Tightening a belt, energetically

Transmission and conveyor belts have a wide range of applications in industrial and service industries. In place of the classic leather belts, other high quality materials have long entered the market. These materials are carefully combined in layered structures so that they can be optimally designed for a specific application. The design of the belt has a large impact on energy consumption. The belt manufacturer Ammeraal Beltech AG, utilizes a test developed at the University of Rapperswil to optimize energy consumption and thus the lifetime of its products.

"The new testing equipment brings us a big step forward in the market." Dr. Jérôme Lefèvre, Director of Technology & Development at Ammeraal Beltech. Photo: Corinne Alder

Dr. Benedict Vogel, on behalf of the Swiss Federal Office of Energy (SFOE)

Drive belts are used to power transmissions and transport goods from point A to B. Whether to power transmissions or for transport - both applications use flat belts. Other important areas for flat belts are the packaging, printing and textile industries, in contrast to applications for V-belts (or toothed belts), which are better suited for robust applications in polluted environments. Flat belts are used, for example, in packaging machines that fold corrugated boxes, or to enable the spindles to rotate in spinning machines. They are also used in the sorting of mail-letters and packages, but at much lower speeds.

In fast moving belt applications, with up to 80 m / s, the faster the belt runs, the higher the heat loss from the rotating pulleys that hold the belt in place. A belt circles over the pulleys ten or more times per second and consequently heats up to temperatures of 60 °C and higher. Although modern flat belt systems have an efficiency of 95 to 98 %, si-

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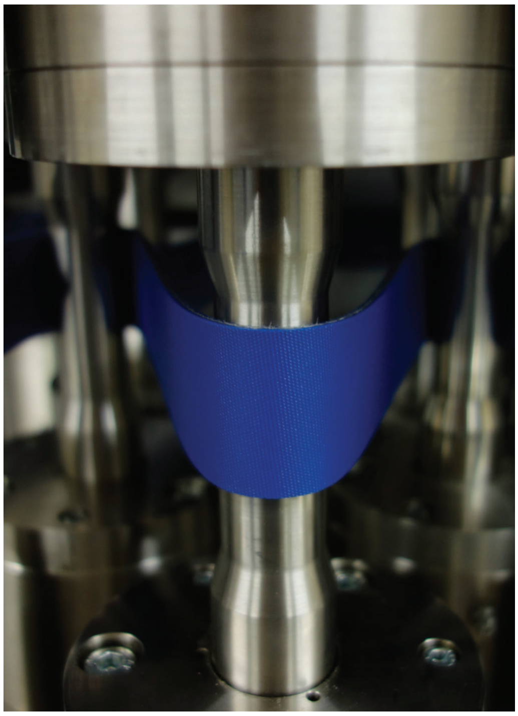
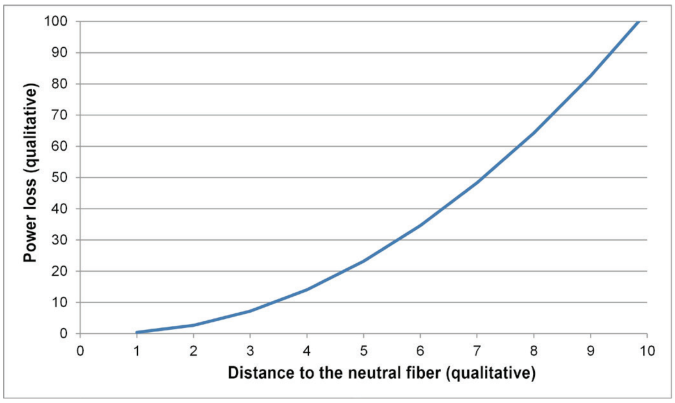
gnificant gains in efficiency can still be achieved through proper material selection and belt design. For the user, the energy savings mean decreased operating expenses. It is not surprising that the low energy consumption of their product is a major selling point for the belt manufacturer.

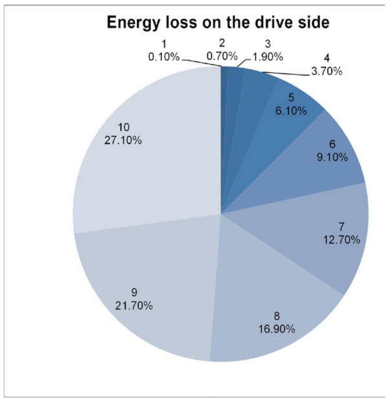
A unique belt for every application

The Dutch company Ammeraal Beltech AG is a leading global belt manufacturer. The company has a development and production site in Rapperswil-Jona. This site occupies a former leather tannery where leather belts were produced during the 19th century. Today there are 95 Ammeraal Beltech employees still here producing belts. But instead of being made from animal skin, the belts are made of synthetic material that is layered and laminated to efficiently power transmissions and transport goods. The company manufactures over 150 types of high-performance flat belts for various industrial applications. Every application requires the appropriate belt. Antistatic belts, for example, are required for letter-sorting. In this application, a conductive layer is incorporated, which dissipates static electricity so letters do not stick to the belt. Customers can have belts custom made according to defined characteristics such as thickness, texture of the cover material and other specifications.



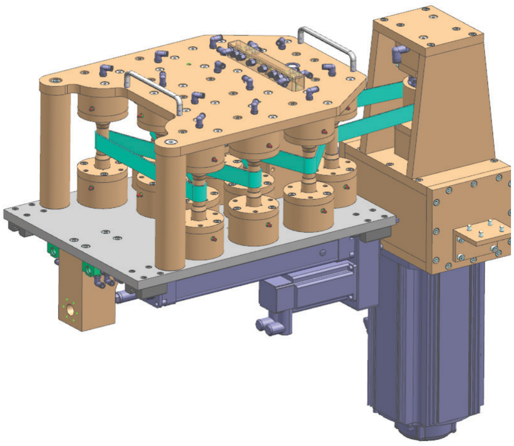
The flat belt is run over a pulley. During this process, its direction is changed. The heat and energy losses that occur during this process are reduced with the correct measures. Photo: Jérôme Lefèvre





The graph shows the variation in energy dissipation as a function of the distance to the traction layer (z = 0) for a 1 mm wide belt consisting of 10 identical individual layers, each with 0.1mm thickness: Losses due to repeated bending increase exponentially with increasing distance from the neutral axis (left). The belt should be thin and wide instead of thick and thin. The pie chart on the right shows the energy losses per layer. One can see seen that the chosen material for the outer layers is particularly important for the reduction of losses. Illustration: Final Report HSR

"Our goal is to increase the efficiency of the flat belt through the use of more efficient materials and the construction of an optimized belt body," says Dr. Jérôme Lefèvre. Lefèvre studied materials science at ETH Zurich and wrote a doctoral thesis in the plastics sector. For two years he has led the Department of Technology & Development at Ammeraal Beltech. Lefèvre can boast his company's considerable success: "The belts for a mail transport system from Siemens



The test facility consists of a rotor mounted on ball bearing guides set on a platform with twelve pulleys that can reverse movement to simulate the entire life cycle of a belt by alternating bending movements. Illustration: Final Report HSR

require 12% less energy than those of our competitors," says Lefèvre. Even 14% less is the energy consumption in the case of a corrugated folding-box machine manufactured by the western Swiss company Bobst SA. At least 90% of the energy required to run corrugated folding-box machines is used to propel belts and pulleys.

Exploring potential efficiency

In order to increase the energy efficiency of their belts, a few months ago Ammeraal Beltech incorporated a new test facility into their manufacturing process. Previously only the belt life could be determined. The new facility can measure the forces acting around the belt, as well as temperature and the strain encountered by the belt. To determine the energy efficiency, the belt is clamped into the testing machine. The machine is run for one to two hours until the belt relaxes, then the energy efficiency of the belt is determined by the measurement of energy input and energy output. Ammeraal Beltech is currently using this test with three product categories (collapsible box machines, textiles, logistics). Here, three to four belts from each catagory are investigated with different thicknesses and strengths. "Those are the three areas with the highest efficiency potential," says Head of Development Lefèvre.

The materials used to produce the belts have a significant impact on energy consumption (see text box at the bottom). According Lefèvre energy efficiency can be improved by a further 15 to 20% with the new test. In addition Ammeraal Beltech uses a valuation software tool that can improve the layer structure of the materials from which Lefèvre expects an additional 6 to 7% gain in efficiency. The full potential energy savings, however, can only be reached if the belt manufacturer works together with users and machine manufacturers. According to Jérôme Lefèvre, industry and service companies today continue to sometimes use thicker belts than necessary. But these belts straps can be made more energy efficient, thanks to fiber-reinforced traction layers of thin (2 to 2.5 mm instead of 3 to 4 mm) synthetic material. "If the industry comes along with us, we can realize a new boost in efficiency," says Lefèvre.

HSR researchers have built the test facility

Thanks to the new testing facility, Ammeraal Beltech can analyze their belts in house, which shortens the development time of the product. For the customer, this translates into the advantage of receiving a product already tested for strength and efficiency that they can use immediately. Jérôme Lefèvre: "The test brings us a major step forward in the market. With our test we are now better equipped as a supplier than many machine manufacturers.” If machine manufacturers were to build energy-efficient belts into their machines, this would benefit the industrial user. Development Manager Lefèvre points to the example of a large Indian textile company. With the use of modern belts manufactured by Ammeraal Beltech in 100 of the company’s two-for-one twister textile machines, operating for 12-hours a day, the company saves $US 110,000 in energy costs per year.

The flat belt testing machinery used by Ammeraal Beltech was developed by the Institute of Materials Technology and Plastics Processing (IWK) at the University Rapperswil (HSR) in the framework of a project that was supported by the Swiss Federal Office of Energy (SFOE). The parts of the machine include 12 pulleys with different diameters (25, 30, 40, 60 mm). A double-sided storage unit with an integrated compressed air cooling system ensures high mechanical stability. Another pulley provides the drive. The testing machinery is equipped with a climate-controlled chamber and extensive sensors. "With our own specially developed software, belt speed, belt tension, and respectively predicted belt tension, and ambient temperature can be adjusted in targeted and relevant parameters (relaxation / creep, energy losses, local and global temperatures) and then recorded and analyzed," IWK researcher Dr. Gion A. Barandun notes, who helped develop the test.

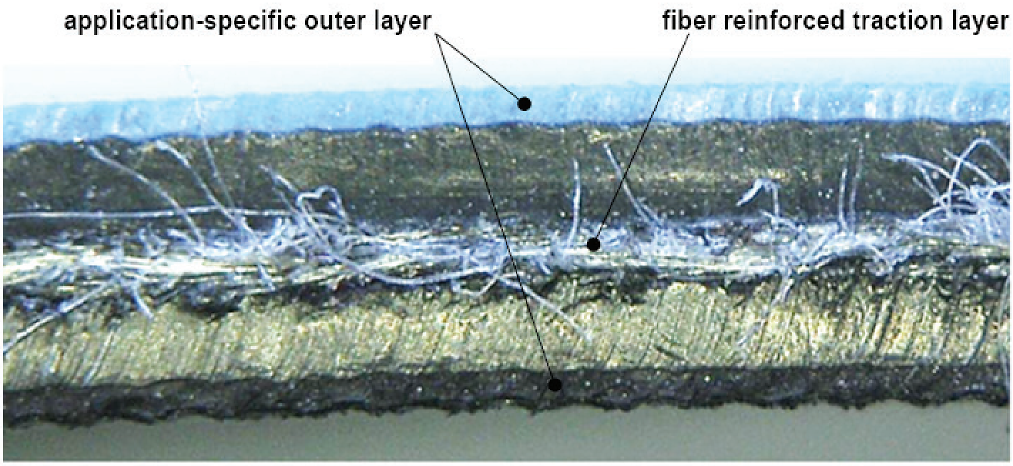
Calculation program for energy losses

In addition to the energy efficiency test, scientists at the University of Rapperswil have also developed a calculation program. This software tool can predict a belt’s energy loss in the form of heat by entering geometric and material-specific parameters. This is the sum of energy losses from weight on the belt, traction-and tensile stresses. "It is also possible to look at the percentage loss for a single layer, and thus develop an optimized layer structure,” Barandun notes. But even though the calculation tool can help create an optimized product, it has limitations. For example, in the prediction of the friction forces, the program is still imprecise. Consequently, it cannot not yet give an exact prediction of the total energy losses but 'only' a qualitative comparison of different belt structures and materials. "We hope to address this deficiency in the future," says Gion A. Barandun.

» For further information on the project, please contact Michael Spirig (m.spirig[at]fomenta.ch), head of SFOE research program in Industrial Processes.
» Further technical papers about research, pilot demonstrations and lighthouse projects in industrial processes can be found here: www.bfe.admin.ch/CT/prozesse

Energy efficiency – packed in two millimeters

A modern flat belt consists of three layers: a fiber-reinforced traction layer on which an adhesive layer is applied to both sides (each consisting of an in between layer and a top layer). Experts speak of multilayer belts. The traction layer provides the robustness of the belt. The top layer is configured in a way that is optimized according to the adhesive requirements of the application. The adhesive and top layers are affixed to the traction layer by lamination. In the past, lamination rubber was used in the process. Today, special thermoplastic materials are used to affix the adhesive layers. Lamination rubber was also used in the past to affix the outer layers since it had good abrasion properties over the lifetime of the belt. Today a broad range of thermoplastic materials are used instead.



Multilayer belts consist of a traction layer (center) and a top layer with application-specific adhesive properties attached on both sides. Traction layer and the two outer layers are stitched together with an intermediate layer (laminated). Photo: HSR / IWK, a photomicrograph of a multi-layer composite belt Ammeraal Beltech

So that as little energy as possible is expended by the belts, materials for the intermediate and top layers must be chosen such that at the bends and at the pulleys, the belt heats up as little as possible. Depending on the selected material, belts can be constructed thinner - and therefore more energy efficient. Belts that previously were made 3 to 4 mm thick can today be made with a thicknesses of 2.5 and 2 mm. These thinner belts are already in use, they are not widespread however. Achieving such thinness is a challenge for manufacturers since the thermoplastic that forms the intermediate layers must be strong enough to bind the traction and durable outer layers and hold them together over long periods of time. For a good result, at Ammeraal Beltech granules are extruded onto a film that can be laminated with the traction and top layers. BV

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