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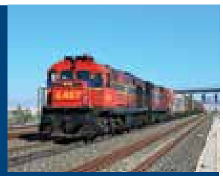

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Harnessing innovation in Italy

Front Cover: The robotic welding and milling station developed at Saga's plant at Scurcola Marsicana near Roma allows for the repair of austenitic manganese steel crossings to enhance quality and durability. Saga developed the robotic repair methodology itself, and the company also arranges for the pick-up and delivery of turnout crossings.

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CONTACT US

Railway Gazette International
NINE, Sutton Court Road, Sutton,
SM1 4SZ, Great Britain
Tel +44 20 8652 5200
Fax +44 20 8652 5210
editor@railwaygazette.com

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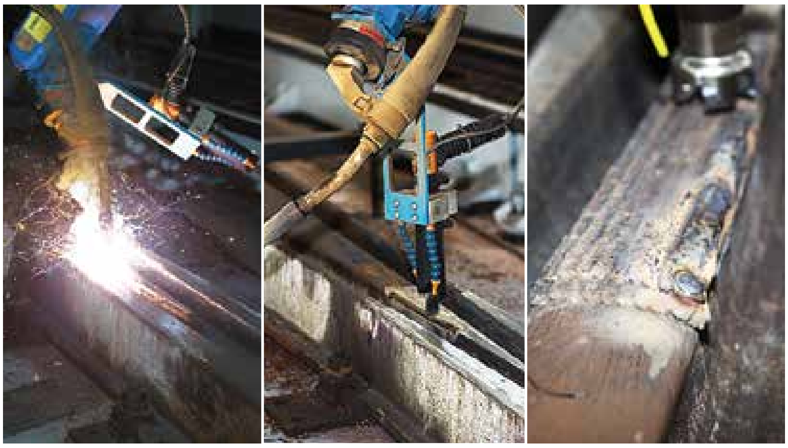
Taking care of the heart of a turnout

ROBOTS Collaborative research has supported the development of an automated plant to repair work-hardened turnout crossings made from austenitic manganese steel.

Prof Andrea Bracciali
Department of Industrial Engineering
University of Firenze



Right: After the worn crossing has been built up using electric arc welding (left of picture), it is descaled using a needle gun (centre) ready for milling (far right).

Turnouts are a challenge for railway infrastructure managers all around the world. They are expensive to install, difficult to maintain, and subjected to heavy wear. But as turnouts are absolutely fundamental to the rail mode, they remain the focus of extensive research into design, performance, wear and maintainability.

Recent research at the University of Firenze has helped in the development of a new technique for restoring and life-extending crossing noses, which are one of the most complex and expensive elements in a typical turnout.

Because of routine wear and tear, an infrastructure manager operating a relatively large rail network may be faced with the challenge of repairing or renewing several hundred turnouts a year. In many cases, this work will focus specifically on the replacement of a heavily worn crossing nose, which can be changed directly without removing the rest of the turnout. Even when a turnout is dismantled at the end of its useful life, not all of its components are automatically sent for scrap.

The shape of the crossing nose and wing rails is restored using a milling process (right), followed by finish grinding (far right). The completed crossing is then checked using non-destructive testing before dispatch (below).

Typically manufactured from austenitic manganese steel, which has good work-hardening properties, the crossing is probably the single most expensive component of a turnout. So there are significant potential economies to be gained from repairing and reusing them, rather than replacing them every time.

Techniques to build up worn crossing noses by electric arc welding have been around for many years, but it has been difficult to ensure the quality of in-situ repairs which have to be done under difficult access conditions and in all kinds of weather. A far more consistent result can be obtained when the repairs can be undertaken in a workshop, using a rigorously-controlled industrial process.

Having built up considerable experience with in-situ restoration of turnout crossings, Italian company Saga srl has recently opened its first workshop in Scurcola Marsicana, 90 km from Roma, to repair crossing noses under contract to RFI. According to one of the company's founders, Panfilo Salciccia, 'we started thinking about an industrial way to repair crossings a few years ago. We wanted to set up a flexible low-cost plant that could offer the best quality at competitive price.

'After analysing in detail all the phases involved in repairing a crossing, from initial measurement through welding, and machining to finishing, we decided to investigate the possibility of using a robotic plant for both the welding and machining phases.'

Robotic welding is already widely used in many sectors of industry, but using a robot for machining a 'difficult' material such as austenitic manganese steel is a very different proposition. Because of its work-hardening properties, the material requires a very stiff machine and special geometry tools.

It soon emerged that grinding was not an option, as the cutting forces were too high, and the pressure on the grinding wheel would be too great for the limited stiffness of a robot. Thus Saga was forced to use a milling tool, which Salciccia explains 'unfortunately results in extremely periodic excitations in the slender arm of a robot'.

Having sourced suitable milling tools from a specialist manufacturer, Saga worked with the University of Firenze to address the problem of machining vibration and stability. Chatter is a very complex phenomenon, and it normally takes a long time to study the effect and limit its consequences on surface quality and tool life. However, we did not have a lot of time to investigate the phenomena.

The company had already decided to use robots from the same manufacturer for both the welding and milling operations, which dictated a precise architecture for the machine tools. Nevertheless, the collaborative research enabled us to reach a satisfactory compromise between machining time and tool life.

Using an experimental modal analysis, the university investigated the dynamics of the robot in the entire machining area. This enabled us to identify an interesting combination of anti-resonances around a spindle rotation speed that was perfect for machining. Practical tests confirmed that this would give satisfactory results in terms of productivity, quality and tool life.

The robots were then programmed with the geometries needed to machine various types of crossing. In fact, the plant has considerable flexibility, as it is possible to draw up and programme a working cycle for virtually any crossing type in around two working days.

Saga is now able to offer a 'full service' package to any railway administration, including collection and delivery. On arrival at Scurcola Marsicana, each crossing undergoes a first rough milling and dye-penetrant checks, followed by the welding, needle descaling, machining and finishing operations. Non-destructive tests ensure that the repaired crossing meets the appropriate national and international standards.

Pointing out that 'there are no limitations on the use of restored crossings', Salciccia says the process offers considerable savings for infrastructure managers, as 'a refurbished crossing is much cheaper than a new one'.

Having been awarded a contract from RFI to refurbish 770 crossings over the next three years, the company is now looking to double the capacity of its production facilities for the domestic market. It is also evaluating the opportunity to open a second plant in Central Europe.

An instrumented hammer was used to measure the point frequency response function at the spindle of the robotic milling tool.

References

Bracciali A and Salciccia M. Restoration of manganese steel switch crossings by electric arc welding in a robotized plant. Paper to be presented at the 2nd international conference on Railway Technology, Research, Development & Maintenance, Ajaccio, April 8-11 2014.

Overall view of the Saga robotic crossing restoration plant at Scurcola Marsicana.