TECHNOLOGY Track

The quest for quieter trams

Researchers are looking at ways to mitigate wheel-rail noise, including improved rail grinding technologies.

Common rail defects for grooved rail include wheel burn (left) and corrugation (right).

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Over the past two decades, trams and light rail have undergone a renaissance as an efficient, accessible and environmentally-friendly mode. However, they still have external impacts, in particular the noise and vibration generated by steel wheels on steel rails. It is well proven that noise and vibration have a negative impact on human wellbeing. In addition to hearing loss, sleep disturbance and tension, persistent exposure to noise can affect cognitive performance and hormone balance.

As the use of physical barriers is not feasible on street tracks, noise must be mitigated at source. This means keeping the wheels and rails as smooth as possible. Wheels can be turned regularly, so rough track surfaces are often the main contributor to noise generation.

The issue is being addressed as part of an EU-backed Shift2Rail research project. To assess the scale of the problem and identify possible mitigation techniques, the team asked operators about the characteristics of their infrastructure.

Track types and rail damage

Unlike main line railways, tram routes often share space with road traffic and pedestrians, with embedded tracks, while compact city centres may necessitate sharp curves and steep gradients. Independent network development also led to a proliferation of track designs.

Embedded track using grooved rails remains predominant, although flat-bottomed rails are often used on segregated alignments. 'Green track', with grass or other vegetation between the running rails, accounts for about 20% of the route length of the 25 networks responding to the survey (Table I).

More than 60% of total network length is straight, while 3% is formed of curves with radii less than 50 m, an average of more than two curves per route-km. While new networks generally avoid radii much lower than 50 m, the minimum radius in legacy tramways is just 17 m. Such tight curves lead to high wear rates and curve squeal noise emissions.

The combination of embedded track plus frequent services imposes high forces on the rails. These cause wear, rolling contact fatigue and other faults on the rail surface and running edge, increasing roughness. When asked to identify their most frequent track defects (Fig 1), 17 respondents named wear and corrugation, the latter usually caused by differential slip in curves. Squats were cited by 12, and wheel burn by five. Of the operators, 55% said noise and vibration were a major issue, and 80% said they had already faced complaints from residents. There was a widespread expectation that more stringent regulatory requirements would be introduced.

Table I. Average distribution of rail types across the tram and light rail networks surveyed

Grooved rail	**72%**
Embedded track	52%
Green track	18%
Open/ballasted track	2%
Flat-bottomed rail	**28%**
Open/ballasted track	26%
Green track	2%

Mitigation measures

Half of the respondents use speed restrictions as a quick way to cut noise, but the impact on service quality means this is not a long-term solution. Another option is to reduce the friction between rail and wheel by lubrication, particularly in sharp curves.

The treatment of rough rail surfaces includes build-up welding to counteract abrasive wear. After welding, the rails have to be ground precisely to restore the profile. Grinding is also used to remove rail damage and profile errors, while preventive grinding reduces the emergence of defects. However, this does not necessarily lead to a reduction in noise and vibration as surface roughness depends on the grinding technique used.

Passive grinding with sliding stones is the most basic technique. The stones are applied to the rail head under pressure and towed by a separate vehicle. This creates relatively little noise and can be undertaken at up to 30 km/h, so it can be deployed during service hours. However, only a small amount of material can be removed in a single pass, and the rail profile cannot be altered.

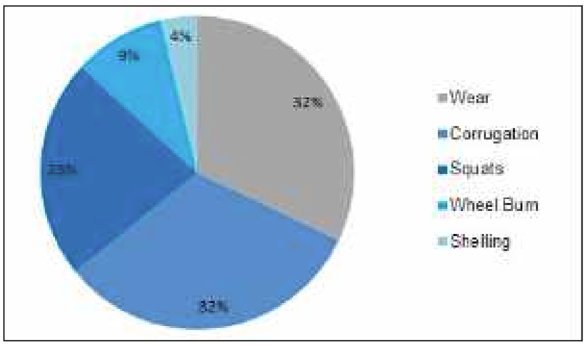
Rotary grinding typically uses multiple rotating abrasive wheels treating the rail head at different angles, which also allows the rail profile to be corrected. This method generates flying sparks, dust and noise, and leaves a relatively rough rail surface.

Oscillating grinding is derived from the sliding method, but to increase material removal the grindstone oscillates in the direction of the rail axis. Since any chatter marks on the newly-ground rails lie in the direction of travel, the noise generated by passing vehicles is significantly reduced. This technique provides a homogeneous removal of corrugations and other surface irregularities, but because of geometric constraints it has yet to be applied successfully to sharply curved tram tracks.

All the respondents currently use rotary grinding, at least for spot treatment and reprofiling. More than half also use sliding grinding, but oscillating grinding is only used by a few networks which have a large amount of segregated track with flat-bottomed rails.

Nevertheless, the survey suggests that oscillating rail grinding holds great potential, and the development of a prototype grinding machine is to be taken forward in a future phase of the project. ■

Fig 1. Most common rail surface defects in light rail networks.



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