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Tribological optimisations in press operations

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Tata Steel offers two lubrication solutions, both of which simplify the manufacture of exterior components made from hot-dip galvanized steel sheet – a second-generation pre-lube and a booster lubricant. The latter also helps improve adhesion properties – even on zinc-magnesium coatings.

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BACKGROUND

OEMs are still using electrogalvanized steel sheet (EG) and prephosphated EG (EG-p) for exterior components, such as bonnets, doors and vehicle roofs. They could use a more cost effective full-finish hot-dip galvanized steel (GI) for these components, further reducing material cost and improving corrosion protection. However, hot-dip galvanizing impairs process stability and surface quality through tool pollution.

The additional costs associated with cleaning the tool and an increased rejection rate – due to scratches or simple defects – have thus far reduced the cost benefits of GI. It therefore needs specific solutions, such as enhanced mill-applied lubrication to enable vehicle manufacturers to switch from EG-p to GI without any loss of quality and to take full advantage of the cost benefits.

In 2011 Tata Steel launched MagiZinc, a hot-dip galvanized steel strip for particularly demanding components. It offers significantly improved corrosion protection and substantially reduced tribological interaction between tool and steel [1]. However, customer difficulties with the adhesive compatibility of the zinc-aluminium-magnesium coating remain unsolved.

LUBRICANT FOR BETTER PRESSING CHARACTERISTICS

Exceptionally good surface finish quality on exterior components requires sheet products with a low roughness profile and high peak count. However, this also means the lubricant film pockets for holding the lubricant are smaller. Moreover, the surface is more susceptible to uneven oil distribution. A further issue is the increased risk of zinc adhesion and zinc abrasion, which can lead to scratches or indentations on the component and subsequent wastage.

Since 2009, Tata Steel has been working together with lubricant suppliers on second generation prelubes. These oils are applied at the mill, and not only protect the steel from corrosion but also aid the forming process in the press shop. The second generation prelube (PL2) achieves 20% higher drawing performance, reduced migration within the coil and uses the same or even as little as half the amount of prelube compared with the first generation [2]. The reduction in the quantity of lubricant also lowers the risk of uneven distribution of PL2 across the surface of the coil. PL2 ensures that less oil runs out of the coils or stacked plates, minimises lubricant run-off from the pressed parts and reduces the chemical waste for disposal following cleaning prior to painting. Zinc abrasion following application of pre-lube was investigated using strip drawing tests with drawbeads. **FIGURE 1** shows that, particularly in combination with wash oils for ensuring even oil distribution and spot lubes for especially difficult deep-draw parts, there was a significant reduction in zinc abrasion with GI+PL2. PL2 thus enables the manufacture of exterior parts using hot-dip galvanized steel, albeit not for all component shapes.

The positive results cannot be repeated on pressed parts with sharp contour lines in the tool. For such exterior components, the coefficient of friction cannot be too low. The sheet must be sufficiently firmly held in the drawbead to apply the necessary yield strain in the tool along the entire contour line without zinc build-up in this highly stressed part of the tool.

This requires additional drawing assistance that makes the run-in characteristics controllable by drawbeads, while retaining the greatest possible consistency in friction coefficient but separating the zinc layer from the tool to prevent zinc transfer to the component surface.

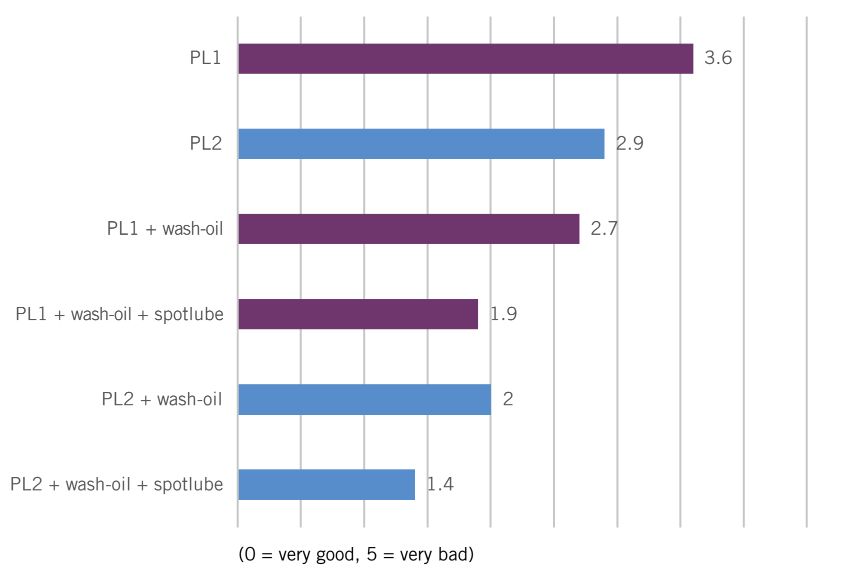

FIGURE 1 Effect of PL2 with wash oil and spotlube on zinc abrasion behavior (© Tata Steel)

SEPARATION AND LUBRICATION

Conventional additional press shop lubricants, which in combination with pre-lube could result in lower friction, are insufficient for solving the problem of zinc abrasion. This applies in particular when changing over from EG or EG-p to GI with tools configured for EG.

Working with Dutch chemical supplier Coil Coating Technologies, part of the AD International Group, Tata Steel developed a new booster lubricant: Prime Lubrication Treatment (PLT). The aqueous liquid consists of soft, lubricating nano-spheres and is applied as a 20 to 50nm reactive separation layer between the layer of zinc on the sheet and the pre-lube. The separation layer reduces the transfer of zinc to the tool and is designed to handle the interaction with the pre-lube corrosion protection oil [3].

The effectiveness of PLT was initially verified in a modified strip drawing test [1] based on a Renault test procedure. The contact of a cylinder to flat tooling simulates the high normal contact tension around the drawbead and sharp radii in order to assess the risk of zinc build-up or material damage to exterior components. **FIGURE 2** shows the results of this strip drawing test with GI and MagiZinc with PL1 and PLT+PL1 respectively. The GI strips with addition PLT treatment deposit considerably fewer zinc particles through adhesion to the tool compared with GI+PL1. Although the initial friction is somewhat higher, it then diminishes and is ultimately consistently lower. Correspondingly, the associated scratches or damage to the material are also significantly lower. With the aid of PLT, exterior components with sharp contour lines can thus also be produced using more cost-effective GI. The effect of PLT in achieving stable, low friction characteristics is considerably greater with GI than with MagiZinc, because Tata Steel developed this sheet steel with a surface finish already configured for significantly reduced tribological interaction between tool and sheet.

COMPATIBILITY WITH JOINING PROCESSES

In vehicle manufacturing, adhesives and spot welding are the most important methods for joining metal parts. Usually, good lubricant performance in combination with drawing aids or additional coatings in the press shop have a negative impact on adhesion properties. Some OEMs also report problems with the adhesion of zinc-aluminium-magnesium coatings. In contrast to additional coatings for conventional GI, which have a positive effect only in the press shop, subsequent production processes were also considered during the development of PLT in addition to the minimisation of zinc abrasion. These were spotwelding without electrode cap adhesion, good adhesion characteristics and zero residue removal during treatment prior to painting [3].

The adhesion characteristics of GI treated with PLT and MagiZinc were examined in a tensile shear test in accordance with VDEh-SEP-1220/6. Initial testing was conducted to determine the tensile shear strength and failure symptoms of different epoxy, rubber and filler adhesives. Susceptibility to corrosion was also determined through initial testing and through the VDA 621-415 cyclic climatic test. **FIGURE 3** shows the adhesion characteristics of GI and MagiZinc with and without PLT, with green representing a positive fracture pattern. The fracture patterns of GI with and without PLT are almost identical and indicate the positive adhesion characteristics of PLT. On MagiZinc, it is evident that the samples treated with PLT display significantly better adhesion characteristics.

One problem with conventional additional coatings containing sulphur is that, under high currents, the copper electrode sticks to the sheet with increasing adhesive strength after just 1 to 200 welds. This is caused by the rise in transfer resistance leading to higher temperatures at the electrode surface.

If the electrode cap sticks so hard to the sheet that it is pulled off, serious damage could be caused by the coolant water. Tata Steel therefore tested the susceptibility of PLT to electrode cap adhesion. The weldability of relatively thin and soft sheet (BH180, DX57 in 0.7mm) was tested using a current just below the spatter limit in the weld area. The results show excellent welding characteristics with PLT from 3.2 kA. There was no electrode cap adhesion with PLT. Testing conducted in accordance with SEP1220-2 indicated electrode service life of more than 1,000 spot welds.

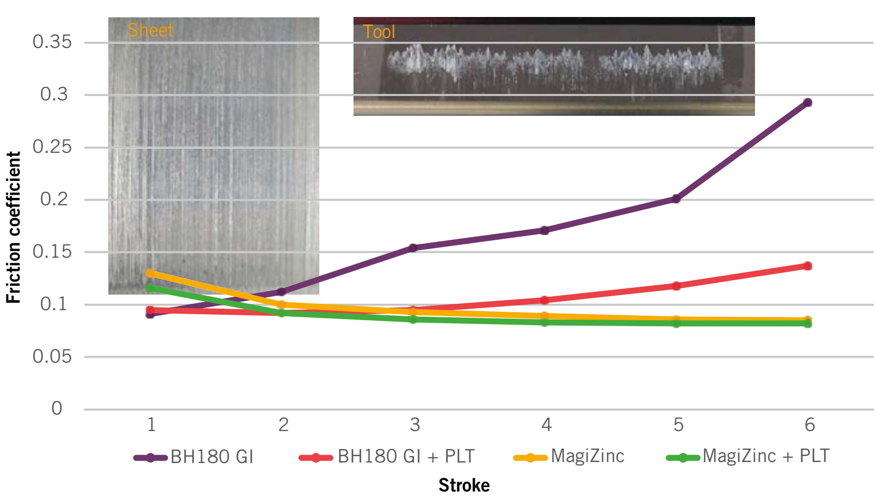

FIGURE 2 Strip drawing test with GI and Magizinc with PL1 and PLT+PL1 (right top: zinc transfer on the tool and next to it the consequences of this being scratches in the sheet) (© Tata Steel)

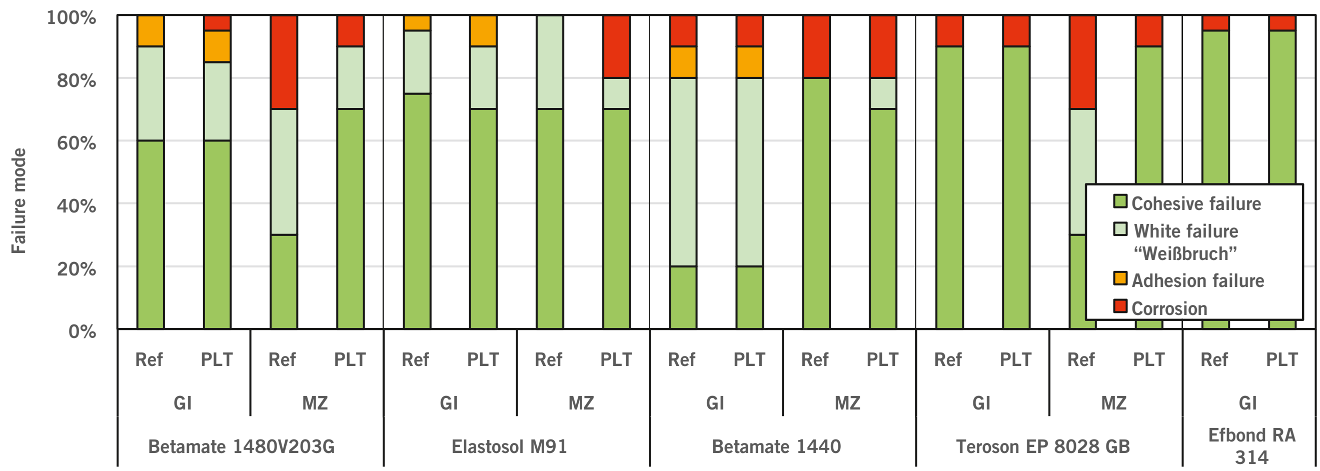

FIGURE 3 Adhesion behavior of PLT on GI and Magizinc on different adhesives, where green stands for a positive working range (© Tata Steel)

REAL MANUFACTURING ENVIRONMENT

For OEMs to consider using PLT in their factories, the booster lubricant must have at least the same or better workability in all manufacturing processes as the conventional drawing aids, booster lubricants and post treatments currently in use. To qualify PLT, Audi formed, cut and edged a 500mm wide mini-coil on its so-called endurance tool using a variety of different drawbeads. The zinc abrasion results and the volume of sliffers were deemed positive.

Audi then pressed the first 500 fenders in GI+PLT and found no differences at all between them and the regular production material, neither in the press shop nor after painting. The second test component selected was a motor hood in order to incorporate adhesion characteristics and spot welding. Here, too, 500 pressings were successfully carried out.

In parallel, Skoda also successfully pressed fenders and hoods in its press shop. In real-life manufacturing, and in contrast to laboratory experiment predictions, blank washing had no negative influence on the PLT layer. Skoda and the technical university in Liberec had tested the tribology of GI+PLT with and without blank washing. They examined the coefficient of friction and static friction after strip drawing tests with increasing normal contact tension of 8 MPa to 83 MPa. The lab test showed lower friction with GI+PLT without washing compared with GI without PLT, and only a slightly negative influence on the PLT coating by the washing process. However, the latter was not evident in the actual press shop [4].

OUTLOOK

Depending on component geometry, OEMs can manufacture their exterior parts using more cost-effective hot-dip galvanized steel with the PL2 or PLT lubricant solutions or a combination of both. Tata Steel was able to demonstrate a reduction in zinc abrasion and improved pressing properties – with no negative influences on subsequent manufacturing steps. The PLT separating layer even solves problems with adhesion characteristics on zinc-magnesium coatings. At the same time, the quantity of mineral-oil based lubricant required also reduces with PL2 and PLT, making production processes more sustainable and cost efficient.

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PLT for a smooth transition to hot-dip galvanised steels

Our Prime Lubrication Treatment (PLT) makes it easy to switch from electro-galvanised steel to cost-effective, hot-dip galvanised steel. Applied in our galvanising line and working with a conventional oil layer, we developed this thin booster lubricant for smooth processing of high quality exposed automotive panels.

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Learn more on the tribological optimisation in the press shop on page 36.

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