

## Self-lubricating, maintenance-free sliding materials

The use of self-lubricating sliding materials is gaining steadily in importance in all areas of production in the steel industry. Particularly against the background of constantly increasing competitive pressures, plant and equipment makers and operators are today calling for solutions that offer technical and also economic benefits in equal measure. Sliding bearings and guides that can do without lubrication, or critical applications which cause problems even when additional lubrication is available, consequently represent an enormous potential for optimisation and savings.



**Figure 1.** Thick-walled sliding bearings, Deva-Metal type

Far-reaching changes that have taken place in the steel industry in past years caused an increased interest in maintenance-free sliding materials. The heavy workforce cut-backs of recent years especially present problems when it comes to carrying out the (lubrication) activities that are required, for example, while the steadily rising expense of disposing of spent greases offers a further incentive for doing without lubrication where possible. There are, for these reasons, continuous efforts in the steel industry to change over as many bearings and guides as possible to maintenance-free sliding materials.

Thyssen Krupp Stahl AG, Germany, for instance, which has taken on a pioneering role in this regard and has its

own tribological department to deal with the topic of "cost reduction through freedom from maintenance", also cites the more stringent requirements regarding plant and equipment availability, occupational safety and, not least of all, product quality as the reasons for the greater use of self-lubricating materials.

### Thick-walled sliding bearings with microscopically distributed solid lubricant

Various sliding materials are designed for different fields of use. The Deva-Metal product encompasses a group of composite materials based on three different families of alloys,

Hubert Hilp, Application Manager Steel,  
**Federal-Mogul Deva GmbH**, Stadtallendorf,  
Germany

namely, bronze, iron and nickel. They contain solid lubricant, which is uniformly distributed and embedded in the metal structure (**figure 1**).

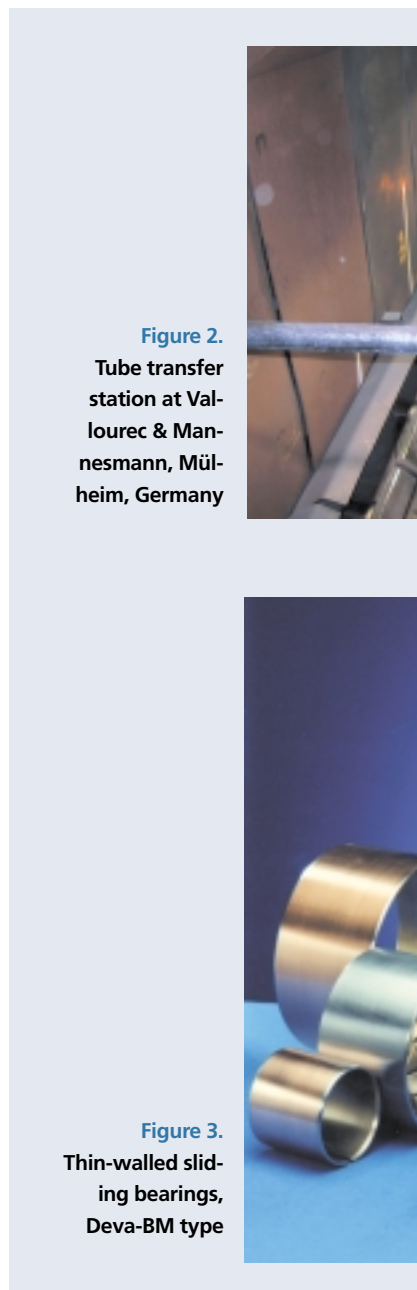
The composition of the metallic structure determines the physical, mechanical and chemical properties of an alloy and therefore serves as a basis when a material is to be selected for a special application. The main criterion is the temperature at the bearing location.

Bronze and lead bronze are very frequently used for temperatures up to 350°C, with the material having to undergo a special heat treatment for continuous service at temperatures from 150°C and above. Iron- and iron-nickel-base alloys are used for continuous service at temperatures over 350°C. Applications involving particular requirements with regard to temperature and corrosion conditions necessitate a nickel-base or corrosion-resistant steel sliding material.

The type of solid lubricant, its form and, above all, its content of the metallic structure in terms of percentage depend on the operating requirements, e.g. the sliding velocity and contact pressure. The solid lubricants therefore have a decisive role to play, in principle, in the sliding behaviour of an alloy. Graphite, molybdenum disulphide, tungsten disulphide and, increasingly, PTFE are especially used as solid lubricants in sliding bearing technology.

**Example: tube transfer device.** As shown in **figure 2** the equipment installed by SMS Demag in 1972 at Vallourec & Mannesmann in Mülheim serves to transfer tubes from the production line sideways onto a rake-type cooling bed. In order to avoid major deformations of the still hot tubes, the height of fall in-between is surmounted in two steps. First of all, the tubes fall into an angular repository, from where they are then lifted in a second step by pusher devices and roll onto the rake-type cooling bed.

The lever mechanism beneath the pusher devices that initiates the necessary motion sequences was fitted with pure graphite sliding bearings to start with. In 1983 the maintenance department changed the bearings over to metallic sliding bearings with embedded solid lubricant, which tripled the



**Figure 2.**  
Tube transfer station at Vallourec & Mannesmann, Mülheim, Germany



**Figure 3.**  
Thin-walled sliding bearings, Deva-BM type

service life of the most heavily stressed sliding bearings in the forward area of the cooling bed. The new bearings achieve a service life of approximately 2 years despite temperatures of about 200°C, a slewing motion through 45° and around 5700 movements per day. The bearings at the rear of the cooling bed have not as yet been replaced.

This example is one of several identical applications around the world. At the present time, projects and test runs are in progress in Canada and Italy, for instance, where despite permanent lubrication of the conventional bronze sliding bearings, plant and equipment operators are failing to achieve satisfactory service life spans. The sliding bearings are replaced in either case some 3 times per year.

Given the experience available, it can be assumed that the life span can be prolonged considerably and the maintenance costs greatly reduced as a result.

### Thin-walled sliding bearings with microscopically distributed sliding material

The Deva-BM bimetallic composite is produced in a special rolling and sintering process. It comprises a steel backing and a self-lubricating bronze sliding layer with a microscopically distributed solid lubricant (**figure 3**). Besides high stability under load, thin-walled sliding materials combine the tribological properties of thick-walled bronze with compact design.



**Figure 4.**  
Ladle tilting stand at the Hüttenwerke Krupp-Mannesmann works in Duisburg, Germany

Particularly worthy of mention here is the increasing use of PTFE as a solid lubricant, which utilises the acknowledged good sliding characteristics of this material and combines them with the wear resistance of a metallic matrix.

One aim is to avoid the undesirable stick-slip effect, often referred to in everyday language as chatter or back-slip. The stick-slip effect is a phenomenon that occurs with unfavourable mating surfaces, which, as a result of their movement in relation to one another, alternate between sliding and static friction.

**Example: ladle tilting stand.** The special ladle tilting stand structure at Hüttenwerke Krupp-Mannesmann (HKM) in Duisburg, Germany, is an illustration of good cooperation between the plant and equipment operator (facility planning department), plant and equipment maker (design) and sliding bearing manufacturer (figure 4).

Initially, the use of 30 mm thick bronze sliding plates with macroscopically distributed solid lubricant was planned for the structure. The customer's requirement for stick-slip-free movement, and maximum permissible wear of 1.5 mm, led to the use of thin-walled sliding plates with a self-lubricating sliding layer. In view of the general on-site conditions, the sliding layer was additionally provided with cleaning grooves to reduce the abrasive effect of scale deposits. The sliding plates were underlaid with steel plates for height equalisation purposes.

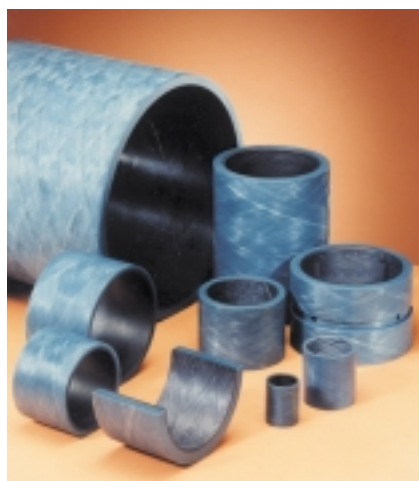
The benefit for the customer has been, first of all, the avoidance of the

stick-slip effect. In addition, the changeover has led to even better utilisation of the material because, given the permissible wear of 1.5 mm, the first design would have meant that 28.5 mm of the material thickness would not have been used.

The ladle tilting stand, which was put into service in 1996, was fitted with new sliding plates in the summer of 2002, corresponding to a service life of around 6 years.

### Composite sliding bearings made of glass-fibre plastics

Deva-Tex, a self-lubricating, glass-fibre-reinforced composite shown in figure 5, is manufactured using a special winding technology. The carrying layer makes the high strength levels possible, while the sliding layer contains special fibres and solid lubricant that provide the tribological properties.



**Figure 5.** Composite sliding bearings, Deva-Tex type

In comparison with metallic materials, glass-fibre-reinforced plastics are clearly limited when applied at temperatures above 150°C and in very abrasive environments. The plastics display their advantages, though, when it comes to applications involving high shock loads or heavy edge loading.

### Use in cranes and braking systems.

Hardened bushings or also metallic special-purpose materials have been replaced with plastics-based sliding bearings in diverse crane systems, for example. The reason for this has chiefly been that metallic bushings have not withstood the high shock loads and in some cases have been completely destroyed.

Slab brakes are special constructions with which slabs approaching on a roller table are decelerated by means of a lever protruding between the rollers. A plastic has already been used successfully for original equipment in expectation of a high contact pressure exerted by the lever combined with the shock loading of the bearings.

### Dry running tribological system

The principle according to which all the materials described here are also able to operate without the presence of conventional lubricants is basically the same. The movement taking place in the bearings generates continuous micro-abrasion, thereby releasing the solid lubricant, compressed and embedded in the sliding material, from the sliding layer. A durable lubricant film forms as a result on the mating material. Because of their chemical structure, the solid lubricants are able to separate the two mating surfaces permanently.

The wearing of this sliding film, e.g. due to high frequency of movement, scale, dust, etc., leads, through the increasing friction, to the release of lubricant and hence to the renewal of the lubricant film, resulting in maintenance-free self-lubrication.

In comparison with lubricated sliding bearings, the benefits of this functional principle become evident particularly when giving closer consideration to the critical operating conditions within a



| Operating conditions  | Effects on the sliding bearings   |
|-----------------------|---|
| High temperature      | Special lubricants necessary, lubricants can decompose, lubricants resinify in lengthy lines, increased consumption possible      |
| Edge loads            | Local increase in contact pressure, lubricant film may be interrupted, increased wear   |
| High contact pressure | Lubricant film is interrupted, lubricant film is pressed from the bearing, increased wear   |
| Dirt                  | Adsorption of dirt in the bearing, formation of an abrasive paste, constriction of diametral clearance, possible jamming of shaft |
| Angular movements     | No lubricant reaches the actual load zone   |
| Lengthy downperiods   | Lubricant is squeezed from the load zone  |

**Table 1.** Effects of difficult operating conditions on sliding bearings

steel plant. **Table 1** shows some of these conditions and indicates which have effects on the bearings.

## Outlook

A recapitulative look at the abundance of uses for self-lubricating



materials that have already established themselves in the steel industry over the long term, such as in flame-cutting machines, presses, sheet levellers, tube straighteners, ladle turrets, cooling beds, reel mandrels, heat-treating furnaces, finishing equipment, roll-changing systems, and guide systems, clearly illus-



trates the broad spectrum of applications.

The question as to when the use of appropriate materials is technically possible and economically practical has to be clarified individually, which is why particularly close cooperation between the user and manufacturer is necessary beforehand.


This offers the opportunity for adequate consideration to be given to all the operating conditions when selecting the material or mechanical construction and for finding the best solution both technically and economically.

An overall look at all the costs involved, from the procurement costs, to the costs of lubricant consumption, disposal, manpower assignment, repair and lost production, through to scrap costs, reveals what financial savings potentials there are and whether they justify the use of maintenance-free sliding bearings. Should the mentioned competitive pressures on the market intensify further, and that is to be expected, then this will call for innovative solutions. ■



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Federal-Mogul Deva GmbH
Schulestrasse 20
D-35260 Stadtfellendorf
Phone +49 (0)6428 701-0
Fax +49 (0)6428 701-108
<http://www.deva.de>