Pumps and Compressors for the World Market 2021
with Compressed Air and Vacuum Technology
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Pumps and Compressors for the World Market 2021

with Compressed Air and Vacuum Technology
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Pumps and compressors survive the crisis year better than other mechanical engineering sectors

Dear Customers and Readers,

The year 2020 won’t be forgotten quickly. The coronavirus pandemic not only caused an economic slump around the globe. It also affected each of us in one way or another. We can also already say that it will have a lasting impact on behaviour in many areas of business, from travel and trade fairs to working from home. This global crisis also hit the pumps and compressors sector hard, even though our very wide-ranging customers helped ensure that our slump was far milder than that of mechanical engineering as a whole. This edition of Pumps and Compressors for the World Market 2021 begins with an interview with Christoph Singrün, the managing director of our associations, in which he presents the situation facing our companies and outlines their expectations for the future.

The omnipresence of the pandemic has forced many issues into the background. And yet, away from the worldwide infection-related activity and its direct consequences, important work was done last year. In the summer, the German government passed its National Hydrogen Strategy, which aims to provide a coherent action framework for the future production, transportation, use and reuse of hydrogen. It is a framework designed to encourage innovation and investment in new value-adding chains. For manufacturers of compressors in particular this represents a chance to expand their market significantly. The industry is ready. Also with regard to the required path. For the time being, in line with the phase-out of coal and lignite as well as nuclear energy, at least in Europe, natural gas and liquid natural gas must plug the gap previously filled by oil and gas applications. Here too compressors are employed. In this issue, we will be discussing hydrogen no fewer than three times: in an interview with Christoph Singrün, in an overview by association of the specific opportunities for this energy source, and finally in an article by a new VDMA member company in Switzerland.

Almost completely out of the public eye, the Asia-Pacific free trade agreement known as the RCEP was signed in late 2020. This has created a common economic space that covers 2.2 billion people and about a third of the world’s economic output. This doesn’t exactly facilitate matters for the export-oriented companies in our sector. We and others must therefore urgently consider how the EU can respond to these new developments. From our perspective, there is a lot to be said for creating a counterweight with the United States and thus making another attempt at establishing a transatlantic free trade agreement.
The pandemic has been extremely challenging for the companies in our industry. Nevertheless, it has not slowed the pace of innovation or crushed our optimism about the future. Our companies are tirelessly driving forward their development work, enabling new applications and presenting their customers with the best possible solutions. The specialist articles in this issue also showcase this in impressive manner.

As usual, you will also find lots of exciting information in this magazine. If you are particularly interested in a certain topic or have questions about it, simply contact the authors. The experts will be happy to discuss the matter with you. For now we wish you pleasant reading.

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Compressors, Compressed Air and Vacuum Technology
“We got through the crisis year relatively well”

Pump and compressor manufacturers have often been able to compensate for slumps. They are benefitting from strong demand from China.

Interview with Christoph Singrün, the Managing Director of the VDMA associations Pumps + Systems and Compressors, Compressed Air and Vacuum Technology.

What impact did the coronavirus pandemic have on the companies in your sector in 2020? Mechanical engineering as a whole managed to end last year reasonably well. According to estimates by the German Federal Statistical Office, we in the mechanical engineering sector suffered a drop in sales of about 12% in real terms. That’s the biggest slump since the 2009 financial crisis. The pumps and systems sector and that of compressors, compressed air and vacuum technology also witnessed a slump, although theirs was not quite as dramatic. Pumps and systems recorded an 8% decline in sales in 2020. Exports fell by about 10%. The internal market was somewhat more stable than export business. Sales of compressors, compressed air and vacuum technology decreased by about 5%. Exports dropped by 11%. The decline in exports has a very significant impact on the economic situation at individual companies because exports make up 70-90% of their sales, depending on the sector. Overall we can say that we got through the crisis year 2020 relatively well.

Why wasn’t the slump as pronounced for pumps and compressors as it was in other areas of mechanical engineering? Both sectors produce what are known as interdisciplinary technologies that are supplied to many different areas. If one customer segment is suffering, another is doing better. For example, there was a drop in sales in the chemical

Incoming orders and turnover in Germany – Pumps

![Incoming orders and turnover in Germany – Pumps](image)

Source: VDMA

Pumps and Compressors for the World Market with Compressed Air and Vacuum Technology 2021
industry, which is especially important for fluid pumps in particular. By contrast, there was a growth in building technology – another important customer sector – because construction remains strong both in Germany and elsewhere in Europe. Another reason is that our industries depend less on the hard-hit auto industry and the associated supply industry.

Did the supply chains remain intact during the various lockdowns?
Many people were holding their breath in March and April last year and were curious to find out whether the procurement lines would hold. At times, things got extremely tight, partly because some suppliers were affected by the complete lockdowns imposed in Spain and Italy, countries that were hit especially hard at the start. However, some manufacturers had the wisdom and foresight to increase their stocks very early on in the year. These were then able to maintain their ability to supply customers during the particularly difficult period in March and April. The situation then stabilised again for many companies from May onwards.

How important is it for companies that China recovered quickly from its economic downturn and even managed to grow over the year as a whole?
Since the middle of last year, China has once again been the global growth driver. Our companies benefit from that too. In 2020, we sold China pumps worth a total of EUR 600 million. That’s more than 10% of our domestic production. China has also become the most important market for pump manufacturers, even ahead of the United States. The situation is similar for compressors, compressed air and vacuum technology, which exported goods worth almost EUR 700 million to China. Business is booming. Manufacturers are profiting from very high demand from there.

Will this continue?
As China continues to grow, strong competitors will also develop there, and sooner or later they too will be on the global market. We are already seeing Chinese colleagues becoming more active in the international standardisation bodies that develop internationally applicable standards for pumps and compressors. Certain standards are even being set in China for the domestic market. These must be followed if, for instance, you want to develop together with the Chinese. Efficiency standards are one such example. Climate change affects us all worldwide, so we must try to develop global standards.

The Regional Comprehensive Economic Partnership (RCEP) has created the world’s largest free trade zone. Standards will probably be developed there too.
Free trade zones generally have their own specific standards. Manufacturers outside such zones must ensure they meet these standards well so that they can offer the relevant products efficiently and cost-effectively. It’s not as if outside manufacturers are excluded. But it’s clear that the customs issue will arise in the medium term. We at the VDMA see the RCEP agreement as a kind of warning shot for the EU: a wake-up call for EU trade policy. In our view, it’s very clear that China wants to use this agreement to underpin its economic and political aspirations.

Isn’t this development an incentive for a new TTIP?
A transatlantic trade agreement like the TTIP would be equally beneficial to Europe and the US and could indeed constitute a counterbalance to the RCEP region in Asia. Without a doubt, Asia is the world’s fastest-growing continent. You can see that in the pace of market development and the rapidly growing wealth of the people there. In the light of this, the US and Europe must watch out that they don’t weaken each other. Although there are many challenges, primarily with regard to standards, their respective economic blocks should move closer together.

Many people see hydrogen as the new crude oil. What opportunities does this offer mechanical engineering?
The increasing use of hydrogen is bringing wide-ranging opportunities for compressor manufacturers in particular. After all, compressors are an indispensable link in the hydrogen value-adding chain. That’s why representatives of compressor manufacturers sit on the National Hydrogen Council, which advises the German government on the implementation and further development of its National Hydrogen Strategy. The VDMA already set up its Power-to-X working group two years ago in an effort to sound out the opportunities hydrogen offers the mechanical engineering sector in general.
How is the sector progressing with digitisation?
We are continuing to work on an OPC UA standard. This will set a milestone in machine communication by providing a common machine language and thus accelerate digitisation significantly. In future, pumps or compressors will have a communication interface what can be addressed from various directions – by the manufacturer as well as the user. The draft for the OPC UA standard for regular and vacuum pumps is already at the international approval stage. The compressed-air sector will also be ready in the first half of 2021.

What advances have been made with the extended product approach (EPA)?
We are confident that we will make a large stride forwards in this area too this year. That’s important because the EPA is about improving the energy efficiency of pumps and thus about climate protection. We would be further still by now if the European Commission hadn’t surprisingly demanded clarification on some formal issues.

What’s your prognosis for 2021?
There is a great deal of uncertainty. Nevertheless, the companies we represent have done an enormous amount to remain productive. They have also learnt a lot. Thanks to the measures they have implemented, the supply chains are very stable again. For mechanical engineering as a whole, we at the VDMA predict real production growth of about 4%. We are a little more cautious with regard to pumps and compressors because they are classic late-cycle movers: Anyone building a new plant orders his pumps and compressors last. We therefore expect sales in the pump sector to be stagnant or maybe even a little more. For compressors, compressed air and vacuum technology, we are assuming real sales growth of at least 1%. 
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Hope about a revival of trade fair business

Ulrike Mätje

The coronavirus pandemic almost brought trade fairs to their knees in 2020. However, as the crisis is mastered, business will pick up anew. Small and medium-sized companies will then once again be able to take part in foreign trade fairs cost-effectively through involvement in joint German booths.
International trade fairs tumbled like dominos in 2020. This further slashed the sales of many companies for whom trade fairs are an important revenue stream and who were already struggling because of the pandemic. Because trade fairs were often cancelled at short notice, companies were frequently left sitting on their preparatory costs. Some organisers tried to save what could be saved through hastily conceived virtual trade fairs. However, a survey of mechanical engineering representatives found that such solutions could never be a satisfactory alternative. Even fairs held with hygiene measures and strict social distancing rules were considered unattractive by respondents because it allegedly prevented spontaneity. This, they claimed, was particularly important at industrial trade fairs. Work is currently underway developing hybrid concepts combining online and in-person events for the future. Even so, it’s still unclear what these will look like, which elements of in-person events can successfully be transferred online or how the two formats can be combined. All hopes are therefore currently pinned on eliminating the virus – or at least keeping it in check – so that trade fair business can be ratcheted up again. We can see this in China, where infections had been brought under control by the middle of last year and where the first in-person fairs have already been held.

That’s because companies that take part in joint booths needn’t bear the cost of either booth building or organisation. They can therefore primarily focus on their own exhibits and booth personnel. Of the approximately 3000 internationally significant trade fairs held outside the EU, between 250 and 280 a year have been integrated into the BMWi foreign trade fair programme.

The ministry is assisted in its selection by the Association of the German Trade Fair Industry (AUMA) and industry associations. The programme is aimed at SMEs in order to support them in opening up international markets and thus also creating and maintaining jobs in Germany. Every year, the industry associations tell the BMWi which trade fairs they believe Germany should have joint booths at. AUMA finally agrees the overall programme together with the associations and the ministry.

The German Federal Ministry for Economic Affairs and Energy (BMWi) is sticking to its foreign trade fair programme in spite of the coronavirus pandemic and will continue offering joint German booths at many international trade fairs. These “German pavilions” offer companies an opportunity to present themselves that they would not otherwise have been able to envisage due to the associated cost and organisational effort. Such presentations on the relevant markets are particularly important for small and medium-sized mechanical engineering firms with high export quotas. Companies that appear under the “Made in Germany” banner at such joint booths also save themselves a lot of organisational effort at a reasonable price.

Useful links and further information:
www.auma.de/en
www.vdma.org/messeservice_weltweit
www.german-pavilion.com
The technologies for the hydrogen economy are ready

Christoph Singrün

Green hydrogen represents the energy source of the hour for tackling climate change. It is an indispensable part of the energy transition in industry, transportation and the heating sector. However, before we can capitalise fully on the advantages of this environmentally friendly gas, we must first invest in the infrastructure for hydrogen technology.
At the very latest since the German government passed its National Hydrogen Strategy in the summer of 2020, hydrogen has been on everyone’s lips. That’s because it signals the government’s intention to make Germany a forerunner in green hydrogen and the global leader in hydrogen technology in the long term. The VDMA wholeheartedly welcomes this aim. Mechanical engineering and plant construction companies already provide all the technologies needed to implement the strategy at every level, from hydrogen production and transportation to the various applications. Specifically, the plan is to, for example, build electrolysis plants, transform natural gas networks into hydrogen networks and even provide hydrogen refuelling stations for end users. Compressors – especially piston and diaphragm compressors – play an important role at every level. Representatives of compressor manufacturers therefore sit on the National Hydrogen Council, which advises the German government on how to implement the National Hydrogen Strategy.

Enormous volumes of this energy source will be needed to build up a hydrogen economy. However, there is not currently enough so-called “green” hydrogen, which is produced through electrolysis using electricity from renewable sources. And only green hydrogen can help slash our CO₂ output. A number of electrolysis plants are planned in the windier regions of northern Germany and are expected to begin operation in the coming years. But the volumes won’t be sufficient. In the medium term, we will therefore have no choice but to import green hydrogen.

To promote the expansion of the hydrogen economy, we could begin by approving “blue” hydrogen alongside the green variety. Although blue hydrogen is made from fossil fuels, the CO₂ generated by this process is scooped up in a process known as carbon capture and storage (CCS). Norway has been employing CCS for a long time. There, carbon dioxide produced when splitting fossil methane to generate hydrogen is pumped into disused oil and gas industry mineshafts, which are subsequently sealed. Germany has so far rejected such an approach. Climate protection is a global task. Green hydrogen can play an important role in this. However, because regenerative energies like wind and sunlight are not available equally everywhere, we will need international cooperation in the future to ensure that green electricity can reach those areas where it is needed to produce hydrogen.

Green hydrogen is essential for the energy transition in industry, transport and in the heating sector

The basic technology is available. The resulting opportunities and requirements have already been discussed within the VDMA’s P2X4A (Power to X for Applications) working group for the past two years. In a next step, we must now create the framework conditions that will allow the hydrogen economy to be built up as quickly and broadly as possible. In principle, hydrogen technology is nothing new. Hydrogen is still a comparatively expensive energy source. Scaling up production will make it cheaper. However, the crucial aspect here is that the system concept is taken into account.
Smart pumps prevent clogging in wastewater systems

Matthias Pantze

Pump systems with integrated control are not just reliable and energy-efficient. They also help operators deal with the ever-increasing challenges they face in terms of sewage transport. As a result, they contribute to higher economic efficiency and better environmental protection.
When looking to improve sustainability, resources should be conserved wherever possible. In terms of water, this means only using as much as is necessary to achieve a reliable supply. Water-saving measures are therefore becoming increasingly important in many applications. However, these savings also pose significant challenges for the industry. Reducing flushing volumes, for example, results in a greater concentration of solids in domestic sewage. These solids then increasingly settle in the pumps, hindering their operation. In addition, items such as wet wipes that contain fibres are increasingly being disposed of in toilets – which is not the proper place for them, and it leads to additional burdens being placed on the pumps. Due to climate change, longer dry periods alternating with heavy rainfall are increasingly causing solids to be deposited in channels in combined systems. These are then carried in high concentrations into pumping stations along with rainwater. When all of these problems occur together, a classic sewage pump can barely function properly. Other challenges the pumps are facing include demands for higher energy efficiency and greater digitalisation to further increase integration into processes. In order to meet all these challenges, a new smart-pump has been developed. It provides a holistic solution for the three essential aspects of sewage transport: reliability, energy efficiency and connectivity. The new pump combines the latest insights in hydraulic design, motor technology and integrated control intelligence completed with Ethernet connectivity.

The pump can easily be retrofitted, as is the case in Hamburg

In the city of Hamburg, the foundations for a modern drinking water and sewage network were laid as part of a reconstruction process carried out after the Great Fire of Hamburg in 1842. In Germany’s second largest city, parts of it still remain in operation today. With the growth of the city, the capacities of the water infrastructure were continuously expanded and modernised. Today, the local HAMBURG WASSER utility supplies 2.2 million people with over 110 million m³ of water every year via its 16 waterworks. 420 pumping stations pump both domestic and commercial sewage, as well as rainwater, to the Hamburg wastewater treatment plant where over 150 million m³ of sewage are treated each year.

System efficiency is now 10 percentage points higher than the level of the old pump due to the combination of new hydraulics and high efficiency motor.

The problem with pumping station 87

One of the 420 sewage pumping stations is located in the district of Billstedt, in the very east of the city. It was here in 1975 that pumping station 87 was constructed on Max-Pechstein-Straße. It receives 1,400 m³ of sewage each day from the Mümmelmannsberg residential area and conveys it via a nominal diameter DN 500 pressure pipe under the A1 motorway and the Glinder Au river into the next open channel. As time went on, it became apparent that the sewage was increasingly contaminated with fats, solids and fibres from domestic sewage and roadway drainage. In 2009, the structure was upgraded: the three old pumps were replaced by two new units integrating

Fig. 1: High breakdown costs made the utilisation of new technology at the pumping station a necessity.
cooled motors in a vertical dry well installation. Machines in a 6-pole design with single-channel impellers and a discharge port nominal diameter of DN 200 were installed. The increasing amounts of solids in the pumping station resulted in the formation of thick floating layers that had to be regularly extracted every four weeks at high cost. To try and mitigate the problem, a mixer was installed in the pump sump as part of modernisation works in 2016. This measure solved the problem with the floating layers but meant that all solids now had to be conveyed through the two pumps, which led to clogging up to 27 times in 2016 for one of the pumps alone. The pump was subsequently retrofitted with a fixed blade insert, and frequency converters with integrated flushing programmes were also installed. As a result, instances of clogging in the pump had been halved, with an average of one incident remaining per month. However, even this outcome was not satisfactory since it still involved high and unscheduled service costs.

**New pump with several special features**

HAMBURG WASSER decided to use a new pump, which had been launched in 2018, at pumping station 87. The utility supplier hoped that problems could be got under control there once and for all. The newly developed system solution consisted of a new hydraulic in which an open two-channel impeller runs against a fixed suction port with a spiral groove, in combination with a permanent magnet motor with integrated control electronics and a network interface. The goal of this development was finding the best possible compromise between the highest levels of reliability in connection with very high energy efficiency due to an overall efficiency of up to 70 % and state-of-the-art Ethernet-based connectivity. For the first time ever,
motor sets of energy efficiency class IE5 and an Ethernet interface were installed in a submersible sewage pump. This new development made it the first submersible pump that could communicate directly with the station’s control system via the standard Modbus TCP, as well as via the new industry standard OPC UA.

Another special feature is the integrated pump control software. It is available in two versions: it can be connected to existing PLC systems or independently control the operation of up to four pumps of the same type. Along with processing the integrated vibration sensor technology, which is visually displayed in the integrated web interface alongside the digital rating plate and maintenance logbooks, the electronics in the pump always includes integrated clogging detection in connection with automatic flushing cycles. In addition to the above-mentioned multi-pump control that operates according to the master-slave-logic principle, the extended software version also includes an automatic function for an operating mode that optimises energy efficiency.

**Higher efficiency**

As per the concept design, the new DN 150 nominal diameter pump with cooled FKT motor was installed along with the smaller software version in February 2019. System efficiency is now 10 percentage points higher than the level of the old pump due to the combination of new hydraulics and high efficiency motor. This has already resulted in an annual saving of 1,300 kWh per pump despite the short running time of the pump in the system of only 4 hours per day. The energetic effect would be much higher with an extended running time. Operational reliability was an even more important...
factor for the operator than these savings because, up to the start of the upgrade, the old pump had already failed three times since the beginning of the year.

The pump control software is fundamentally designed in such a way that all parameters are pre-set at the factory so that commissioning can take place as quickly as possible.

One special feature of the new system is that the pump always controls the external frequency converter and not vice versa, as is usually the case. This innovation means that the pump – complete with a system to detect clogging that is specially adapted to the hydraulics – can carry out specific flushing cycles in the event of imminent clogging of the pump impeller. In addition, the pump can automatically parameterise the frequency converter, which is why the electrical commissioning in the pumping station could be carried out on the existing frequency converter within a matter of minutes. During the one-year trial period, there was a specific focus on the autumn and winter period since experience has shown that most problems occur during this time. Since this was the first pump of its kind in the field, adjustments to the pump parameters were to be expected.

The pump control software is basically designed in such a way that all parameters are pre-set at the factory so that commissioning can take place as quickly as possible. The control programs, however, are of an open design so that the operator can adjust practically any setting. This permitted, for example, changes to be made to the responsivity of the clogging detection so that the system eventually settled at five flush cycles per 100 pump cycles. Using the new pump, which is not only significantly smaller but also only half the weight of the old model at the same duty point, has already resulted in an additional 65 % reduction in the number of times the pump has clogged up in the first year compared with the previous measures; this corresponds to a more than 80 % reduction in the number of breakdowns compared with the original set-up. For the operator HAMBURG WASSER, this has resulted in further savings of around 5,000 euros per year in relation to the cost of resolving breakdowns. This means that the replacement pump has reached it’s return on invest after approximately two years. The open design of the software allows reliability to be further optimised and continuous updates ensure that the system remains at the cutting edge of development.

Predictive maintenance options

Connectivity is a further advantage of the smart sewage pump. In the event that a fault message is received from the pumping station, the operator HAMBURG WASSER has the option to use the existing control system to connect to the pump’s web server via the VPN tunnel in order to obtain further information on the status of the pump system. Using this technology, main-
Maintenance requirements can be detected remotely and error messages can be evaluated and further differentiated in order to better assess how urgent it is to deploy personnel.

While it remains the case that hydraulics, mechanics and electrics require increasingly high levels of expenditure to gain small improvements, digitalisation in the form of intelligent control systems still holds enormous potential for optimising pumping stations. The case study in Hamburg shows that the combination of reliability, energy efficiency and connectivity can provide operators with significant potential for savings. Intelligent sewage pumps therefore represent new means to meet the challenges of sewage transport, both now and in the future.

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**Fig. 6:** The integrated graphical web interface enables the operator to carry out remote access and remote diagnosis.
Dry-running special pumps ensure maximum safety levels when tankers and railway tank cars are being emptied – even with difficult media

Frank Bungartz

The emptying of tanker trucks and railway tank cars containing difficult media is a major challenge for standard centrifugal pumps. Substances such as sulfuric acid, phenol, tar and zinc tetrachloride or even muddy, crystallizing or corrosive media push them to their limits. Dry-running special centrifugal pumps are a help here. They enable fast and complete emptying and also offer operators the highest levels of process reliability.
Conventional centrifugal pumps quickly reach their limits in the case of applications involving certain gases or media that are difficult to pump. During the pumping process the liquid level falls, which causes gas to be entrained towards the end. However, gases reduce the performance of the pump and cause uneven running. If there is a high gas input, there is even a risk that the flow will break off completely. Breakdowns are then unavoidable. Many operators attempt to prevent these unplanned downtimes through the use of diagnostic and early warning systems for fault detection. However, there is also a disadvantage to this solution. Additional monitoring systems result in further sources of error. Moreover, residual quantities of the pumped medium remain in the tank. Time-consuming and costly cleaning work and potential complications are the result.

Operators do not have these problems if they use special centrifugal pumps for difficult media. These special pumps do indeed have a high degree of intrinsic safety, i.e. their design ensures that no unsafe condition occurs even if there is a fault. In technical terms, this is achieved through the intelligent application of process physics. The design of these vertical pumps has unique control characteristics that work without suction. Without any mechanical or electrical control device, the flow rate is reduced automatically. The principle is based on pressure equalization between the pump impeller and the feed vessel. This pump type, which is self-venting even during operation, does not require a frequency converter or volumetric flow measurement. Their NPSH value is almost zero, which means that they generally operate without cavitation. This applies to all media, including substances with hazard potential, which is the decisive aspect for the selection of the appropriate seal of the pump shafts with respect to the atmospheric environment. The combination of an extremely low NPSH value, the ability to pump gas-laden liquids as well and the use of intrinsically safe seals enables tanker trucks, railway tank cars and other vessels to be emptied quickly and completely without any vortex and without the pumping process being interrupted while maintaining maximum safety levels – even in the event of operating errors.

**It all depends on the seal**

Also in the case of centrifugal pumps, the task of the seal is to prevent the discharge of the medium between the rotating shaft and the stationary housing. In the case of difficult media in particular, this could result in environmental and health hazards. There are numerous requirements on how these hazards should be minimized or avoided. Maximum allowable workplace concentrations, for example, indicate the maximum permitted concentration of a substance as a gas or vapor at a workplace. The Technical Instructions on Air Quality Control (TA Luft) and the ATEX guidelines for Germany stipulate which shaft seals must be used in such cases.

**Special pumps have a high degree of intrinsic safety, which means that their design ensures that no unsafe condition occurs even if there is a fault.**

The hydrodynamic shaft seal is best suited for preventing the leakage of a medium. This seal predominantly consists of additional blades on the rear of the impeller. This conveys the pumping medium away from the shaft opening and thus protects the downstream secondary shaft seal system. This seal was used in combination with the conical stuffing box as long ago as the 1930s. During subsequent development it was even used later on for a single-stage, horizontal chemical pump with magnetic coupling. Thanks to the intelligent design, in which not...
only the magnetic coupling but also the bearing unit runs without any product contact, this hermetically sealed pump is permanently capable of dry running.

As hydrodynamic sealing systems are wear-free, they can be operated for several years with little maintenance and high annual pumping times. The intrinsically safe and self-regulating special pumps combine the so-called hydrodynamic seal as the primary seal with a downstream secondary seal. Depending on the requirements of the medium to be pumped, this can be a gland, a lip or mechanical seal or a magnetic coupling.

All sealing systems have one thing in common. Even at zero delivery, neither the pump nor the seal or bearing is negatively affected. Even if the tankers or railway tank cars are completely emptied or if the suction slide valve has been accidentally closed, there is no risk whatsoever to the pump or shaft seal. Due to the permanent venting effect, gas bubbles do not result in any interruption to delivery. These are also partially returned to the respective intake vessel through a gas balance line.

Repeatedly tested in practice

Special centrifugal pumps are the solution of choice for many plant operators. One example: an international corporate group required pumps for unloading sulfuric acid from railway tank cars in a new construction project. Three aspects were of priority for this customer: the unloading should be carried out from below, the emptying of residues should be complete without additional vessel pressurizing and – finally – the highest level of safety had to be guaranteed. Through early planning and the use of a special centrifugal pump from the vertical range, the self-regulating physics with an NPSHR < 0.1 m meant that it was possible to dispense with the construction of a pit. Other infrastructure adjustments that would have been necessary with standard pumps due to the corresponding suction head were not required either. Further advantages of the magnetically coupled pump used are the maximum levels of safety in the event of leakages, the ease of use and savings in energy consumption. The intrinsically safe special centrifugal pump will discharge the media without any faults for the next 15 years.

Important features of an intrinsically safe pump design:

- self-regulating
- self-venting
- zero delivery rate-proof
- dry-running and operationally safe
- 3-phase compatible
- insensitive to gas bubbles

Source: Bungartz
In another project, the unloading of an entire train for the delivery of raw materials was to be made possible for reasons of economic efficiency. One difficulty was the product that was to be pumped. The pumped medium was difficult to handle because of its high viscosity. A different special vertical centrifugal pump was designed for such challenges. On the product side, this special pump is equipped with a gap seal, and on the atmosphere side with a dry-running magnetic coupling. The pump works without bearings in the pumped liquid.

A gas barrier with friction-free throttle bushings protects the grease-lubricated roller bearings from the product vapors. The shaft gap sealing concept is characterized by several components. On the one hand, the complete hydrodynamic relief of the bearing and sealing unit from the pump delivery pressure. This is achieved by means of back vanes and the gas barrier, which prevents the pumped product and product vapors from entering the bearing unit. On the other hand, there is the eddy current-free magnetic coupling, which hermetically seals the pump from the environment. Thanks to the vertical orientation of the pump, the bearing and sealing unit runs entirely without product contact, even in the event of a sealing gas failure. The roller bearings have a service life of up to 50000 hours.

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- a wide range of oil-free, dry-running and oil-lubricated compressor types suitable for a variety of gases
- maintenance-free drive due to gas-tight magnetic coupling
- high inlet pressure for energy-efficient operation

**Inlet Pressure:** up to 30 barg  
**Final Pressure:** up to 500 barg  
**Max. Power:** 1 – 250 kW

---

*Fig. 3: A complete pumping system consisting of a self-regulating centrifugal pump, pump stand and feed vessel saves both time and space.*
Success factor for difficult media: dry-running safety

Many pumps use the medium that is to be pumped to adequately lubricate the slide bearings and cool the seal that is used. Dry-running safety is the ability of a pump to operate permanently without any medium. This is achieved by decoupling the bearing and sealing unit from the pumped liquid.

In another application, an operator collects different substances for residual recycling in tankers under environmentally-friendly conditions. Everything is there – from tar, heavy oil and grease to flammable liquids or solvents, textile residues and plastic parts. For emptying the tankers, a discharge device is used, consisting of the pump combined with a filter for the coarse parts and a reservoir. The discharging process takes place from below. The most important condition was the complete emptying of the tankers. Here, too, a special pump was used. Despite the high viscosity of the mixed substances, it is now possible to discharge them quickly and safely. Due to the fact that the special pump has proved to be reliable over many years, no thought was given to an otherwise standard redundant design. This saved costs. Changing the mechanical seal cartridge after a long period of use was quickly carried out during maintenance. Due to the unusual control characteristics and the sealing concept selected for the application, the complete emptying of the tankers was carried out reliably without any outages or problems.

Significant Cost Advantages

Through the use of special centrifugal pumps, the operator can save costs to a significant extent. For example, no pits need to be excavated, which normal priming centrifugal pumps require as a rule for the necessary suction head. Furthermore, no monitoring is required, so that investments in additional control or regulation systems can also be saved. There is therefore no need to be wary of malfunctions or breakdowns caused by measurement and control technology. High operational reliability, generous maintenance intervals and long service lives are typical of all special centrifugal pumps.

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Hydraulic diaphragm metering pumps with linear drives allow precise metering of minute quantities

Michael Birmelin

Oscillating displacement pumps are ideally suited to metering liquids. Metering small or micro-quantities at medium or high pressure levels does however place serious demands on the pump. Adapted systems should ensure that the end product satisfies the quality standards required. In many cases, this cannot be achieved with commercial technologies or can only be done at great cost. Metering pumps with linear drives open up new possibilities here.
With an oscillating displacement pump, each metering process comprises the steps of pumping, measuring and setting the fluid flow to be metered. It also pumps and thereby raises the pressure level just like any other pump. Its delivery flow can be adjusted by continuously altering the stroke length, stroke volume or stroke rate. It measures following the measuring cup principle by repeatedly displacing a specified stroke volume. The specified stroke volume depends on the construction of the liquid ends: a metering unit with plunger or fitted with a diaphragm.

Hydraulics at high feed pressures

Diaphragm heads with a mechanically driven diaphragm are suited to small to medium metering flows and low feed pressures of up to around 20 bar. Fitted with step motors or a solenoid drive, they are a popular choice and dominate the current metering pump market. However, with diaphragm heads with a hydraulically driven diaphragm, the plunger is not in direct contact with the delivery fluid as is the case with plunger pumps. Rather, the plunger moves around in a hydraulic liquid and the volume displaced by the plunger is transferred to the actual liquid being pumped via a diaphragm. The main difference from the mechanical diaphragm drive is the fact that the diaphragm always operates with pressure compensation and is therefore also suited to very high feed pressures of up to 3,000 bar. Thanks to their high compressive strength, diaphragm pumps with hydraulically driven diaphragms achieve considerably better dosing precision than those with mechanically driven diaphragms. Both step motors and 3-phase AC motors are used as drive motors.

Changeable adjustment ranges

The metering process is basically characterised by two parameters: the stroke length and speed. The stroke length is set between 0 and 100 percent. The parameters are adjusted mechanically or electrically. In practice, an adjustment range of 1:10 is normal. The speed of the electric drive motor is controlled in an adjustment range of 1:3 to 1:5 with a frequency converter. If the entire adjustment range needs to be bigger, the two parameters must be combined. Adjustment ranges of up to 1:30 can then be reliably achieved. The adjustment ranges of the individual parameters are either connected in series by a process control system or are linked with two independent control circuits. Ideally operators want the metering for their applications to be individually adapted to their needs. In the best case scenario, this means a variable motion profile: a discharge stroke individually matched to the job in hand and a suction stroke also optimised for the application. The properties of the fluids being metered, such as viscosity and chemical resistance, also need to be taken into account as do any special hydraulic features.
Unregulated metering pumps in standard technology meter low-viscosity media in a gently pulsating manner using equal discharge and suction strokes (Fig. 1). Conventional drives, such as step motors or solenoid drives, are used. In the case of regulated metering pumps, such as pumps with linear drives, virtually continuous metering can however be achieved with minimal pauses in metering. A long, slow metering stroke is performed followed by a rapid suction stroke (Fig. 2).

More complex metering processes, such as those used for filling, can only be achieved with an individually optimised speed profile.

The metering profile of a regulated metering pump with a linear drive can also be adapted especially to the flow characteristics of highly viscous fluids: the dosing head is completely filled in a slow suction stroke, followed by a short discharge stroke to inject the medium (Fig. 3).

Both pumps with regulated solenoid drives and vector-controlled frequency converters modify the distance-time diagram, but these are still a long way off a real, free definition of the complete motion profile.

More complex metering processes, such as those used for filling, can only be achieved with an individually optimised speed profile. In the best case scenario, this means two-parameter control, combined with a third parameter, which corresponds to a variable motion profile. This allows the profile to be matched precisely to the prevailing requirements: when the pump is injecting medium into a process, the discharge stroke and suction stroke profiles can be set separately as required. Both the properties of the fluids being metered, such as viscosity, chemical resistance etc., and the special hydraulic features are thereby taken into account during the metering stroke.

With filling processes, for example, this includes minimising the amount of fluid splashed onto the nozzle and avoiding drips. The metering motion needed for this is the oscillating dynamic stroke travel in both directions (Fig. 4). A drive unit, which performs a directly controlled oscillating motion for the discharge and suction stroke without any deflection of motion or power, would be ideal for this. And a pump with a linear drive does just that. The electrical energy supplied is converted straight into an oscillating motion.

Advantages of the direct drive

Linear motors are direct drives, which produce linear motion in a purely electric manner without gears or other mechanical deflection aids. The function of a linear motor can be envisaged as follows: With a rotating synchronous motor, the magnetic rotating field is produced by coils offset in a circle (stator). When rotating, the rotor follows the energy field with the permanent magnets. With linear motors, the windings are arranged on a straight section. The so-called rotor, fitted with permanent magnets, follows the offset coils of the stator and therefore the oscillating travelling magnetic field. The stator length and the pairs of coils and magnets are proportional to potential force. The excess length of the magnets thereby produces a constant force over the entire movement range.

In comparison, with motor-driven metering pumps the motion of the electric rotation motor is reduced by a gear reduction ratio from the motor speed to the stroke rate needed for
the metering pumps. For example, 1400 rpm is reduced to 140 strokes/min, which is a control ratio of 1:10. This is then converted into usable oscillating motion by a crank drive with adjustable eccentric, for example. Four changes are therefore ultimately needed to produce an adjustable form of oscillating motion which can actually be used.

The advantages of a linear motor are obvious:
Since the construction has no gears, no deflection is needed, which reduces costs and saves space. The low number of mechanical components means that the construction incurs virtually no wear and requires little maintenance. The high dynamics can compensate for shortcomings in the hydraulics, with valves for example.

Fig. 4: Recently developed linear motor-driven metering pump – filling process with nozzle thanks to individual/optimised speed profile with drip-free effect

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Unlike solenoid or motor-driven diaphragm pumps with a spring-cam drive where the backwards motion is delivered by a spring, with linear drives both forwards and backwards motion is undertaken. Force is not dependent on the location and is proportional to flow.

Integrated distance recording

The motor characteristics of the drive are also excellent thanks to their integrated distance recording feature, which is perfectly suited to controlling metering profiles. An integrated position sensor continually measures and monitors the current position of the rotor at all times, when stationary and during motion. Deviations are detected instantly and reported to the higher-level control, guaranteeing excellent operating safety and reliable detection of errors. Other benefits: Both the movement speed and acceleration can be specified with precision. More complex motions can be stored with any movement profiles and run at the desired speed.

High feed pressures possible

In practice, alongside the long stroke path and its highly dynamic motion and speed sequences, the relatively low stator power is used for the linear drive in combination with a hydraulic diaphragm metering unit. High feed pressures of up to 400 bar can be achieved with the hydraulic piston-based power reduction. Despite the small piston diameter, the large stroke length makes a useful stroke volume possible. At the same time this means that the piston can be positioned with great precision. This is reflected in the excellent accuracy of the metering flow.

The result is a high-pressure hydraulic diaphragm metering pump, especially suited to small and tiny volume ranges from 0.02 to 18 l/h at up to 400 bar. Its huge volumetric flow adjustment range of up to 1:200, its great positioning accuracy with micrometre precision, its simple control features and high degree of synchronisation make the new pump ideal for a number of applications.
Typical applications include metering additives in the chemical, petrochemical and food industries, gas metering, general filling processes in industry and universal lab applications.

**Individual and optimised to your application**

When metering small and tiny quantities coupled with medium and high pressures you need an individual system or one optimised to your application. So you no longer need to ask: What can the metering pump do? Instead you should be asking: What does the kinematic metering profile need to look like to achieve the perfect metering results? A linear motor with its highly dynamic and precise drive can achieve these requirements for individual adaptation and optimisation.

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![High-pressure hydraulic diaphragm pump with electronically regulated direct linear drive for the most precise metering of 0.02 to 18 l/h at up to 400 bar](source: ProMinent)

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[Source: www.kaeser.com]
Speed-controlled, high-pressure and metering pumps ensure efficient water recycling

Martin Palsa

Water is a precious commodity. This is why industry is increasingly relying on water recycling. Diaphragm technologies are used to remove pollutants and germs from the water, which can then flow back into the utilisation cycle. The water consumption and amount of wastewater can be reduced in this way. Making its reuse worthwhile from both economic and ecological points of view. Speed-controlled high-pressure and metering pumps play an important role in water recycling.
Germany doesn’t appear to have any shortage of water at first glance. According to the German Environmental Agency, we use only about 13% of the 188 billion cubic metres of water available in the country each year in the form of rainwater and rivers. However this figure is misleading, because Germany is, in fact, encountering an increasing number of problems with water. More and more often, it is not available when needed. This is due to a shift in weather conditions: winters tend to be wetter and summers drier. This means that during the summer, competition for the available water increases between the largest user groups consisting of agriculture, industry and the water industry. This imbalance can be redressed only by more intelligent use of water as a commodity. Unfortunately, we still have no reasoned system of water management. It would be sensible, for example, to save the abundant rainfall in winter for times of less rainfall, rather than allow it to go unused. This would require a significant expansion of storage capacities. We already have powerful network pumps for this job.

However, it would also be beneficial to treat and reuse water that has been conditioned and possibly cooled or heated for a specific industrial production process rather than draining it into sewage treatment plants and receiving waters. It could then be used to replenish cooling towers, for cleaning or purging as well as to feed boilers, for example. If water is recycled, this also reduces the quantities of waste water and disposal costs accordingly.

On a global scale, it can be assumed that the demand for industrial water, and thus the wastewater loads, will continue to increase over the coming years, particularly in growth regions. The OECD estimates that the demand for water in industry could increase by up to 400 percent by the year 2050. Resources thus have to be conserved wherever possible.

This could take the form of a bespoke process control in the industrial sector, where the water and energy demand, use of raw materials and recovery of recyclables can be perfectly coordinated with the help of innovative and integrated technologies and management systems. But it could also be through water recycling. Worldwide this can reduce the risk of restrictions or even interruptions to production resulting from insufficient water availability. At the same time, this creates potentials for increasing productivity, without having to rely on additional supplies of freshwater. The Federal Ministry for Education and Research has also recognized this potential and has therefore promoted research and development projects for recycling water since July of 2019.

Variable speed pumps compensate pressure losses and increase the cleaning intervals without reducing the flow rate for the water produced.

Speed-controlled pumps facilitate treatment

Both chemical and physical treatment play an important role in industrial recycling processes. The water is hereby conditioned so that it has the desired pH value, for example.

Furthermore, all particles up to a size of 0.01 μm are also removed, frequently through ultra-filtration. The water is then ready for the final stage: the complicated concentrate treatment.

This process is frequently accomplished using crystallisation or reverse osmosis (RO) in up to three stages. The high pressure and chemical constitution of the water place high demands on the diaphragms as well as on other components such as pipes, valves and pumps. The “Smart RO” concept analyses the data from standard sensors already installed in the RO systems (pressure, temperature and conductivity). The sensors monitor the operation and respond to changes in the diaphragm’s performance. The data can be transferred to the metering pump or a cloud server where it is saved.

All diaphragms clog up with time and therefore require cleaning. The more the diaphragms clog up, the higher the pressure required to treat the water while maintaining the same flow rate. In systems with unregulated pumps without a
drive, the permeate decreases until the flow rate drops below the design value. Variable speed pumps, on the other hand, compensate pressure losses and increase the cleaning intervals without reducing the delivery rate for the water produced.

Metering pumps are frequently used to limit biological infestation, so-called fouling. They are able to transport exact amounts of the necessary chemicals. An integrated system for measuring the flow rate compares the current quantity from the metering pumps with their set value and regulates the metering feed rate accordingly. All of the available variants are based on the same digital metering technology. They offer powerful, variable speed motors, a universal power supply and a full PTFE diaphragm that meets the challenging demands on chemical resistance and durability.

A special feature of the new digital metering pumps is a fundamentally different drive concept using a stepper motor. Whereas conventional, compact metering pumps meter by changing the stroke length and/or by intermittent metering with pauses, these “digital metering” pumps always use the full stroke length. The metering quantity is changed only by the discharge stroke rate.

Stepper motors provide digital metering pumps with an adjustment range of up to 1:3000. This is nearly 30 times greater than the range for conventional metering pumps. And because one type covers a huge performance range (for example 7.5 to 0.0025 ml/h), the number of products and thus spare parts is reduced.

A further advantage is the constant, low pulsation metering rate, providing a significantly higher process quality. No downstream mixing sections are needed. which is particularly
important for water treatment, where it is frequently necessary to add treatment agents to control the pH. The type of metering and additions in the stream of water as well as the fastest possible mixing rate have a crucial influence on the processing results. This is true with regard to both the processing target and efficiency as well as in terms of the statutory principle of minimisation, which prescribes using the fewest additives possible.

Cooling water requires recirculation with a special treatment

Special demands are made on the reuse of cooling water that surrenders the heat it has absorbed beforehand in a process or machine in industrial cooling towers/wet coolers. Four goals have to be taken into consideration here: protection against corrosion, avoidance of deposits (scale), limitation of biological growth (germs, Legionella) and the general minimisation of clogging through solids. If these four aspects are under control, the plant usually runs well.

Biological growth in recooling plants impairs their efficiency, and may even lead to their failure. If nothing else, this can result in hygiene risks for the local population. The use of chlorine dioxide is recommended if an increased number of Legionella are measured: chlorine dioxide kills microorganisms in the water by

If water is recycled, this also reduces the quantities of waste water and disposal costs accordingly.

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Chlorine dioxide is a powerful oxidizing agent used for water treatment. Its main advantage over chlorine or hypochlorite is its gradual effect on degrading biofilm that forms from bacteria and is deposited on walls. Even small quantities of chlorine dioxide destroy this biofilm. Chlorine dioxide can be produced, for example, from diluted solutions of sodium chlorite and hydrochloric acid.

If the concentration of contaminants in the cooling water reaches a certain level, it is necessary for the solids to be discharged (blowdown) and new water (make-up water) to be fed into the system to maintain the water balance. The so-called cycle of concentration refers to the ratio of contaminations or the total content of dissolved solids in the circulating water to the total content of dissolved solids in the make-up water. This is one of the key parameters for regulating the efficiency of a cooling tower.

It is difficult to measure the total content of dissolved solids directly in practice. Instead, the electrical conductivity can be used for the calculation, for example with the DID measurement and control device. This consists of two conductivity sensors (one for the make-up water and one for the cooling water circuit) and a controller. The DID steps in if the cooling water displays a critical content of dissolved
Smooth, low-pulsation metering results in much higher process quality.

solids. A blowdown can thus be initiated automatically and the make-up water valves are activated. The quality of the water therefore remains within the set parameters without any need for a manual intervention. Moreover, the device informs the chemical metering pump of the necessary quantity of biocide to prevent adding too much or too little and keep bacterial growth under control.

Numerous advantages

The demand for fresh water can easily be reduced nowadays by treating used water using efficient filtering and disinfection technologies. This benefits sustainability and cuts costs at the same time. Among other things, recycling water reduces the requirements for heating and cooling (by using temperature differences already present). This, in turn, reduces the required boiler and cooling capacities as well as the pump capacities themselves. Moreover, recycling helps reduce the volume of waste water and thus disposal costs.

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Additive manufacturing enables the production of innovative heating and cooling elements for controlling the temperature of metering pumps

Klaus Lorenz, Ralph Merget und Dietrich Witzler

Additive manufacturing methods are being used in ever more industries because of their immense benefits when compared to conventional manufacturing processes. This also applies to pump technology. In the case of heating and cooling elements, the new technology delivers not only optimal distribution of fluids but also innovative and compact components shorter delivery times and easily installed temperature control devices. Users must be comprehensively trained to recognize the entire bandwidth of possibilities that can be achieved.
Currently, heating and cooling elements for single pumps and small series are usually produced using conventional manufacturing methods. Either by machining components and then subsequently welding them to create hollow bodies or by fabricating from sheet metal and then welding on connection flanges to form the heating / cooling chamber. The time required and the cost are usually considerable in both cases. Furthermore, the design possibilities for the components are limited by these manufacturing processes. There is always a compromise between the function of the component and the ease and cost of its production.

The new additive manufacturing (AM) process delivers with virtually no compromises. Although some small factors need to be taken into consideration with regard to the design these only result in minor limitations. Designers can generally implement the optimum geometry desired for the respective temperature control task. Cross-sections, transitions, wall thicknesses, connection geometries, fixing points – virtually anything is possible. In this way, an ideal fluid flow path can be formed within the component. Consequently, the pump can be heated or cooled in a far more even and consistent way.

In addition to this, in many cases it is possible to directly integrate related components, hence reducing the number of individual parts in an assembly. This results in extremely compact and efficient components that are superior in design to conventional solutions. For this reason, additively-manufactured temperature control devices offer substantial cost benefits for single pumps and small series face to face solutions. A further plus point is that the parts are generally available faster than conventionally-manufactured components. Often, receiving a ready-to-install temperature control device is possible just two weeks after ordering. Here, suppliers utilize CAD solid modeling and implement this for production using advanced CAM software. Various metals can be chosen as materials. Aluminum is the ideal choice due to its good thermal conductivity. But corrosion-resistant steels can also be used for more aggressive environments.

Selective laser melting
Laser-based powder bed fusing of metals (LB PBF), also known as selective laser melting (SLM), is an additive manufacturing process with which complex metal prototypes or serial parts can be quickly produced without tools. For similar reasons it is also used in the manufacture of innovative heating and cooling elements. Components manufactured using the SLM process can also be heat-treated, welded and finished using conventional processes. SLM has become an established manufacturing technology and has achieved a high degree of maturity, with systems available offering various sizes and laser configurations. Various components of the same material can be combined in a single fabrication bed in order to manufacture inexpensive prototypes.

It is very important to use the fabrication bed to the optimum considering design, intelligent construction and laser strategy so that the process chain can be reproduced when manufacturing multiple series parts. Close collaboration with customers from the design stage allows the benefits of additive manufacturing to deliver through the manufacturing process to ultimately achieve the best quality and cost effective components.

Additive manufacturing processes are relatively new and many people are still unfamiliar with them and unable to imagine the benefits they might offer. This is why it is important to inform and educate potential users. Users also need comprehensive consultation and guidance with regard to the manufacture and performance of heating and cooling elements. It is also important that the respective design and engineering teams are trained to recognize the full potential offered by additive manufacturing. Here, the fundamental design guidelines must be conveyed, as must the utilization of AM constructions for increasing the functional integration of...
different components. Together with their customers, suppliers of additive manufacturing methods must identify the components that are most suitable for additive manufacturing. In the best-case scenario, these can be used to develop business cases for the future.

**Heating of metering pumps**

The following example illustrates the heating of a metering pump used for processing adhesives. The difference between conventional production methods and additive manufacturing is explained.

In Figure 1, the pump is heated by a hollow body constructed using two stainless steel rings that have been produced by turning and milling and then welded together. A cylindrical aluminum sleeve is installed between the steel body and the pump to better conduct and distribute heat across the entire pump body. This is fixed to the pump body using two clamping screws. The heating medium inlet and outlet are positioned 180 degrees opposed on the radius of the heating body. This results in the inlet side of the pump being subjected to more heat than the outlet side of the pump.

The Figure 2 shows the same pump, this time with an additively-manufactured heating sleeve made from aluminum. The sleeve is slid onto the pump body and then directly fixed to it using a clamping screw. This enables extremely efficient heat transfer to the pump body. Heating medium inlet and outlet connections are directly adjacent to each other on the radius of the heating element. The pressurized heating medium flows through intricate pathways inside the heating sleeve in such a way that the temperature is evenly controlled and consistent on all surfaces.

**Temperature control for booster pumps**

The additively-manufactured plates also replace a conventional solution for controlling the temperature of booster pumps deployed in polymer processing.

The pump shown in Figure 3 is fitted with conventional heater plates with drilled channels. Here, the drilled heating channel holes must be externally capped using welded-in stoppers to seal the heating medium flow circuit. To achieve sufficient heating channel cross sections using a drilled method, the plates must be considerably thicker than in the case of the additively-manufactured design shown in Figure 4 where flat section heating medium channels can be produced. This new manufacturing method provides significantly improved and efficient heat transfer from the heating plates to the pump.
Cooling seals

In the case of extruder pumps with polymer seals, cooling of the sealing bush influences the desired leakage rate. An additively-manufactured cooling sleeve (highlighted in blue) is employed on the pump shown above. The design is an extremely compact and evenly cools the entire circumference of the sealing bush with an optimal even cooling performance. The assembly is very straightforward and the sleeve is simply slid over the sealing bush and kept in place by means of a fixing screw.

The selective laser melting (SLM) process can be used to produce complex metal prototypes or serial parts quickly and without tools.

Figure 3: Conventional heating plates (dark-gray)
Figure 4: Additively-manufactured heating plates are considerably more compact.
New approach – numerous benefits

Today, manufacturing companies are under considerable pressure. They are obligated to lower their consumption of energy and raw materials, while simultaneously fulfilling increasingly complex construction requirements. Here, additive manufacturing has developed from a valuable support process for making product prototypes into a sustainable, inexpensive industrial manufacturing process that is able to compete with conventional solutions such as casting, forging, fabricating and machining.

As illustrated by the example of the heating and cooling elements, these process offers a completely new approach that has already opened up many new opportunities particularly for manufacturers in high-tech sectors. Aerospace, power generation and automotive plus other sectors where increased technical complexity and rising demands for quality, durability, weight reduction and lower costs are expectations. For more and more industrial sectors the progress made with additive manufacturing is opening up new solutions.

The key to success lies in mastering the entire process chain.
On the one hand, progress has been made on developing the powder(s). On the other hand, the application technology expertise, the available digital tools for component and process planning and the machines and laser systems offered have all been further developed. Additionally, important innovations in the surface finish treatment of additively-manufactured components continue to evolve. The key to overall success is rooted in mastering the integration of entire process chain. Overall knowledge and expertise allows customers to be fully consulted on the manufacture of heating and cooling elements, allowing products to be immediately successful in service.

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Figure 7: A component data set is prepared for 3D printing using special software
## Applications
### Pumps & Systems

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<td>Gather Industrie GmbH</td>
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<td>GEA Group Aktiengesellschaft</td>
<td><a href="http://www.gea.com">www.gea.com</a></td>
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## Applications

- **Water supply/wastewater disposal**
- **Sewage engineering**
- **Construction industry**
- **Overhead irrigation**
- **Irrigation**
- **Well**
- **Drainage**
- **Garden**
- **Groundwater conservation/lowering**
- **Cellar drainage**
- **Sewage treatment plant**
- **Agriculture**
- **Seawater desalination**
- **Drainage, irrigation, lifting stations**
- **Swimming-pool technology**
- **Fountain**
- **Deep well**
- **Reverse osmosis**
- **Water treatment**
- **Mine drainage**
- **Water supply**
- **Hygiene/cleanliness**
- **Biochemistry**
- **Brewery**
- **Dosing technology**
- **Injection**
- **Beverage industry**
- **Cosmetics**
- **Laboratory**
- **Dairy**
- **Food industry**
- **Nuclear power station technology**
- **Odorisation**
- **Pharmaceutical industry**
- **Sample taking**
- **Sterile technology**
- **Industry-/chemical industry processes**
- **Tank, container, barrel**
- **Chemical industry**
- **Draining**
- **Gas dehydration**
- **Gas washer**
- **Industrial technology**
- **Surface treatment**
- **Steel construction and vehicle construction industries**
- **Stone, earth and glass industries**
- **Storage tank installation**
- **Textile industry**
- **Environmental technology**
- **Building applications: heating and cooling**
- **Pressure boosting**
- **Fire-fighting system**
- **Building controls and systems**
- **Refrigeration and air-conditioning engineering**
- **Heat transfer**
- **Energy engineering**
- **Energy generation**
- **District heating**
- **Firing technology**
- **Geothermics**
- **Prime movers**
- **Prime movers**
- **Flue gas purification**
- **Petrochemical; Oil**
- **Oil and petrochemical industry**
- **Off-shore technology**
- **Mining; Metallurgy and rolling technology**
- **Mining**
- **Iron and steel industry**
- **Rolling-mills**
- **Chemical engineering/Process technology**
- **Process engineering**
- **Sugar industry**
- **Oil supply/Hydraulics**
- **Lift manufacturing**
- **Oil hydraulics**
- **Centralized lubrication system**
- **Testing**
- **Hydrostatic (pressure) test**
- **Cleaning**
- **High-pressure cleaning**
- **Pulp and Paper**
- **Paper and cellulose industry**
- **Marine, shipyard technology**
- **Marine, dockyard**
## Applications

### Pumps & Systems

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<th>Applications</th>
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- Lift manufacturing
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#### Pumps & Systems

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<td>ORPU Pumpenfabrik GmbH</td>
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<td>OSNA-Pumpen GmbH</td>
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<td>PCM Deutschland GmbH</td>
<td><a href="http://www.pcm.eu">www.pcm.eu</a></td>
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<td>PF Pumpen und Feuerlöschnotechnik GmbH</td>
<td><a href="http://www.johstadt.com">www.johstadt.com</a></td>
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<td>Ponndorf Geräteotechnik GmbH</td>
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<td>Richter Chemie-Technik GmbH</td>
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<td>SERO PumpSystems GmbH</td>
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<td>SKF Lubrication Systems Germany GmbH</td>
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<td>Spandau Pumpen – Produktbereich der SKF Lubrication Systems Germany GmbH</td>
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<td>SPECK Pumpen Verkaufsgesellschaft GmbH</td>
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<td>SPX Flow Technology Norderstedt GmbH</td>
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<td>ViscoTec Pumpen- u. Dosiertechnik GmbH</td>
<td><a href="http://www.viscotec.de">www.viscotec.de</a></td>
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## Applications
### Pumps & Systems

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Pumps and Compressors for the World Market with Compressed Air and Vacuum Technology 2021
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Frequency of publication
annual

Copyright 2021
VDMA Pumps + Systems
VDMA Compressors, Compressed Air and Vacuum Technology
Frankfurt am Main

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Publishing house
VDMA Verlag GmbH
Lyoner Str. 18
60528 Frankfurt am Main
Germany
Phone  +49 69 6603-1580
Fax  +49 69 6603-2580
E-Mail  verlag@vdma.org
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VDMA Verlag GmbH

Printing
Druck- und Verlagshaus
Zarbock GmbH & Co. KG
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CO₂ heat pumps with turbo compressor are driving forward the energy transition on the district heating network

Rasmus Rubycz

The energy transition will only be a success if sector coupling/integrated energy is successful. The switch to renewable energies is already advanced in electricity generation, but not yet in the heat and transport sectors. Instead of just waiting for new technologies to provide the solution, we should also focus on projects that can be implemented quickly and with limited effort. Using heat pumps in district heating networks is a step in this direction.
Heat pumps can increase otherwise unusable heat from a low to a higher temperature level, so that the heat can be put to good use heating buildings or for industrial processes. The energy source is mainly electricity. If such electricity comes from renewable sources, the widespread use of heat pumps is a possible solution for the urgently needed sector coupling between the electricity and heating sectors. Although renewably generated hydrogen is another solution for sector coupling, it will be some time before it can be used on a widespread basis.

It would therefore be appropriate to focus for the time being on projects that are technically feasible right now. One option is to provide district heating via industrial heat pumps without having to make any changes to the district heating network itself.

**Leveraging existing infrastructure**

In recent decades, many municipalities have built district heating networks that supply a large number of heat customers from a central heat source, usually fired by natural gas or coal. Currently, this accounts for around 14% of the heat supplied to private households. District heating therefore is at third place as a heating source, behind natural gas and heating oil.

Changing over central district heating generation to renewable energies represents a great opportunity to reach a large number of heat users at a manageable cost. However, existing district heating networks cannot simply be retrofitted with a heat pump, as is often feasible for residential buildings. Both the pipes of the heating networks and the transfer points to customers are designed for a certain flow temperature, which is usually between 80 and 140°C. Once in operation, these installations can only be modified with substantial effort. Such high temperatures also cannot be easily achieved with commercially available heat pumps. Another problem is the high heat demand on a district heating network. Depending on the number of connected customer, common peak outputs reach up to hundreds of megawatts.

**CO$_2$ heat pump with turbo compressor required**

A tailor-made solution is required in each case to meet the demands placed on a large heat pump for performance, reliability and efficiency. Natural, low-cost refrigerants with low global warming potential (GWP) should also be used whenever possible. Ammonia and carbon dioxide (CO$_2$) are particularly suitable operating media for the high temperatures required,

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Fig. 1: Schematic of a transcritically operated CO$_2$ heat pump for large outputs. Source: Atlas Copco
while maintaining good efficiency. These two naturally occurring refrigerants are non-critical for the environment. Both substances are also relatively cheap and available. Using CO₂ – the "climate killer" – as a refrigerant may initially seem counter-intuitive. In fact, however, the gas can help reduce further CO₂ emissions by being used as a refrigerant in the closed loop of a heat pump.

**The Coefficient of Performance (COP) describes how much environmental heat can be provided in addition to the electrical drive power that is used.**

In addition to selecting the right refrigerant, a suitable mechanical compressor concept is also important. While heat pumps of lower capacity are typically equipped with scroll, reciprocating or screw compressors, the high outputs on a megawatt scale make it necessary to use a turbo compressor. It is at this point that CO₂ is the clear choice as refrigerant. Given its high molar mass and density, CO₂ is much more suitable for use in turbo compressors. The machines can be made much more compact and with fewer compression stages compared to ammonia. However, the high pressures generated during the compression of CO₂, which are well above 100 bar, add complexity. Fig. 2 illustrates the different thermodynamic cycles of CO₂ and ammonia with the same ordinate scaling. It shows the significantly higher pressure level of CO₂ achieved with significantly fewer compressor stages. CO₂ also becomes supercritical above the critical point, so that the heat pump is then "transcritically operated" (transritical operation).

Supercritical fluids are compressible, but have the density of a liquid. This provides a number of special properties for technical applications. Firstly, the power density per volume increases significantly – piping, valves and heat exchangers can be designed many times smaller. Secondly, the heat output of the heat pump is not via latent condensation of a gas, but via sensible cooling. If the medium on the other side of the heat exchanger is water, for example, heat utilization is then optimal in counterflow operation. Condensing ammonia, on the other hand, gives off its heat at a high, continuous temperature, resulting in a high temperature gradient, which reduces the overall efficiency of the heat pump. To achieve high efficiency, the temperature gradient should be as low as possible.

![Fig. 2: The compression of CO₂ reaches higher pressures than ammonia with fewer compression stages.](source: Atlas Copco)
Deployment in a typical metropolitan district heating network

Theoretically, then, there is much to be said for converting district heating networks to renewable energy sources, such as environmental heat by using heat pumps. As part of a case study, Atlas Copco Gas and Process, as a turbomachinery manufacturer, investigated the use of a heat pump in a typical metropolitan district heating network. Currently, many municipal utilities supply district heating customers with heat from cogeneration plants that are predominantly fossil-fueled. Natural gas is used as fuel in approximately 42% of the plants, and coal in 25%. Modern natural gas-fired heating plants emit around 150 g CO$_2$ per kWh of district heating, while older coal-fired heating plants emit 300 g/kWh or more. The average for Germany as a whole is approximately 270 g/kWh.

For high outputs on a megawatt scale, heat pumps have to use a turbo compressor.

To supply the district heating network of a large city with a heat pump, one needs to start by finding a suitable heat source. Small heat pumps extract the required energy from the ambient air or the ground. However, this is not nearly enough for the high outputs required in a large city. It helps in this regard that the cogeneration plants in many large cities are located on rivers. When heating was primarily obtained from coal, it used to be delivered by ship. These rivers and canals are ice-free even in winter, because cooling water and wastewater are discharged into them. These rivers are a year-round source of ambient heat that can be tapped without much technical effort. Another usable heat source is the wastewater from the sewer system. The heating network of a typical large German city requires several hundred megawatts of heat output at up to 140°C flow temperature at peak load times in winter. The flow temperature must still be guaranteed, even when using a heat pump. The major rivers in Germany all have a temperature in winter that makes this possible.
Useful CO₂ in the heat pump “compander”

A heat pump system in the case study was designed in several identical blocks for the purpose of reliability of supply and of scalability. A thermal output of 50 MW was found to be a technically feasible size. Given the compressibility of supercritical CO₂, the gas was able to release any remaining energy in a turbine stage after the heat had been released. It was possible to use this energy directly to relieve the turbo compressors without any further conversion losses.

Integrating a turbine stage poses design challenges for conventional turbocompressors with a continuous rotor shaft and several stages arranged in series. The integral gear design, in which several compressor stages are arranged around a central gear, is therefore ideal for this purpose. Each stage has its own housing, so the turbine stage can be placed at any point. This type of compressor and turbine is also known as a “compander”, which is a portmanteau of the terms “compressor” and “expander”.

The Coefficient of Performance (COP) is an important parameter for heat pumps. It describes how much ambient heat can be provided in addition to the electrical drive power that is used. The COP is significantly influenced by the temperature difference and is usually between 2 and 6. This means that, for every kWh of electrical energy used, two to six times the ambient energy can be added to the usable heat. The heat pump considered for a typical municipal district heating network has a COP of 2.5. At first glance, this seems low, but it is substantial, when you consider the temperature range of this application. The system had to raise the environmental heat from 1 - 5°C river water to approx. 80 - 140°C flow temperature.

Benefits for the environment

A major city such as Cologne consumes 1 500 GWh of district heating per year; Flensburg consumes 1 000 GWh; the Rhine-Neckar region around Mannheim consumes around 2 200 GWh. On average, the typical large German city emits around 500 000 tons of CO₂ via district heating generation. However, if the district
heating is provided by a heat pump that uses electricity generated from renewable sources, there are no CO₂ emissions. The emissions generated during the production of wind turbines and solar modules are correctly included in the CO₂ balance of the electricity, however, which is on average about 25 g/kWh. At a COP of 2.5, the CO₂ emissions from operating the heat pump therefore amount to approx. 15 000 tons per year. The bottom line is a huge CO₂ saving of 485 000 tons per year – almost 5% of Cologne’s annual CO₂ emissions.

Implementation takes time

Comprehensive conversion of district heating to heat pumps would have an enormous impact and would not even impose high investment costs on end consumers. The fact that such an advantageous solution is not yet in use on a large scale has to do with the fact that the existing fossil-fueled plants are still quite modern. Many local district heating utilities have invested enormous sums in high-efficiency combined-cycle powerplants over the past two decades to replace aging plants. They need to see a return on these investments before considering spending money on better technology. Heat pumps could get a major boost from the political environment. The CO₂ tax introduced at the beginning of the year will gradually increase the price of electricity from fossil-fueled power plants. This should increase the willingness in municipalities to look at alternatives sooner rather than later.

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Compressors are key elements in building an efficient hydrogen economy

Beat Frefel

Hydrogen plays a key role on the path to a decarbonised future. However, building the hydrogen infrastructure is a gigantic task. Powerful compressors with high-energy efficiency and the ability to compress high pressures are indispensable at all stages. However, compressors must also become much cheaper. Therefore, new concepts and the possibility of standardisation and modularisation are needed in order to be able to reduce manufacturing costs through scaling effects. With hermetically gas-tight compressors that work with higher inlet pressure, investment and operating costs can be saved.
The EU and the USA want to be climate neutral by 2050. So do many other countries. The transformation process began long time ago. The basic technologies are available. They must be further developed. Above all, however, large-scale industrial deployment must be tackled now. The buzzwords are modularisation, serial production, decentralisation, scalability. As a result, costs will drop considerably. For example, the study “Path to hydrogen competitiveness” published in 2020 predicts that if the production of fuel cells is increased from 10,000 to 200,000 units, a cost saving of 45 percent will be possible. The production of green hydrogen is expected to drop by 60 percent by 2050 thanks to drastically lower prices for renewable energies. The cost reductions will be achieved primarily through scaling effects in production and through an increase in output and capacity. Hydrogen can thus advance to become the energy carrier of the future.

All the more since its potential usage in mobility and industry, as well as for heating and power generation, is almost unlimited. With hydrogen, solar energy from the summer can be stored and then used in the winter. There are also interesting new applications for hydrogen in the future in connection with emergency power supplies. Hydrogen will play a central role as an energy carrier in the future. However, the infrastructure needed for this, from production to storage to transport, still has to be built. The technology already exists. The most important factor for the environment is that the hydrogen is produced with renewable energy sources.

Hydrogen will play a central role as an energy carrier in the future.

Two dominant production processes

Hydrogen can be found on earth almost only as a bound - with oxygen as water, in organic compounds or as methane in natural gas. It is produced by breaking down the compounds into their components in a chemical reaction. There are various ways to do this. The most commonly used processes are hydrogen steam reforming and the electrolysis of water. Each process has different requirements for the used compressors.

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### Fig. 1: The hydrogen economy at a glance

**Renewable energy sources**
- Photovoltaics
- Wind energy
- Hydropower
- Biomass and waste
- Various energy sources (geothermal energy, wave energy, etc.)

**Hydrogen generation**
- Electrolysis
- Steam reforming
- Partial oxidation
- Plasma process
- Various types of generation (algae etc.)

**Storage and transport**
- Compressed gas storage in the natural gas or hydrogen network and in compressed gas cylinders
- Compressed gas storage underground (caverns)
- Cryogenic liquid gas storage
- Chemical storage in liquid form (LOHC, ammonia)
- Chemical storage through the generation of synthetic fuels (power-to-liquid)

**Hydrogen applications**
- Mobility and logistics
- Heat and thermal power applications in buildings and industry
- Industrial applications for the production of plastics, ammonia, steel, in refineries, etc.
- Power stations and generator groups for cross-regional power generation
- Emergency power supply

Source: HAUG Sauer
Hydrogen steam reforming

The feedstock for this type of production is natural gas or biogas, but other long-chain hydrocarbons or solid or liquid biomass can also be used. However, biomass must be first converted into a gas through pyrolysis. In steam reforming, a two-stage chemical reaction of water vapour and hydrocarbons at high temperature and pressure of about 25-30 bar(g) first produces a synthesis gas, which is then upgraded to hydrogen and purified. The process of low-pressure steam reforming with downstream gas purification is relatively new.

APPLICATION EXAMPLE 1:
The new process for low-pressure steam reforming was developed in Italy and used in a pilot plant. It is an on-site hydrogen production plant with a capacity of 250 kg hydrogen per day. The plant is modularly scalable. At atmospheric pressure, a gas mixture of natural gas or biogas and water vapour is fed into a reactor.

Piston compressors compress hydrogen most efficiently.

A chemical reaction produces a hydrogen-rich synthesis gas mixture, which is then dried and purified into high-purity hydrogen in a pressure swing adsorption process. After low-pressure steam reforming, the synthesis gas is compressed for downstream gas purification by an oil-free piston compressor with a magnetic coupling. The hermetically gas-tight design has significant advantages in terms of plant design and explosion protection.

Water electrolysis

There are three variants: alkaline or acid electrolysis, PEM electrolysis and steam electrolysis.

In alkaline electrolysis, water is separated into hydrogen and oxygen with potassium or sodium hydroxide solution in an electrolyser with direct current. As an alternative to the alkaline solution, an acid can also be used as a conductive medium. The operating pressure of the electrolyser varies between atmospheric pressure and 30 bar(g).

In the PEM electrolyser, distilled water is separated into hydrogen and oxygen by means of an electric current. The ionically conducting liquid is replaced by an ion-conducting membrane - hence the name PEM electrolysis for “polymer electrolyte membrane” electrolysis. PEM electrolysers can work both as a fuel cell and as an electrolyser and are therefore very well suited for sector coupling. The operating pressure is between 10 and 30 bar(g).

After electrolysis, a hydrogen booster compressor is needed to store the hydrogen in the gas pipeline network or to refuel it at a filling station. The higher the operating pressure of the electrolysis, the smaller the required compressor and the lower the energy demand.

APPLICATION EXAMPLE 2:
In 2019, the gas manufacturer Air Liquide opened a new hydrogen filling station on a Public Access section of the Henkel site in Düsseldorf. The compressor used for this compresses hydrogen in two stages from 15 to 60 bar(g) into an intermediate storage tank. A hermetically gas-tight, oil-free piston compressor is used for this purpose. This has considerable cost advantages in the electrical design of the entire plant. The maximum capacity of the compressor is
660 kg of hydrogen per day. Downstream, two hydraulically driven compressors compress to the hydrogen filling station’s maximum storage pressure of 900 bar(g).

APPLICATION EXAMPLE 3:
In the hydrogen demonstration project Lhyfe in Nantes on the French Atlantic coast, hydrogen is produced in an electrolysis process using electricity from wind energy. The hydrogen is then compressed with a piston compressor, stored and made available as fuel at hydrogen filling stations for buses. The compressor compresses the hydrogen in 5 stages from a slight gas over-pressure of 0.2 bar(g) to 350 bar(g). For this purpose, an oil-lubricated piston compressor with downstream gas purification is used, which ensures a residual oil content of less than 0.01 mg/m³ hydrogen. The production capacity of the hydrogen production for the first phase, which will go into operation this year, is 300 kg of hydrogen per day. It is planned to expand hydrogen production to 40,000 kg per day by 2023.

Steam electrolysis is a new process in which steam and CO₂ react in a high-temperature electrolysis to form a synthesis gas. This gas contains hydrogen and carbon monoxide. Synthesis gas can be used for energy purposes or as a chemical raw material.

APPLICATION EXAMPLE 4:
The water vapour electrolysis from the company Sunfire was used in the research project Kopernikus at the Institute for Micro Process Engineering of the KIT in Karlsruhe in a pilot project for the production of synthetic fuels. In this high-temperature electrolysis, a hydrogen-rich synthesis gas is formed from water vapour and carbon dioxide. An oil-free and hermetically gas-tight compressor with a magnetic coupling compresses the synthesis gas to a maximum of 60 bar(g) for the following Fischer-Tropsch process, where the gas mixture is converted into long-chain hydrocarbon chains. In a further process step, the hydrocarbon chains are “trimmed” with the help of catalysts (hydrocracking). They are then transformed into either synthetic aircraft fuel or petrol. The entire process has a high-energy efficiency of 60 per cent. The pilot project produces 10 litres of synthetic fuel per day. In the follow-up project, several thousand litres per day are to be produced from 2025.

Hydrogen storage
The hydrogen economy only works if the gas is available in sufficient quantities wherever it is needed. For this, it must be stored after production. This is done either through gaseous storage in pressure vessels or pipelines; or in liquid form at a temperature of -252 °C; or in chemically bound form in oil or as ammonia. Compressors and pumps are always key components in hydrogen storage.

In the relatively new method of LOHC (Liquid Organic Hydrogen Carrier) storage, hydrogen is chemically stored in oils. The carrier oil is easy and safe to transport. The energy content of the loaded LOHC liquid corresponds approximately to the energy content of a 700 bar(g) pressure bottle with hydrogen. The chemical bonding of hydrogen takes place via a catalyst in a continuous process at 30 bar(g) in an exothermic reaction by releasing 9 kWh of thermal energy per kilogram of hydrogen. For the release of hydrogen in a chemical reaction, 11 kWh of thermal energy per kilogram of hydrogen with a temperature of 200-300 °C are needed. The release takes place close to ambient pressure. A compressor then compresses the hydrogen to the desired application pressure.
APPLICATION EXAMPLE 5:
Hydrogen is chemically stored and transported via the LOHC process. The hydrogen is supplied at a slight overpressure of about 0.5 bar(g). A compressor compresses the hydrogen to 10 bar(g) for purification in a PSA (Pressure Swing Adsorption) system. Afterwards, a second compressor compresses to a pressure of 47 bar(g)
into an intermediate storage tank as feed pressure for a compressor that further compresses the gas for refuelling. This pilot plant is located in Erlangen. The maximum capacity is 50 kg of hydrogen per day. This plant can also be enlarged in a modular way.

Energy consumption and energy efficiency of compressors
Piston compressors are best suited for the compression of hydrogen because they are the most efficient due to the positive displacement principle. Piston compressors also have relatively small mechanical energy losses. They store the changing energy demand due to the oscillating stroke movements via a built-in flywheel.

How much compressor energy is needed for the compression of hydrogen depends on its construction and the design for the respective operating case. For example, the energy requirement for a 1-stage compressor compressing from 30 to 70 bar(g) is only about two percent of the energy value of the compressed hydrogen. In comparison, the energy demand of a 5-stage compressor compressing from atmospheric pressure to 350 bar(g) is about twenty percent of the energy value of the compressed hydrogen. This shows the positive influence of the inlet pressure on energy efficiency.
Summary

The development of a hydrogen infrastructure requires truly enormous efforts and the use of various technologies that are optimally coordinated and used appropriately. The total costs of the infrastructure for production, transport and storage must be significantly reduced. This is possible through standardisation, modularisation and the pursuit of concepts that coordinate the systems. Keywords here are sector coupling and cross-period energy storage. On the one hand, massive investments must be made in large-scale projects and in a basic infrastructure, but on the other hand also in local, decentralised systems. Compressors have a key role to play in building the infrastructure. The overall efficiency of compressors is influenced by their design and by their mode of operation. The design and specification of inlet and discharge pressures are also linked to this. Whether a compressor is hermetically gastight has an influence on the safety assessment and thus also on the investment costs of the overall system. Some applications related to catalytic converters and fuel cells require high hydrogen purity, making oil-free compressors preferable or necessary based on the risk assessment. In applications where gas quality is not a critical issue, oil-lubricated compressors with subsequent gas purification can be used. Finally, in addition to the investment and energy costs, the maintenance costs of the machines are also decisive in the long term. Due to the volatility of hydrogen and the high compression pressures, the maintenance intervals of the sealing elements are of particular importance.

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<td>Volumetric efficiency</td>
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<td>The smaller the piston stroke and the smaller the cylinder diameter, the greater the relative dead volume. Especially at high final pressures and at high-pressure ratios, the volumetric efficiency decreases.</td>
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<td>Dead space volume</td>
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<td>Thermodynamics</td>
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<tr>
<td></td>
<td>Compression ratio</td>
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<tr>
<td>Pressure ratio</td>
<td>Thermodynamics</td>
<td>Due to thermodynamics, compression should take place in several stages with a small stage pressure ratio.</td>
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<td>Compression ratio</td>
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<td>Internal leakage</td>
<td>Piston rings</td>
<td>The amount of leakage is strongly dependent on the differential pressure and the design of the components, especially the suction and pressure valves, as well as the piston rings and sealing elements.</td>
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<td>Compressor valves</td>
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<tr>
<td>External leakage</td>
<td>Drive</td>
<td>Leakage occurs via the sealing of the drive shaft and via the stuffing box packing for sealing the piston rod. Compressors with a drive via magnetic coupling or with built-in motor have no external losses.</td>
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<td>Sealing elements</td>
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<td></td>
<td>Piston rod seal</td>
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<tr>
<td>Mechanical losses</td>
<td>Friction</td>
<td>The friction losses of the moving components and the flow losses of the compressed gas lead to mechanical losses in the compressor. A lack of flywheel mass leads to losses because the oscillating kinetic energy is not sufficiently stored.</td>
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<td></td>
<td>Flow losses</td>
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<td></td>
<td>Means of energy storage</td>
<td></td>
</tr>
<tr>
<td>Electrical losses</td>
<td>Efficiency of components</td>
<td>These losses depend on the electric motor and compressor control.</td>
</tr>
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</table>
Digitalisation ensures a more reliable supply of compressed air for the pharmaceutical industry

Dr. David Bruchof

The pharmaceutical industry works to very high safety standards. The compressed air required in many of its processes must be absolutely clean. This is why it is prepared in more than one airend. Oil-free condensing compressors offer certain advantages here as they provide clean air as early as the preparation stage, which means preparation involves less work. Thanks to a new drive, a newly developed oil-free screw compressor is able to increase efficiency. It can also be upgraded if additional compressed air is required. This saves both space and time.
The timing of this new development could hardly be better. During the approval processes for vaccines against the new coronavirus, pharmaceutical companies worldwide were already gearing up to manufacture vaccine doses in huge quantities. Fast implementation is required, now the first approvals have been granted – there is simply no time for lengthy advance planning or the construction of completely new production facilities. Large volumes of vaccine also mean large volumes of additional compressed air. The new oil-free compressor is a godsend for pharmaceutical companies in this situation.

**Digital control**

Digitalisation of the drive is at the heart of the new development. In collaboration with suppliers, a high-speed permanent magnet motor has been developed, along with a tailored frequency converter that supports precisely controllable speeds of up to 22,000 rpm at an efficiency level significantly in excess of the IE4 efficiency standard. Each airend is driven by a separate and independently controlled motor. And the electronics in the frequency converter are responsible for synchronisation. Thanks to this electronic control, it is now possible, for the first time, to dispense with a mechanical gearbox, which drains energy from the system and requires lubricants. The result is an oil-free compressor with a higher power density. It is also more compact and weighs less.

This digital drive concept has also made it possible to directly and independently drive the low-pressure and high-pressure airen ds, with their high-precision screws - with the result that the compression ratios for both airen ds are optimally tailored to each other at any time and at any operating point. The constant maximum efficiency achieved this way helps reduce energy costs by up to 13 per cent. The result being the problem of unused energy when speed-controlled compressors are off load has also been significantly reduced. Off load, the new compressor uses up to 45 per cent less power than conventional two-stage compressors.

Apart from the energy efficiency achieved, this digitalisation of compressed air generation also brings with it another specific benefit: there is the option to upgrade power at a later date. If the compressed air requirement increases over time, this compressor can be upgraded to the desired capacity within the available rated power range of 75 kW to 160 kW. Not only is this much more economical than investing in a larger or additional compressor, it also avoids downtime, long delivery periods, installation

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Source: CompAir
costs and the need to find extra space. All these factors play a significant role in supplying the world’s population with a vaccine.

**Innovative cooling concept**

The innovative cooling concept behind this new compressor technology is changing basic perceptions of the energy profile associated with oil-free compressors. Generally over 90 per cent of the energy used by compressed air compressors converted into heat, therefore it is a case of creating the right conditions to exploit this (waste) heat. As part of the new development, a closed internal cooling circuit was devised, which draws heat directly from wherever it arises – such as the motors, the frequency converters and the compressor block. This leads to a decisive improvement in the heat profile compared with the two-stage oil-free compressors usually found on the market.

The compressor’s patented closed cooling system makes it possible to exploit the waste heat arising during compression with a view to generating hot water for process purposes at usable temperatures of up to 85 °C. Now, for the first time, this is possible for both water-cooled models and air-cooled models. This can pay dividends in the pharmaceutical industry, which has a high requirement for process heat, at various temperature levels, for its numerous production processes. This ranges from room heating to, say, supplying jet mills. If desiccant dryers are used to reach an optimal pressure dew point for compressed air, part of the waste heat may also be used to regenerate the desiccant.
Significant cost benefit

As this is the first air-cooled oil-free compressor that can reclaim up to 98 per cent of the heat generated during compression – for the purpose of generating hot water for processes – a comparison of operating costs is only possible with the air-cooled oil-free compressors currently on the market. Calculations based on different conditions of use have shown, when the new technology is used to its full potential that annual operating costs of 40,000 to 80,000 euros can be saved if this heat reclamation is exploited to the maximum.

With the new oil-free compressor, the reclaiming of heat for the generation of hot water for process purposes at up to 85 °C is also possible in the air-cooled version. This was not previously possible with air-cooled oil-free compressors.

As a result, conditions are met for claiming assistance with investments under the programme known as ‘Energy Efficiency and Process Heat from Renewable Energies in the Economy’ from the Federal Office for Economic Affairs and Export Control (BAFA), which covers both support for highly-efficient compressors with speed control and also heat exchangers for the reclaiming of heat in compressed air generation systems. This is because the new oil-free compressor helps businesses achieve their production-related sustainability goals: greater energy efficiency, fewer CO2 emissions, and savings in terms of resources. It, therefore, becomes possible to calculate the Product Carbon Footprint (PCF) in relation to compressed air generation. For the pharmaceutical industry in particular, it is also important that compressors are produced in accordance with the rules of Good Manufacturing Practice (GMP), which guarantee a high standard of quality assurance through for example thorough documentation and preventive maintenance.
Extremely compact and quiet

The economic benefits of this largely plug-and-play installation for these compact machines are also evident in the pharmaceutical industry. If connected to a water cooling circuit, they do not require any time-consuming installation of air ducts. As they take up 37 per cent less floor space than conventional oil-free compressors, they save valuable space. This means retrofits and upgrades in compressed air stations can also be performed where space is limited. Another benefit is the noise level of just 69 dBA – another result of the compact gearless design.

Thanks to the electronic control, it is now possible, for the first time, to dispense with a mechanical gearbox, which drains energy from the system and requires lubricants.

Numerous compressed air applications

There are no specific statutory conditions for the compressed air used in pharmaceutical production settings. Medicine manufacturers are, therefore, responsible for defining the compressed air quality for the various production areas in a way that ensures compliance with the strict provisions applicable to medicines. Typical uses of compressed air in the pharmaceutical industry include:

- Compressed air as process air or conveying air for blowing out bottles and ampoules in the sterile area following cleaning with compressed air
- Compressed air for mixing, sieving, and bottling
- Compressed air for filtering hormones
- Compressed air for milling and micronisation of high-quality powders (air-jet milling/contract micronisation)
- Compressed air as control air for pneumatic valves used in laboratory equipment
- Compressed air as purging air at bearing seals
- Colour coating of tablets

High levels of customer satisfaction

This new oil-free compressor is already being used in many applications at pharmaceutical companies. Apart from efficiency, customers mainly appreciate the flexibility the compact unit brings to their production and the way they can quickly integrate it into their pressure management system. In short, the design offers a lot of freedom from a production perspective. The new compressor is the only one on the market in which the low-pressure and high-pressure airends are driven and controlled separately without being connected by a gearbox. Many customers see this as a benefit as much greater efficiency is achieved in the intermediate and partial load range. The separate drive ensures that both compressed air airends are always running at optimum speed, even when there are fluctuating load requirements.

Author:
Dr. David Bruchof
Product Manager Europe Oil Free Screw Compressors GDL CompAir, Simmern

Fig. 4: The new compressor technology generates oil- and silicon-free compressed air for the requirements of Class 0 in accordance with ISO 8573-1.
DAS NETZWERK FÜR INTELLIGENTE PRODUKTION

www.future-manufacturing.eu
High-performance vacuum technology and reliable leak detection improve the efficiency of solar power plants

Dr. Rudolf Konwitschny

In the context of the worldwide focus on renewable energies, the use of solar energy is also coming increasingly to the fore. The power of the sun can be used to generate not only electricity, but also heat. Solar power plants are thus increasingly helping to draw the heating sector into the energy revolution. Vacuum technology plays an important role here, because in addition to ensuring more environmental protection, it also facilitates greater economic benefits.
Large-scale solar power plants are ideal for regions all over the world that have a high level of direct solar radiation. One of the largest projects of this kind was the Desertec initiative, which sought to generate electricity from a huge area in the Sahara and transfer it to Europe and other locations. In the meantime, the focus has shifted from transmitting electricity to producing hydrogen on site and then exporting it. Although this is still just a project here, it has already been successfully implemented elsewhere. Large solar power plants have been in operation for some time in Spain, Morocco, California and Arizona. More recently, such plants have also been installed in India, Israel, and on the Arabian Peninsula, as well as in Australia, South Africa and China.

**Parabolic troughs dominate**

Solar radiation can be concentrated and thus made usable with the help of various technologies. Most installations today, however, use parabolic troughs. In a solar thermal parabolic trough power plant, trough-shaped mirrors reflect the incident solar rays onto an absorber tube, the so-called receiver, that runs along the focal line of the mirrors. A heat transfer fluid, such as a thermal oil or molten salt, runs through the tube. The coupled receivers, which are connected in series, transfer the fluid to the steam turbine in the system’s power plant. Additional heat collectors in the power plant can compensate for sudden fluctuations in solar radiation and thus ensure operation even at night.

This makes a solar thermal power plant with heat storage manageable, since energy production can be adjusted to the consumption rate or grid load. Parabolic trough technology has been tried and tested over many years and is characterized by a high degree of efficiency, excellent reliability and comparatively low electricity generation costs.

**The thermos flask principle**

Vacuum plays a decisive role in parabolic trough power plants, because it can be used to improve their efficiency. Parabolic troughs sometimes achieve collector efficiencies of more than 80 percent. The receiver must be evacuated, i.e. be free of air, to prevent it from immediately losing the heat it has absorbed. The receiver consists of an outer glass tube and an inner steel tube. Flexible bellows are used to compensate for the different linear expansion of glass and metal under changing temperatures. The steel tube through which the heat transfer fluid flows needs to be insulated in a way that does not restrict the solar radiation. This is achieved with vacuum insulation, following a similar principle to that of a thermos flask. Losses in radiation and convection are considerably reduced thanks to the special coatings of the two tubes and the use of special glass that allows good transmission of solar light. Evacuation takes place at a high temperature in a furnace where the typically 4- to 5-meter-long receivers are connected to the pump station. The connection to the pump is achieved via a connection nipple. From a vacuum technology perspective, the diameter of the nipple must be as large as possible in order to minimize the loss of pumping power caused by flow resistance (conductance loss) during the evacuation process.

Parabolic trough technology has been tried and tested over many years and is characterized by a high degree of efficiency, excellent reliability and comparatively low electricity generation costs.
However, the glass nipple still has to be melted down in order to hermetically seal the receiver tube. A compromise has to be made regarding the nipple dimensions, and this limits the effective suction capacity at the nipple and results in comparatively long process times during the thermal treatment. In this process step, the surface of the receiver material is degassed in order to minimize the emission of gas from the surfaces of the glass and the steel tube (gas desorption load) during long-term operation.

**Stable pressure is imperative**

To achieve an insulating effect, heat transmission via convection must be prevented. For this reason, air, which acts as a heat transfer medium, is pumped out. Heat loss can then only occur via radiation, which transfers far less energy than convection. In practice, this is achieved at pressures below 10⁻³ mbar. Consequently, the specified pressure must be maintained throughout the entire lifetime of the receiver. In addition, the introduction of gas, due to permeation through sealing materials, desorption from the walls, or through leaks, needs to be minimized.
There is a wide range of possible solutions for generating the required vacuum in the receiver. For example, specially adapted turbopumping stations are used for evacuating the receiver tubes, which represent a technical vacuum optimization and can also be geometrically adapted to fit into the production facilities.

An example of an adapted pump group is shown in Figure 2. The components are selected not only for their technical vacuum parameters, but also for their high resistance to glass particles after the possible breakage of a receiver tube and the associated high force applied to the pumps after this sudden ingress of air.

**Maximum possible leak tightness**

The receiver manufacturers need to be able to guarantee the insulation for a period of at least 20 years in order to maintain efficiency during power plant operation. Since, depending on the power plant capacity and design, a large number of receivers are connected in series, changing them during operation involves enormous effort and high costs. One hundred percent leak tightness is technically impossible to achieve. The permissible amount of leakage must therefore be determined along with the extent to which the original pressure upon delivery has to be lowered in order to compensate for the corresponding pressure increase expected over a defined period of time.

The requirements for the maximum permissible leakage rate $Q_L$ result from the projected service life $\Delta t \ [\text{s}]$ of the receiver, the maximum permissible pressure increase $\Delta p \ [\text{Pa}]$ and the free internal volume of the receiver tube $V \ [\text{m}^3]$ in the glass outer tube. As already mentioned, attempts to achieve the lowest possible pressure are limited by the geometry of the receiver and by the flow resistance of the pump nozzle, whose diameter is rather small from a vacuum technology point of view.

The molecular flow conditions in the high vacuum extend the pumpdown times required to reach lower pressures. Thus, the pressure achieved in the receiver represents a functional compromise between the theoretically achievable pressure and the permitted cycle time in production.

The restrictions regarding the leakage rate and final pressure may also necessitate the use of a getter material that will bind gas molecules and keep the pressure low. This still leaves us with the challenge of ensuring, in the production stage, that the insulating vacuum in the receiver can be maintained throughout its entire service life. This leak-tightness requirement is checked with a helium leak detector. Helium is an inert noble gas. It does not react with other substances. Other advantages are that helium is non-toxic, non-explosive and relatively inexpensive. This means that it poses no danger to operating personnel and, as a natural component of air, is not harmful to the environment either.

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Reliable measurement method

Helium is present in air, with a natural concentration of 5 ppm. For highly accurate measurements, the residual helium component of the air in the test chamber must be evacuated in order to produce the lowest possible background signal. For conclusive verification of the maximum permissible leakage rate, the background signal must be at least half a decade below the defined leak-tightness requirement.

The receiver manufacturers need to be able to guarantee the insulation for a period of at least 20 years in order to maintain efficiency during power plant operation.

Vacuum offers many advantages

The evacuation of solar receiver tubes is a compromise between the requirements of vacuum technology and glass processing technology. Special pumping stations are used to ensure optimum vacuum performance combined with

The challenges involved in creating a test system for receiver tubes lie in adapting the system to the cycle times used for testing during production, and in the technical, vacuum-related problems arising from the difficult geometry of the test object and the adapters with regard to the pump system and test conditions. Also, in the case of measurements as sensitive as these, outgassing effects from the receiver materials must be taken into account, as well as dead volumes, caused by valve connections, for example.
a high degree of robustness and protection in the case of glass breakages. Testing the receivers during production to detect leaks presents a major challenge. When designing industrial leak detection systems for integration into modern production lines, full automation is important in ensuring high process consistency and reliability. The complex physical relationships involved must also be taken into account in order to meet the high quality requirements and to achieve reproducible results.

Author:
Dr. Rudolf Konwitschny
Leak Detection Application Team
Pfeiffer Vacuum GmbH, Aßlar
## Applications

### Process & Compressed Air Technology

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Pumps and Compressors for the World Market with Compressed Air and Vacuum Technology 2021
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# Applications

## Process & Compressed Air Technology

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### Applications

**Process & Compressed Air Technology**

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<th>Food industry</th>
<th>Packaging (except Food)</th>
<th>Laboratory</th>
<th>Cleaning (Purging)</th>
<th>Oil/Gas</th>
<th>Natural gas industry</th>
<th>Petrochemical industry</th>
<th>Refineries</th>
<th>Biogas</th>
<th>Gas stations (natural gas, LPG)</th>
<th>Workshops</th>
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<th>Garages</th>
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<th>Mechanical engineering</th>
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Applications

Process & Compressed Air Technology

- Hygiene
- Breweries
- Medical technology
- Food industry
- Packaging (except Food)
- Laboratory
- Cleaning (Purging)
- Oil/Gas
- Natural gas industry
- Oil fields
- Petrochemical industry
- Refineries
- Biogas
- Gas stations (natural gas, LPG)
- Handicrafts/Workshops
- Workshops
- Handicrafts
- Garages
- Pneumatic
- Mechanical engineering
- Switchgear
- Control air
- Instrument air

Chemical industry

- Chemical industry
- Fertilizer production

Construction/Woodworking/Textile

- Construction
- Woodworking and processing
- Textile industry

Storage and transport

- Filling systems
- Silos
- Bulk handling
- Pneumatic dispatch blowers

Sewage plants

- Sewage plants
- Aerating

Foundries/Wind channels

- Foundries
- Wind channels
- Blast furnace blowers
- Coke oven blowers
- Oil field blowers

Paint plants/Sand blasting plants

- Paint plants
- Sand blasting plants

Vehicles and Navigation

- Railway vehicle
- Road vehicle
- Navigation
- Starting of engines and power units

Other fields of applications

- Drying
- Drives
- Heat recovery
## Applications

### Vacuum Technology

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1. (Metal Degassing, Melting, Re-melting, e-beam welding, casting, ...)
2. (Brazing, Carburising, Nitriding, Quenching, ...)
3. for Semiconductor including focused ion beam systems and electron beam systems

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Pumps and Compressors for the World Market with Compressed Air and Vacuum Technology 2021
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# Applications

## Vacuum Technology

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1. [Metal Degassing, Melting, Re-melting, e-beam welding, casting, ...]
2. [Brazing, Carburising, Nitriding, Quenching, ...]
3. for Semiconductor including focused ion beam systems and electron beam systems
### Applications

#### Vacuum Technology
- Rough Vacuum
- Packaging (except Food)
- Central Vacuum
- Printing and Paper Handling
- Pick and Place
- Conveying
- Air sampling
- Medical
- Process Vacuum
- Chemical
- Petrochemical
- Pharmaceutical
- Plastics
- Food
- Beverage
- Textile
- Paper
- Ceramics
- Freeze drying
- Energy (Wind, Nuclear, Steam turbines, ...)

#### Industrial Vacuum
- Vacuum Metallurgy
- Vacuum Heat Treatment
- Laser Technology
- Electron Tubes
- TV Tubes
- Lamps and Bulbs
- Industrial leak detection
- Refrigeration and Air Conditioning
- Automotive (Dehydration, Charging and Test)
- Electrical (Encapsulation, ...)

#### Semiconductor Process Vacuum
- Silicon Semiconductor
- Compound Semiconductor
- TFT-LCD Displays
- MEMS
- Crystal pulling

#### Thin-Film Deposition (non-Semiconductor)
- Glass/Web/Optical
- Data storage (CD, DVD, Hi Def. Disc, ...)
- Magnetic Data Storage (HDD)
- Thin Film Heads
- Surface Coating (wear protection, decorative, ...)
- Display Coatings (OLED, FED, PDP, SED, ...)

#### Solar
- Photovoltaic Solar
- Thermal Solar (Solar Water heaters, ...)
- Crystal growth (re-melt, ...)

#### Instrumentation Manufacturers
- Mass Spectrometers
- Electron Microscopes
- Leak Detectors
- Surface Analysis
- Gas Analysis
- Metrology/Inspection/Defect Review systems
- Focused Ion Beam systems
- Electron Beam systems
- X-Ray Analysis
- MRI and NMR
- Sample preparation

#### R & D
- Universities
- Government Labs
- Scientific Research Laboratories
- Space Simulation
Brand name & trade fair register

Alltech Dosieranlagen GmbH
Rudolf-Diesel-Str. 2
76356 Weinlauter
Phone +49 7244 7026-0
Fax +49 7244 7026-50
info@alltech-dosieranlagen.de
www.alltech-dosieranlagen.de

We offer dosing systems from a single source: from planning and production through to installation / service. Our products: solution preparation and dosing systems for dry, liquid and gaseous products, piston diaphragm metering pumps FKM with intelligent control logic, with linear and infinitely variable dosing, even for highly viscous media, dosing stations and accessories, process and storage tanks, control and regulating systems.

FAT, Munich, 30/5–3/6 2022

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- Roots Booster Packages
- Vacuum systems with tanks
- Centralized air supply systems

For current exhibition activities please visit our website
www.becker-international.com

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Dr. Ing. K. Busch GmbH
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sales@busch.de
www.buschvacuum.com

Busch Vacuum Solutions operates worldwide as one of the largest manufacturers of vacuum pumps, blowers and compressors. The extensive product portfolio covers vacuum and overpressure applications in all industry sectors. A dense service network coupled with many years of experience and expertise in developing vacuum systems makes it possible to provide customised integrated solutions.

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Pumps & Valves, Dortmund, 19–20/5 2021, Hall 5, Booth R50-6 parts2ikan, Stuttgart, 21/24/26 2021
WEFTEC, Chicago, USA, 18–20/10 2021, via our representative in the USA

EDUR-Pumpenfabrik
Eduard Redlien GmbH & Co. KG
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Find out more about the World of Vacuum in our webinars and online events.
Upcoming dates and more information under
www.buschvacuum.com

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Trade Fairs 2022
Achema, Frankfurt, 4–8/6 2022
HIM, Hannover Fair, Hanover, 25–29/4 2022
VALVE WORLD EXPO, Dusseldorf, 29/11–1/12 2022

HNP Mikrosysteme GmbH
Bleicherufer 25
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Pumps & Valves, Dortmund, 19–20/5 2021
pharmatech-cosmetech, Chartres, France, 1–3/6 2021
Motek, Stuttgart, 5–8/10 2021
FAKUMA, Friedrichshafen, 12–16/10 2021
Compamed, Dusseldorf, 15–18/11 2021
Achema, Frankfurt, 4–8/6 2022
Further trade show dates
Since more than 130 years, Pfeiffer Vacuum has served the semiconductor industry with the highest degree of precision and reliability. We are a leading German manufacturer of gear pumps, flow measurement, hydraulic components and valves. Around 400 employees worldwide design, produce and sell products in both standard versions as well as special solutions tailor-made to customer wishes.

For current trade fairs, please visit our homepage: www.homa-pumps.com

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Industriestr. 1
53819 Neunkirchen-Seelscheid
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Pumps and Compressors for the World Market with Compressed Air and Vacuum Technology 2021

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JAB is a globally active medium-sized company with more than 120 years of experience in mechanical and plant engineering. Our product portfolio includes air- and water-cooled compressors for the compression of air, inert gases and natural gas as well as for a wide range of customized solutions up to 400 bar.

For current trade fairs, please visit our homepage: www.jab-becker.de

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Koellmann compact HANDY membrane compressors and vacuum pumps offer a mobile and universally applicable solution for oil-free compressed air and vacuum production under challenging operating conditions. Comprehensive technical support including a 24-hour hotline, straightforward and fast spare parts delivery complete the portfolio of Koellmann Airtec.

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www.kracht.eu

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Our current trade fair dates: www.kracht.eu

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Energy Decentral, Digital fair, 9–12/2 2021
OTC, Houston, TX, USA, 9–12/5 2021
Pumps & Valves, Dortmund, 19–20/5 2021, Hall 5, Booth R03-6
Offshore Europe, Aberdeen, UK, 7–10/9 2021, German Pavilion
Drinktec, Munich, 4–9/10 2021, Hall B3, Booth 338
Tausendwasser, Berlin, 27–28/10 2021

For current trade fairs, please visit our homepage:
https://group.pfeiffer-vacuum.com/plannedatthecurrentmoment.

19–20/5 2021, Hall 5, Booth R03-6

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ACHHEMA, Frankfurt, 4–8/4 2022, Hall 4.0, Booth L44

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Hannover Messe Digital, 12–16/4 2021
7th International LNG Congress, Madrid, Spain, 7–9/6 2021
9th WHTC & f-cell+HFC, Montreal, Canada, 20–24/6 2021
Gastech Exhibition & Conference, Singapore, 13–19/9 2021
Mission Hydrogen Online Conference, Digital, 9/10/2021

For current trade fairs, please visit our homepage:
www.osna.de

Pfeiffer Vacuum GmbH
Berlinstr. 63
35614 Aslar
Phone +49 6441 802-0
Fax +49 6441 802-1202
www.pfeiffer-vacuum.com

Since more than 130 years, Pfeiffer Vacuum has served as a guarantee for advanced vacuum technology and first-class service. The product portfolio comprises hybrid and magnetically levitated turbopumps, backing pumps, leak detectors, measurement and analysis devices, components, vacuum chambers and systems. The company employs a workforce of some 3,300 people and has more than 20 sales and service companies as well as 10 manufacturing sites worldwide.

Due to the current situation, no participational live events are planned at the moment. Current information can be found at:
https://group.pfeiffer-vacuum.com/en/group/dates-events/
**RKR Gebläse und Verdichter GmbH**
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31737 Rinteln
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www.RKR.de

RKR is a medium-sized company, with a workforce of around 60. For over 40 years, RKR has been building customised blower and compressor systems for oil-free gas conveyance worldwide. Qualified service and original spare parts complete the range of services.

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The Wilo Group is a global leading premium provider of pumps and pump systems for Building Services, Water Management and Industry. Using smart solutions that bring together people, products and services, the Wilo Group is on the path to becoming the digital pioneer in the sector. Around 8,000 employees support the company worldwide.

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