Railways standard gauge (1432 mm) and is able to reprofile both rails simultaneously. The operating speed is up to 60 m/min and it is able to cut sections up to 25 mm^2. The cutting heads are controlled hydraulically and are guided by a series of rollers (Figure 7).

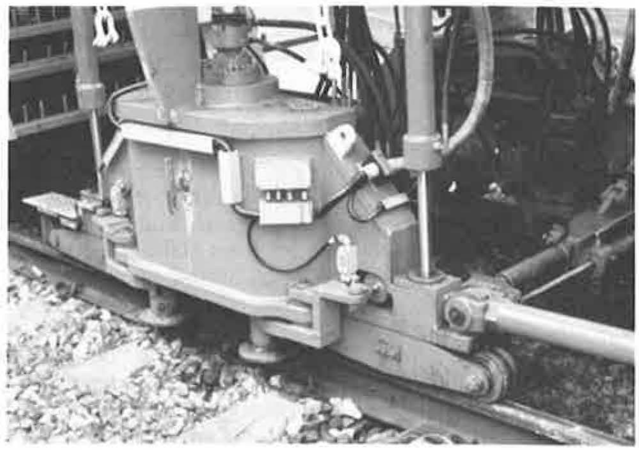

FIGURE 7 Cutting head in working position.

FIGURE 8 Cutting tools.

The unit is designed to be operated by a crew of two. The cutting process is observed using a TV monitor.

The cutters are of the chip breaker variety to reduce the risk of producing long lengths of swarf (Figure 8). The operator can change the cutters without having to stand on the "six foot" side, that is, risking being foul of an open track.