Photo: Plasser & Theurer

How yellow machines can become GREENER

Reducing the emissions of the track machines used to maintain and build railway infrastructure is a challenge which can be met by the deployment of alternative drive technology, as **Markus Buchner**, **Matthias Landgraf** and **Simon Misar*** explain.

REDUCING emissions is one of the main challenges facing society today, with the focus on CO_2 as the main driver of climate change. Under the Green Deal, the European Union (EU) aims to reduce greenhouse gas emissions to become climate-neutral by 2050, while the Fit for 55 package requires emissions to be lowered by at least 55% by 2030, when compared with 1990. Infrastructure managers are therefore under pressure to reduce their carbon footprint, but around 75% of their greenhouse gas emissions are Scope 3, not caused by the company itself but by the products it consumes being made of steel, aluminium, concrete or plastic, as well as the services it procures such as construction and maintenance.

Environmental impact also encompasses noise as well as the emission of particulates and nitrogen oxides (NO_X). The EU's National Emission Ceilings Directive requires all member states to gradually reduce their annual NO_X emissions, which is leading to stricter emission limits for diesel engines and construction processes. Measures to reduce NO_X emissions in the rail sector include further electrification or alternative drive systems using batteries or hydrogen.

In the Benelux countries in particular, and especially in the Netherlands, high NO_X and ammonia emissions are having a significant impact on the environment and are jeopardising compliance with EU environmental protection requirements. There have also been far-reaching economic consequences, as many infrastructure projects have been cancelled or delayed in order to reduce NO_X emissions.

A fundamental aspect of this problem is that during any combustion process, the formation of NO_X is inevitable regardless of the type of fuel, be it diesel, hydrotreated vegetable oil (HVO) or hydrogen. NO_X emissions result from the reaction of the nitrogen contained in air with oxygen at high temperatures in the engine. Even alternative fuels cannot completely prevent NO_X from forming, but only reduce the amount produced.

Stricter emission standards for diesel engines have been gradually introduced in the EU, with track machines classified as auxiliary railway vehicles in EU Regulation 2016/1628 that is currently in force. But as even the most modern combustion technology cannot completely eliminate emissions, manufacturers and operators of track machines are increasingly focusing on alternative, low-emission solutions such as battery-electric or hybrid-powered vehicles. Apart from a few exceptions, track construction and maintenance equipment in Europe still relies on diesel for power, although nearly 60% of the European rail network has already been electrified. As a result, the potential is already there for track machines to be electrically powered, provided that safety regulations allow the overhead contact wire to remain energised while track maintenance work is carried out on the line below.

In 2014 Plasser & Theurer took the first step towards implementing hybrid drive technology by choosing to electrify its core product, the tamping machine for the European mainline market. Studies have shown that it is precisely this machine that offers the most promising potential for reducing CO_2 emissions within the track construction and maintenance fleet.

Plasser & Theurer has developed the E^3 variant, equipped with a pantograph, transformer, converter and electric motor, with energy to power tamping equipment distributed by means of tried-and-tested hydraulic systems. Retaining the diesel engine enables operation in diesel-hydraulic mode where an overhead supply is not available. The E^3 electro-hydraulic system can be seen as an enhancement of existing conventional drive technology, producing comparatively little change in the way the vehicle is operated and maintained. Operational experience with the E^3 drive system has been gained in Austria, Germany, Switzerland, and Italy.

The next technological milestone was achieved in 2017 by using electricity to power all equipment with the complete electrification of a Unimat 09-4x4/4S E³ tamping machine, using electric motors to power all equipment rather than a hydraulic system. With an electro-hydraulic drive system, there are limits to the efficiency of the system as a whole, which is improved by powering all rotational movements electrically. As these all-electric E3 machines are still equipped with a diesel engine to provide power, they can also work in diesel-electric mode independently of the overhead supply.

The increase in efficiency can be seen by comparing two tamping machines with identical functions working in diesel-powered mode, one using an electric drive and the second the traditional hydraulic system. The electric tamping machine consumes 28% less energy during tamping operations.

By improving efficiency, track construction and maintenance machines will be better equipped for the final stages of decarbonisation. In the diesel-free future, alternative technologies such as batteries or hydrogen systems will have to be used, but these are more expensive, require more space, and are heavier than existing diesel technology. Longer and heavier vehicles will limit potential deployment of track construction and maintenance machines, and a more efficient drive such as the E³ system can reduce space requirements by up to 30%. This has a direct benefit in terms of investment and lifecycle costs, lowering them significantly, and without these efficiency increases it will be difficult to continue to develop green technologies.

Based on measurements taken in the field in the Netherlands, Figure 1 (right) shows the potential for reducing both NO_X and CO_2 emissions by comparing a diesel-powered machine with an E³ tamper drawing power from the overhead electric supply. The calculation is based on average consumption values, using the limit values of EU Stage V emissions regulations which assume 1.6g of NO_X produced per litre of diesel fuel consumed. A value of 2.67kg CO_2/l is used for direct emissions and 0.64kg CO_2/l for indirect emissions. For electrical energy, 0.26kg CO_2/kWh is assumed for indirect emissions. Should it be possible in future to rely exclusively on the overhead supply during work, or should suitable battery technology be available, emissions at point of use could be reduced by 100%.

Using the overhead power supply to operate track construction and maintenance machines presents a number of challenges. Developing new rules and regulations to ensure safe operation beneath catenary is probably the greatest challenge, ensuring that both the infrastructure and the machine itself are protected.

One particular aspect that makes the deployment of track construction and maintenance machines different from regular rail operations is the low speed at which the machines work, moving only a few km/h. Existing operating guidelines should be precisely adapted to take this into account, and the success of any project seeking to combine track machines and overhead electrification technology thus depends to a large extent on close cooperation between infrastructure manager and equipment manufacturer.

Diverse range

The diversity of requirements that infrastructure managers have to comply with as well as compatibility with existing fleets is currently reflected by an equally diverse range of alternative drive technologies. One example is partial electrification, as seen in the Unimat 4x4e universal tamping machine, which combines electrically-powered tamping units with a modern internal combustion engine. Staff experienced with earlier designs are able to operate and maintain the new machine, while the advantages of electric drive technology quickly become apparent: less noise pollution, lower fuel and hydraulic oil consumption, and less wear.

The use of auxiliary battery systems also offers potential that should not be underestimated, as track machines usually need an internal combustion engine to provide power for air-conditioning and other auxiliary systems. Installing a smaller genset ensures that the larger main engine does not have to be used for these duties.

Another example of a greener option is the Plasser & Theurer CompactFlex tamper for Busan Metro in Korea, on display at the IAF track technology exhibition in Münster, Germany, in May. This machine features a built-in battery system to power electric air-conditioning systems, which can also be recharged from an external power supply such as at the depot.

Decarbonising track machine fleets is a key lever for reducing CO_2 and NO_X emissions from infrastructure maintenance and construction. As exhaust emissions regulations for internal combustion engines become increasingly strict, electric and partially electric machines are the next technological step needed to consistently implement climate change reduction targets. As the example of the Netherlands shows, with hybrid machines and realistic operating scenarios it is already possible to reduce emissions by up to 85%.

Funding programmes to leverage the economies of scale could reduce time to market, enabling this green transformation to be implemented across Europe. Decarbonisation of the rail infrastructure construction and maintenance sector is a joint task, and manufacturers, operators and politicians must set the right course in order to successfully guide the transition to low-emission machines. IRJ

About the authors

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