Matrox Imaging helps keep trains on the right track

By **Kelly Davis,** Matrox Imaging

AEA Technology Rail in Derby, United Kingdom, was born out of the R&D facilities of former state-owned British Rail – BR Research. In 1997, BR Research was the first post-flotation acquisition of AEA Technology plc, formerly the technical support, research and development arms of the UK Atomic Energy Authority.

Now, AEA Technology Rail is primarily an engineering consultancy and development company serving the rail market. "We tend to get people coming to us with specific technical problems and we provide solutions across the whole range of railway activities, from signalling, civil and mechanical engineering, vehicles, track and so on,' explains Jon Pocock, VIEW™ Product Manager at AEA Technology Rail. The company services clients worldwide, although most of its rail business is UK-based.

From this 'think-tank' came a number of condition-monitoring products that together make up the VIEW application family of automatic vehicle inspection systems. These include examinations of brake pads, blocks, shoes and wheel profiles. Pocock's group installs a wide range of computer systems – either on trains or by the side of the track – to measure various train or infrastructure parameters and to enable maintenance decisions to be made based on the information gathered.

The product range has evolved out of initial work on diesel engine monitoring to seeking accurate ways to predict likely failures, calculating passenger numbers by weighing the train as it travels, measuring the stress a train places on the track by recording vibration levels and force exerted on overhead catenary wires. Although many of the monitoring exercises themselves are relatively straightforward, the operating environments are mechanically and electrically harsh.

Monitoring wheel wear-and-tear

TreadVIEW™ is one member of the VIEW™ family of products used to monitor wear on steel train wheels. The profile of the wheel and flange is critical to the smooth and safe running of the train. The shape of the wheel allows the train to steer itself around bends and return to a neutral position on the track. Everyone is familiar with the squealing sound that train wheels make as they negotiate bends – according to Pocock, this is the sound of the wheel and rail milling each other and it's not good news for either train or track. As material is removed from the wheels, hollows are created where the flange is worn away and this can be dangerous when the train is passing through points and crossovers. Once worn in this way, however, the wheel can normally be turned or machined back into the ideal profile.

Deciding when to carry out this work has to be carefully judged in order to maximise safe and efficient operation, while keeping maintenance costs under control. As re-turning wheels on a train vehicle necessitates withdrawing it from service and taking it to a special wheel lathe, rail operators try to avoid having to do this until absolutely necessary. Abnormal wheel wear can be symptomatic of other problems, such as faulty suspension on bogie units or track faults: for example, lubrication failure in high-friction areas such as bends. Track problems can cause considerable damage across a fleet before they are identified.

The VIEW systems are typically placed at the end of train-wash stations that trains frequent every 2-3 days, moving slowly through the wash at 5-6mph. This location allows the trains' wheels to be checked frequently and ensures each wheel is scanned and captured. The disadvantage of this location, however, is that trains emerge from the wash not just dripping water but various acidic and alkaline solutions as well – a truly hostile environment for sensitive electronics. The location is also electrically noisy, therefore the system shelter has to be robust and sealed, right down to being equipped with a windscreen wiper to ensure the CCTV camera's view is not distorted by droplets on the cover glass. Coping with these environmental problems actually represented the major element of the challenge facing Pocock and his team, as compared to the machine vision element, which represented only 15-20% of the work involved.

A light challenge

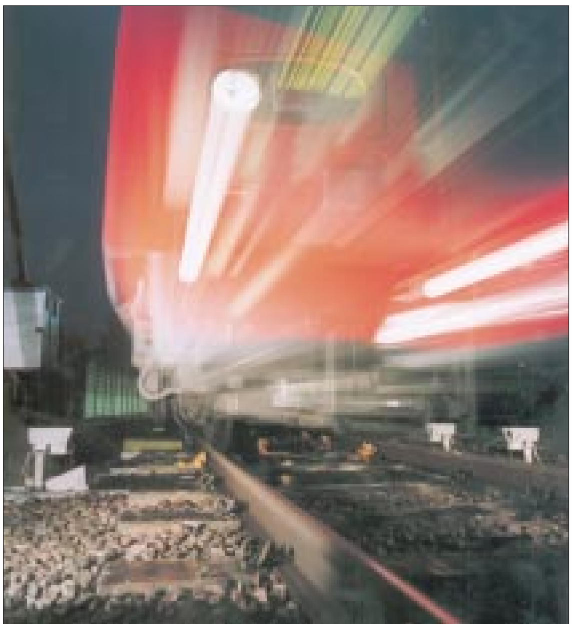
In the TreadVIEW application, the wheels are lit by structured lighting in the form of a divergent beam point source laser projected as a line onto the wheel.

The laser is a Lasiris 100mW laser – 670nm nominal frequency. It is fitted with a beam-splitting head to produce a reasonably constantly intense diverging line that is used to highlight the wheel shape at one point on its circumference. This ensures constant brightness across the whole lit area. In the prototype system, problems of laser brightness over the ambient light conditions were experienced. The highly polished wheels tended to reflect ambient light straight into the camera, while the laser light was reflected back into the laser itself. An optical band pass filter with its pass frequency centred around that of the laser was integrated into the camera lens, enabling most of the ambient light to be removed before the image was captured.

"Where the Matrox Imaging Library software was especially helpful was in enabling us to get into the image and still extract the detail we needed," says Pocock. Once captured to a Matrox Pulsar frame grabber board, the image is filtered in software to eliminate spurious light effects – although this process also removes some of the laser light. That problem has been resolved by reprocessing the image line by line, extracting each peak value. Where no peak occurs, the grey-scale values need to be equalised until a peak is detected. If that fails, then the process moves on to the next line until the peak is picked up once more. This process makes intensive use of calls to the Matrox Imaging Library and Pocock says he found very few other application libraries that allow developers even to start designing such a process, let alone to carry it out at a reasonable speed. TreadVIEW pictures take 0.5-1 second to process and while real-time speed is not important, producing an answer in a reasonably short time is.

Saving time and resources

In comparative tests with the highly accurate hand-held 'Miniprof' gauge used in manual wheel checks, Treadview is proving accurate to within 0.5mm on a moving vehicle – this is sufficient for providing regular measurements in a cost-effective manner. Pocock illustrates this by observing that it took a two-man team about three man-months to carry out a complete Miniprof assessment of one of the fleets on the London underground system, while the same job took



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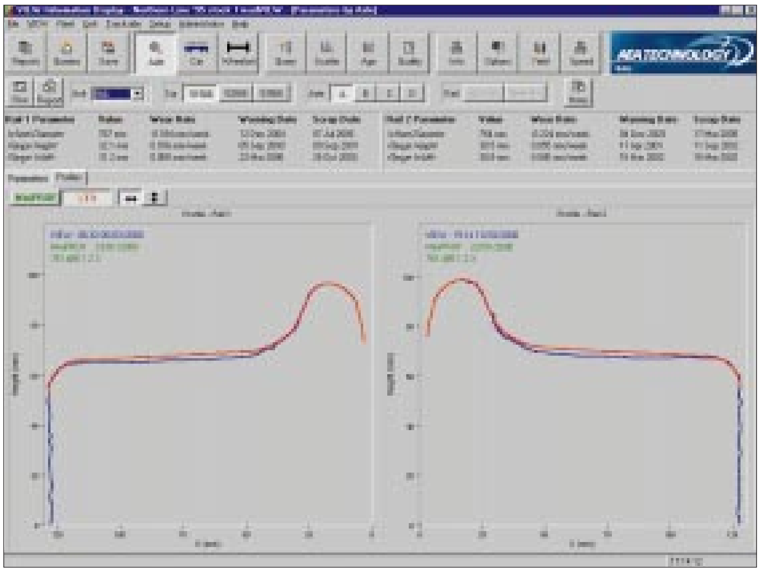

a mere seven days – without human intervention – once a TreadVIEW system had been installed. The rolling programme that Treadview makes possible enables the information that is gathered to be averaged and this reduces the already small possibility of error by a third.

Limits to further increases in accuracy are imposed by the power of the laser and by not being able to extract the laser line accurately enough. In the prototype system, it was found necessary to keep the camera shutter open longer in order to increase the amount of laser light collected, but in the prototype system this also caused slight flaring from an increase in ambient light entering the camera. The use of a more powerful – 100mW – laser in the production system has eliminated this problem. Other factors include the width of the laser beam itself – about 1mm – and the fact that there is variance in the geometries of the wheels as they roll past the laser and camera. The alignment of the wheel, the laser and the camera is critical in carrying out an accurate geometrical transformation as the image is captured. The Tread VIEW software contains 3D geometrical conversion elements to correct these errors.

In practice, Pocock has found that if measurement can be made to within ±0.5mm in a viewing range of ±10mm, the system will be able to accurately advise whether remedial action needs to be taken immediately or at some point in the future. Regular inspection using Treadview can also detect variations in the rate of change, which might bring the scheduling of remedial action forward or delay it further.

Worn rail will tend to cause new wheels quickly to adopt a worn profile and vice versa. After that, the wheel/rail wear takes place much more slowly, with the wear rates increasing slightly as the profiles become more worn. Over a period of time, the track and rolling stock on a rail system therefore reach a kind of equilibrium. A major change – say from the introduction of a new fleet or the replacement of a large section of track – can upset that equilibrium. New patterns of wear can start to appear on both track and wheels, and the position of the average wear profile is altered. TreadVIEW can be used to spot such large-scale changes before they cause a sudden deterioration in the quality of the wheels across an entire fleet. Of increasing importance in privatised rail networks, TreadVIEW can also help all parties determine liability for track and wheel wear.