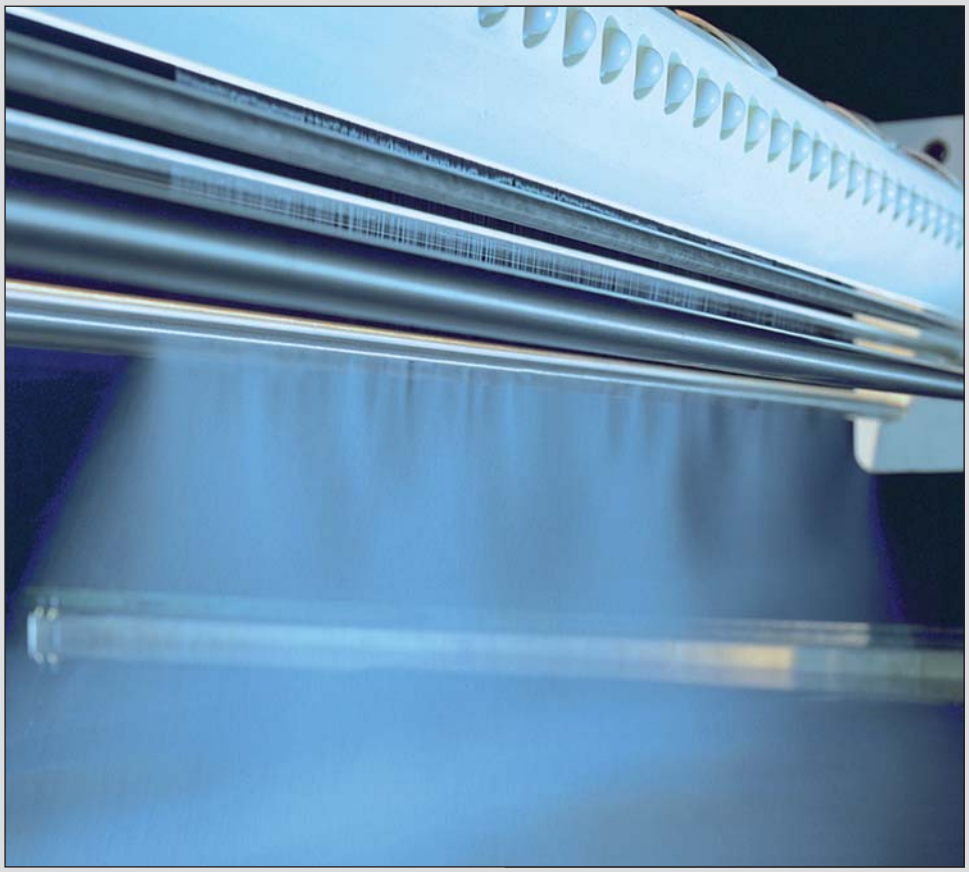
Publication 127 – E

# Lubrication of sheet strip and panels



Stahl-Informations-Zentrum

## Stahl-Informations-Zentrum

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**Publisher:**
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P.O. Box 10 48 42
D-40039 Düsseldorf, Germany

**Author:**
Dipl.-Ing. Norbert Petsch
38304 Wolfenbüttel, Germany

**Editor:**
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**Cover picture:**
Electrostatic lubrication of sheet by atomised spray



## Contents

# 1 Introduction

Cold-rolled and hot-dip or electrolytically galvanized sheet is usually lubricated with corrosion protection oils to protect it from corrosion during storage and transport and from mechanical damage (e.g. scratches, frictional oxidation). A further development in corrosion protection oils, so-called prelubes, are of assistance in the manufacture of automotive bodies, for example during the forming process in press shops. In some cases additional lubrication is required for complex deep drawing components. This is to a large extent not necessary if dry lubricants, so-called hotmelts, are used. Skin parts and also visible inner parts are often cleaned with washing oils during the cutting of blanks process in press shops. The washing oil can serve as a forming aid as well. The various process stages up to painting of the car body, which require the oils to have multi-functional properties, are shown in **Fig. 1.**

Lubricants that protect the surface from the sheet production to painting of the body in white, must be compatible throughout the processing chain. Oils developed by lubricant manufacturers combine the requirements of good corrosion protection, supplements to forming in the press shop, compatibility with adhesives and cathodic immersion priming as well as removability. They must be approved in accordance with the directives in VDA Test Specifications 230-201 (Prelubes) [1], 230-202 (Hotmelts) [2] and/or other customer specifications. This publication deals with the requirements to the various types of oil, as well as their properties and possibilities of application.

# 2 Requirements to the oils in the processing stages

## 2.1 Sheet production

The oils must be suitable for
- Different surface textures.
- Giving a homogenous coating of the top and bottom surfaces over the length and width of the strip.
- Providing excellent corrosion protection of the various types of sheet.
- Processing in application aggregates such as electrostatic lubricating machines or roll coating equipment.

Furthermore, the oils must have a low tendency to run off.

## 2.2 Press shop

The oils must
- Be compatible with other oils.
- Have a uniform oil film.
- Ensure stackability.
- Improve formability and thus process reliability.
- Guarantee cleanness of the surfaces.

## 2.3 Body shop and paint shop

The oils must guarantee
- Transportability, storability and corrosion protection.
- Weldability.
- Compatibility for adhesive bonding.
- Removability.
- Phosphatability after cleaning.
- Paintability after cleaning.

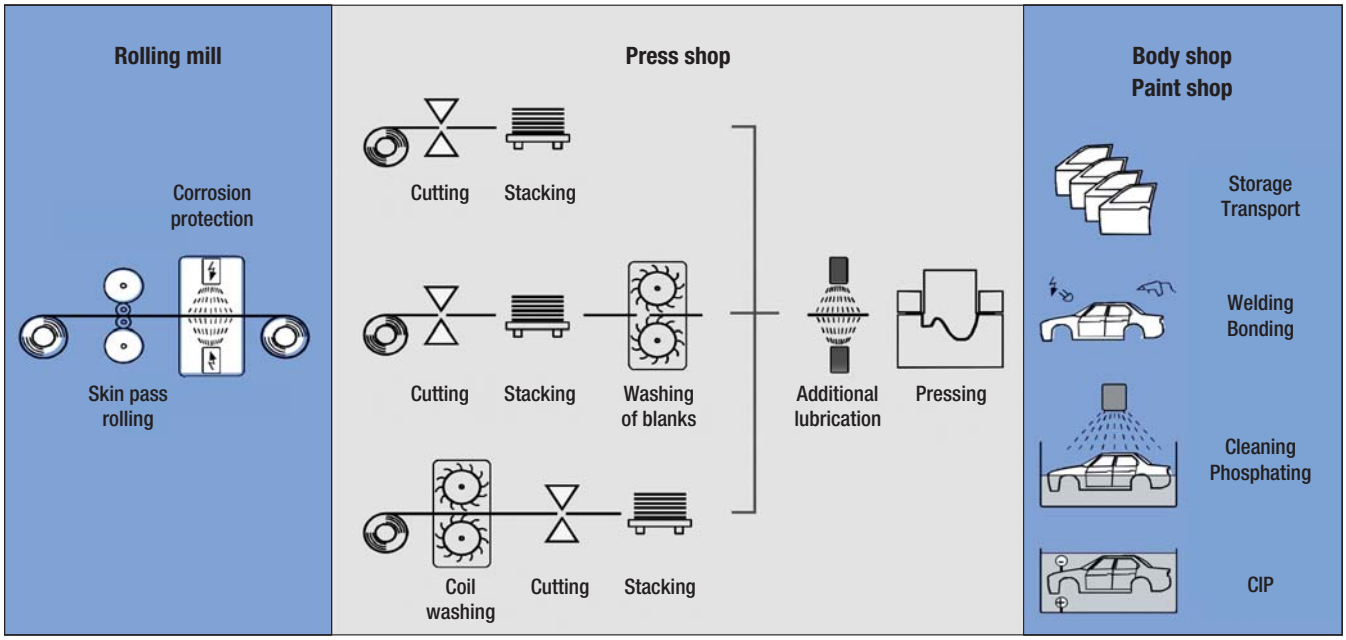


Fig. 1: Manufacturing process [3]

## 3 Lubrication of strip and panels

Due to their increased thixotropic properties, modern corrosion protection oils extend storage times. Thixotropy is the ability of materials to become more liquid under forming pressure, e.g. during pressing. Highly developed corrosion protection oils (prelubes) with extra additives and thixotropy agents improve run-off resistance, thus extending achievable storage times and optimising frictional properties during forming.

A further improvement in these effects is achieved by hotmelt products on account of their dry-to-touch surface condition. Development of the types of oil is shown in **Fig. 2.**

Corrosion protection oils with low amounts of thixotropy agents can be applied with roller systems or airless spray systems, **Fig. 3.** On account of the higher thixotropic properties of prelubes and hotmelts with paraffin particles, economical coating, e.g. at sheet producers, is only possible by means of electrostatic lubricating systems, **Fig. 3.** In these aggregates, the oils and parts of the aggregate coming into contact with the oil are heated and the electrostatically charged oil drops are applied to the surface of the sheet. Initially, the fine oil drops lie side by side on the surface. The homogenous, integrated film of oil is formed after coiling or stacking due to the surface pressure.

Sheet producers use direct or indirect measuring processes to determine the oil film from the quality assurance aspect, **Fig. 4.**

**Fig. 5** shows the coating of the oil film determined by direct measurement. In the case of the UV fluorescence process, the not inconsiderable costs for incorporating the UV markers into the oil matrix have to be taken into account.

Measuring the quantity of flow and visual control or irradiation of the oil shower using a coloured laser, **Fig. 6,** allow a relatively firm assumption about the oil distribution over the surface of the sheet to be made. Additional offline measurement ensures the oil distribution over the surface of the sheet.

Sheet processors require uniform lubrication over the length and width of the sheet. In spite of thixotropic oils, this demand is not easy to fulfil, especially when supplying coils. For technical reasons during rolling, cold rolled strip always has a cambered profile, resulting in greater surface pressure occurring in the middle of the strip, which squeezes the oil to the edges. Longer storage times and higher temperatures increase this effect. Since the oil is squeezed towards the outside, this effect has no influence on corrosion protection during transport and storage, **Fig. 7.**

Lubricating sheet surfaces with hotmelt products (drylubes) results in a significant improvement in respect of a uniform film. In the case of these products, which are dry to touch, the uniformity of the oil film is retained even after longer periods of storage. No oil comes out of the windings of the coils or the stacks of panels.

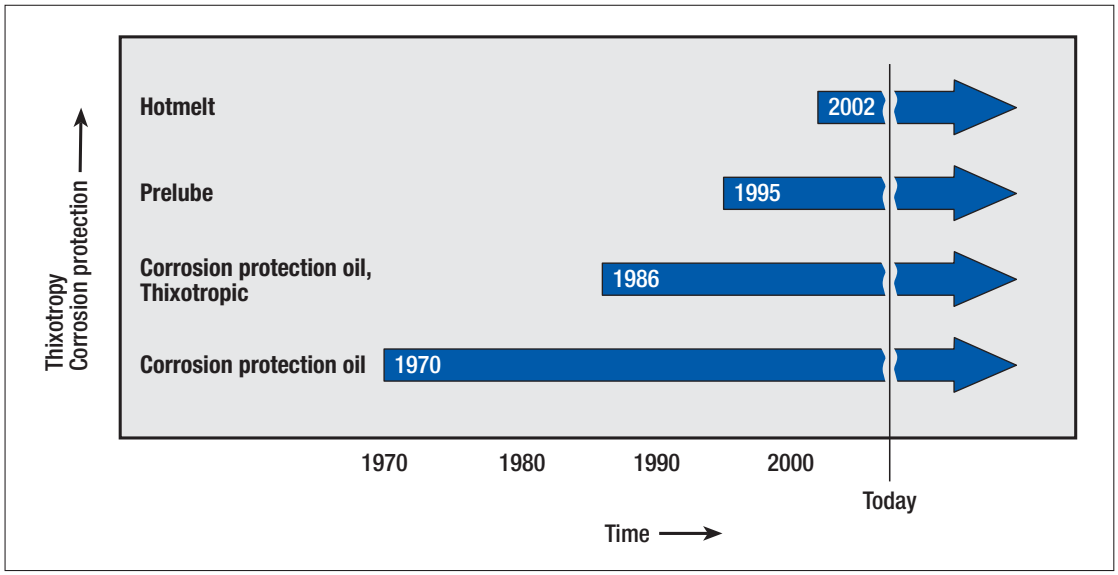


Fig. 2:
Development of the types of oil, on the basis of [4]


Fig 3: Lubricating aggregates: Roll lubrication (top left) [5], Spray lubrication (bottom left) [5], Electrostatic lubrication with an inline hotmelt device (top right) and electrostatic lubrication by means of atomised spray (bottom right)

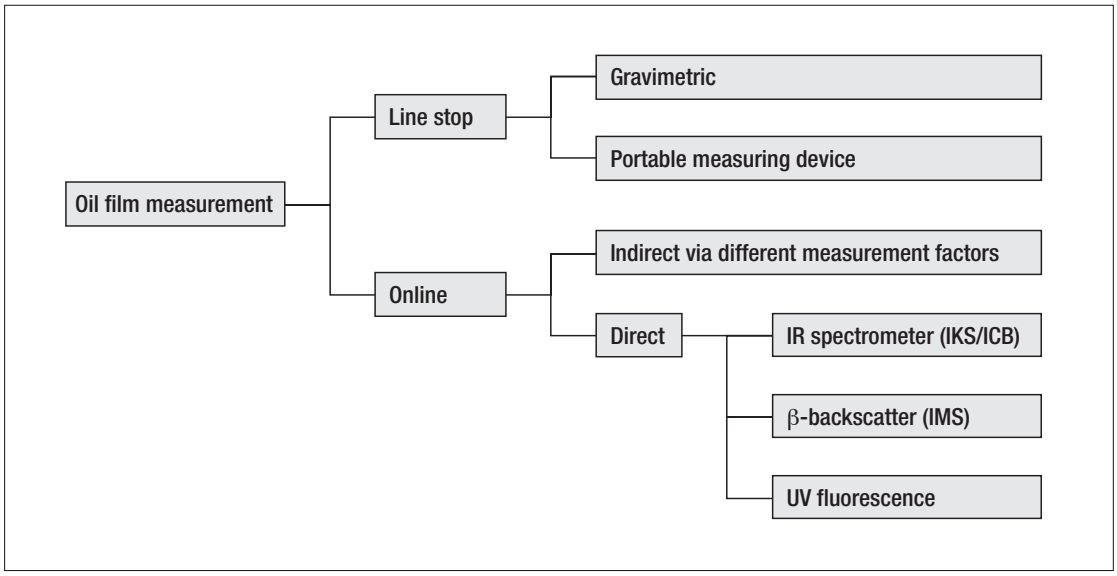


Fig 4: Processes for determining the oil film [6]

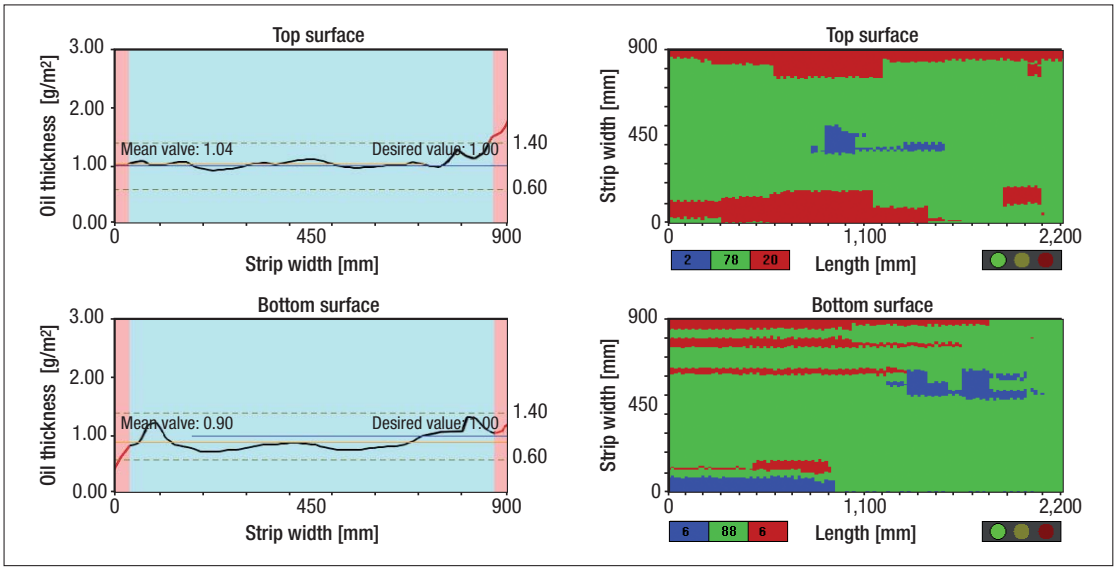


Fig. 5:
Measuring of oil films by means of the Amepa system

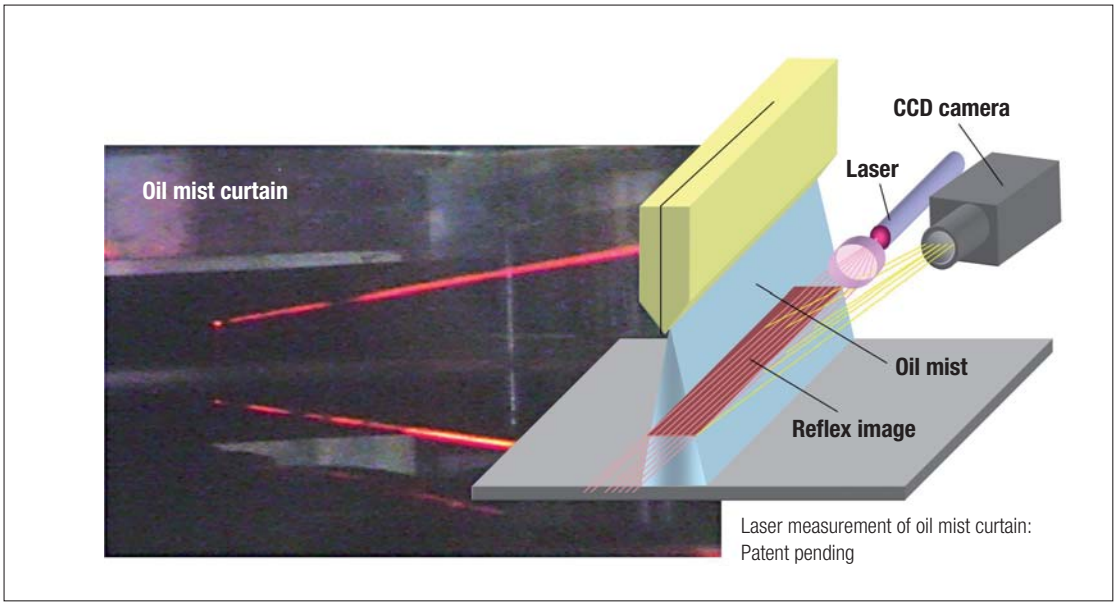


Fig. 6:
Laser detection of the oil mist curtain [6]

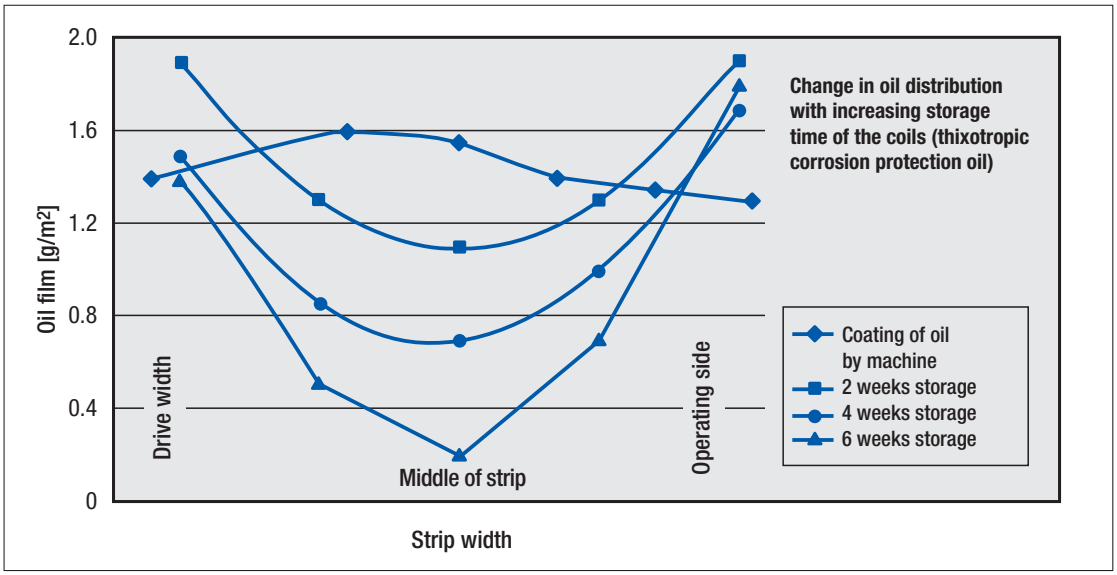


Fig. 7:
Distribution of oil follows strip camber – effects of lubrication over storage times;
On the basis of [7]

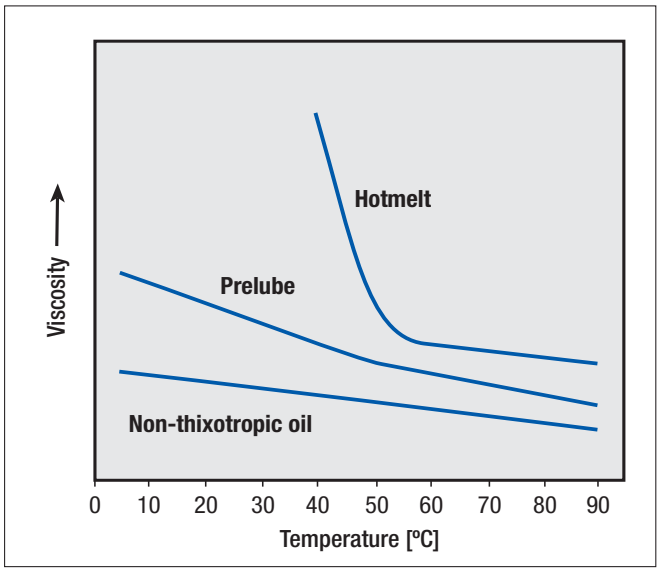


Fig. 8: Viscosity of the oils [8]

## 3.1 Oil films and oil distribution in coils

The oil gauge depends on the intended use of the sheet material. Sheets for skin parts are mostly slightly oiled sufficient for corrosion protection during transport and storage, since some processors clean these coils or the cut blanks with washing oils. The mixture of prelubes and washing oils is sufficient for forming simple parts.

In the case of sheet for complex drawing and deep drawing parts (mostly inner parts), the drawing behaviour of the oil is important, along with the corrosion protection. Therefore thicker films of oil, thixotropic prelubes or hotmelts are used. In principle, there is a trend towards thinner coatings because "a lot of oil does not always help a lot".

A uniform film of oil over the length and width of the strip can be achieved with modern electrostatic oiling machines. Numerous physical factors affect the oil film when the strip is coiled with sufficient strip tension to achieve stable, tightly wound turns of the coils with straight edges. The greater the thickness of the oil film, the greater are these factors. Even after short periods of storage, oil can run out of the face side of the strip. In worst case, the coil can ovalise, depending on the type of transport and the duration of storage.

The differing viscosity of the oils speeds up or slows down the variable oil distribution. Only in the case of hotmelts, which form a dry-to-touch surface at room temperature, **Fig. 8,** were no differences in the thickness of the film found over lengthier periods of storage.

The different distribution of the oil due to coiling and storage can lead to the forming of spots on the sheet surface, as can be seen in **Fig. 9.** Such non-uniform films can cause material deposits on tools during forming.

In the case of slit strip and wide strip slit in the middle, the cambered profile can lead to non-uniform oil distribution over the strip width and thus to processing problems. Post-lubrication by the processor or homogenisation (e.g. by washing) might be necessary.

## 3.2 Types of oil used by sheet producers

Corrosion protection oils
- Non-thixotropic
- Thixotropic

Prelubes
- Non-thixotropic
- Thixotropic

Hotmelts (Drylubes)
- Highly thixotropic

All oils must be tested and approved in accordance with VDA directives or other customer specifications.


Fig. 9: Formation of oil islands and prevention [9]

# 4 Properties of the types of oil

## 4.1 Corrosion protection oils

These oils have good temporary corrosion protection for storage and transport of coils and panels, but in spite of this, the consumer should process the material within as soon as possible. The oils are manufactured on a mineral oil basis.

The very low lubrication effect when pressing is a disadvantage, that means additional lubricants or lubricating after washing the blanks are necessary for pressing. Modern thixotropic corrosion protection oils have good lubrication properties and are in many cases sufficient for forming.

Oil displacement over the length and width of the strip occurs during storage and transport, Fig. 7. In the case of panels and blanks, "oil spots" can form after longer storage times, Fig. 9.

Corrosion protection oil films are usually between 0.5 and 1.5 g/m$^2$ per surface. It is possible to remove them in low-alkali baths. Total costs for normal corrosion protection oils are relatively low in comparison to other lubricant products.

## 4.2 Prelubes

Prelubes (drawing oils which are run- off inhibited) are corrosion protection oils with improved drawing properties on a mineral oil basis with corrosion protection and forming additives.

Due to their higher viscosity, oil displacement and tendency to run off is lower in comparison to pure corrosion protection oils. The tendency to form oil spots on the panels is lower.

Prelube films are usually between 0.5 and 1.5 g/m$^2$ each side. It is possible to remove them in low alkali cleaners.

Total costs for lubricating with prelubes are higher in comparison to pure corrosion protection oils.

## 4.3 Hotmelts

The term hotmelts, also known as drylubes or dry lubricants, means that these products can be applied electrostatically to the strip surface in their melted state and are based on a mixture of mineral oil, high melting point hydrocarbons and corrosion protection and forming additives. Hotmelts are water-free.

The tribology, i.e. the frictional behaviour between tool and pressed part, lubrication and corrosion protection is excellent.

Hotmelt films are usually between 1.0 and 1.5 g/m$^2$ each side. Blanks can be stacked, stored and finally pressed without supplementary treatment. Pressed parts coated with hotmelts have a homogenous, virtually dry film after forming. Tools, storage areas and workplaces therefore remain free from oil and clean.

Hotmelts are used in the case of the highest demands on lubrication ability, e.g. in the case of forming of highstrength steels, sometimes additional lubrication in the press shop is no longer necessary. Various alterations to existing electrostatic lubricating machines are required to achieve the necessary processing temperatures for the application of hotmelt products.

It is possible to remove them in low-alkali cleaners if the temperature of the cleaning bath is higher than the melting range of the hotmelt. When using these products, care has to be taken that waste-water treatment is trouble-free, and this should be checked in advance.

The whole cleaning process is significantly more difficult and complex than in the case of pure corrosion protection oils or prelubes.

Total costs are higher in comparison to other lubrication products due to the application costs and the price of the oil, but these can be compensated by the advantages to the consumer in processing and handling, as well as transport/storage.

## 4.4 Washing oils

Washing oils are low viscosity oils on the basis of corrosion protection oils or prelubes. Cleaning of visible surfaces by means of washing oils is often done in the press shop before cutting the blanks or prior to the drawing press.

The washing process

- Improves the cleanness of the sheet.
- Removes metallic particals occurring during cutting of the blanks.
- Removes oil spots arising in the lubricant film during longer storage of coils and blanks.

There are advantages in the press shop, such as a decrease in surface defects through dents, scratches and zinc abrasion. Furthermore, a uniform film of oil is achieved before pressing, which reduces the build-up effect on tools.

When washing surfaces lubricated with hotmelts, careful monitoring of the washing oil is necessary, as these low-viscosity oils absorb high melting point hydrocarbons and can thus tend to gel and become increasingly thixotropic. This can even lead to blockages in the fleece squeezing rolls of the washing equipment.

# 5 Cleaning of surfaces

Decisive for the effectiveness of the removability of lubricants are

- The chemical composition and concentration of the cleaning agent.
- The mechanical aids by spraying, immersion, brushing and ultrasonic during the cleaning process.
- The duration of cleaning.
- The temperature of the cleaning solution.

After the cleaning process, it is important that the surface is freed from cleaning products and other dirt in a suitable rinsing bath. Testing the removability of oils is described in VDA Specifications 230-201 [1] and VDA 230-202 [2] and/or other customer specifications.

## 6 Conclusions

Oils applied by the sheet producers fulfil three tasks. They ensure corrosion protection of the coils, panels, blanks and pressed parts during storage and transport, prevent mechanical damage to surfaces and improve the frictional properties during forming. More detailed considerations on packing, storage and transport of (coated) sheet are contained in the Stahl-Informations-Zentrum Publications 112 and 474.

The more thixotropic the oils are, the lower is their tendency to run off and thus to oil displacement in coils, packages and pressed parts. Lubrication behaviour and run off behaviour are improved when thixotropic additives are increased. The development of oils therefore led from thin corrosion protection oils, which could still be applied with felt rolls, via thixotropic corrosion protection oils and prelubes through to hotmelts (drylubes) applied with electrostatic lubricating machines. Hotmelts are characterised by dry-to-touch films and very good deep-drawing properties.

The advantages of these run-off-resistant and dry-to-touch films with significantly improved corrosion protection also based on the risk-free transport over long distances of the pressed or pre-assembled parts. Furthermore, using prelubes and hotmelts can significantly reduce additional lubricants in the press shop.

An essential precondition for the use of anti-corrosion and lubricant products by the sheet manufacturer and in the press shop is compatibility within the whole process. Lubricant manufacturers provide for this in close co-operation with their customers, who have to comply with to the specification elaborated by the automotive companies in VDA 230-201 [1] and VDA 230-202 [2] or other customer specifications.

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P.O. Box 10 48 42
40039 Düsseldorf, Germany
E-mail: siz@stahl-info.de
Internet: www.stahl-info.de