ELECTRICITY INSTEAD OF COMPRESSED AIR

They are inconspicuous, yet ubiquitous in Swiss industrial processes: compressed air cylinders that perform mechanical back-and-forth movements in production machines and other applications. If these cylinders were operated electrically instead of with compressed air, a lot of energy could be saved. A pilot project has investigated the energy savings potential of switching to electric cylinders, but also highlights the hurdles.

At Micarna, the meat processing plant of the Swiss supermarket chain Migros, electric cylinders installed as part of a SFOE pilot project are used to stop containers that are being transported in the internal logistics system and to clock them into the subsequent process. Photo: Cyltronic

A technical report about the results of a pilot project in the field of electricity technologies, which is financially supported by the Swiss Federal Office of Energy. The report has been published in the technical magazine Bulletin Electrosuisse (issue March 2023).

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In industrial production plants, there are countless applications in which a back-and-forth movement must be executed — to open a flap or move a package, for example. To perform such back-and-forth movements mechanically, compressed air cylinders are generally used today. These cylinders operate with compressed air that has been generated in a compressor using electrical energy. According to one estimate, two million compressed air cylinders are in use in Switzerland, many of them in industrial production machinery. In addition, there are applications in fire doors, dump trucks or milking robots.

Air cylinders (also: pneumatic cylinders) are an established technology and available today at little cost. From an energy point of view, however, they are not an ideal solution. In generating compressed air with electric current alone, almost half of the energy is lost as heat. Further losses occur when the compressed air is distributed and when it is converted into mechanical energy. "The mechanically usable power is only 6% of the electrical output energy. So there are large losses, a significant part of which could be avoided. If you consider that today around 1.5% of the country's electricity consumption is accounted for by the generation of compressed air, there is a huge savings potential lying dormant there," says Jeremias Wehrli.

Electricity instead of compressed air

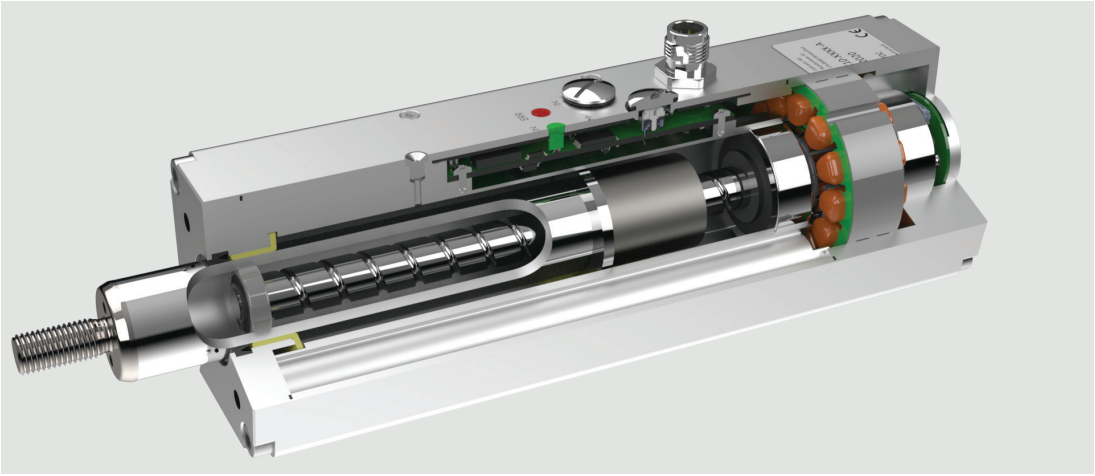
Jeremias Wehrli trained as a mechanical engineer in Winterthur at the Zurich University of Applied Sciences (ZHAW). Together with colleagues from the ZHAW, he designed a prototype of an electric cylinder. This led to the founding of Cyltronic AG in October 2020, which further developed the prototype into a marketable product. Managing director Wehrli wrote a business plan for the young company for his master's thesis. He was assisted by co-founder and power electronics developer Daniel Baumann. The start-up's mission: to replace the widely used compressed air cylinders with energy-efficient electric cylinders. At the beginning of 2023, 12 employees at Cyltronic were working towards this goal.

The company has been selling their product commercially since 2022. It aims to break even by 2025/26. Around 100 Cyltronic electric cylinders are currently in use by a handful of companies in Switzerland as well as in Germany, Austria and Italy. Compared with electric cylinders developed earlier by other manufacturers, the new electric cylinders are more compact in design and have the same dimensions as pneumatic cylinders; they are also easier to adjust and control than earlier electric cylinders. From summer 2021 to summer 2022, prototypes of the new cylinders were tested in practice as part of a SFOE pilot project and examined for ease of installation and energy efficiency. Wehrli draws a positive conclusion: "We were able to show that our electric cylinder not only works, but that it replaces compressed air cylinders 1 to

P+D PROJECTS OF THE SFOE

The project presented in the main text was supported by the Pilot and Demonstration Program of the Swiss Federal Office of Energy (SFOE). With this program, the SFOE promotes the development and testing of innovative technologies, solutions and approaches that make a significant contribution to energy efficiency or the use of renewable energies. Applications for financial assistance can be submitted at any time.

↗ www.bfe.admin.ch/pilotdemonstration



View inside an electric cylinder: The servo motor (right) drives a spindle (left), which causes the linear back-and-forth movement. Centered above the spindle is the control panel with the potentiometer, and directly below it are the servo controller electronics. Illustration: Cyltronic

1 in existing applications and offers a more energy-efficient alternative to them." The machine control system (PLC) does not have to be adapted, because the electric cylinder is controlled with the same electrical signal as the compressed air cylinder that it replaces.

Ninety-three percent less energy consumption

According to the project team, replacing compressed air cylinders with electric cylinders can save an average of 93% in electrical energy. The calculation was based on the use of electric cylinders in several pilot plants. One of these was the Stihl Kettenwerk in Wil in the canton of St. Gallen, which uses the cylinders to open and close furnace flaps. With three electric cylinders, electricity savings of 98%, 89% and 82% respectively were achieved compared to the compressed air cylinders previously used. The annual savings amount to 1800 kWh equivalent to just under 380 Fr. (the calculation was based on a standard electricity price of 21 Rp./kWh).

Three electric cylinders at the Nutrex rice mill in Brunnen (Canton Schwyz) brought a similar reduction in expenditure. The replaced pneumatic cylinders together consumed compressed air with an energy equivalent of 44,519 kWh (and costs of 9,349 Swiss Fr.) during their lifetime. With the use of electric cylinders, it is 2,361 kWh with energy costs of 496 Fr. According to Cyltronic CEO Wehrli, further advantages of the electric cylinders are a lower noise level and short adjustment times in case of changes in the operating mode.

Stihl Kettenwerk is one of the companies that replaced compressed air cylinders with electric cylinders. Electric cylinders are likely to be superior to compressed air cylinders in terms of service life because of their high-quality components. Photo: Cyltronic

Focus on machine builders

Despite such advantages, switching to electric cylinders has a downside. An electric cylinder from Cyltronic costs around 1500 Fr., i.e. about six times as much as a pneumatic cylinder (if the costs for generating the compressed air are not taken into account). The payback period for the additional costs due to energy savings is six to nine years (again calculated with an electricity price of 21 Rp./kWh). Although the payback period can be significantly shorter in the case of intensive use (short cycle times), Wehrli nevertheless remains realistic: "As impressive as the energy savings are, we still have to offer additional added value to justify the higher costs for our cylinder." In this context, Wehrli points to the positioning capability of the Cyltronic electric cylinders, i.e., the ability to precisely control the position of the back-and-forth movement via a communication interface (IO-Link). Speed and force can also be flexibly adjusted.

Pneumatic cylinders can be replaced by electric cylinders in existing machines. However, for a machine to be completely converted from compressed air to electricity, all compressed air cylinders must be replaced. This can be time-consuming because sometimes up to 20 different cylinders are instal-

BUILT COMPACTLY

Conventional electric cylinders consist of a controller, which controls a motor that generates the mechanical movement via a spindle. The controller is usually located in a control cabinet, and the motor and spindle are also connected via a coupling unit. Cyltronic's electric cylinder integrates the controller, motor and spindle in a single housing unit. This makes the electric cylinder particularly compact and easier to handle, according to Cyltronic.

led in a single machine. Ideally, therefore, machines would be equipped with electric cylinders during manufacture. This would simplify commissioning, maintenance and operation. With this in mind, Cyltronic would like to sell its electric cylinders primarily to machine builders in the future.

Great potential for replacement of pneumatic cylinders

Users of Cyltronic's electric cylinders during the pilot phase rate them positively. They have had a "very good experience from testing to implementation," says Gerhard Marty, managing director of the Nutrex rice mill in Brunnen. According to Roy Baumann, energy manager at the Stihl chain plant in Wil, "in particular, the freely selectable positioning without an additional control unit offers a high additional benefit." Like Marty, he also sees the preferred area of application for electric cylinders in the construction of new plants: "We see great potential in the procurement of new plants that can do completely without compressed air supply through the use of electric cylinders."

As part of the SFOE pilot project, interviews were conducted with representatives of 12 mechanical engineering companies and 16 end users. The responses indicate that electric cylinders are only used sporadically in Switzerland. The potential is correspondingly large, both in the construction of new machines and in the replacement of pneumatic cylinders in existing machines. The survey of end users revealed that companies sometimes have to replace several hundred pneumatic cylinders per year. If machine manufacturers decide to install electric cylinders, this tends to make their products more expensive. In return, they can promise their customers lower operating costs due to the significantly lower energy consumption.

Around 300 pneumatic cylinders are used in the Nutrex rice mill in Brunnen, which belongs to the Swiss wholesale and retail giant Coop. Three of them were replaced by electric cylinders as part of the SFOE pilot project. The electric cylinder in the picture is used to drive the pivoting flaps of a scale that weighs the residues that accumulate during rice processing. Photo: Cyltronic

Compressors provide compressed air to operate pneumatic cylinders. To generate one cubic meter of compressed air, 0.1 to 0.14 kWh of electricity is required. Photo: Cyltronic

- The **final report** on the project ‹Elektrozylinder als Pneumatikzylinder-Ersatz› (Electric Cylinder as Pneumatic Cylinder Replacement) is available at: https://www.aramis.admin.ch/Texte/?ProjectID=48060
- For **information** on the topic, please contact Roland Brüniger (roland.brueniger@brueniger.swiss), external head of the SFOE's Electricity Technologies research program, and Cyltronic CEO Jeremias Wehrli (j.wehrli@cyltronic.ch).
- For more **technical papers** on research, pilot, demonstration and flagship projects in the field of electricity technologies, visit www.bfe.admin.ch/ec-strom.

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