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Friction and wear-optimised sliding materials for materials-handling technology

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APPLICATION-ORIENTED DEVELOPMENT | With its global subsidiary companies, the Röchling Engineering Plastics Group leads the field internationally in developing, manufacturing as well as machining engineering plastics for materials-handling technology. In product development, the company essentially focuses on constant improvement of the tribological properties of these materials. For detailed examination of the friction and wear behaviour, a model test procedure has been applied developed by the Institute of Materials Handling, Conveying and Plastics Engineering (ifk) of Chemnitz University of Technology in close co-operation [1, 2]. Based on these results, it is possible to test the development products under practically relevant stress and to make a preselection for further tests in real conveying plants.

TECHNICAL PLASTICS ARE APPLIED in practically all production, storage and logistic processes in materials-handling technology. Favoured by a variety of positive properties, such as, by way of example, the inexpensive mass production of complex components through injection moulding or extrusion, low density, very good wear and sliding properties and high noise reduction capacity, the majority of all conveyor chains as well as the pertinent sliding rails are made of plastic today. A further important benefit is the operation of such conveyor systems without additional lubrication, which is of great significance particularly in sensitive areas, such as the food and packaging industries.

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Planning and optimising the intra-logistical processes of companies is increasingly aimed at reducing energy costs, acquisition costs as well as repair and maintenance costs. Accordingly, it is not adequate to provide "only" material combinations with as low as possible coefficient of friction for the tribological chain/sliding rail system in order to minimise the drive power required and the chain tensile forces. The materials must also have a high degree of wear resistance and be manufacturable at an acceptable price. Moreover, the conveying capacity attainable with the tribological combination that also takes the material mass and speed into consideration is essential for planning the plants.

To develop new sliding combinations operating without lubrication on the basis of technical plastics, the individual transport sections of a complete conveyor plant is to be precisely analysed with regard to the stress incurred. This is necessary, because the tribological properties of the systems with plastic participation very greatly depend on stress conditions. Only if all influencing factors as well as the parameters of the conveying process proper are taken into due consideration in development will energy-efficient and sustainable solutions be attainable.

Development and testing methods

When new products are being developed, they should be analysed with regard to all their relevant properties, whereby in this paper only the tribological tests on the example of sliding elements from the LubX® product family from Röchling Engineering Plastics for chain conveyors are to be taken into account. Here, the principal procedure is

- development of the material mixture and the procedural parameters;
- evaluation of wear and friction on the model test stand;
- evaluation of the tribological properties on the demonstrator conveyor system;
- functional verification at the user's.

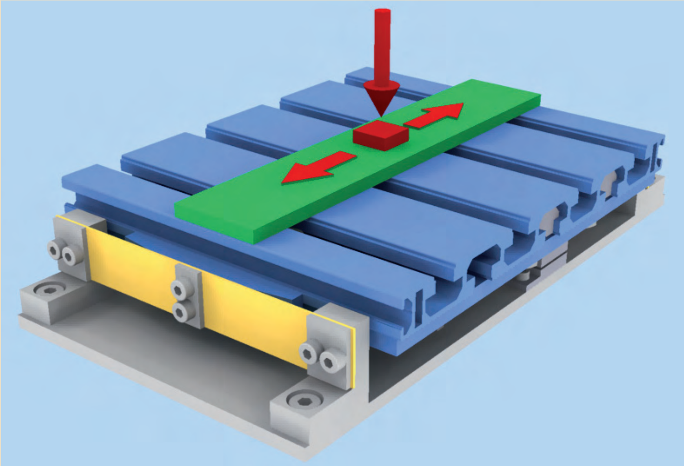
LubX® products are PE-based materials, whose tribological behaviour has been significantly improved over standard materials by special additives. Produced from these materials are RAM-extruded profiles or machined sliding rails for chain conveyors, on which moving plastic or steel chains are abraded. One of the major markets for such conveyors is the beverage industry, where glass or PET bottles have to be transported through the cleaning, bottling and packaging plants. It is from these applications that the sliding partners required – in this case the sliding rail, chain and bottle materials – as well as the loads incurred can be deduced.

The tribological model test procedure works on the test principle sheet-sheet with linearly oscillating motion of a test specimen [1, 2]. The top specimen is 10 x 10 and 15 x 15 mm in size, is pressed onto the bottom specimen with a defined force and is moved with a stroke of up to 600 mm, whereby speeds of up to 2 m/s may be reached. The bottom specimen, an extruded, injection-moulded or machined profile piece, is clamped onto a measuring table, which measures the friction force generated by the movement (fig. 1). Due to the fact that the coefficients of friction with plastic participation are mostly subjected to running-in behaviour or elevated deviations, they must necessarily be measured over a protracted period of time, which as standard is 24 hours.

The wear behaviour of the top and bottom specimen is evaluated according to a special assessment procedure. A so-called tribo-characteristic KT can be calculated from the coefficient of friction measured as well as the wear characteristics at the end of the testing period, enabling a direct comparison and evaluation of material combinations to be made with regard to the tribological effects that invariably have to be considered together [1]. In detailed or comparative graphic and tabular interpretations, the relevant results can thus be analysed both individually with regard to wear and / or friction as well as total-tribologically.

Subsequent to preselection of suitable development products, there is a further test run in a real conveyor system, where the functional test of the new materials is conducted under practice-oriented conditions. To this end, there are several plants available in the test field of Röchling Engineering Plastics KG, including a modular designed bottle conveyor (fig. 2), which can be equipped with different conveyor chains made of steel or plastic as well as sliding rails made of the newly developed materials. Empty or filled beverage bottles made of plastic or glass are used as goods to be conveyed depending on actual requirements.

Fig. 1 Functional principle of the oscillating friction coefficient measurement



The conveyor plant is currently equipped with sensors to measure the drive torques, the backing force of the bottles as well as the temperatures in the friction surfaces. This enables material improvements to be verified quantitatively. However, the essential points of the practical tests are also the analysis of the noise generation caused by friction (e.g. stick-slip movements), which mostly cannot be recorded definitively in the model tests, as well as temperature measurements on load-critical contact surfaces that provide valuable evidence to determine the system's maximum loads.

From the results of the above-mentioned tests, not only the tribological suitability of certain material combinations can be characterised, but also important properties calculated for dimensioning complex installations. Moreover, for plant builders and end users, the functional verification for optimised development products can, in particular, be provided through the practical test stands.

When launching the new products onto the market, it is important for Röchling Engineering Plastics KG to continue to attend to the thus equipped conveyors and, in cooperation with the end users, to obtain valuable references for further developments.

Development results

Testing the sliding rail material on the tribological model test stand occurred against the materials POM, stainless steel (transport chains) as well as PET (beverage bottles) in an unlubricated run.

Improvements in the coefficient of friction to the chain materials could already be obtained compared to the reference material PE-UHMW, which is predominantly applied in current plants, with the product LubX® S (fig. 3). However, LubX® S offers special benefits in conjunction with plastic bottles, so that the material is outstandingly suited for lateral guides and – particularly in accumulation mode – contributes to the drive power and chain stress being unequivocally reduced.

With LubX® C, another sliding rail material has been especially developed for application with steel and plastic chains. With coefficients of friction of 0.08 - 0.11, these tribological systems show excellent surface sliding characteristics (fig. 3), and are there-

Fig. 2 Bottle conveying plant in the test field in Haren

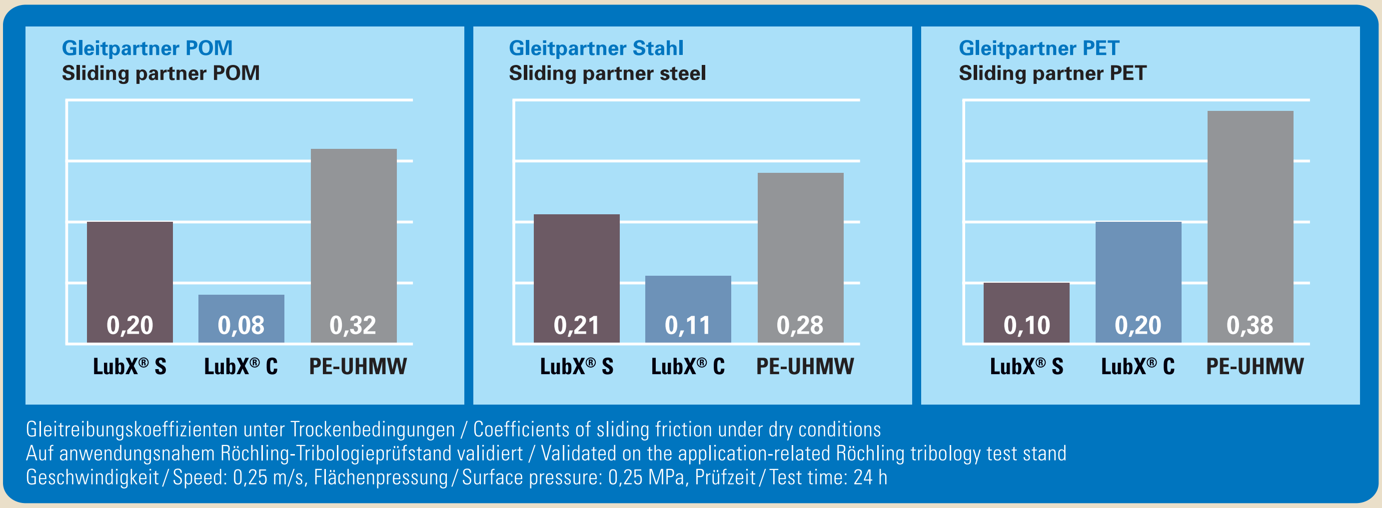


Fig. 3 Sliding properties of LubX® products

fore best suited for the operation of even complex conveyor systems not requiring lubrication.

What potential such developments display is shown in figure 4. Calculated here was progression of the chain tensile force as well as the required drive power of a conveyor plant operating without lubrication for 1.5 l PET bottles with plastic chains, equipped, by way of comparison, with sliding rails made of standard PE-UHMW (coefficient of friction $\mu = 0.32$) as well as LubX® C (coefficient of friction $\mu = 0.08$). In the layout example considered, the required drive power can be thus reduced by more than 80 %. Chain stress is appropriately reduced, so that the conveyor plants have a longer service life, are more heavily used or can be built for longer and more flexible applications.

Summary and prospects

Results presented show that the targeted development of tribological sliding combinations can offer enormous benefits for the functionality, service life and design of conveyor plants. The new products facilitate operation of the conveyors operating without lubrication that is increasingly demanded by users, as well as replacement of heavy steel chains by plastic chains in a host of application cases.

Taking the example of the LubX® product family, the system character of wear and friction also becomes clear due to diverging tendencies. The tribological properties always depend on the two sliding partners as well as the prevalent stress and ambient conditions – particularly when running without lubrication, and must therefore be preferably developed specific to the application. The tests thus showed that it is really meaningful to utilise different materials for sliding rails and lateral guides, if they are in contact with dissimilar counter bodies (chain or bottle).

Development of high-grade tribological systems is marked by practice and target-oriented testing methods and planning. In model tests, development products can be initially evaluated and optimised with the help of simple test specimens, however, under application-related conditions with regard to their essential tribological suitability as well as the effect of the individual additives on wear and friction.

Validation of the results occurs in the next step under the real practical conditions of a conveyor plant, in which the functionality of the materials can be verified. Integration of measuring technology enables comparative tests to be conducted as well as characteristic parameters and maximum loads to be identified, facilitating dimensioning of conveyor plants with a great degree of reliability. ■

Literature

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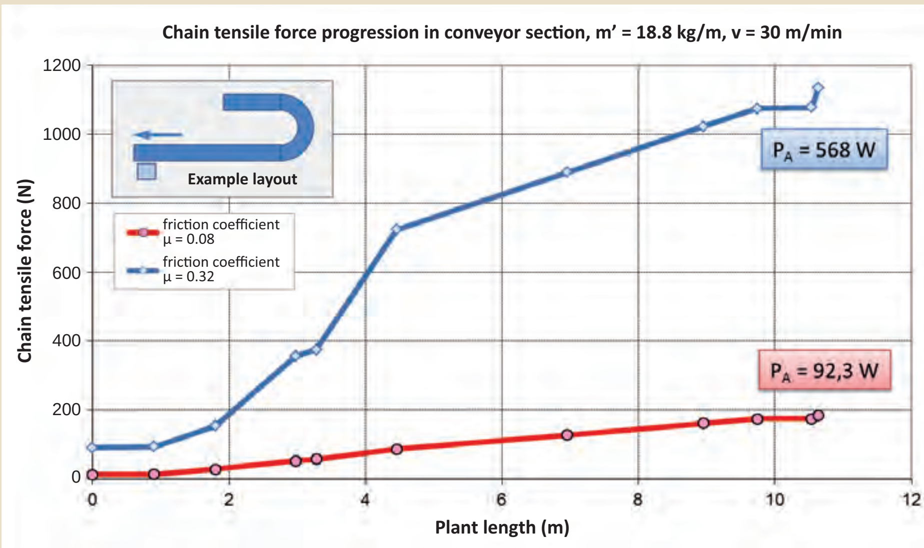

Chain tensile force progression as well as the required drive power of a conveyor plant with sliding rails LubX® C ($\mu = 0.08$) compared to reference PE-UHMW ($\mu = 0.32$)

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