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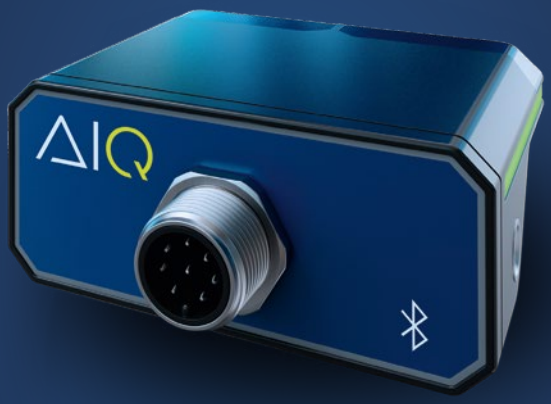

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Pumps and compressors are ready for the current year

Dear readers,

Nicolaus Krämer

Alexander Peters

We continue to live and work in uncertain times. Global crises such as the ongoing wars in Ukraine and the Middle East and, above all, the associated human suffering keep us on tenterhooks. Last but not least, such political escalations also cause a certain amount of uncertainty among investors. In addition, the climate crisis has once again left its mark in many countries, for example through more severe storms or even greater flooding. It is therefore of the utmost importance that we will achieve the climate targets for future generations. We can also see this as an opportunity. After all, our members have always scored with innovations that are becoming increasingly energy-efficient, as you can read in the latest issue of our magazine “Pumps and compressors for the global market 2024”.

We have seen a positive development in terms of supply bottlenecks. While many of our members were still severely affected by these in 2022, the situation eased last year. In the flash survey last October, only 5 per cent of our members still stated that they were facing significant restrictions on the procurement side, as you can read in the interview with Christoph Singrün. Their resilience thanks to their global presence has also proven itself over the past year. In addition, the transformation of the markets with regard to the construction of LNG terminals and the production of green hydrogen is opening up new areas of business, which our members have already been able to put it in their order books. On the other hand, the EU’s regulatory frenzy is putting companies under sustained pressure, as Christoph Singrün emphasises. Most recently, a full 76 per cent of respondents in the flash survey stated that they would like to see an improvement in bureaucratic requirements.

In principle, the trade fair business was back in full swing last year after the coronavirus pandemic. Unfortunately, however, the Federal Ministry for Economic Affairs and Climate Action (BMWK) massively cut foreign trade funding for German companies in 2023, which particularly affected small and medium-sized enterprises (SMEs). Fortunately, the ministry will not make this cut again this year, which will benefit SMEs. We at VDMA are committed to the concept of the German Pavilions and look forward to further developments in this area. Exhibitors benefit from online registration, which is now possible, as you will read in this issue. At this year’s IFAT in Munich and ACHEMA in Frankfurt am Main, we will once again be represented with an information stand of the Process Technology Forum.

Our manufacturers see a major hurdle above all in the proposal submitted to the EU Commission by three member states and Norway to ban perfluorinated and polyfluorinated alkyl substances (PFAS). A general ban would jeopardise the existence of many companies. It is not without reason that the European Chemicals Agency has received more than 6,000 comments on this. And many of our members have also expressed their concerns about a blanket ban. We in the VDMA are clearly in favour of a risk-based approach, as we show in this issue. On the association's website, we inform our members about current developments and offer comprehensive information about PFAS.

Progress is being made with regard to digitalisation and sustainability, as you can read in the interview with Christoph Singrün: Together with its members, the VDMA trade association has created the so-called OPC UA Companion Specification, which enables manufacturer-independent data exchange. In addition, our members have access to a guide entitled "Smart Service Compressed Air 4.0/Vacuum 4.0", which focuses on remote monitoring, among other things. This guide has been developed for customers. It describes in detail how users can make the right choice for a solution for a predictive energy and maintenance strategy.

In this year's magazine, you will once again find numerous examples of pioneering solutions from our members: here you can find out, for example, how sewage lifting units protect homes, progressive cavity pumps handle battery sludge and large heat pumps ensure grid stability. These are just some of the solutions for the numerous possible applications of pumps and compressors. As is the case every year, the authors of the respective articles will be happy to answer any questions you may have if a topic has piqued your interest. The experts look forward to exchanging ideas with you. We wish you an exciting and insightful read.

Nicolaus Krämer
Technical Managing Director
HERMETIC-Pumpen GmbH
Chairman of the VDMA association
Pumps + Systems

Alexander Peters
Managing Partner
NEUMAN & ESSER GROUP
Chairman of the VDMA association
Compressors, Compressed Air
and Vacuum Technology

“Well maintained”

Despite global crises and supply bottlenecks, manufacturers of pumps and compressors are reporting good results for 2023. However, this year will be challenging.

Christoph Singrün

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

At the beginning of last year, your members expected a solid market development for 2023. Has that materialised?

That has materialised. We had quite high order backlogs due to the previously very tight supply chain situation. According to our statistics, the real turnover of pump manufacturers in 2023 was at the previous year’s level, while that of manufacturers of compressors, compressed air and vacuum technology fell slightly by 2 per cent.

You just mentioned the supply bottlenecks. How did this develop for the electronic components that you described as the „Achilles heel“?

In some cases, this has hit our members hard, as the electronic components were not available to the extent that our members needed them. However, the situation has eased considerably. In our flash survey last October, only 5 per cent of members spoke of serious restrictions on the procurement side, while 35 per cent spoke of noticeable restrictions. In comparison: in June last year, 20 per cent reported serious restrictions and 47 per cent reported noticeable restrictions. Not everything is back on track yet. But it is fair to say that the Achilles heel is clearly on the mend.

Nevertheless, the members have to deal with a shortage of skilled labour, climate targets and global crises. Did this have an impact last year?

Global crises are always a challenge – including the terrible, ongoing war in Ukraine and the political escalation in the Middle East. This causes a certain amount of uncertainty in the markets and among investors. The climate targets, on the other hand, are not just a burden, even if the temporarily high energy prices have placed a heavy burden on many members. We see the climate targets as an opportunity. There is potential in improving energy savings in pumps and compressors, which manufacturers are continuously realising through innovations. Green hydrogen offers another opportunity. Some customers have commissioned major projects in the past year that will be reflected in sales in the current year. What continues to concern us, however, is the shortage of skilled labour. Our manufacturers are making tremendous efforts to recruit and retain junior technical staff such as fitters and service specialists. Unfortunately, this will remain a major challenge in the future.

Many manufacturers are equipping their systems with predictive maintenance. Is there a development in the use of artificial intelligence in this context?

In principle, this involves networking the components, for example in a compressed air system. This makes it possible for the user to evaluate the system. This also applies to predictive maintenance with regard to energy efficiency. This offers a great opportunity. When we talk about the use of artificial intelligence (AI) in this context, we are talking about analysing, combining and interpreting the data generated during operation. Some manufacturers already have highly interesting products on the market in this area. I would be delighted if many more users would take up these offers. But in the end, it‘s not about every user having AI in their pumps and compressors, it‘s about the benefit to the user. In each individual case, a cost-benefit analysis must be carried out before implementing AI, because AI is not an end in itself.

In your opinion, can AI help to counter the shortage of skilled labour?

I see the use of AI primarily in cost-efficient operation. AI can certainly help to optimise service and maintenance intervals based on consumption. But ultimately, we still need skilled service technicians, because maintenance in particular literally needs to be hands-on. And for this we need intelligent, trained minds.

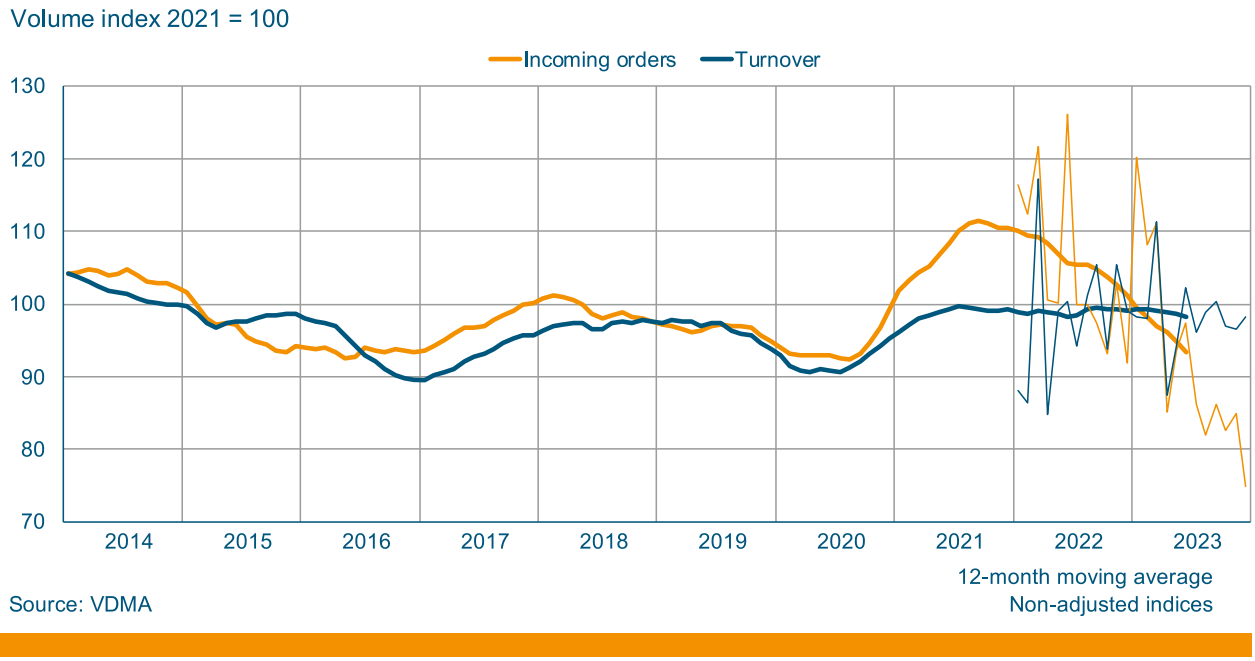
The importance of liquefied natural gas is growing. How are manufacturers adapting to the new media?

Manufacturers from Germany and Europe are very strongly represented in this environment with corresponding products. We now have the trend and are building LNG terminals in Germany. These were not built for years because we sourced the gas from Russia. Triggered by the war in Ukraine, we are switching to liquefied natural gas. This is creating a new market for equipment suppliers. However, new terminals need to be built not only in Germany, but worldwide. Our members have been able to make a positive note of this in their order books this year. We can therefore speak of a temporary strengthening of the market, but this may weaken again in the foreseeable future.

Can you give us another example from which companies benefit?

Another interesting medium in this context is green hydrogen. This medium has been transported in compressors for several decades. German and European suppliers are leading the way here. The topic is currently being dramatically ramped up in a positive sense. We can currently talk about a transformation of economic processes. In the Federal Republic of Germany, however, we will not be able to produce green hydrogen from alternative energies alone. We nearly don't have enough sun and wind. Therefore, we need to import green hydrogen. The question is how and in what form. There are already valid considerations today to bind the hydrogen in the form of ammonia and to transport liquid ammonia globally via the world markets, including to the terminals in Germany. There it would be split back into hydrogen and utilised. Unlike green hydrogen, ammonia can be transported without any problems, but it does harbour certain health risks, for example if it escapes. The costs and benefits need to be weighed up here. But green hydrogen could open up a new business segment for manufacturers in the future.

Incoming orders and turnover in Germany – Pumps



Source: VDMA

Source: Shutterstock

The supply bottlenecks have eased considerably.

Let‘s take a look at EU regulation. Are your members suffering from the „regulatory tsunami“?

Yes, very much. It‘s a huge problem for our members at product and company level. We are clearly committed to the climate targets, there is no doubt about that. But the question is how to get there. Will we achieve this through bureaucracy or through technology? Politicians must create simpler and clearer framework conditions and not predefine everything in minute detail. The resulting bureaucracy is hardly or not at all manageable. The planned Supply Chain Act is also causing massive problems for many companies due to the effort involved in sustainability reporting. Of course, we need to further reduce CO_2 emissions in our production processes. But I won‘t save a single gram of CO_2 by being obsessed with documentation. Instead, we need to turn existing opportunities into action. This includes optimising the choice of materials used in pumps. We also need research and innovation, stable materials, new calculation methods and no oversizing. In the flash survey last October, a full 76 per cent of respondents stated that they would like to see improvements in bureaucratic requirements with regard to location factors. The most critical location factor for them is bureaucracy. For smaller companies, bureaucracy costs now account for 10 per cent of turnover.

Keyword PFAS regulation. Your manufacturers have actively participated in the public consultation organised by the European Chemicals Agency ECHA.

If the PFAS regulation is implemented as proposed, it would jeopardise the existence of many companies. Many would have to close. The reaction was correspondingly strong. The European Chemicals Agency received more than 6,000 comments. Our members have also expressed their concerns. A blanket ban on the use of PFAS would affect well over 10,000 perfluorinated and polyfluorinated substances. Some PFAS groups can be harmful to humans and the environment. This would have to be assessed on a substance-by-substance basis. But a blanket ban on PFAS makes no sense. The VDMA is in favour of a risk-based approach. For example, there is a subgroup known as PTFE materials, which are also used in our products. Quite a few of these materials also have medical authorisation, such as for implants, and are used in the human body because they are not

compatible with cells. At some point, such non-degradable chemicals can end up in the environment. Such materials should therefore be labelled accordingly so that they can be recycled properly.

Are manufacturers making progress in terms of digitalisation and sustainability?

Our members have always been innovative. We provide them with intensive support on key topics. As part of digitalisation, we have developed the OPC UA Companion Specifications together with our members. These enable manufacturer-independent data exchange. We have also developed a guide entitled "Smart Service Compressed Air 4.0/Vacuum 4.0". Remote monitoring, for example, plays a role here. The guide is intended for customers. The topics of digitalisation and sustainability will continue to accompany us for many years to come.

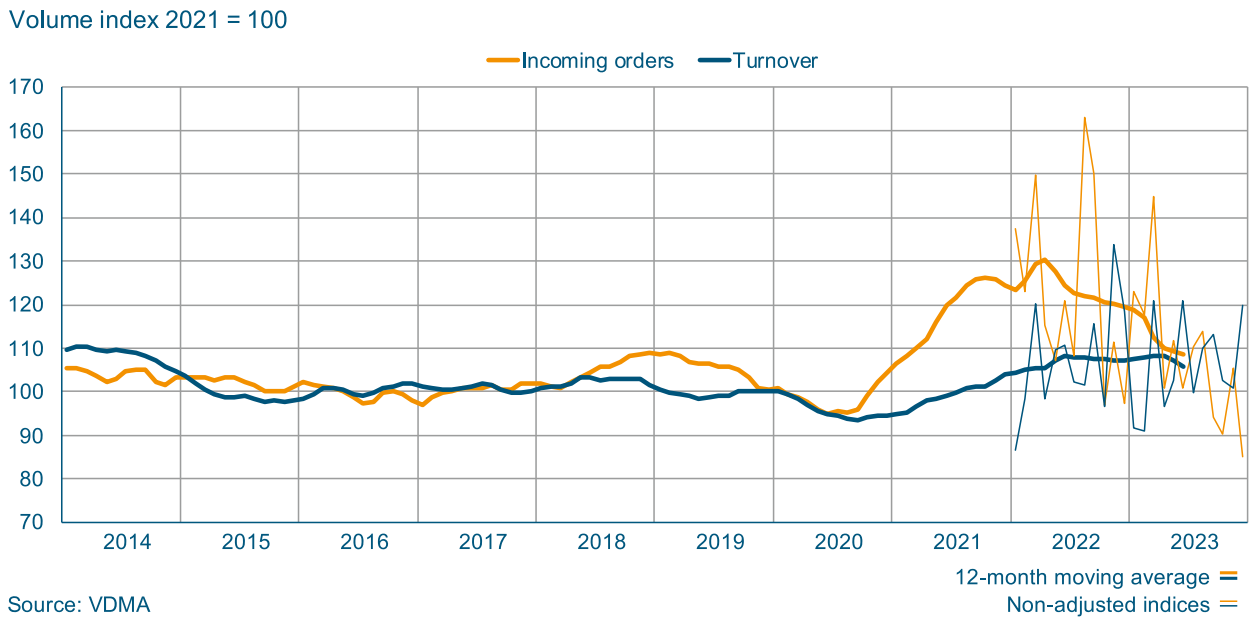
Keyword sustainability: users can also conserve resources by retrofitting. What role does this play in the industry?

When we talk about sustainability, retrofitting is not mentioned first. When our members think of sustainability, they primarily think of: their own production, reducing the use of resources, the materials used, less energy and lower quantities of water or waste water. Retrofitting can be an opportunity, especially for large pumps and compressors, to restore old machines and systems at a relatively manageable cost. This is already being done today, but retrofitting is not a clearly recognisable market trend.

Please give us an outlook for 2024.

This is difficult given the current situation. We are currently seeing opposing trends. On the turnover side, many of our members will report a record year in 2023, as many old orders that were invoiced last year have been included. However, orders in 2023 have fallen by around 12 per cent in real terms. Overall, we expect a slight real decline in turnover this year of between 0 and minus 5 per cent, depending on the sub-sector. However, this is heavily dependent on sub-sectors, which are developing very differently. It will not be a year of crisis, but it does harbour challenges for our sectors. But I am confident, because despite the political crises, supply chains have proven to be resilient.

Incoming orders and turnover in Germany Compressors, Compressed Air and Vacuum Technology



Source: VDMA

PFAS – general ban does not make sense

Friedrich Klütsch

In 2021, three member states and Norway submitted an application to the EU Commission with the aim of banning the use of around 10,000 perfluorinated and polyfluorinated alkyl substances – known as PFAS. The best-known of these alkyl compounds include Teflon© and Viton©.

As pumps and compressors would also be significantly affected by such a ban on substances, the VDMA Pumps + Systems and Compressors, Compressed Air and Vacuum Technology associations informed their members about the proposal in a timely manner. The association also asked its member companies to express their opinion on such a ban. The ECHA consultation, which was conducted by the European Chemicals Agency from May 2023 to September 2023, provided the opportunity to do so. The ECHA received almost 6,000 comments during this period.

Environmental impact of PFAS

PFAS stands for a group of several thousand different chemicals. They are based on the combination of carbon atoms with a halogen (periodic table of elements, group 17). The hazards that can emanate from PFAS depend on the length of the molecules and the elements attached to the carbon atoms in addition to fluorine.

The least environmental influences or hazards come from long-chain PFAS, the fluoropolymers widely used in industry. Users utilise these as seals or as coatings when processing aggressive substances such as acids or alkalis, which are necessary for the production of various basic chemicals. Without the use of fluoropolymers, many of today's products could not be manufactured.

The danger of fluoropolymers lies in their durability. They are water, dirt and grease repellent, thermally and chemically stable and therefore unfortunately also difficult to degrade naturally. This is why they are increasingly being used in innovative technologies such as semiconductors, fuel cells and wind turbines, in addition to coating machine surfaces and seals. Fluoropolymers are also found in ski waxes, paper and film coatings for functional clothing and in many everyday products, which many users do not realise. This is where the real danger lies. Because at the end of their life cycle, everyday products such as paper end up in the environment in various ways - be it with domestic washing water, as an admixture to biomass or via run-off surface water (rain).

However, it will not be easy to satisfy the call for substitute substances. This is because the so-called C-F compound of carbon and fluorine is the most stable possible chemical compound of a carbon atom with a halogen. Every other compound has qualitative limitations. In addition, an alternative substitute must first prove that it is more environmentally friendly.

New approaches offer alternatives

Doing without fluoropolymers altogether would mean having to live with a range of goods from 1950 and only being able to realise the stop of climate change with rigorous renunciation together with giving up today's prosperity. But there are already alternatives today.

To achieve this, it is necessary to change the way these substances are handled. It should not be the case that a pizza box coated with PFAS is shredded and mixed with manure on fields. Explicit labelling of products containing PFAS would be one approach to ensure that these products are disposed of appropriately or recycled in an optimised manner at the end of their life cycle. In addition, chemical recycling processes must be developed and the processes

The durable fluoropolymers are also used for wind turbines that have to withstand wind and weather. Source: Shutterstock

from production to – if not otherwise possible – incineration must be optimised from a safety and environmental point of view.

Where users receive products containing PFAS, producers should replace the PFAS they contain with other compounds with equivalent properties. These products should be placed on the market PFAS-free. Manufacturers could utilise this approach and extend it to other products, combined with the declaration of conformity, which emphasises the manufacturer's responsibility.

In the case of seals and coatings, which are used in manufacturing processes in the chemical and pharmaceutical industries, energy technology and many others, the end-of-life processes (recycling, incineration) can be optimised.

All this cannot be realised without investment, but in the end it is cheaper and also more acceptable for emerging nations because there is a single common goal – to prevent the future release of hazardous PFAS into the environment.

Political outlook

The members of the ECHA committees will need some time to analyse the comments received from manufacturers and announce a result. The two internal ECHA committees, the Committee for Risk Assessment (RAC) and the Committee for Socio-Economic Analysis (SEAC), will ultimately draw up a harmonised report and submit it to the EU Commission. However, the growing concerns about the impending socio-economic effects of a PFAS ban have already led to the first „cancellations" by German ministries and state governments. In addition, the ECHA has already partially withdrawn bans, for example on the use of bisphenol A. A draft regulation is not expected to be published before the EU elections in May 2024. The risk-based approach proposed by the international industry would be the desired outcome, knowing full well that even if it is implemented, there is still a lot to be done to avoid future hazards from PFAS as far as possible.

Members can find up-to-date and comprehensive information about PFAS on the association's website. Members support VDMA appeals, particularly on their social media channels, thereby raising awareness of this essential topic.

Author:
Friedrich Klütsch
Consultant VDMA Pumps + Systems

www.vdma.org/pfas

The German Pavilion at ADIPEC is one of the largest trade fair participations in the AMP. Source: VDMA

The international trade fair programme turns 75

Ulrike Mätje

The international trade fair programme – AMP – was launched three quarters of a century ago. More than 220 German Pavilions are currently planned for 2024, over 200 outside the European Union. The key point is that the responsible Federal Ministry is not continuing the cuts to foreign trade funding for German companies from last year. Exhibitors can now also register online.

The Federal Ministry for Economic Affairs and Climate Action (BMWK) recently made massive cuts to foreign trade funding for German companies. However, the ministry will not be repeating the 2023 cuts this year. Instead, the ministry's draft budget provides for a funding budget of 43.7 million euros, while the Association of the German Trade Fair Industry (AUMA) had requested 45.5 million euros. Accordingly, the programme was expanded by two dozen participations last summer, contrary to plans. This means that more than 220 trade fair participations in over 40 countries are currently planned. The VDMA and other industry associations support the Ministry and AUMA in the selection of trade fairs. Small and medium-sized companies in particular benefit from the programme.

With the AMP, the BMWK offers German joint stands – the so-called German Pavilions – at international trade fairs. Participation in the German Pavilions helps companies to open up international markets, thereby creating and securing jobs in Germany and maintaining their international competitiveness. Companies represented at the joint stand under the slogan „Made in Germany" benefit from favourable conditions.

In addition, the exhibiting companies are relieved of numerous organisational tasks. This allows exhibitors to concentrate on the essentials – their own stand personnel, the presentation of their products and services and the acquisition of new customers and sales and investment partners. The German Pavilions are particularly interesting for small and medium-sized companies, which can boost their export quota through their participation.

Asia remains the most important target region

As in previous years, according to AUMA, the Asian markets will remain the programme's most important target region in the current year. In this context, the BMWK will support almost 100 joint participations by German companies. With 28 participations, the United States of America will be also an important target country in the AMP for the first time. This is followed by Near and Middle East with 24 and Africa with 23 participations. And eleven investments are planned for Latin America and Australia will be represented with three investments. Central Asia is also moving more into the focus of German business as a target region this year: six investments are planned for Kazakhstan and five for Uzbekistan.

Online registration now possible

Slowly but surely, the AMP is also switching to digital processes. The usual registration forms are being replaced by online registrations. To be able to register online, companies must register in advance with a one-off accreditation. Only then will they be activated and it will then be possible to register for individual trade fair participations. However, activation can take one to two working days. Companies should take this into account with regard to the registration deadline. Early registration is therefore recommended.

Above all, online registration saves time: The company data is stored and automatically transferred for further registrations. The new platform also provides exhibitors with recommendations for other trade fair participations in the target region or for their sector. Furthermore, companies can also research trade fairs here and register for future projects. Interested parties who have registered in advance will then be informed directly about the start of the registration phase. This is particularly advantageous for German Pavilions that are in high demand - for example for ADIPEC in Abu Dhabi, the capital of the United Arab Emirates. The German Pavilion there is one of around 60 a year that the VDMA actively supports. With 1,400 square metres of exhibition space, the German Pavilion at ADIPEC is one of the largest trade fair participations in the AMP.

Author:
Ulrike Mätje
Public Relations and Market Information Officer
VDMA Pumps + Systems and
VDMA Compressors, Compressed Air and Vacuum Technology

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Lifting units with macerators reliably shred solids such as wet wipes, therefore preventing clogging. Source: Shutterstock.com

Sewage lifting units with macerator to protect your home

Björn Sparbrod

As a result of reduced water consumption and a higher amount of solids such as wet wipes and sanitary products, it is becoming increasingly challenging to efficiently dispose of sewage in buildings. This is particularly the case if the connection to the residential building does not enable gravity drainage. This happens when the connection is located at a lower level than the public sewage network. However, a new generation of pump systems can now solve these problems sustainably and intelligently.

People living in detached and semi-detached houses have significantly reduced their water consumption in recent years due to a desire to protect the environment and resources. Today, a large number of people predominantly have water-saving flushes on their toilets, use shower heads that minimise water consumption, and select energy-saving programmes on their washing machines and dishwashers. Although fundamentally a positive development, it does also pose a new challenge in the form of problem-free drainage. This is because it is more difficult to transport the sewage due to the lower levels of water consumption and a simultaneous rise in the proportion of solids in the sewage, which increasingly results in clogging, blockages and increased wear. This applies to both the public sewer network and within buildings, although it is particularly problematic in residential buildings that cannot be drained via the natural downward slope as a result of how they have been constructed.

Minimal space requirements

But what is an efficient solution for this problem in new buildings and existing buildings without the need to undertake massive structural works? The solution is a new generation of pump systems. As lifting units, they enable drainage to occur safely by pumping the sewage through piping to the level of the public sewage disposal network. They also incorporate a particularly effective macerator that reliably shreds problematic solids such as wet wipes, cloths, cleaning rags and sanitary products, thereby helping to prevent clogging. Modern systems such as this are not just suited to the drainage of a single room like a basement bathroom, but their optimal performance allows them to be used to dispose of sewage for a complete building. Depending on requirements, as well as structural and installation conditions, another potential solution could be a pump that does not have a macerator, but which has a large free ball passage.

Dr. Jörg Praczyk, Senior Vice President Research & Development for the Wilo Group, explains this further: “In light of increasing challenges in sewage disposal, innovative solutions such as pumps that incorporate macerators are crucial to ensure we can reliably dispose of sewage in an environmentally friendly manner in the future.”

This new solution brings together a number of technologies that enable a system to be created that is both extremely compact and simultaneously optimised for performance. This is because until now separate sewage chambers with submersible grinder pumps were usually required to ensure lifting units were reliable and provided sufficient performance. This new generation, however, can be easily installed in substructures. Due to their compact size, new installation options are now available for lifting units. They can be installed in confined spaces, such as the smallest of concealed-wall installations.

Finely ground up by the macerator, the mixture can be easily transported through pipes.

Up to 5.5 litres per second

“Our new lifting units with grinder pumps are future-proof systems. The series designed for detached and semi-detached houses include seven variants in different output levels, ranging from S, to M, to L”, says Praczyk.

Depending on the version, the output can be between 15 and 20 cubic metres per hour, which corresponds to approximately 4.4 to 5.5 litres per second. The system is made up of an optimised

Source: Wilo

The double pump lifting unit is fitted with a macerator.

Source: Wilo

The sewage lifting unit ensures safe drainage for a detached house at a level below that of the backflow.

combination of hydraulics and macerator, a motor housing made from corrosion-resistant stainless steel with a double seal, and a compact tank which, despite its small size, provides a large switching volume. A float switch and switchgear are used to enable automatic mode (activation/deactivation). "Other features include a 50 mm connection for manual draining, a non-return valve, a DN 32/40 drain connection, inlet ranges as required from DN 100 to DN 150, and a tank lid complete with viewing window to perform a visual inspection", continues Praczyk.

Lifting units that incorporate macerators offer a long service life, and are sustainable and cost-efficient.

The space-saving design of the equipment also makes it easier to transport and handle when installing it. Since solids are reliably shredded, despite the small unit size, it is also possible to use the more cost-effective sewage pipework from the DN 32/40 range. Overall, this solution is significantly more cost-effective and energy-efficient for owners of properties. "The compact nature of grinder pumps not only provides an advantage in terms of space requirements, but also allows them to be more flexibly integrated into current and future sewage systems", explains Praczyk. This generation of pumps also comes with a macerator with double shear effect. The macerator is able to shred all solids in the sewage. Furthermore, because of the new macerator, sewage lifting units can now be designed to have very small dimensions without compromising on switching volume or pump capacity. The resulting sewage lifting units with macerators are more powerful and more compact and they can achieve particularly high delivery heads despite their small size and motor power – all while consuming significantly less energy. This new generation also offers an impressively long service life since it is manufactured from a targeted combination of corrosion-free, resistant materials including engineering plastics and stainless steel.

How the grinder pump works

A sewage pump that incorporates a macerator is a sophisticated system that is designed to efficiently and reliably pump sewage and associated solid components. Traditional submersible pumps carry the risk of clogging because of larger particles. To counteract this problem, grinder pumps were developed: a macerator represents the centrepiece of such pumps. It consists of two shear blades, one of which is fixed while the other rotates at high speed. The

sewage, including the solids, flow into the inlet where they come into contact with the macerator. The high rotational speed of the rotating blade allows all solid content within the sewage, like remnants of fabrics or wet wipes, to be reliably shredded. The result is a finely ground mixture that can be easily transported through the piping without causing it to become clogged. “When developing sewage pumps that incorporate a macerator, the focus is on design. It all comes down to finding the balance between robust construction and efficient functionality so that the requirements of modern sewage systems can be properly met”, says Praczyk. “We have succeeded in achieving high delivery rates and shredding capability in a reliable and safe manner, even within the smallest of spaces. It opens up the possibility of new and efficient approaches, especially when looking at building installations in detached and semi-detached houses.”

Wastewater versus sewage

It is quite often the case that the terms wastewater and sewage are interchangeably used, but sewage is in fact a generic term for water that comes from various sources that is discharged via installations. Wastewater is the product of water that is used within a household and then discharged into the sewage system. Typical household activities that generate wastewater include flushing the toilet, using the dishwasher or washing machine, or having a shower. In Germany, only pumps certified in accordance with DIN EN 12050-1 are permitted for the pumping of wastewater. The purpose of the standard is to ensure that the pumps can cope with the specific challenges posed by sewage, especially sewage containing faeces. To meet the standard, all systems must either guarantee the inclusion of a macerator or a free ball passage measuring a minimum of 40 mm.

Source: Wilo

The macerator lifting units are suitable for installation situations where space is restricted.

Sustainability from the outset

Nevertheless, it is not simply the technology and functionality of a product that proves decisive; their sustainability must also be taken into account. In this, Wilo has adopted a holistic approach, both in terms of the development and production, as well as regarding usage and ultimately the disposal of the product. Praczyk explains this further: "When we developed our new pump systems, we focussed on how to conserve resources. This means that we have designed the size of the housing and the thickness of its walls to be both robust and provide a long service life, as well as to save on the materials used." By using materials by type, we are not only improving its service life, but also facilitating recycling options at a later date. "This is because the ability to recycle is another component of our holistic sustainability strategy", adds Praczyk. "In this respect, we make use of detachable connection techniques and biopolymers or biodegradable materials. We also prefer to use materials that include a high or increased proportion of recycled material."

Logistics also plays a role in sustainability. If products are lighter and delivery routes are shorter, fuel consumption is therefore lower. By increasing its own vertical integration and prioritising internal production processes, Wilo has further reduced its CO_2 footprint. Praczyk explains: "We've also reduced the number of variants and minimised the number of components and assemblies. It not only makes production and maintenance simpler, it also reduces the amount of material used."

It goes without saying that two particularly important factors are efficiency in terms of production and the energy efficiency of the pumps when they are in later use. This is why the company continues to optimise its product-related processes on an ongoing basis. At the same time, the pump and pump system manufacturer is maximising how efficient the products themselves are in terms of energy, by optimising their efficiency rate, for example.

Guaranteed reliability

"Reliability and energy efficiency are crucial when it comes to lifting units. We achieve this, for example, through a big switching volume, thermal motor protection, a mains-independent alarm function, and the optimised and harmonious interaction of the hydraulics and the macerator", explains Praczyk. Pump systems such as these enable a wide coverage area to be created while keeping energy consumption low. When all of the factors are taken into consideration and the total cost of ownership is accounted for, the new lifting units with integrated macerator achieve a high degree of sustainability and are particularly cost-efficient due to their long service life.

Author:
Björn Sparbrod
Group Vice President Product & Product Information Management
WILO SE
Dortmund

The odorisation of natural gas and hydrogen requires the admixture of odour-intensive chemicals. Source: Yingyaipumi-stock.adobe.com

Micro-metering pumps with linear motors for dynamic metering

The trade audience first became acquainted with micro-metering pumps with linear motors four years ago at ACHEMA. Now this technology is living up to expectations in practice. Use cases often include needing to meter small and micro-quantities precisely, apply a highly dynamic metering profile or handle a range of different processes. In addition, many users are looking for low-wear pumps with minimal maintenance as a standalone solution. Micro-metering pumps, which are highly compact, flexible and reliable, are ideal for such cases.

Benefits of micro-metering pump technology

For users who need to meter fluids in small and micro-quantities under moderate or high pressure with a high degree of precision, oscillating micro-metering pumps are a good choice. Almost all systems today work on this principle. Inlet and outlet valves separate the suction and discharge sides from one another, allowing metering of the fluid under stable pressure.

All commonly used micro-metering pumps with hydraulic diaphragm technology work with the oscillating motion of a piston: the movement of piston and diaphragm during the suction stroke produces negative pressure. This causes the valve on the suction side to open and the required fluid enters the conveying chamber. The discharge valve is closed. By setting the stroke length appropriately, this step results in a precise metering volume. At the second stage (the discharge stroke), the piston and diaphragm return to the front. This causes the suction valve to close, while the metering volume previously drawn in opens the discharge valve and enters the process.

Source: ProMinent

The gearless construction of the micro-metering pump is low-maintenance, virtually free from wear, compact and space saving.

The linear motor used in this generation of pumps has key advantages over a 3-phase AC motor. The most significant point of difference between the two drive technologies is the concept underlying the motor. Whereas a 3-phase AC motor provides rotational motion that has to be laboriously converted into oscillating motion, the way a linear motor works is naturally oscillatory. This has major implications for the construction of the metering pump, because a linear motor eliminates all the mechanical transmission components and adjusting eccentrics that allow stroke lengths to be set.

Micro-metering pumps with linear motors can therefore have a significantly more compact design. In addition, they are less subject to wear, since fewer moving parts are involved. As a result, they are impressively low-maintenance. The stroke lengths are set electronically and applied by means of control electronics. This is much more precise and reproducible than using a manual adjustment wheel.

Individual metering profiles

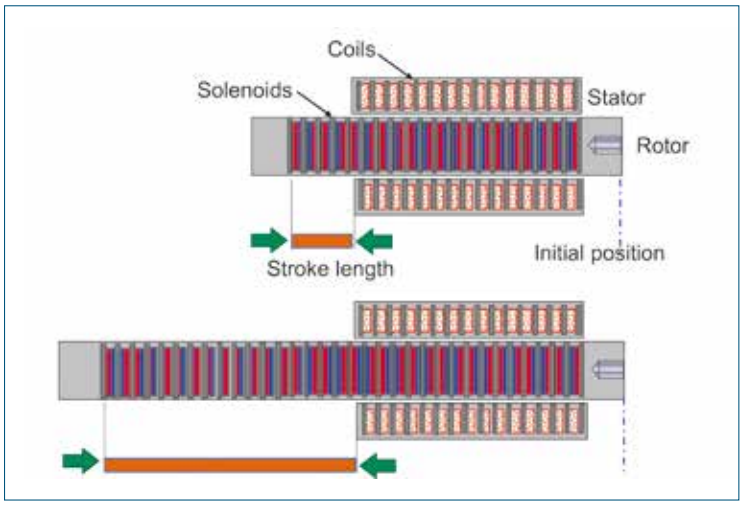
Linear drives are direct drives. This means that their motion profiles are controlled by software and then transferred to the linear motor by means of programmable logic controllers, for example, or electronic control technology. This provides the opportunity to program any number of metering profiles. It goes far beyond the bounds of what can be achieved with pumps driven by 3-phase AC motors.

It is true that with the latest generations of traditional metering pumps, it is sometimes possible to generate asymmetric suction and pressure metering profiles. Nonetheless, and despite painstakingly integrated crank mechanisms, vector control and variable frequency drives, the degrees of freedom are severely limited. Where highly precise metering of a variety of fluids is required, with individual flow curves and different processing parameters, linear metering pumps are in a class of their own.

Two practical examples illustrate this unique position: the metering of additives and reagents in chemical processes requires a high degree of precision. Often at the level of a laboratory or pilot-plant, absolutely zero spillage is also a requirement. In addition, to control the chemical or physical processes accurately, cycles of constantly variable duration are required.

In a laboratory system for metering a viscous fluid, a four-stage metering profile with a linear pump was deployed:

- **Phase 1:**
  Discharge stroke and metering: in order to open all valves on the metering side simultaneously and set the fluid in motion, the process starts at high speed.
- **Phase 2:**
  After a short period, the speed is reduced and maintained at a constant level. This allows the fluid to be metered continuously.
- **Phase 3:**
  The slight reduction in speed prevents spillage.
- **Phase 4:**
  This is followed by a short suction process and the transition to the next discharge stroke.



Source: ProMinent

In linear motors, the coils are arranged on a flat track.

Micro-metering pumps with linear motors can therefore have a significantly more compact design.

Source: ProMinent

The traditional metering pump has transmission gearing and an adjusting eccentric.

Source: Metamorworks-stock.adobe.com

Typical application: micro-metering of additives and reagents in the chemical and pharmaceutical industries.

Gas odorisation

The metering task when odorising natural gas or hydrogen is quite different. These gases are odourless by nature but are highly dangerous due to their flammability. Chemicals with powerful odours are therefore mixed into them so that any leaks in the pipework can be detected as quickly as possible. Substances regularly used include tetrahydrothiophene (THT) and mercaptans as well as some sulphur-free compounds. The metering of these substances needs to be as continuous as possible because this is the only way of ensuring broadly homogeneous distribution in the gas flow. Depending on the odorant involved, metering flows will be between 3 and 10 mg/m³. In these cases, the metering profile is characterised by a short suction stroke (< 0.5 sec) and a long, even discharge stroke (up to 30 sec).

The odorising systems developed by Honeywell Gas Technologies use linear motor pump technology. They are low-maintenance and virtually self-venting. Due to the space saving design of linear motor pumps, it is even possible to equip a system with several of them so that backup or parallel operation is possible if required.

Micro-metering in the desert

Micro-metering pumps with linear motors have further features that come into play with standalone equipment responsible for the metering of anti-corrosion agents or odorants in pipelines. Since such equipment is mostly located in the middle of the desert, far from civilisation, reliability and low maintenance are essential. Photovoltaic systems are generally responsible for supplying the power. The DC electricity produced by the semiconductor elements drives the linear motor pumps directly. Frequency converters are unnecessary. If such systems are fitted with a web-enabled control system, they can be monitored and controlled entirely remotely. Diagnostics, amendments to parameters and uploads of new functional software are all possible without the need for anyone to be present on site. For standalone equipment in remote locations, this is an extremely important benefit.

Flexibility matters

Many users do not know exactly what their operating parameters are, or else the parameters keep changing because metering systems are used in various different processes. In such cases pump systems with a high degree of flexibility are needed. This is one of the key strengths of linear pump technology. With this technology, a highly dynamic process involving 200 strokes per minute can be configured as accurately as metering with just one stroke for 30 seconds. In a two-stage, stable-pressure operation, this allows such equipment to be used across a wide range of operating pressures from 5 to 260 bar (design: 400 bar).

Depending on the pump model, pump capacities are spread across a range from 0.01 l/h to 20 l/h. Three different control types are possible here: stroke or frequency control, stroke and frequency control, and stroke and frequency control including preset motion profiles. “With this new linear motor pump technology, the focus in discussions with customers has completely changed,” says Bernd Freissler, Product Manager at ProMinent GmbH, reporting on his experience. “We used to get asked: ‘What can your pump do?’ Nowadays the prime question is: ‘What metering

profile will yield the best outcome in my process?' That's what the universal adjustability of the linear motor metering pump offers."

Oscillation as the drive principle

On all metering pump systems fitted with 3-phase AC motors, rotational motion has to be converted into oscillating motion. This is achieved by the use of appropriately designed gear reduction ratio equipment, which converts the rotational speed of the motor into a stroke rate. The precise stroke or metering volume is usually set by means of a crank mechanism with an adjusting eccentric, using a manual adjustment wheel.

ProMinent GmbH takes a new approach. The company fits its micro-metering pumps with a linear motor. Motors of this type are direct drives which inherently provide oscillating motion. This eliminates the entire mechanism of transmission gearing and adjusting eccentrics. The system is characterised by a high degree of dynamism and precision, and by unrestricted flexibility with regard to the achievable flow curves. With no conversion or transmission tolerances of any kind, individual metering curves can be programmed.

Conventional rotating asynchronous or synchronous motors generate the magnetic field by means of orbitally offset coil windings (stator), which the rotor follows with its permanent solenoids. In linear motors, on the other hand, the coils are arranged on a flat track. Here, the armature fitted with a permanent solenoid follows the offset coils of the stator. This results in an oscillating travelling field by purely electrical means. The length of the stator with its coils and pairs of solenoids is proportionate to its propulsive power. Across the entire length of the package, a constant force is available in both directions. The key benefits of the linear motor can therefore be summed up as follows:

- The direct drive allows any number of metering profiles to be programmed.
- The gearless construction is low-maintenance, virtually free from wear, compact and space saving.
- Its highly dynamic nature balances out inaccuracies in the hydraulics – in valves, for example.

Author:
ProMinent GmbH
Heidelberg

The employees examine an innovatively manufactured stator. Source: NETZSCH

Innovative Progressing Cavity Pump Overcomes Challenging Battery Slurries

Thomas Böhme and Roger Willis

It is well known that Europe needs to develop secure supply chains for the manufacture of Lithium Ion (LiB) Batteries especially for the rapidly increasing demand for full electric or hybrid electrical vehicles. Asian manufacturers have dominated the supply of lithium batteries in recent years but the rapidly expanding production capability in Europe presents challenges for battery manufacturers and consequently equipment suppliers.

Such a challenge was presented to NETZSCH Pumpen & Systeme GmbH, a manufacturer of positive displacement pumps, regarding the difficulties of transferring and accurately dosing anode and cathode materials. One of the main challenges is the safe handling of cathode slurries containing the solvent N-Methyl-2 pyrrolidone (NMP). Ideally, the pumping of such a toxic solvent would be handled by hermetically sealed pumps using a magnetic coupling. Magnetic couplings are used where leakage must be avoided when handling corrosive, hazardous or toxic fluids, or generally speaking to avoid the concerns associated with traditional mechanically sealed pumps.

Such systems would be pumps equipped with packed glands or mechanical seals in various configurations. A pump fitted with a packed gland system in no way addresses the requirement for a leak free pump, whereas a pump fitted with a double mechanical seal with the requisite seal support system can fulfil the leak free requirement whilst introducing requirements for increased maintenance and control. Therefore, for a toxic product such as NMP, a magnetic coupling is an ideal solution addressing the need for a hermetically sealed pump. There are, however, drawbacks with proprietary magnetic couplings available from well-known manufacturers for applications requiring a progressing cavity pump.

Limits of magnetic couplings

Progressing cavity pumps are used typically in applications where the fluid to be pumped is abrasive, contains solid particles, is viscous or shear sensitive or the application requires accurate dosing or any combination of two or more of these characteristics. Specifically, when handling cathode slurries for the production of lithium ion batteries, the fluid is viscous, typically in the region of 8000 to 20,000 mPas, naturally contains solid particles and for coating applications needs to be extremely accurately dosed.

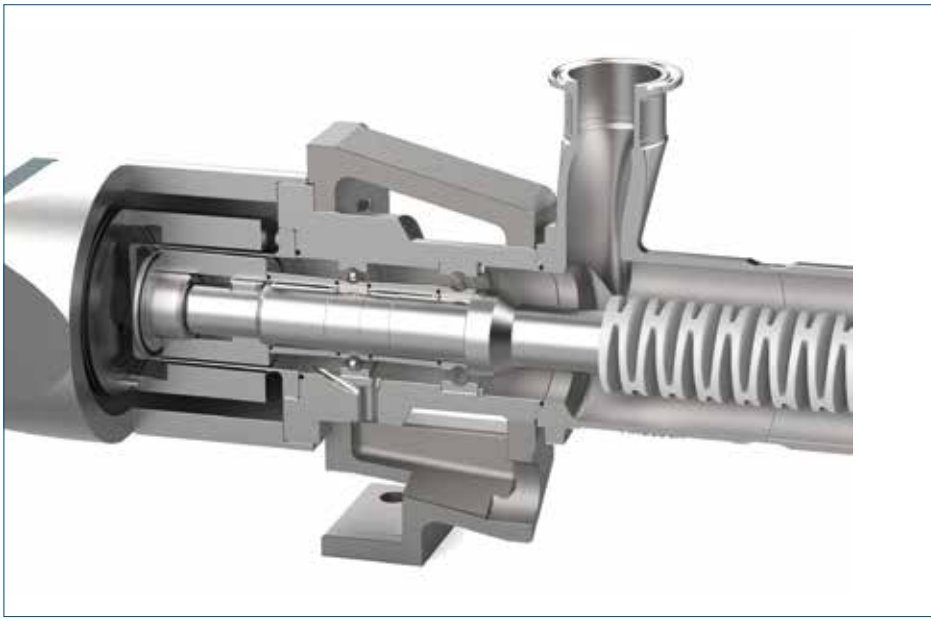
The combination of these characteristics means that standard magnetic couplings designed for direct coupling to a centrifugal pump, running at 2 pole and 4 pole motor speeds, are not suitable for such types of applications. When running a magnetic coupled pump at high speeds, 1400 or 2800 rpm, circulation of the pumped fluid will be required for cooling of the coupling. This is achieved by the fluid passing through cooling channels within the coupling. Such cooling channels are small in diameter and consequently are easily blocked by higher viscosity fluids. A progressing cavity pump pumping a product of up to 20,000 mPas would typically run at speeds of around 100 to 200 rpm, although this should not be considered as the maximum viscosity capability for progressing cavity pumps. There are applications where progressing cavity pumps are used for products well in excess of 1 million mPas.

The special pump design prevents the escape of toxic vapours and, above all, the penetration of air bubbles into the battery slurry.

New magnetic coupling meets requirements for battery sludge

Therefore, it was necessary to develop a magnetic coupling specifically designed to meet the requirements of typical progressing cavity applications. In the case of battery slurries, a

Source: NETZSCH



The progressing cavity pump is designed for complex battery applications.

Source: NETZSCH

The pump specialist develops industrial solutions for every application.

coupling needed to be developed that would be capable of handling the viscosity of the slurries. As previously described, as the rotational speeds of the progressing cavity pump would be lower than would be usual for a centrifugal pump application, excessive heat generation within the coupling was not to be expected. There were, however, other challenges for which a solution would need to be found. One such challenge would be the torque that the coupling would have to transmit.

Ceramic rotors are significantly more wear-resistant than metal rotors and do not produce metal abrasion in the battery slurry.

NETZSCH successfully developed a magnetic coupling to meet the demands of battery slurry applications, that is to say a pump that is hermetically sealed preventing the escape of toxic vapours and also importantly the ingress of air bubbles into the slurry, a point that is of special importance in the foil coating process. However, customers then presented the NETZSCH development engineers with other challenges specifically related to battery applications.

The newly developed magnetic coupling prevents air ingress into the product through the pump itself but nevertheless air bubbles can be present in the anode and cathode slurries originating from the slurry preparation process. Although deaerators can remove air bubbles from the slurries, customers have the experience that occasionally some bubbles find their way into the coating process. The newly developed magnetic coupling offers the possibility to add additional air extraction directly from the magnetic coupling when the pump is correctly orientated. Consequently, for very little capital outlay, bubble free coating of the anode and cathode slurries can be guaranteed, significantly increasing quality and reducing wastage

Source: NETZSCH

The employees assemble a progressing cavity pump.

and recycling costs. To meet the requirements of ATEX regulations a temperature probe can be fitted to the magnetic coupling where necessary.

Automatic cleaning of the pump

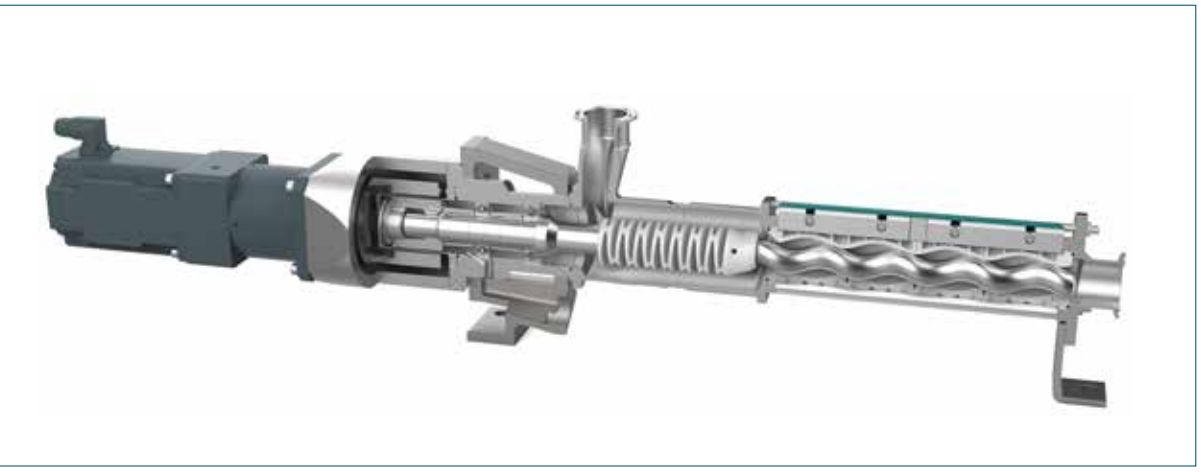
Where the battery foil production process is a batch operation, the pump, along with all of the other production equipment, needs to be cleaned between cycles. Often this would be a completely manual process with the corresponding effort and expenditure.

The challenge was presented to the NETZSCH development engineers if it would be possible to construct the pump in order that it could be cleaned using an automated system. This would require additional constructional changes to the pump. These included adding a flushing connection into the magnetic coupling. However, major adjustments were needed in the area of the pump suction housing and coupling rod.

A progressing cavity pump requires a coupling rod that accommodates the requirements of both the rotational and eccentric movements. For battery applications involving anode and cathode slurries, the most suitable solution would be to select a flexible shaft. Such an arrangement has the benefit of needing no joints to accommodate the eccentric movement as would be fitted in the vast majority of applications. The main deciding factor for using a flexible rod would be that the lubrication required for joints is eliminated. The benefit would be that there would be no contamination of the slurries by the lubricant when using lubricated joints, in the event of a joint seal failure.

Additively manufactured coupling rod integrated

For hygienic applications, a coupling rod system is available with open joints using a stainless steel rod and pins. For battery applications, such a system is not suitable due to the abrasive nature of the slurries and the danger of metal particle contamination of the anode and cathode slurries. This would lead to a reduction of final product quality.



Source: NETZSCH

Elastomer stators and additively manufactured stators are compatible with a detachable stator system.

Therefore, a flexible shaft is the obvious choice, however there is a disadvantage to using a standard flexible shaft. The traditional flexible shaft is manufactured from metals, often titanium or duplex stainless steel. Due to the limited flexibility of such a construction, the flexible shaft needs to be longer than would otherwise be the case with a coupling rod featuring a joint system. When considering automated cleaning, the increased volume within the pump housing due to its increased length would lead to increased product wastage. Ideally therefore, a concept was needed to reduce the length of the pump housing as much as possible whilst providing sufficient coupling rod flexibility to ensure reliable pump operation. New production techniques opened possibilities to resolve this conundrum without incurring the significant tooling costs associated with injection moulding. By using additive manufacturing, it was possible to rapidly prototype potential designs and subsequently manufacture the final production components. To develop a shorter coupling rod that would reduce the pump housing length, be able to withstand the mechanical loads and to fulfil the demands of automated cleaning presented a challenge. Using the latest CFD programs, a coupling rod design was eventually finalised and incorporated into the final battery pump configuration.

Using experience from food applications where cleaning in place to hygienic levels is the standard, a tangential inlet connection was incorporated to improve the cleanability of the pump by providing optimised flow conditions within the housing.

Additively manufactured stators for battery production

To successfully cover the demands of battery slurry applications, a new concept would be required also for the pump stator. Normally, progressing cavity pumps are fitted with a stator manufactured from an elastomeric material. However, due to the chemical aggressivity of some of the fluids used in battery production, especially the NMP for cathode slurries, an alternative stator material would need to be used.

In such applications it was usual to use a stator manufactured from PTFE. The manufacture of PTFE stators is a mechanical process where the stators are produced on a lathe, the inside profile being turned to size. However, given the success of manufacturing the flexible rod using additive manufacturing, it was decided to try and produce stators using the same process. After extensive testing a new design was born offering increased accuracy in the production process as well as guaranteeing the necessary chemical resistance. The efficiency of the new stator design was such that for slot die coating applications the pump could easily exceed the accuracy requirements with regard to uniform film thickness both across the width and along the foil length.

Ceramic rotors are wear-resistant

The counterpart of the stator, the rotor, also needs high levels of accuracy which can be achieved with both a metallic rotor or a ceramic rotor. The ceramic rotor offers a significant advantage over metal rotors in as much that the wear resistance is dramatically increased and more importantly there will be no metal wear particles in the slurries from the rotor. Customers have the choice what combination of rotor and stator best suits their application. This is made simple by both elastomeric stators and additive manufacturing stators being compatible with a separable stator system as shown in the graphic.

By using the latest manufacturing techniques and designing a magnetic coupling it was possible to produce a progressing cavity pump, incorporating a magnetic coupling, a flow optimised housing for automatic cleaning and additively manufactured coupling rod and stator, to suit the exacting requirements of the battery market.

Authors:
Thomas Böhme
Head of Global Key Account /
OEM Management
Business Development Battery EMEA
NETZSCH Pumpen & Systeme GmbH
Waldkraiburg

Roger Willis
Global Business Field Manager
Chemical Pulp and Paper
NETZSCH Pumpen & Systeme GmbH
Waldkraiburg

The Harm Drewes biogas plant is fed with liquid manure, solid matter separated from liquid manure, dung and renewable resources.

Source: Vogelsang

Conical progressive cavity pump ensures longer service life

Michael Brinkmann

Progressive cavity pumps are a proven solution for situations where viscous media need to be pumped against high pressures, especially when the media to be conveyed are often abrasive. Although this type of pump is suitable for these media, it has become more durable over time thanks to design modifications and the development of more wear-resistant materials and coatings. However, in practice, the wear parts of a progressive cavity pump often have to be replaced several times over the course of its life cycle. A new type of progressive cavity pump featuring a conical rotor and stator now offers longer service life, lower life cycle costs and increased energy efficiency.

Due to parts that wear out, users of progressive cavity pumps are repeatedly faced with high repair costs. Constantly having to replace worn parts is not only costly, it also fails to meet the objectives of an economical and sustainable business. These costs are usually significantly higher than the initial investment costs when purchasing the pump. For this reason, Vogelsang GmbH & Co. KG in Essen, Germany, put the progressive cavity pump concept to the test and developed it further. The result is a new type of progressive cavity pump featuring a conical rotor and stator. This innovation enables companies to set themselves up far more efficiently. The conical shape of the rotor and stator makes it possible to precise adjust the pump. Adjustments can be made quickly and easily, without the need for costly, time-consuming parts replacements.

Source: Vogelsang

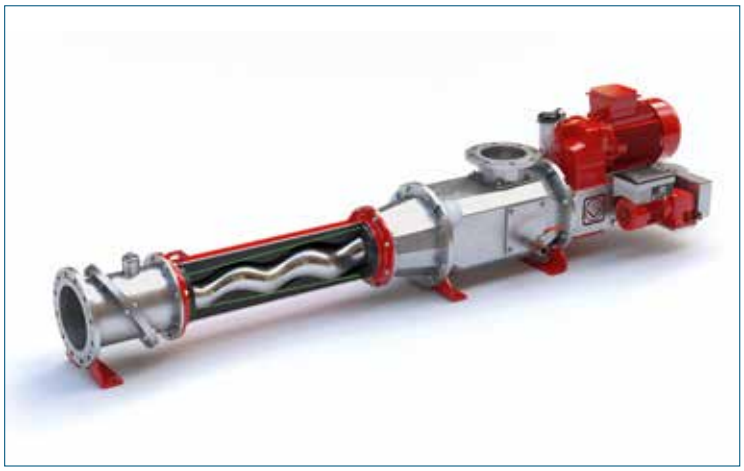
Several progressive cavity pumps are installed on-site at the Harm Drewes biogas plant.

Adjustment instead of replacing parts

In this new type of pump, the Essen-based mechanical engineering company has combined the conical shape of the rotor and stator with a cleverly designed adjustment system. As a result, the service life of the progressive cavity pump can be extended many times over, as practical trials have demonstrated. The adjustment system even enables readjustment during operation. In conventional progressive cavity pumps, a gap between the rotor and the stator that forms over time due to wear leads to reduced capacity. The user is then compelled to replace the worn parts. With the new pump solution, however, the gap can be compensated by adjusting the rotor axially, thanks to the conical shape of the rotor and stator. After adjustment, the size of the conveying chambers, the conveying capacity and the efficiency are the same as when the pump was first put into operation. This improvement ensures constant capacity with high efficiency. The adjustment system also reduces the amount of power the pump requires, a key factor in terms of energy efficiency.

Advantages of the conical progressive cavity pump

- Conical rotor-stator geometry and true-to-shape adjustment for longer service life
- Regulation of the gap during ongoing operation
- Reduction in costs and maintenance work
- Increased energy efficiency
- Intelligent automatic start-up for reduced torque when starting
- Real-time monitoring so maintenance can be planned in advance
- Easy parts replacement thanks to service-friendly design



Source: Vogelsang

The progressive cavity pump is characterized by the conical shape of the rotor and stator.

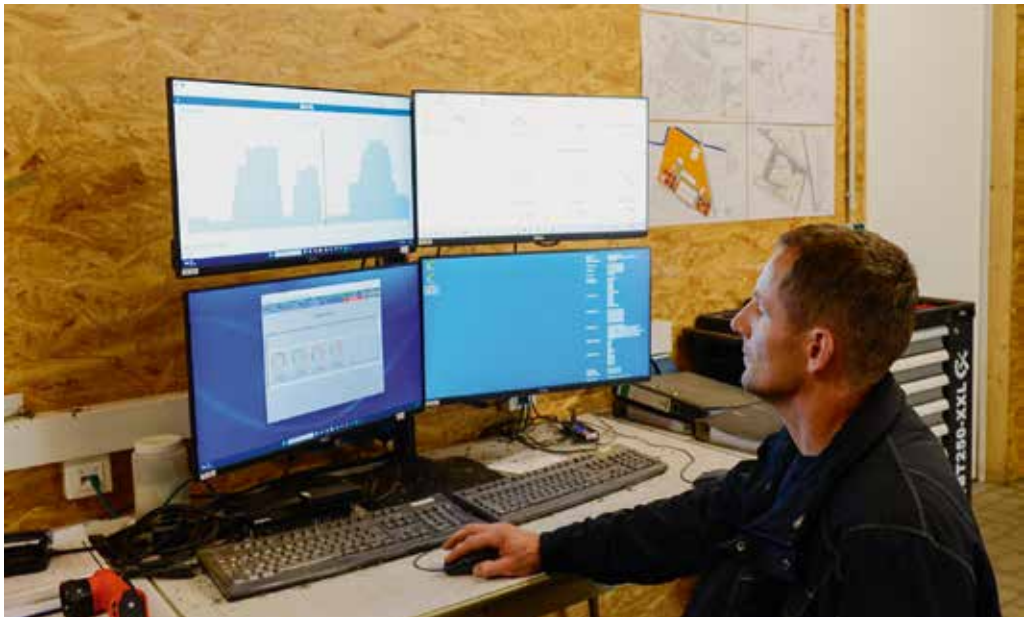
Individual adaptation to operating parameters

Varying operating parameters such as pressure, temperature or viscosity change the demands on the pump. For optimum operation, users need to adapt the interaction between the rotor and stator, which is not possible with conventional progressive cavity pumps. The adjustment system of this advanced pump ensures that the rotor and stator can always be optimally positioned in relation to each other at the touch of a button or by a mouse click in the control room. If the conveying elements are optimally attuned to the operating conditions, the contact pressure between the two parts is reduced, thus minimizing both wear and power consumption. Users benefit from long-lasting, highly efficient pump technology and reduced costs for spare parts and replacements.

The adjustment system also reduces the amount of power the pump requires, a key factor in terms of energy efficiency.

Automatic start-up: fully automated and energy-efficient

The smart automatic start-up system also helps to improve energy efficiency. The high starting torque of progressive cavity pumps usually determines the size of the drive motor. However, thanks to the adjustable clamp between the two pumping elements, the new pump series is different. Generally, a smaller motor is required to start the pump than with conventional models, keeping power consumption to a minimum due to the optimized motor size. The innovation also improves energy efficiency and reduces the costs for power electronics and safety elements at the same time. The start-up process is fully automatic and does not require a separate control system.



Source: Vogelsang

Marco Blanken, an employee at the Harm Drewes biogas plant, monitors the progressive cavity pump.

Users can view the status of the pump's wear parts on a real-time display. Instead of being surprised by a sudden breakdown, they receive continuously updated information and can plan ahead to replace parts as the need arises. When parts finally do need to be replaced, the process is quite straightforward because of the pump's service-friendly design. The rotor-stator unit swings out and can then be renewed either by replacing it in one piece or by replacing individual parts. A wear-resistant sleeve that does not have to be removed when replacing parts protects the robust cardan shaft. The new design provides the user with durable, highly efficient pump technology that can be flexibly adapted to handle a variety of pumping tasks and operating parameters.

The durable, highly efficient pump technology can be flexibly adapted to a variety of pumping tasks and operating parameters.

Pumping technology in practical use

This advanced progressive cavity pump is in operation at the Harm Drewes biogas plant in Breddorf, Germany. The company uses the new pump to make the biogas plant even more efficient. Together, the two farmers Uwe Ringen and Harm Drewes farm an area of around 900 hectares. They also operate two biogas plants: the older of the two is fed with agricultural residues such as liquid manure, dung and energy crops. These are also included in the input materials that are digested in the second plant, which has been in operation since 2010.

The first of the two biogas plants was built in 2006. Originally, the plant generated an electrical output of 530 kilowatts (kWel). At that time, only maize silage was fed in. In the same year, Drewes and Ringen put a combined heat and power plant (CHP) into operation as a satellite unit. The waste heat from the biogas plant is currently used both in pig farming and for drying items such as firewood. Over the years, the two owners have steadily expanded the biogas plant, increasing the rated output to two mega-

Source: Vogelsang

To convey the liquid phase to the liquid feeding system, the operators of the biogas plant installed the progressive cavity pump with its conical rotor-stator geometry.

Source: Vogelsang

For the external heat exchanger, the biogas plant operators used the automatic version of the conical progressive cavity pump.

Source: Vogelsang

The progressive cavity pump running on the heat exchanger is particularly energy-efficient thanks to the automatic start-up feature.

watts in 2010 and installing additional CHP units based on gas engines. Today, these produce most of the electricity. During peak loads, the older dual-fuel engines are also started up, giving the system a peak output of almost five megawatts. Today, electricity production is controlled remotely by a service provider.

Long service life despite abrasive input materials

Up to 2019, maize silage was almost the only input material for the biogas plant. Today, however, the operators rely on a mix. The plant digests around 20,000 tonnes of input material per year – including around 8,000 tonnes of dung and solid matter separated from liquid manure, supplied by surrounding farms. Almost 75 tonnes of input material are fed into the biogas plant each day. The switch to highly fibrous input material contaminated with foreign matter placed a greater strain on the plant's components. The dry matter content in the digester rose to between 14 and 15 percent, which also increased power consumption and the operating time of the pumps and mixers. In order to boost efficiency and modernize the system, the operators installed a liquid feeding system. The solid matter feeder mixes the dry solid matter with recirculated material from the digester to form a feed slurry, prepares everything as a homogeneous suspension and pumps it into the digester. This was a challenging process for the pump that conveys the highly viscous recirculated material from the digester to the liquid feeding system. Due to the high viscosity, long distances and sometimes unfavorable pipe routing, the unit had to pump against pressures of up to five bar.

"We had to replace wear parts in the feed pump every two to three months," said Marco Blanken, an employee at the Harm Drewes biogas plant. The plant operators decided to replace the feed pump with the conical progressive cavity pump in order to improve this aspect of their operations. Because the rotor and stator can be readjusted, the operators have significantly reduced the frequency of parts replacement. In addition, service life has more than quadrupled since the pump was installed and there is still capacity for further readjustment.

Wide range of applications

Impressed by the design of the conical progressive cavity pump, Drewes and Ringen then also used the pump on their external heat exchanger, which ensures that the temperature in the digester is kept at a constant 53 degrees Celsius. Depending on the weather conditions, the pump runs for between four and six hours a day. The automatic version of the new pump is in use here. This means that the pump does not have to be switched off for readjustment, but can be readjusted while running. It also means that the pump requires a smaller motor and therefore less energy overall due to the lower starting torque. Uwe Ringen, the plant operator, said: "We are in a good position with the use of the conical progressive cavity pumps. They pump without fluctuations, which is to say, more smoothly and evenly than is the case with conventional pumps of this type." He added: "Thanks to the modernization of our system, we can react flexibly to new requirements."

The conical progressive cavity pump provides users with economical, energy-efficient pump technology. Its constant capacity makes it a key component for ensuring smooth biogas plant operation. In Ringen's words: "We needed technology that was durable and could be flexibly adapted to our operating parameters. With the conical progressive cavity pump, we have a highly efficient solution that we can adjust and readjust to suit our requirements."

Author:
Michael Brinkmann
Chief Sales Officer, CSO
Vogelsang GmbH & Co. KG
Essen (Oldenburg)

Biogas plants work with different substrates, taking into account seasonal and regional fluctuations. Source: Pumpenfabrik Wangen

Increasing the efficiency of biogas plants

Meike Winter and Raam Badde-Morgenthaler

There has been considerable progress made in the production and use of biogas: in 2022, European biogas plants produced a total of 105 terawatt hours (TWh), providing around 2.5% of the electricity generated in the European Union. Various technologies are used for biogas production, with the general conditions varying in the individual European countries. Adaptive pump systems for biogas production are already available today, which meet the wide-ranging requirements, and increase the efficiency of biogas plants.

As a renewable energy source, biogas can contribute to the energy transition, as it is baseload-capable and can be easily stored: biogas is also available when solar energy or wind energy cannot be used. These are key requirements for reducing dependence on fossil fuels and achieving global climate goals. The potential uses of biogas extend across various sectors, from power generation to heat production. Technical advances in recent years have made the production of biogas more efficient and cheaper. At the same time, the political framework has improved and both the European Union and the individual countries themselves are mainly promoting the production and use of biogas. Technological innovations and a harmonised European policy are crucial to further advance the development of biogas to create a sustainable energy future.

From substrate to biogas

To obtain biogas, biomass or slurry is supplied to the plant and decomposed by microorganisms in the fermenter to produce biogas. The digestate can be reused as fertiliser, while the biogas is made usable in a treatment plant. There are four key process steps:

- **1. Substrate management:**
  The starting materials are pumped into the pre-chamber and the substrate is shredded and mixed so that the microorganisms can ideally utilise it.

- **2. Biogas production:**
  The fermenter into which the prepared substrate is pumped is the heart of the system. The substrate is fermented anaerobically and continuously mixed while the microbes work.

- **3. Digestate management:**
  Substrate residue is pumped out and further processed.

- **4. Biogas storage:**
  The biogas produced is stored and can be used when required.

The experts at Pumpenfabrik Wangen GmbH analysed the entire manufacturing process in order to make the process as energy-efficient as possible. “Biogas plants work with very different substrates. The substrate can consist of maize or green waste, as well as manure or slurry. In addition to seasonal fluctuations due to agricultural cultivation, there are differing raw material preferences in different countries. Overall, this results in a wide range of viscosities – both in the substrate and during biodegradation,” explains Raam Badde-Morgenthaler, Application Engineer at Wangen Pumpen. The manufacturer’s focus is on the feed technology: various feed systems are available depending on the medium. Last year, one pump was often called for to pump maize, grass silage, whole crop silage, solid manure, poultry litter, waste and co-fermentation products. There is currently a need for substrate conditioners that mix solids and liquids, actively remove foreign matter, and thus improve the efficiency of the plants. Other pumps are specially developed for pumping substrate in biogas plants and also take over the role of separator feed or even the feed of difficult solids, such as grass silage or solid manure.

Germany: potential of slurry and manure

There are two very different sides to the general picture of biogas in Germany: on the one hand, the Federal Government’s target is to meet a quarter of Germany’s electricity consumption through a mix of renewable energies by 2030. On the other hand, the ruling of the Federal Constitutional Court on the Climate and Transformation Fund is resulting in a gap in the funding opportunities for the expansion

Source: Pumpenfabrik Wangen

The pump manufacturer develops pumps and modules for the pumping of substrate, separator feed and substrate preparation.

The biogas plant in Wolfegg, Baden-Wuerttemberg, has three fermenters. Source: Pumpenfabrik Wangen

of renewable energy sources. The Federal Ministry of Food and Agriculture (BMEL) writes on the role of biomass in the amendment to the Renewable Energy Sources Act (EEG) 2023: "Biomass continues to be of particular importance for the energy transition. It is the only renewable energy carrier that can be stored simply and easily and used on demand. [...] The aim is to limit the expansion of biomass to waste and residual materials." But this expansion threatens to stagnate without funding opportunities for the construction of biogas plants, without the development of new technologies for biogas production or the integration of biogas plants into energy systems, as well as an improved infrastructure for the utilisation of biogas. Biogas plants are currently mainly using maize silage – the Federal Ministry of Food and Agriculture wants to change this: "Slurry and manure still offer considerable potential that can be exploited for energy in future. Currently, around one third of the existing potential is being used and, according to expert opinions, another third can be tapped with appropriate effort for the use of biogas."

There is currently a need for substrate conditioners that mix solids and liquids, actively remove foreign matter, and thus improve the efficiency of the plants.

The quality of the biogas is crucial

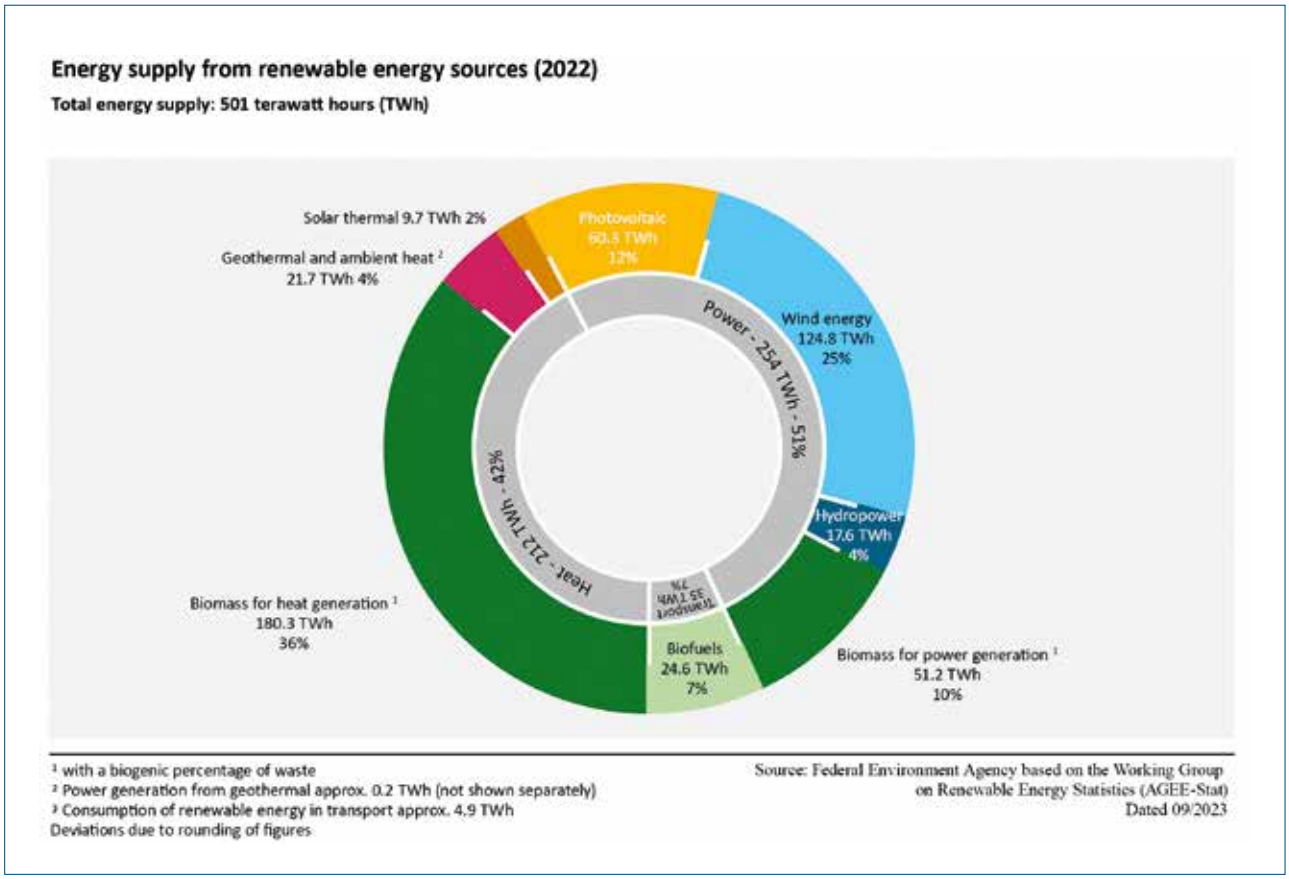
In principle, biogas can be converted into electricity and heat in combined heat and power plants or refined into bio-natural gas and fed into the natural gas grid. The war of aggression in Ukraine and the sanctions against Russia have brought the use of biomethane into focus as a natural gas substitute. "The quality of the biogas is crucial, and its oxygen content is governed by strict criteria. To comply with the specifications, the substrate pumped into the fermenter must be ideally processed to reduce the subsequent work involved in gas purification," continues Raam Badde-Morgenthaler. When the first subsidies for biogas plants from the EEG 2004 expire in the coming years and these plants no longer receive a fixed feed-in tariff from January 2024, this could lead to a decline in plants in Germany despite the huge potential they offer.

France: biogas meets nuclear energy

The development of biogas plants in France is closely linked to the political will of the country. There was a spirit of optimism at the beginning of the 2000s and the government put in place measures to promote its development. Now, funding and its associated expansion have decreased. However, 10% of French gas consumption is to be met by renewable sources by 2030. However, to meet this target, France also has to fund the construction of biogas plants, the development of new technologies for biogas production, the integration of biogas plants into energy systems, as well as an improved infrastructure. “Regardless of the feed substrates, French biogas plants have to be extremely robust and be capable of being operated with a lot of foreign matter without this resulting in early wear. We have adapted our system to this. It features a foreign body sep-

Source: Pumpenfabrik Wangen

An employee assembles a pump for a biogas plant.



Source: Pumpenfabrik Wangen

The chart shows the respective percentage of energy supply generated by renewable energy sources.

Experts believe that the energy transition will not succeed without the contribution of biomass for conversion into electricity, heat or biomethane.

arator and a substrate shredder to protect the systems and improve their service life," explains Badde-Morgenthaler. The pump manufacturer also needs to adapt to specific national regulations governing the operation of biogas plants, which were to be simplified in France at least in 2022.

Denmark: biogas pioneer

Our neighbours in the north are the global pioneers in the use of biogas, according to the 2021 target market analysis by the German-Danish Chamber of Trade and Industry – in no other country is the percentage of biogas in the total gas consumption as high as in Denmark. However, 100% of Danish gas consumption is to be met by renewable energy sources by 2030. In order to achieve this goal, the number of biogas plants is to be further expanded in the coming years and technologies improved to increase the efficiency and cost efficiency of the plants. The Danish government promoted biogas as early as the 1990s, with the result that the industry developed at an early stage. Alongside agricultural waste, food waste and waste water are also systematically used for biogas production. The biogas plants are geographically concentrated around a number of hotspots, so that the transport of the biomass and the infrastructure for feeding it into the gas grid are designed accordingly efficiently. In Denmark, too, there is a move away from the use of maize as a substrate – in future, slurry, straw, food waste and waste water will increasingly be used. "The fermenters, shredders, pumps and pipework will become larger, the

processing of the solid substrates will have to be adapted, and a higher delivery rate will also have to be achieved," explains expert Badde-Morgenthaler.

The energy transition needs biogas

The use of fossil fuels is to be reduced worldwide in order to achieve climate targets and reduce the increase in harmful CO_2 emissions. Experts believe that the energy transition will not succeed without the contribution of biomass for conversion into electricity, heat or biomethane. Biogas is regionally available, easy to store, and versatile. Some countries are undergoing a rethink: valuable agricultural land should be preserved for the production of food and should not be used for the cultivation of plants for biogas plants. Instead, attention is turning to problematic substances, such as slurry, waste water or recyclable waste. Manufacturers of components for biogas plants are faced with the challenge of preparing these substrates for efficient use, guiding them through the entire process, and then transporting them out of the plant so that they can be reused as fertilisers. A broad network of sales partners ensures that Wangen Pumpen can be reached on site to meet the manufacturers and operators of biogas plants worldwide and ensures that specific national regulations are taken into account when installing the pumps in biogas plants.

Source: Pumpenfabrik Wangen

Biogas pumps are ideal for pumping dry substrates as they are mixed with liquid in the pump.

Authors:
Raam Badde-Morgenthaler
Application Engineering / Technical Advice
Pumpenfabrik Wangen GmbH
Wangen in the Allgäu region of Germany

Meike Winter
Journalist & Graduate Media Scientist
Textagentur Winter
Amtzell, Germany

Applications Pumps & Systems

	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**
Alltech Dosieranlagen GmbH www.alltech-dosieranlagen.de		●									●		●						●		●				●								●				
ANDRITZ www.andritz.com/pumps		●		●	●	●	●		●	●	●	●	●	●	●		●	●	●	●	●			●			●				●	●					
Apollo Gößnitz GmbH www.apollo-goessnitz.de				●	●								●					●	●	●	●																
Beinlich Pumpen GmbH www.beinlich-pumps.com																									●	●					●	●		●	●		
ITT Bornemann GmbH www.bornemann.com		●	●								●	●	●										●	●	●	●	●	●		●	●			●		●	
Brinkmann Pumpen K.H. Brinkmann GmbH & Co. KG www.brinkmannpumps.de			●																					●	●				●	●						
Paul Bungartz GmbH & Co. KG www.bungartz.com																																					
CP Pumpen AG www.cp-pumps.com																							●	●		●		●				●	●	●		●	
Crane Process Flow Technologies GmbH www.cranecpe.com		●	●							●	●								●				●	●	●		●	●		●	●	●		●	●		
Deutsche Vortex GmbH & Co. KG www.deutsche-vortex.de																																					
DIA Pumpen GmbH www.dia-pumpen.de		●	●	●	●		●		●	●	●	●								●	●		●	●		●				●	●	●		●	●	●	
Dickow Pumpen KG www.dickow.de													●					●																			
Düchting Pumpen Maschinenfabrik GmbH & Co. KG www.duechting.com							●						●					●	●	●	●																
EDUR-Pumpenfabrik Eduard Redlien GmbH & Co. KG www.edur.com		●	●	●	●	●	●		●		●	●	●		●	●		●	●	●	●						●			●						
FLUX-GERÄTE GMBH www.flux-pumps.com		●	●								●	●			●				●				●	●	●		●	●	●	●	●			●			
Franz Eisele und Söhne GmbH & Co. KG www.eisele.de		●	●								●	●																									
FELUWA Pumpen GmbH www.feluwa.com		●	●		●		●			●	●	●	●					●					●	●	●	●	●	●	●	●	●			●		●	
Flowserve-Sterling SIHI GmbH www.flowserve.com		●	●	●	●						●		●	●				●	●		●		●	●		●	●				●	●		●			
FRISTAM Pumpen KG (GmbH & Co.) www.fristam.de																		●					●	●			●	●		●	●			●	●	●	
Gather Industrie GmbH www.gather-industrie.de											●		●					●	●		●		●	●	●		●	●	●	●	●			●	●	●	
GEA Group Aktiengesellschaft www.gea.com																		●	●				●	●		●	●	●		●	●			●	●	●	
GRUNDFOS GMBH www.grundfos.de		●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●		●	●	●	●	●		●	●			●		●	

		●					●	●			●		●				●						Tank, container, barrel
●	●	●	●	●	●		●	●	●	●	●		●	●	●		●	●	●	●	●		Chemical industry
●	●		●		●		●	●			●		●	●	●		●	●	●	●			Draining
								●											●				Gas dehydration
	●							●							●				●		●		Gas washer
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	●				●		●	●			●		●	●		●		●		●	●		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
●												●								●			Heating technology
●		●						●						●		●				●			Refrigeration and air-conditioning engineering
		●		●				●		●				●		●		●	●				Heat-transfer technology
																							Energy generation
		●		●			●	●	●									●	●	●			Energy engineering
●				●				●											●	●			District heating
								●										●	●				Firing technology
●				●				●							●				●				Geothermics
				●				●										●	●				Prime movers
		●		●	●			●			●		●		●				●	●	●		Power station technology
	●	●			●		●	●	●		●		●		●								Flue gas purification
																							Petrochemical; Oil
	●	●		●	●		●	●	●	●	●		●	●	●		●	●	●				Oil and petrochemical industry
	●	●			●			●		●				●			●	●	●	●			Off-shore technology
																							Mining; Metallury 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
							●	●								●							**Plastic production/processing**
								●															**Hydrogen technology**

Applications Pumps & Systems

	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**
HAMMELMANN GmbH www.hammelmann.com													●					●						●			●			●	●			●			
Hauhinco Maschinenfabrik G. Hausherr, Jochums GmbH & Co. KG www.hauhinco.de			●																●												●					
Herborner Pumpentechnik GmbH & Co. KG www.herborner-pumpen.de		●	●		●		●			●	●			●	●	●			●		●		●	●			●		●	●						
HERMETIC-Pumpen GmbH www.hermetic-pumpen.com																		●					●	●			●	●		●	●			●			
HNP Mikrosysteme GmbH www.hnp-mikrosysteme.de																							●	●	●		●	●	●	●	●	●	●	●	●		
HOMA Pumpenfabrik GmbH www.homa-pumpen.de		●	●		●	●	●	●	●	●	●			●			●				●															
Jung Pumpen GmbH www.jung-pumpen.de		●	●		●	●	●	●	●	●	●	●		●		●	●				●															
KAMAT GmbH & Co. KG www.kamat.de		●	●			●					●	●	●				●	●					●		●	●			●		●	●		●			
KESSEL AG www.kessel.de		●					●			●																											
Klaus Union GmbH & Co. KG www.klaus-union.com													●										●									●		●			
KNF Neuberger GmbH www.knf.com		●									●								●			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Körting Hannover GmbH www.koerting.de		●											●						●								●				●					
KRACHT GmbH www.kracht.eu																									●				●			●				
KSB SE & Co. KGaA www.ksb.com		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●			●			●	●	●	●		●	
LEISTRITZ Pumpen GmbH www.leistritz.com																							●	●	●	●	●	●		●	●		●				
LEWA GmbH www.lewa.com																							●	●	●	●	●	●	●		●		●	●			
Maag Germany GmbH www.maag.com																							●		●			●	●		●		●	●			
Maag Witte GmbH www.maag.com																							●		●			●	●		●			●			
Mahr Metering Systems GmbH www.mahr.com																									●	●		●	●		●			●			
MATO GmbH & Co. KG www.mato.de																																					
Munsch Chemie-Pumpen GmbH www.munsch.de		●											●						●															●			
NETZSCH Pumpen & Systeme GmbH www.pumps-systems.netzsch.com		●	●		●	●	●		●	●	●	●	●	●			●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	

●		●	●	●	●			●	●		●				●						●	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
								●			●								●			Heating technology
							●	●	●		●	●		●				●	●			Refrigeration and air-conditioning engineering
							●	●	●			●						●	●			Heat-transfer technology
																						Energy generation
●								●	●		●	●		●				●	●			Energy engineering
								●														District heating
											●							●				Firing technology
							●	●		●		●		●				●		●	●	Geothermics
●							●		●													Prime movers
●	●						●	●	●	●	●	●						●		●		Power station technology
●	●							●		●	●	●						●				Flue gas purification
								●														**Petrochemical; Oil**
●		●	●	●	●	●	●	●	●	●	●	●		●			●	●	●	●	●	Oil and petrochemical industry
●			●	●	●	●	●	●	●	●		●	●	●					●	●	●	Off-shore technology
																						Mining; Metallury 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
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																						Pulp and Paper
●			●		●	●	●	●	●	●	●	●		●				●	●	●	●	Paper and cellulose industry
																						Marine, shipyard technology
●			●				●	●	●	●	●	●		●		●		●	●	●	●	Marine, dockyard
					●												●					**Plastic production/processing**
								●				●		●			●					**Hydrogen technology**

Applications Pumps & Systems

	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**
oddesse Pumpen- und Motorenfabrik GmbH www.oddesse.de		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●			●			●				●						
Oerlikon Barmag, Zweigniederl. der Oerlikon Textile GmbH & Co. KG www.oerlikon.com/barmag		●									●	●						●	●				●	●	●	●	●	●	●	●	●			●			
ORPU Pumpenfabrik GmbH www.orpu.de		●	●	●	●	●	●	●		●	●	●							●		●															
OSNA-Pumpen GmbH www.osna.de			●	●	●	●	●	●	●	●	●	●					●	●	●	●	●																
PCM Deutschland GmbH www.pcm.eu		●	●				●				●								●		●		●	●	●	●	●	●		●	●			●	●		
PF Pumpen und Feuerlöschtechnik GmbH www.johstadt.com		●				●					●								●				●	●	●		●	●		●	●						
Ponndorf Gerätetechnik GmbH www.ponndorf.com		●	●								●								●		●			●	●		●	●	●	●	●			●	●		
ProMinent GmbH www.prominent.com		●		●	●	●	●				●	●	●		●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●			
Pumpenfabrik Wangen GmbH www.wangen.com		●	●								●	●		●					●				●	●	●	●	●	●	●	●	●	●	●	●			
REBS Zentralschmiertechnik GmbH www.rebs.de											●			●										●	●	●	●										
ITT Rheinhütte Pumpen GmbH www.rheinhuette.de		●									●		●						●				●											●			
Richter Chemie-Technik GmbH www.richter-ct.com		●									●		●						●				●	●			●				●			●			
Rickmeier GmbH www.rickmeier.de																																					
Schmalenberger GmbH + Co. KG www.schmalenberger.de		●		●	●		●	●	●	●	●	●		●	●				●		●		●		●				●					●			
SERO PumpSystems GmbH www.seroweb.com				●	●								●					●	●	●	●		●	●			●	●			●	●		●			
SKF Lubrication Systems Germany GmbH www.skf.com/schmierung		●	●								●	●												●	●	●	●				●						
SPECK Pumpen Verkaufsgesellschaft GmbH www.speck-pumps.com		●		●	●	●	●	●	●	●		●			●	●	●	●	●		●			●			●			●					●		
STOZ Pumpenfabrik GmbH www.stoz.com																																					
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Applications Pumps & Systems

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	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	Heating technology	Refrigeration and air-conditioning engineering	Heat-transfer technology	**Energy generation**	Energy engineering	District heating	Firing technology	Geothermics	Prime movers	Power station technology	Flue gas purification	**Petrochemical; Oil**	Oil and petrochemical industry	Off-shore technology	**Mining; Metallury 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	**Plastic production/processing**	**Hydrogen technology**
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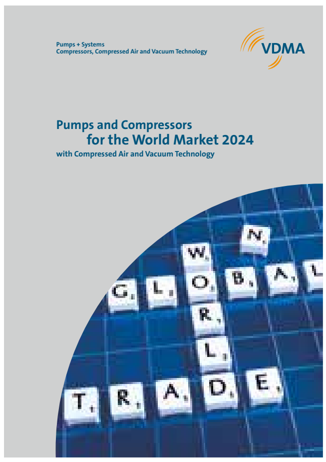

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Editor
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VDMA Compressors, Compressed Air
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Lyoner Str. 18
60528 Frankfurt am Main
Germany
Phone +49 69 6603-1296
E-Mail ulrike.maetje@vdma.org
Internet www.vdma.org

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Project management
Heike Höbel
VDMA Services GmbH

Editorial staff
Antje Stohl,
Freelance journalist, Frankfurt

Design and Production
Martina Becker
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Oil-free and food-safe compressors guarantee high quality standards in the food industry. Source: Adobe Stock

Compressors guarantee oil-free and food-safe compression

Jörg-Peter Mehrer

Health and safety aspects have a high priority in the food and beverage industry. Contaminated gases can lead to product rejects and a considerable health risk for the consumer. Oil-free and food-safe compression can ensure that the final product meets high quality standards. A new product series offers the right compressors for various applications and guarantees this.

In breweries, large quantities of the greenhouse gas carbon dioxide (CO_2) are released during beer production, known in this context as carbonic acid. The CO_2 is produced during alcoholic fermentation and is also required later for a number of downstream processes. Breweries use it to flush and thus clean pipes, as well as pressure and storage tanks. Another important area of application is pre-charging, in which CO_2 is used to build up a counter-pressure in tanks, kegs and bottles before the beer is filled, preventing the beer from foaming up and becoming stale during the filling process.

The gas produced in large quantities during alcoholic fermentation is often released into the atmosphere by breweries as CO_2 emissions. To cover their own needs, other companies in turn buy carbon dioxide for their own production processes. Unused or emitted carbon dioxide therefore has great potential for being recycled. The recovery of carbon dioxide can reduce production costs and greenhouse gas emissions. By using a CO_2 recovery system, companies are making their contribution to environmental protection.

CO_2 recovery in practice

As early as 1972, a small brewery in Belgium installed a CO_2 recovery system with oil-free piston compressors from Mehrer Compression GmbH in Balingen. As a result, the brewery reduced its CO_2 emissions by up to 80 per cent. The system was to be brought up to the latest technical standard in 2022. The brewery once again opted for reliable solutions from the German compressor specialist. As the compressor systems do not require expensive and high-maintenance filters for lubricants, there is no energy loss or waste to be disposed of in the form of filter elements.

CO_2 recovery is a crucial process for the Belgian brewery in order to guarantee the food-safe beer flavour and achieve the associated product quality. The carbon dioxide from the recovery process has a slight beer flavour anyway and is therefore particularly suitable for fizzing up their own drinks – more so than the tasteless and pre-filtered carbon dioxide from a gas supplier's lorry. In addition, in the latter case, the purity and origin of the carbon dioxide is often not entirely certain. Moreover, transport to the consumer generates CO_2 emissions – another reason to strive for oil-free, food-safe and sustainable CO_2 recompression in your own company. Food-safe compression saves energy, reduces CO_2 emissions and sustainably reduces the CO_2 footprint in the value chain.

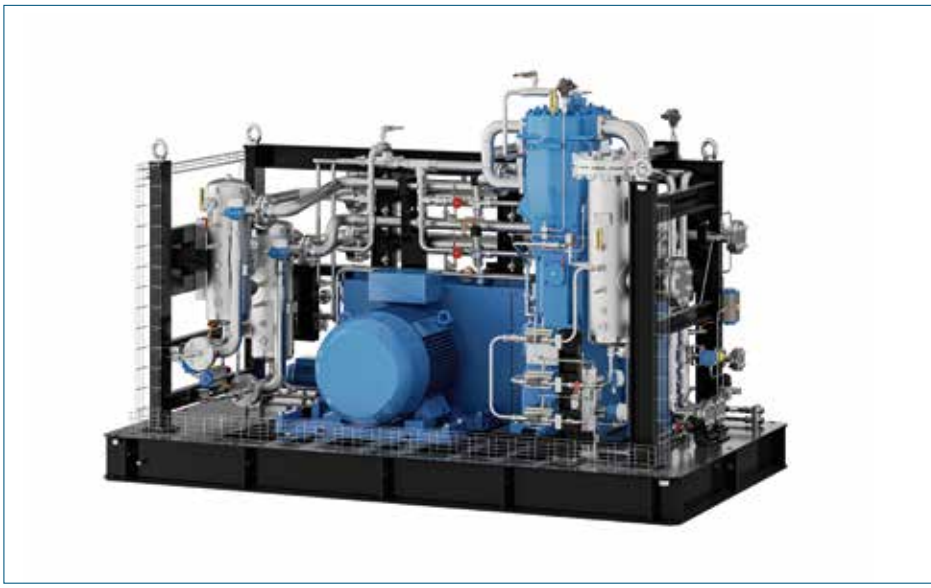
Reusing recovered carbon dioxide

The Belgian brewery's CO_2 recovery system allows the carbon dioxide produced during alcoholic fermentation to be recovered and used for subsequent business processes. The carbon dioxide produced is first collected in a gas balloon, filtered and stored. It is then compressed by an oil-free and food-grade piston compressor and supplied in liquid form in tanks. This allows the user to add the carbon dioxide back to the final beer product in a subsequent process or utilise it for downstream processes.

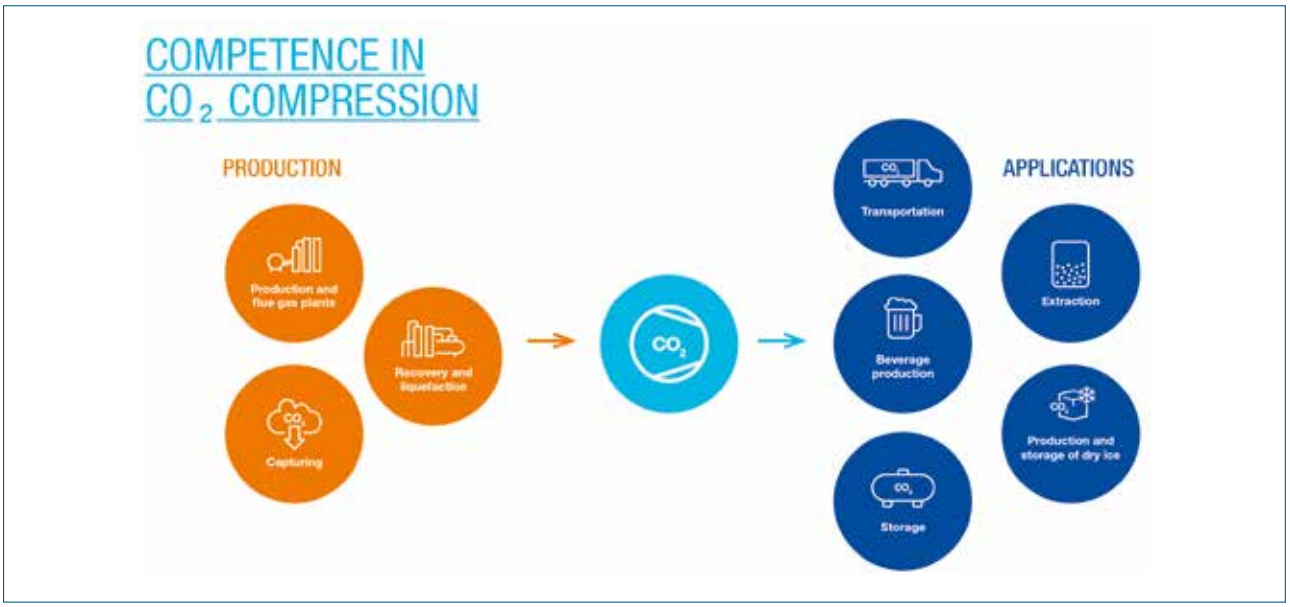
Dry ice production thanks to CO_2 compression

The CO_2 compressed by this process and made available in liquid form has yet another benefit, however. With the help of the Joule-Thomson effect, users can produce food-grade dry ice. During this process, the liquid CO_2 cools down to -78.5° Celsius as it expands, creating carbon dioxide snow – known as dry ice. This can be

Source: Mehrer Compression



This compressor is suitable for coming into contact with food.



Source: Mehrer Compression

Recovered carbon dioxide can be reused in a wide variety of ways.

pressed into various shapes, such as pellets, blocks or discs, and made available for further use.

Dry ice offers various advantages:

- It does not melt, but merely changes from a solid to a gaseous state. This means that direct vaporisation takes place without residues. In other words, no water is produced, as is the case with ice cooling, for example.
- Dry ice is also odourless and tasteless and achieves three times the cooling capacity of conventional ice.
- Dry ice has anti-bacterial properties, is non-toxic, non-flammable and inert.

These properties make dry ice suitable for a wide range of applications. It can be used for cooling food, pharmaceutical products and in medical applications. Dry ice can also be used in the chemical industry and in the cleaning sector due to its positive properties. There are already dry ice pressing systems that are driven electromechanically and therefore do not require any hydraulic oil. These systems are completely oil-free and suitable for safe use in the food sector. These machines are also particularly durable. They produce high-quality dry ice with a conversion rate of up to 45 per cent.

The Joule-Thomson effect

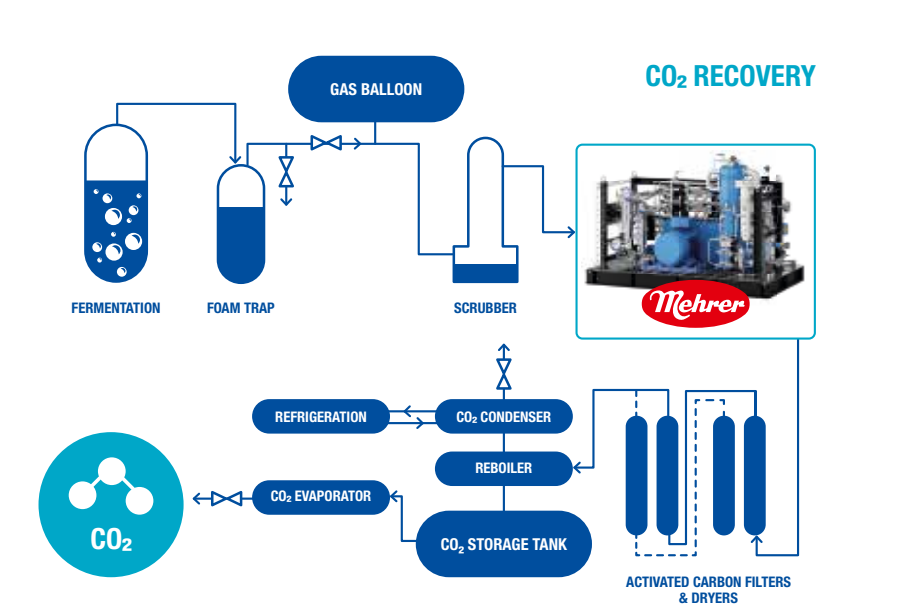
- The effect occurs when a gas or gas mixture undergoes a change in temperature due to a change in pressure.
- Gas expands when it is throttled. The gas volume and the mean particle distance increase, so that work (=force times distance) acts against the attractive forces between the particles. This means that a body is moved with force and receives energy that is extracted from its surroundings – in this case the gas. This reduces the energy of the gas, the particles become slower and the gas cools down.
- The effect is caused by attractive and repulsive forces between the particles of a real gas. The Joule-Thomson effect plays an important role in the thermodynamics of gases and is the basis for gas liquefaction.

Source: https://www.spektrum.de/lexikon/chemie/joule-thomson-effekt/4693 and https://www.chemeurope.com/en/encyclopedia/Joule-Thomson_effect.html

Food safety guaranteed

A growing challenge for the entire food and beverage industry is to provide safe food that is suitable for consumption and does not harm the health of consumers. Regulation (EC) No. 1935/2004 of the European Parliament stipulates that materials or items that come into direct or indirect contact with food must not contain any substances that could be harmful to human health. In this context, machines and systems must fulfil the requirements for food-compatible materials of Regulation No. 1935/2004.

The compressed air quality of a CO_2 recovery system for the food and beverage industry has a direct impact on the safety of food. Therefore, in the event of direct or indirect contact with the product, companies must ensure that there are no oil particles in the compressed air that could



The CO_2 recovery system allows the carbon dioxide produced during alcoholic fermentation to be reused. Source: Mehrer Compression

Greenhouse gas emissions in Germany

Released greenhouse gas emissions threaten the atmospheric balance and lead to a rise in global temperatures.

- Total emissions in Germany in 2022 amounted to 746 million tonnes. This corresponds to a reduction of 1.9 per cent compared to the previous year.
- German greenhouse gas emissions fell by 40.4 per cent between 1990 and 2022.
- Germany's greenhouse gas emissions have to be reduced by at least 65 per cent compared to 1990 levels by 2030. The aim is to achieve complete greenhouse gas neutrality by 2045.
- In 2022, Germany only just achieved the target of minus 40 per cent greenhouse gas emissions set for 2020. Without massive and rapid additional efforts, the further goals will not be achieved either.
- The German Federal Climate Protection Act, which was amended in 2021, significantly reduces the sectoral emission levels for 2030 and brings forward the greenhouse gas neutrality target from 2050 to 2045. In order to achieve the climate protection targets, the German government is developing an emergency climate protection programme based on the Climate Action Programme 2030.

Source: https://www.umweltbundesamt.de/en

contaminate the food. These safety standards also apply to the production and use of dry ice. In order to guarantee an absolutely oil-free and food-safe process, users should rely on appropriately safe machines. This means that the compressed gas can be used without hesitation in downstream production processes – regardless whether that be for direct reutilisation of the carbon dioxide recovered or for further processing into dry ice.

Source: Mehrer Compression

A Belgian brewery reduced its CO_2 emissions by up to 80 per cent by using a CO_2 recovery system.

Contribution to climate protection

Carbon dioxide is considered to be one of the causes of the greenhouse effect and global warming. The functional principle of CO_2 recovery systems therefore not only opens up good opportunities for economical and CO_2-self-sufficient operation. It also offers the opportunity to make a contribution to environmental protection in a sustainable and economically sensible way. A medium-sized brewery, for example, emits around 200,000 tonnes of CO_2 into the atmosphere for an annual production of 200,000 hectolitres of beer. By using a CO_2 recovery system, almost 100 per cent less carbon dioxide is released into the atmosphere, as it is a closed process. This contributes toward the energy revolution. With a continuous recycling process, companies can fulfil their commitment to sustainability and responsibility for the environment.

Author:
Jörg-Peter Mehrer
CEO
Mehrer Compression GmbH
Balingen

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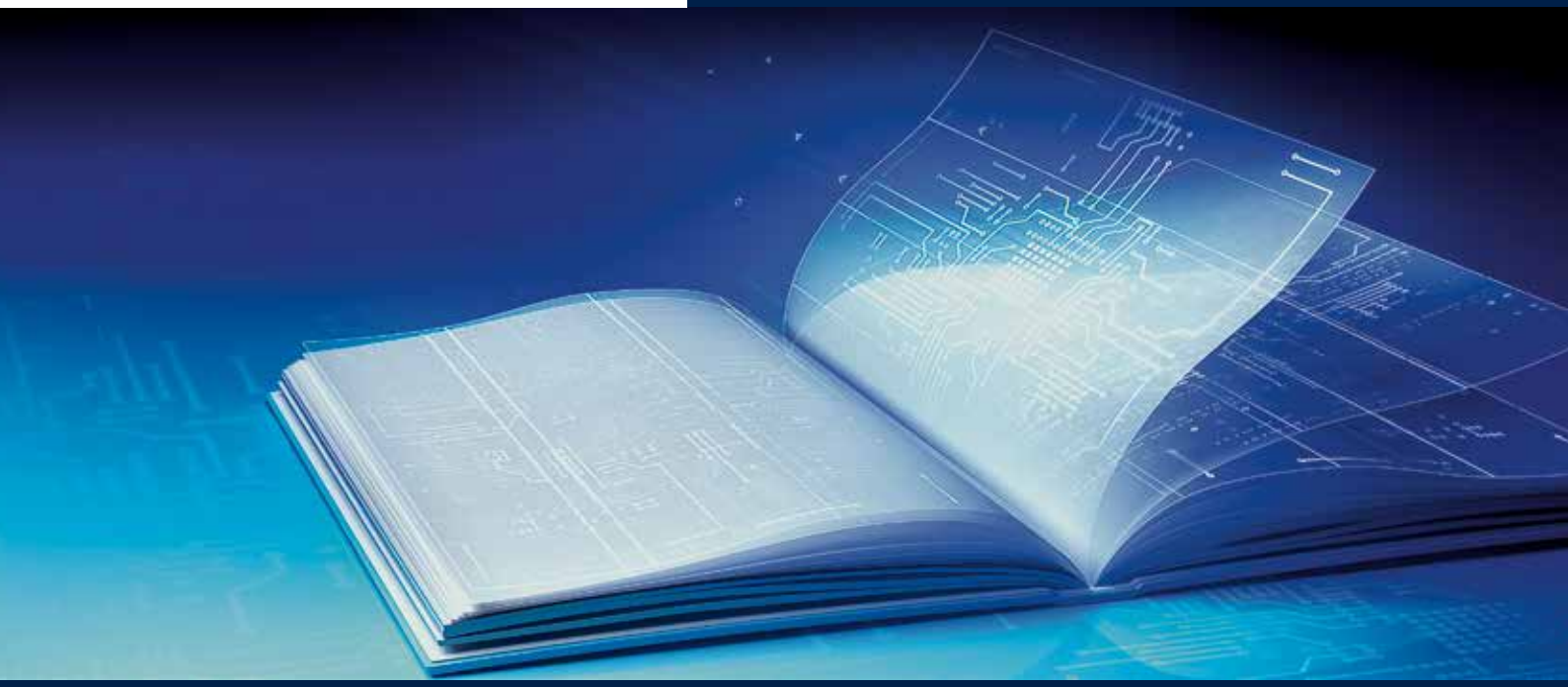

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Ensuring grid stability amidst the irregular availability of renewable energies is imperative. Source: © syeols / MAN Energy Solutions

Large-scale heat pumps ensuring grid stability

Emin Cemberlitas

Amidst the ongoing energy transition, large-scale heat pumps are poised to play a crucial role in maintaining frequency regulation – a key aspect for grid stability. Unfortunately, the potential of heat pumps to emerge as unsung heroes of the energy transition often goes unnoticed. Beyond their primary function of providing heat, large-scale heat pumps hold significant potential in advancing the energy transition by actively contributing to grid frequency regulation.

A notable instance highlighting the criticality of grid stability occurred on November 4, 2006, when a German high-voltage power line experienced a shutdown, causing a massive power outage across Europe. This event underscored the indispensable nature of maintaining stable grid frequency in a world heavily reliant on electricity. As renewable energies continue to expand, the challenge of maintaining constant grid stability becomes increasingly difficult owing to their inherent volatility.

Frequency: the heartbeat of the power grid

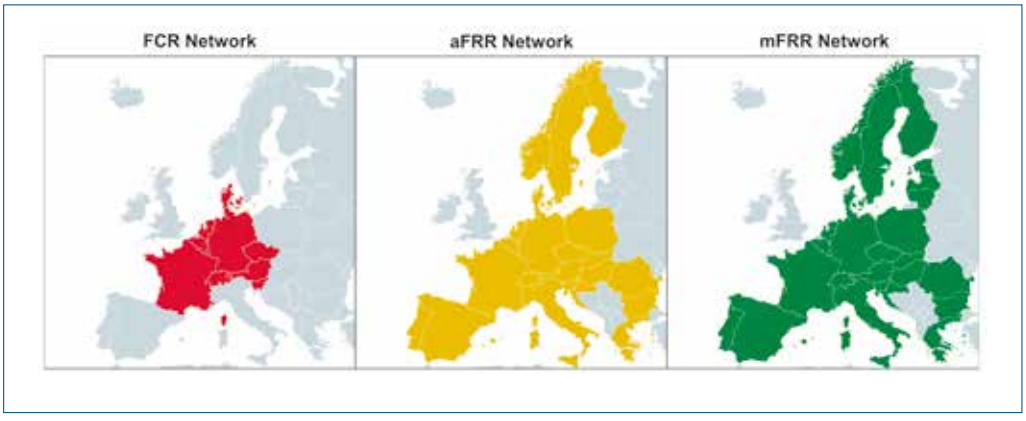
Power grid frequency, measured in Hertz (Hz), is essential for the stability of AC grids and varies between 50 Hz and 60 Hz across the globe, with Europe standardizing on a frequency of 50 Hz. Deviations from this nominal frequency bear serious consequences. Should the frequency plummet below a significant value of 47.5 Hz, all power plants automatically disconnect from the grid to avert potential damage stemming from operating at excessively low frequencies. A massive power shortage can trigger widespread, long-lasting blackouts. Conversely, when the frequency exceeds 50.2 Hz, solar energy systems must be disconnected from the grid to prevent electrical overproduction and potential grid overload. Furthermore, once the frequency reaches 51.5 Hz, an automate protective mechanism activate to forestall overheating and avoid damage to the electrical infrastructure. Hence, sustaining a stable power supply necessitates precise frequency modulation and efficient grid control.

Power balancing: the invisible guardian

The stability of power grids relies on the precise control of grid frequency using three key mechanisms: Frequency Containment Reserve, automatic Frequency Restoration Reserve and manual Frequency Restoration Reserve. Each of these mechanisms has distinct tasks and reaction times in order to maintain the balance between electricity generation and consumption, thus avoiding serious disruptions.

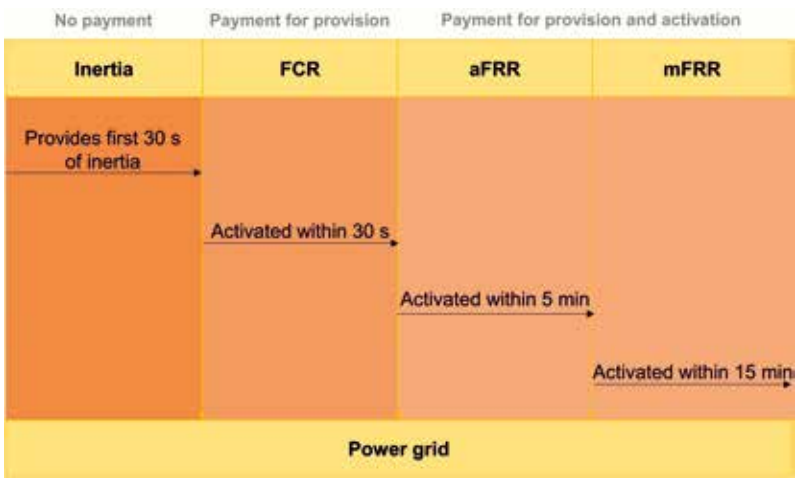
Large heat pumps are one of the most energy-efficient technologies for heat supply.

In the event of a deviation in frequency, the first mechanism to intervene is the instantaneous reserve. This system service, which is not remunerated in the energy market, originates from the kinetic energy of rotating masses within synchronous machines, typically found in power plant generators. The instantaneous reserve serves as an immediate reserve of power during active power imbalances. By providing inertia, it effectively mitigates power fluctuations, thereby bolstering system reliability. The Frequency Containment Reserve (FCR) serves as the initial line of defense against frequency deviations. Activated automatically within 30 seconds, it swiftly rectifies the discrepancy between electricity generation and consumption. The FCR is effective in the short term and responds pro-



Source: MAN Energy Solutions

An interconnected European system: the graphic depicts European operating reserve networks – vital for a robust power grid.



Source: MAN Energy Solutions

Three key mechanisms control grid frequency.

portionally to frequency deviations, primarily drawing on fast energy sources such as hydropower or battery storage. The FCR is used and remunerated not only nationally, but across Europe, fostering cooperation between multiple countries.

If the FCR proves insufficient, the Automatic Frequency Restoration Reserve (aFRR) comes into effect. Although its response time is slower compared to the FCR, the aFRR remains active for a longer duration and is automatically controlled by the grid operator's energy management system in order to balance the grid. The aFRR is part of the Europe-wide PICASSO project, which provides a platform for retrieving aFRR used by several European countries, including Germany.

In situations where FCR and aFRR fall short, manual Frequency Restoration Reserve (mFRR) is activated. Despite a slower response, it remains active for extended periods when required and integrates various demand management measures. The mFRR is part of the European MARI project, providing a platform that covers more countries compared to the PICASSO project. Compensation is provided for the provision and maintenance of aFRR and mFRR services, with higher remuneration tied to swifter reserve offering and accessibility. Participation in operating reserve markets necessitates prequalification, mandating the establishment of reserve units or groups with specific technical and operational standards.

Multifunctional players at the core of the energy transition

The shift toward renewable energies heralds a substantial transformation, introducing fresh challenges to established methods of frequency regulation. Renewable energy sources such as solar and wind power are variable by nature, leading to fluctuations in energy production depending on the weather conditions and time

Source: Andrin Winteler / MAN Energy Solutions

Large-scale heat pumps act as a buffer for grid fluctuations, mitigating potential overload scenarios.

of day. This stands in contrast to conventional energy sources, renowned for their constant output. Addressing the fluctuations stemming from renewable energy necessitates the development of innovative technological solutions and strategies.

In view of the challenges posed by the fluctuating nature of renewable energies and the increasing involvement of consumers in the power grid, the transition within the heating sector emerges as an essential cornerstone for a successful overall energy transition. Considering that around 50 percent of primary energy consumption is used for heating purposes, the urgency for a transition in this sector becomes clear. This is particularly relevant in Germany, where heat generation accounts for around 40 percent of the country's total CO_2 emissions, encompassing both domestic and industrial heating needs. This fact accentuates the pressing need for the implementation of energy-efficient, low-CO_2 solutions.

Cutting-edge technology for enhanced efficiency

Large-scale heat pumps are one of the most energy-efficient technological advancement in heat generation, particularly due to the electrification of the heat supply. They offer the possibility of using renewable energy for CO_2-free heat generation, thereby significantly contributing to the decarbonization of the energy sector. Considering the irregular availability of renewable energies that require constant grid stabilization, large-scale heat pumps with high-speed electric motors stand out as an innovative solution. Thanks to their fast response times, they can quickly regulate the build-up or depletion of electrical load, making them essential for the provision of Frequency Containment Reserves. Large-scale heat pumps actively contribute to stabilizing the grid by absorbing surplus energy during periods of high production and curbing their operation during shortages. Using large-scale heat pumps to supply FCR is not merely a theoretical concept but it is already being implemented in practical scenarios. One example can be found in the Danish harbor town of Esbjerg, where the municipal utilities employ two large-scale heat pump units with a thermal output of 60 MW to participate in the balancing and ancillary services market.

Source: Sebastian Vollmert / MAN Energy Solutions

An industrial-scale heat pump system with a heat output of 60 MW supports the primary operating reserve of the Danish harbor town of Esbjerg.

Moreover, large-scale heat pumps not only fulfill the role of providing FCR but can also effectively contribute to aFRR and mFRR. By integrating these pumps into the power grid, they can play an active, responsive role in the energy market, reducing CO_2 emissions while ensuring grid stability – a crucial element for the transition toward a renewable energy system. Beyond their support for grid stability, they provide essential inertia to the power grid due to their rotating masses. This is becoming increasingly vital as conventional, inertia-intensive power sources diminish. This inertia is important in maintaining power grid frequency stable and preventing potential instabilities or even outages.

Economic viability

When it comes to frequency regulation, large-scale heat pumps significantly differ from conventional technology solutions such as gas turbines and hydroelectric power plants, which incur high operating costs or demand specific locations. While modern battery energy storage systems face limitations due to their elevated costs and storage restrictions, large-scale heat pumps, despite their higher initial purchase expenses compared to fossil-fueled technologies, prove to be cost-effective to operate. This efficiency is further underscored by the rising costs of fossil fuels. Moreover, their participation in balancing and ancillary services markets

has yielded promising returns: an average of 65 EUR per MWel within a four-hour slot on the FCR market alone over the past two years. These revenues vary based on the frequency of market participation and can notably increase through the combined use of FCR and aFRR – especially when large-scale heat pumps are used flexibly in order to react to market prices. This adaptable approach can generate several hundred thousand Euros annually, rendering investments in large-scale heat pumps economically appealing.

Conclusion and future outlook

Large-scale heat pumps are essential for a successful transition within the heating sector. Their integration into the power grid presents significant advantages, from both social and operational perspectives, but especially in their capacity to provide power balancing and ensure grid stability. As Germany moves ahead with the phase-out of nuclear power by 2023 and coal by 2030, the country's power grid is set to become increasingly volatile. This scenario will escalate the demand for operating reserve, amplifying the profitability of investments in large-scale heat pumps.

In light of the pressing timeline to decarbonize our society, large-scale heat pumps stand as a prime example of technological progress, assuming a pivotal role amid the urgency and responsibility associated with this transformative process. Utilizing available technology solutions efficiently and with precision is crucial, ensuring that current endeavors serve as the cornerstone for the sustainable future we aspire to achieve.

Author
Emin Cemberlitas
Business Development Industrial Heat Pumps
MAN Energy Solutions
Zurich

Harnessing waste heat is a sustainable way for companies to reduce CO_2 emissions in the long term Source: Atlas Copco

Waste heat and hydrogen are the energy sources of the future

Hanushan Vasuthevan

Using efficient technologies and resources in industry is becoming more and more important. As compressed air systems reach maximum energy efficiency, alternative concepts such as the use of waste heat and hydrogen are gaining ground in industrial processes. Harnessing the waste heat generated has both environmental and economic advantages. New solutions appear promising and offer enormous potential for sustainable and resource-efficient production.

For decades, the focus in industry has been on maximising energy efficiency. This has produced an array of innovative developments, including in industrial compressed air technology, where modern compressors with variable speed control have become extremely sustainable by only generating the amount of compressed air actually required. This permanently reduces both operating costs and the maintenance needed. But if we can't make compressors any more energy-efficient, what's next?

Waste heat: more than just a by-product

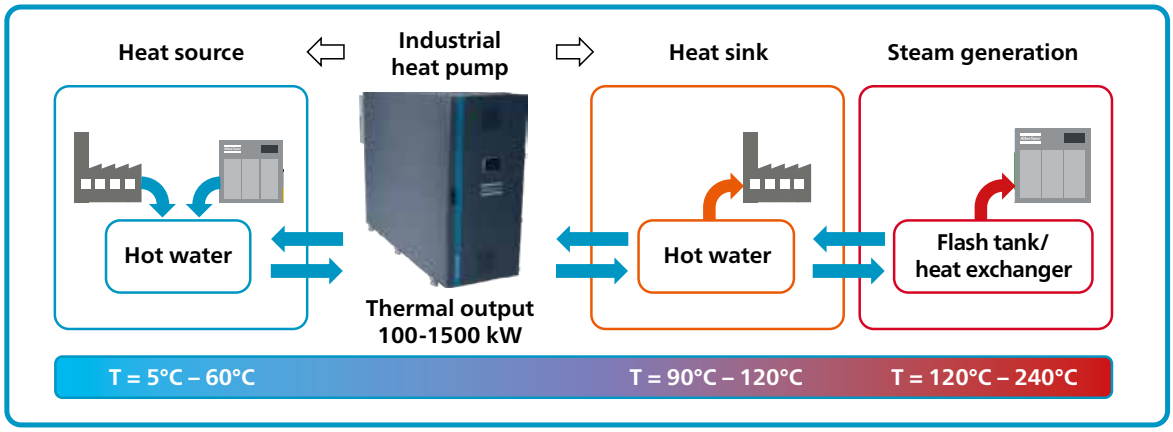
As we progress through the energy transition and against a backdrop of rising energy costs, experts are constantly scouting for new energy sources that not only reduce operating costs but also cut CO2 emissions. Companies can make good use of the waste heat they generate themselves as a by-product of their industrial processes. "Currently, waste heat is typically released into the atmosphere. But we see enormous potential for companies to use it themselves," says Jörg Schwittek, Business Line Manager for New Technologies at Atlas Copco. He no longer sees waste heat as a by-product, but as an alternative source of energy from industrial processes. Waste heat sources can be found in any processes involving cooling systems, condensers or exhaust air systems. But waste water, condensate and other by-products also often have untapped potential as an energy supply for the industry of tomorrow.

Identifying heat output

Before industrial companies can leverage their waste heat, they have to determine its potential. This is where the temperature of the waste heat comes in, since this determines whether the waste heat can be classified as high or low quality. Estimating the available heat output requires information such as the waste heat medium, the temperature and the volume or mass flow rate.

Modular design means that core components can be standardised along the entire hydrogen value chain.

The first step towards recovering waste heat is to identify the amount of heat output available, using a formula that takes various factors into account. These factors include the mass flow rate and the heat capacity (cp) of the waste heat medium. The heat capacity for liquid water, for example, is 4,190 J/kgK, while the figure for air or exhaust gases is 1,005 J/kgK. A number of key findings can be derived from this formula, including the fact that the usable heat output of a waste heat medium increases with the mass flow rate and the temperature difference. This means that to estimate the available heat output, users must know the specific properties of the waste heat medium,



Source: Atlas Copco

Smart systems that connect waste heat sources and heat sinks allow companies to exploit them to their full potential.

Waste heat sources				
Processes	Medium	Temperature inlet [°C]	Temperature outlet [°C]	Heat output [kW]
Cooling-compressed air	water	50	30	400
Cooling condensate	water	60	40	160
Waste heat CHP (summer)	water	90	70	500
Condensation process heat	water	100	125	800

Heat sinks				
Processes	Medium	Temperature inlet [°C]	Temperature outlet [°C]	Heat output [kW]
Process heat - steam	steam	140	140	1.800
Heat and hot water	water	70	50	300
Process heat-water	water	100	80	400

Source: Atlas Copco

To get the most out of waste heat, users must correctly determine the potential of a waste heat source.

as well as its temperature and the volume or mass flow rate in the process at hand. It is important to note, though, that the quality of the waste heat is not always the same, as it depends heavily on its temperature. Different applications are possible depending on whether the temperature of the waste heat is high or low. So, temperature plays a key role in determining how this valuable resource can be used most efficiently.

Integrating waste heat

To get the most out of waste heat, users must correctly determine the potential of a waste heat source. Smart systems that connect waste heat sources and heat sinks allow users to exploit them to their full potential. A heat pump can offer the right solution for this, provided the temperature of the waste heat source is below the temperature required for the heat sinks. Specially developed water-to-water heat pumps can raise the waste heat temperature to meet the process requirements.

Positive displacement compressors

- A bike pump is the simplest form of positive displacement compression. It sucks the air into a cylinder and compresses it using a moving piston. Piston compressors work on the same principle: they use a piston moved backward and forward by a connecting rod and a rotating crankshaft.
- If only one side of the piston is used for compression, this is called a single-acting compressor. If both the top and bottom of the piston are used, it is a double-acting compressor. The pressure ratio is the ratio between the absolute pressure on the inlet side and on the outlet side.
- Therefore, a compressor that sucks in the air at atmospheric pressure – i.e. 1 bar(a) – and compresses it to an overpressure of 7 bar has a pressure ratio of (7 + 1)/1 = 8.

Source: Atlas Copco

Atlas Copco has developed water-to-water heat pumps that can deliver hot water at temperatures of up to 120°C. At even higher temperatures, users can convert the hot water into low-pressure steam; this can be raised to even higher temperatures using a steam compressor and then used as process heat.

Converting waste heat into electricity: reducing costs

Another option is to convert waste heat sources with temperatures above 90°C into electrical energy using Organic Rankine Cycle (ORC) systems. This technology uses the temperature difference between the hot waste heat source and a coolant to generate mechanical energy, which is then converted into electrical energy. This is a sustainable use of waste heat that also helps to reduce overall operating costs.

Sustainability and efficiency thanks to hydrogen compression

In addition to waste heat, hydrogen is a versatile and environmentally friendly energy source that plays a big part in the transition to sustainable energy systems. The use of clean hydrogen is hugely important in industrial processes as it not only helps protect the climate, but also optimises industrial processes.

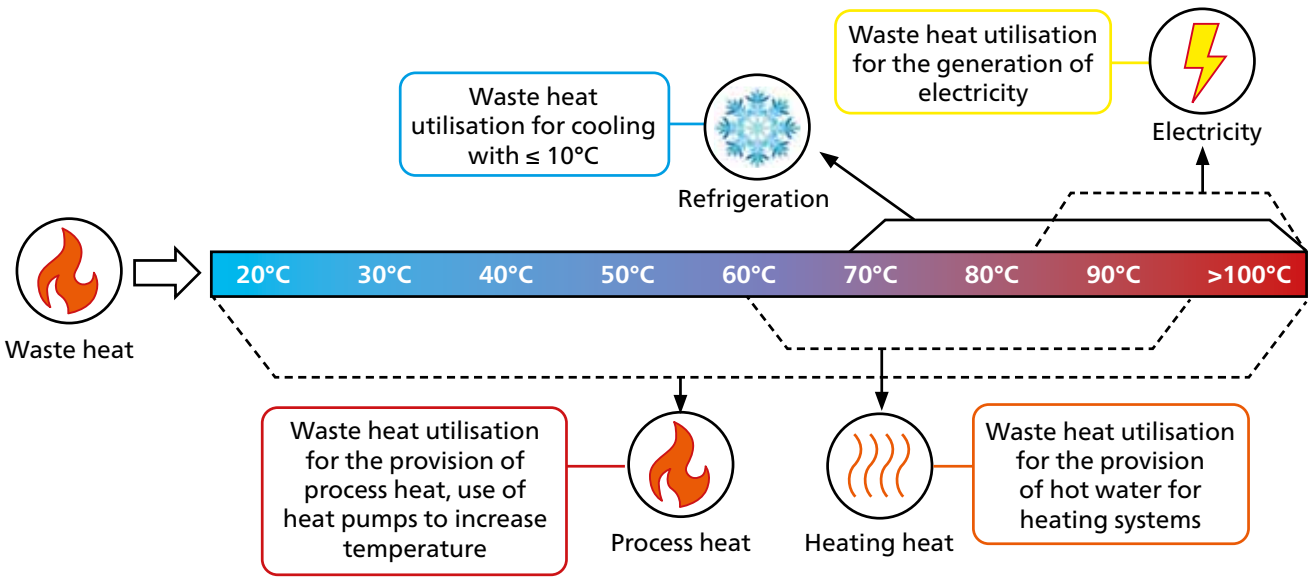
Green hydrogen is typically produced using electrolysis processes, ideally using renewable energies. Depending on the electrolysis technology, the hydrogen produced is available at different pressures, often between atmospheric pressure and up to 35 bar. The compression process therefore plays a key role in the hydrogen economy. Compressors increase the hydrogen pressure, so it can be stored, transported and used in various sectors. In most applications, positive displacement compressors are used to compress the hydrogen.

$$\dot{Q} = \dot{m} \cdot c_p \cdot (T_{Entry} - T_{Exit})$$

$\dot{Q}$	[W]	Heat output
$\dot{m}$	$[\frac{kg}{s}]$	Mass flow rate
c_p	$[\frac{J}{kg \cdot K}]$	Isobaric heat capacity
$T_{Eintritt}$	[°C]	Inlet temperature heat exchanger
$T_{Austritt}$	[°C]	Outlet temperature heat exchanger

Source: Atlas Copco

Companies can use a formula to identify the amount of heat output available.



Source: Atlas Copco

Converting waste heat into electricity: an insight into the energy generation process.

Piston and screw compressors for positive displacement compression

Positive displacement compression is based on the idea of reducing the volume. In this approach, the volume of hydrogen is reduced by compressing it mechanically. The most common types of positive displacement compressors are piston compressors and screw compressors, which are extremely efficient when it comes to raising the pressure of hydrogen.

When using hydrogen, modular compressor concepts offer flexibility in the choice of location.

Benefits of modular design

In the dynamic world of the hydrogen economy, modular designs for electrolysers and compressors have proven to be extremely practical. Rather than relying on single large systems, technology providers are leveraging the benefits of modularity, which uses several smaller units that users can combine with each other as needed. This provides a scalable solution, allowing users to flexibly adapt their production capacity to increasing demand. Only standardised compressor concepts, similar to the arrays of electrolysers, can achieve this flexibility and scalability.

What's more, modular design offers flexibility in where you can deploy the solution. Users can place the units at different locations, depending on the availability of renewable energy sources or water resources. Decentralising hydrogen production is an ideal way to use renewable energy efficiently and reduce transport costs. Knock-on benefits including freeing up transport capacity in pipelines – regionally and beyond – as well as ensuring easier maintenance and efficient servicing. While maintenance work or repairs are being carried out on one unit, the other units can remain in operation to ensure uninterrupted production. The high availability of all components in a hydrogen plant is the key to a reliable supply of vital green molecules to industry.

Standardisation speeds up projects

Crucially, modular design means that core components can be standardised along the entire hydrogen value chain. Flexible and standardised concepts for green hydrogen production speed up projects significantly, with the aim of reducing engineering costs and simplifying the way components are made. This is a direct response to the continuously growing global demand for key components in the energy transition.

The fact that standardised components can reduce engineering costs is especially important given the shortage of skilled workers in the energy transition. More and more companies are looking for specialists and engineers specialising in decarbonisation who can not only develop ideas for a more sustainable industry, but also put these ideas into practice.

Another example of standardisation is the control of reciprocating compressors, as the volume flow rate must be controlled with precision when producing green hydrogen using electrolysis. If standard compressors are used, it is crucial for these to be as flexible and efficient as possible. Controlling the speed using a frequency converter has proved to be particularly efficient compared with other technologies. Another big plus is that compressors have low energy consumption compared with electrolysis, So using compressors does not necessarily increase the costs of producing hydrogen.

Author:
Hanushan Vasuthevan
Business Development Manager
Atlas Copco Kompressoren
und Drucklufttechnik GmbH
Essen

The windy region of Patagonia delivers up to 6,000 full load hours for the production of green fuel. Source: Shutterstock.com

Haru Oni pilot project delivers green fuel

Anja Ehrmann and Christian Schlüter

Haru Oni is the name of the Chilean pilot project that has the goal of producing climate-neutral fuel using the world's first commercial plant. In the language of the native Chileans, Haru Oni means 'strong wind'. And there's enough of that at the Punta Arenas project site in the most southern region of Chile. The climate conditions are perfect for running wind energy plants. The electricity generated will be used to produce green hydrogen and to convert it to synthetic fuel. To run the plant, compressed air and nitrogen are needed, for example, as well as a system that stores and compresses carbon dioxide.

The energy revolution is a central aspect of energy politics in Germany and an important element in achieving climate targets. Renewable energies play a key role here. They are designed to replace nuclear power and fossil fuels in the future. Renewable energies can set the course for climate-friendly energy production and could gain ground in the automotive industry in particular. An example of this is the pilot project in the south of Chile that has the goal of producing synthetic fuel (e-fuel) with hydrogen made using wind power and CO_2 from the air. The Federal Ministry of Economic Affairs and Climate Protection (BMWK) supports this international project for green hydrogen as part of the National Hydrogen Strategy (NWS) with funds from the recovery package. In early December 2020, Siemens Energy received a grant of 8.23 million Euros to implement the future-orientated project. Under the management of the Chilean project company Highly Innovative Fuels (HIF), Siemens Energy, together with numerous international companies, is developing the world's first plant which will produce what is known as e-fuels from hydrogen and carbon dioxide. The project started in July 2021 and in December 2022, the first fuel was delivered. The total investment in the plant is 74 million US Dollars.

How green fuel is made

The principle of producing climate-neutral fuel is based on polymer electrolyte membrane electrolysis (PEM). During this process, water is broken down into its components hydrogen and oxygen using electric energy. The water molecules transport the protons. Water is directed to the anode and split there. The protons that are created during this process diffuse through the semi-permeable membrane to the cathode where they are combined using electrodes to become hydrogen.

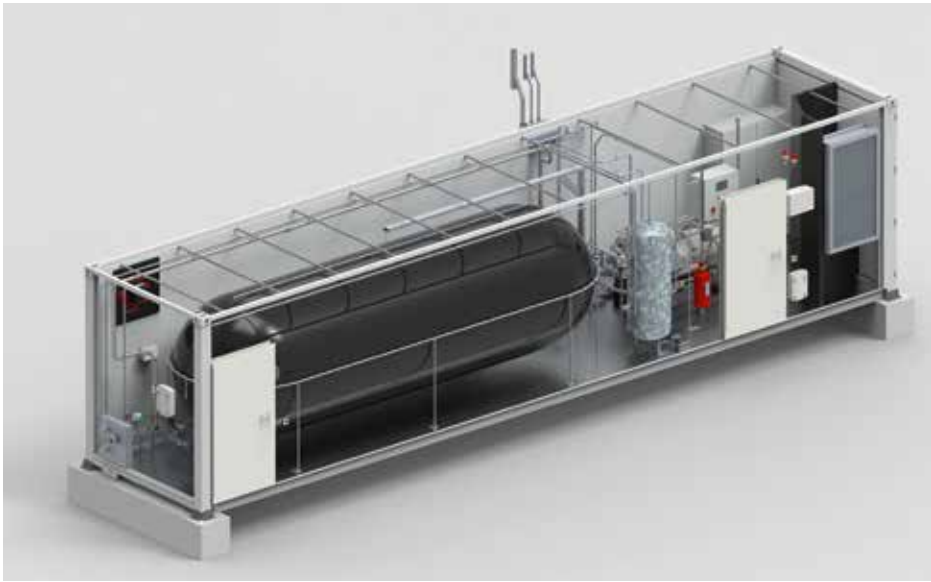
Another element of the pilot plant which is needed to produce synthetic fuel is the system provided by a specialist from Brighton who has developed a patented solution for the direct separation of carbon dioxide from the air. The system absorbs CO_2 from the air, separates it and then stores it. This produces 98 percent pure carbon dioxide which is mixed with hydrogen to create what is known as synthesis gas. This synthesis gas is then converted to methanol on the surface of a catalytic converter. Methanol is converted to synthetic fuel in the Methanol-to-Gasoline (MTG) plant. A special MTG catalytic converter is used for this, which should produce 130,000 litres of green fuel in the first phase of the project. The end product can be transported, distributed and stored like conventional fuel. This fuel will then be refined for direct use in vehicles.

Obtaining CO_2 from the air and storing it

BOGE is supplying the compressed air needed to run the plant. The compressed air will be used as instrument air on the one hand, for example to control pneumatic valves. On the other hand, it is needed to produce nitrogen. In addition, the compressed air specialist designed a system that compresses carbon dioxide from the air. The compressed air specialist has provided two 40 ft containers with different features. One container includes an oil-lubricated, frequency-controlled screw compressor with an output of 75 kW. This pro-

With the forecast 550 million litres, about one million people could drive their cars for one year.

Source: Boge



The container features a special piston compressor, combined with a bladder made of rubberised fabric.

Additional plants for e-fuel production are planned

HIF is using experience from the pilot plant in Haru Oni to implement other projects for the production of e-fuels. A similar plant will be built in Cabo Negro industrial estate in Punta Arenas which is designed to produce 173,600 tonnes of e-methanol per year using renewable energy from the Faro del Sur wind farm. This can help to produce about 70,000 tonnes of e-fuel per year and more than 8,000 tonnes of e-gas.

The required CO_2 is either directly separated from the air or made available from other industrial sources as well as biomass plants. In addition, up to 34 m³/h desalinated sea water is used. Once the environmental approvals have been granted, plant construction can begin. Construction time is estimated to be 26 months.

Source: Boge

vides compressed air at 2.76 m³/min to 12.34 m³/min. Other components include a compressed air treatment system and a nitrogen generator, which works according to the Pressure-Swing-Adsorption (PSA) principle. Purified compressed air flows through a receiver which is filled with activated carbon. The oxygen molecules in the air are adsorbed as it flows through. This produces nitrogen with a purity of 99.99 percent. This nitrogen is stored and is then available for subsequent use. BOGE has also developed a CO_2 system with upstream and downstream equipment.

In the second container, the compressed air specialist has installed a piston compressor, which has been combined with a bladder specially made for CO_2 storage. “We have developed a special storage concept together with a co-operation partner,” explains Bernd Kleffmann, Senior Project Manager at BOGE. “Our first approach was to use a solid container to store the carbon dioxide, the same as conventional containers for storing compressed air. The system’s basis is a bladder made of rubberised fabric that we’ve installed in the container and which fills two thirds of the container

Source: Boge

The container features an oil-lubricated, frequency-controlled screw compressor with an output of 75 kW.

when it's full." In total, up to 20,000 litres of CO_2 can be stored. The temperature and pressure of the carbon dioxide extracted directly from the air in the upstream plant are initially monitored using specialist equipment. The gas is then fed into the balloon, which inflates. Once a pre-defined fill level has been reached, the downstream piston compressor starts up and compresses the CO_2 to 20 bar. The compressed gas is stored again temporarily and then fed out of the container to react with the hydrogen in the next part of the plant and to form the synthesis gas. The entire system is constantly monitored.

The production site complies with all relevant sustainability criteria for green fuel.

Pilot plants require a high level of adaptability

The compressed air has to meet numerous requirements. It has to comply with Quality Class 1-2-1 in accordance with DIN ISO 8573-1, and the particle size of solid contamination must not exceed 0.5 µm. The maximum pressure dew point is minus 40 °C and the oil content a maximum of 0.01 mg/m³. In addition, the HIP Project Management requested comprehensive documentation. "No doubt the biggest challenge was the constant change in the media to be supplied and the CO_2 to be provided," says Bernd Kleffmann. "The integrated plants are mostly pilot plants that are running for the first time in some cases and have to be perfectly co-ordinated with each other. That's why there were constant changes throughout the development phase to which we had to respond. A high degree of adaptability was required." The compressed air specialist adjusted the system in the second container several times, for example, to modified CO_2 delivery amounts as well as different pressure levels. The plant can be converted in such a way that reliable operation is guaranteed even at different pressures. The amount of nitrogen required also varied throughout the development phase.

Source: Boge

The system's basis is a bladder made of rubberised fabric that fills two thirds of the container when it is full.

Sustainable fuel – not just for racing cars

"We're very proud of the fact that we're helping to improve climate protection by combining tried-and-tested technology and our engineering expertise," Bernd Kleffmann is happy to say. "Haru Oni is a special future project that relies on state-of-the-art technology to produce synthetic fuel sustainably." This fuel can be used in existing vehicles which makes it a valuable product for achieving ambitious climate targets. Following the successful start, production will be increased to 55 million litres of e-fuel over the coming years. And from 2028, as much as 550 million litres could be produced.

The main customer of the fuel will initially be the sports car manufacturer Porsche. The fuel will be used in the brand trophy racing series, for example. In general, however, all current vehicles with combustion engines will be able to use this e-fuel without having to be converted. This is initially designed for road traffic but can be expanded in the future to include shipping and aerospace without problems.

A production site with excellent infrastructure

In the windy region of Patagonia, up to 6,000 full load hours can be used for the production of green fuel – significantly more than in Europe because the wind blows consistently on about 270 days a year. The site north of Punta Arenas has another advantage: it is located in close proximity to the Strait of Magellan. From Cabo Negro Harbour, the liquid energy source can be transported, much like conventional fuel, anywhere in the world and be distributed via existing infrastructure. This makes supply with green fuel possible to energy-poorer regions.

Great hope for possible use of fossil fuels is connected with the industrial production of this sustainable e-fuel. With the forecast 550 million litres, about one million people could drive their cars for one year. The production site complies with all relevant sustainability criteria for green fuel. And CO_2 emissions will still be low even when transporting the fuel back to Europe – if the calculation includes the amount of CO_2 being removed from the atmosphere when producing the fuel.

Contact:
Christian Schlüter
Head of Marketing
BOGE Kompressoren
Otto Boge GmbH & Co. KG,
Bielefeld

Author:
Anja Ehrmann
Senior Content Manager
Dipl.-Ing. (FH) Environmental Protection
Redaktionsbüro additiv pr GmbH & Co. KG
Montabaur

Automotive production: Digital monitoring of vacuum generation by robots reduces the risk of injuries from moving parts.

Source: Shutterstock.com

Vacuum technology: Digitalisation enables predictive maintenance in robotics

Cindy Wenzel and Cedric Ries

Industry 4.0 has fundamentally changed the way users operate and maintain their robot handling systems. In particular, the digitalisation of vacuum generation has revolutionised robotics and raised machine availability to a new level. Connectivity between devices via IO-Link and the installation of sensors that collect valuable process information and analyse it thanks to integrated intelligence makes vacuum handling safer. It is also the foundation for predictive maintenance. This increases the availability and service life of the machines, speeds up the maintenance process and reduces costs.

Source: Piab

Predictive maintenance identifies problems such as worn suction cups in advance.

Predictive maintenance (PM) monitors and analyses the performance and condition of robot systems. It predicts potential problems before they occur. This makes it possible to carry out planned maintenance work when it is needed, i.e. before an unscheduled shutdown occurs. The benefits are manifold: PM significantly reduces unplanned downtime and leads to more efficient production processes. In addition, predictive maintenance paired with the right vacuum generation makes it possible to reduce compressed air consumption by 95 %. In addition, predictive maintenance also improves the quality of installations, for example by identifying worn suction cups or clogged filters in good time.

Another major advantage of this technology is that it saves space. Sensors and monitoring devices can be seamlessly integrated into vacuum generation systems, which significantly reduces the space required. Last but not least, PM ensures greater flexibility in the use of robot handling systems. This is because they are less susceptible to unexpected failures, which significantly increases the number of possible applications. “Our aim is not only to offer high-performance gripper and ejector solutions. Above all, we want to ensure that production processes run smoothly and efficiently,” says Nils von Essen, Director Product Management at Piab, and adds: “Predictive maintenance reduces downtimes to an absolute minimum.“

Fieldbus-independent IO-Link communication increases productivity

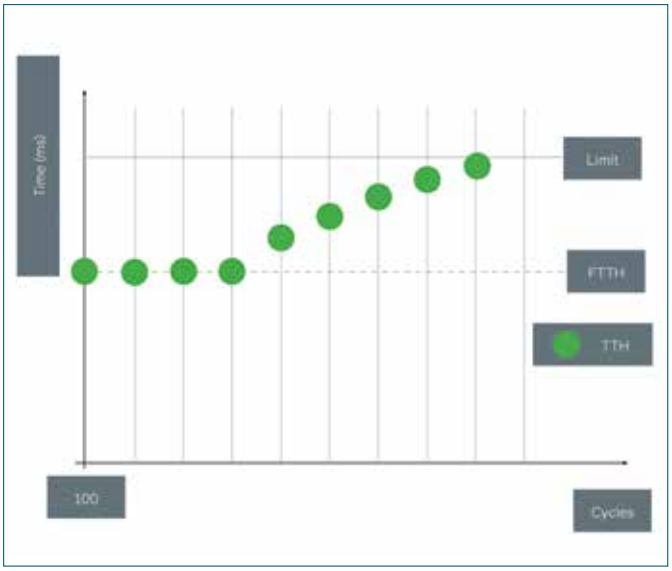
Technologies such as connectivity and big data analysis play a central role in the digitalisation of the robotics industry. Connectivity makes it possible to communicate with other devices and the cloud via IO-Link. IO-Link is characterised by its fieldbus independence and represents a further development in connection technology for sensors and actuators. This technology enables automated parameter setting and allows machine operators to read parameters for various functions even during operation and adjust them manually if necessary. The real-time recording of process data opens up the opportunity to recognise and rectify potential problems before they can affect production. In addition, system diagnostics enable faults to be identified and resolved quickly, which can lead to significant increases in productivity.

A key component of this diagnostic capability is that, unlike conventional technologies, IO-Link has an integrated data storage function. This allows operators to quickly determine whether and for what reason a device may have failed. This function makes it possible to precisely identify the cause of the fault. A defective device may need to be replaced or it could be a simple fault in the electrical connection. When a new, identical replacement device is connected, the parameters of the previous device are automatically transferred, saving valuable installation time.

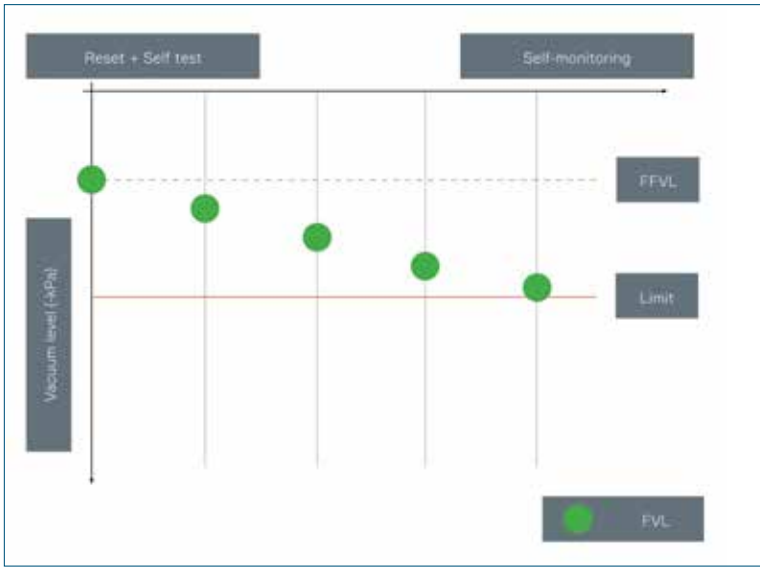
Implement maintenance proactively

For big data analysis, it is necessary to carry out measurements of various characteristics in order to generate the required information. The system then analyses this information in order to use it to improve the production process. Sensors play a crucial role here, as they collect

Source: Piab



The graph represents how long it takes to build the target vacuum level and the maximum acceptable limit.



The graph visualizes the change of the free vacuum level with maximum acceptable limit.

data that increases productivity and can be used to minimise downtime. This contributes to efficient condition monitoring and the implementation of predictive maintenance measures. It therefore makes sense to integrate several sensors in the system that measure the vacuum ejector's direct operating parameters. This enables quick detection of potential operating problems such as leaks in the system and makes it easier to implement proactive maintenance measures.

Operators can plan maintenance in advance by having the system look out for a leak in a vacuum system from the outset and track the evacuation time to a specific vacuum level. Leaks can be, for example, damaged hoses, leaking threads or a defective suction cup. The First Time To Hit (FTTH) function measures the time it takes for an ejector to reach the desired vacuum level when it is first started up. This time period is then compared with the times required in the subsequent operating cycles to

Source: Piab

The two external compact ejector manifolds are attached to a system and connected in series.

Source: Piab

This compact ejector manifold is installed at the so-called end-of-arm-tooling.

achieve the same vacuum level (Time To Hit, TTH). Over time, this period will become longer as the suction cup and the suction cup lip, which seal the product and thus activate the vacuum system, gradually wear out. This leads to more air entering the system, which in turn significantly increases the time required to generate the vacuum. In such cases, it makes sense to replace the suction cup. To proactively counter this problem, users can set a threshold time. As soon as this time is exceeded, the vacuum generator sends a signal recommending that the suction cup be replaced. In this way, the suction cup can be replaced before a complete malfunction of the handling system or the process occurs, ensuring that everything runs smoothly.

Source: Piab

Thanks to connectivity, the vacuum ejector communicates with other sensors and actuators via IO-Link.

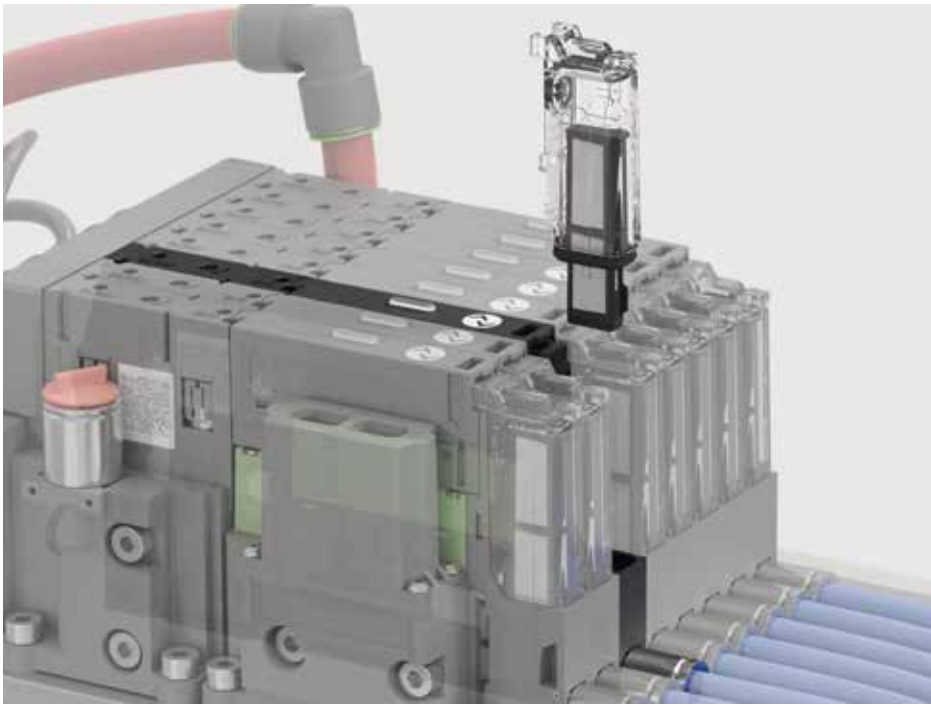
Recognising filter contamination at an early stage

Another important parameter for predicting the maintenance of vacuum-based robotic grippers is keeping them clean. Especially in dusty applications where vacuum filters get dirty over time, unwanted vacuum pressure drops can slow down the process or even trigger false signals. Operators can solve this by monitoring restrictions contained in the vacuum system via the free vacuum level (FVL). After the ejector is commissioned for the first time, a thorough check of the intrinsic vacuum in the entire vacuum system (Fresh Free Vacuum Level, FFVL) is carried out. This process involves suctioning without a product on the suction cup in order to determine the inherent vacuum of the vacuum system. This measurement is repeated regularly in subsequent operating cycles to detect whether the filter has become contaminated or clogged over time. In such cases, a not inconsiderable vacuum level is achieved despite the absence of a product on the suction cup.

A particular advantage of the system is that certain limit values can be set. As soon as these limit values are exceeded, the compact ejector emits a signal that alerts machine operators that the filter needs to be cleaned. This enables early maintenance before the filter becomes so clogged that the vacuum ejector is no longer able to generate the required vacuum level. This level is crucial for the smooth running of the vacuum process up to the suction cup and therefore for the successful and safe handling of the product.

Application in the automotive industry

A significant example of predictive maintenance in robotics can be found in the automotive industry, where robotic systems are essential for the precise assembly of components. Digital monitoring of vacuum generation plays a crucial role here, as it can recognise and rectify potential failures or quality problems at an early stage, which is essential for overall production quality. The automotive industry in particular is characterised by a high degree of automation and the handling of large, heavy parts. As operational safety is always a priority during regular operation and also during maintenance work, this has led to the development of separate power ranges for actuators and sensors. These advanced systems allow independent activation of sensor power by operators, whether for maintenance purposes or for troubleshooting in the robot control cell. At the same time, the actuators remain separated from the power supply, minimising the risk of injury from moving parts.



Visualisation of the dismounted filter - better to clean at the appropriate time and thus keep the vacuum performance at an efficient level. Source: Piab

The major advantage of these separate power ranges is that compact ejectors can be used without the need for separate valve stations. This significantly reduces installation costs and eliminates the need for expensive workarounds or additional modules for compact ejectors. Overall, this leads to a more efficient and cost-effective implementation of vacuum ejectors in robotic systems in the automotive industry.

But robots are also essential for packaging products in the food industry. Vacuum generation plays a key role in the handling of food packaging. Here too, predictive maintenance avoids breakdowns that could lead to delays in delivery.

Greater flexibility

The digitalisation of vacuum generation and the implementation of predictive maintenance methods have fundamentally changed the robotics industry and open up promising prospects for the future. These pioneering technologies not only improve efficiency and quality, but also significantly increase flexibility in production. This leads to fewer robot system failures and enables versatile applications in various industries.

Overall, the robotics industry is facing an exciting future in which the continuous development of digital solutions will lead to even greater efficiency, quality and flexibility. The digitalisation of vacuum generation and the introduction of predictive maintenance are just the beginning of this promising journey.

With the right vacuum generation, it is possible to reduce the consumption of compressed air by 95 per cent.

Authors:
Cindy Wenzel
Marketing Activation Specialist DACH
Vacuum Automation Division
Piab Vakuum GmbH
Butzbach

Cedric Ries
Sales Director DACH
Vacuum Automation Division
Piab Vakuum GmbH
Butzbach

Applications Process & Compressed Air Technology

	Products				Fields of application																						
	Compressed air generation	**Compressed air treatment**	**Compressed air distribution**	**Process compressors**	**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	
ABN Apparatebau Nittenau GmbH www.abn-drucklufttechnik.de						●	●	●	●	●	●						●			●	●			●		
Aerzener Maschinenfabrik GmbH www.aerzen.com				●		●		●	●		●		●	●	●	●	●			●				●	●	
ALMiG Kompressoren GmbH www.almig.de	●	●				●	●	●	●	●	●		●	●	●	●	●			●	●	●		●	●	
Apex Tool Group GmbH & Co. OHG www.apexpowertools.eu			●																	●	●	●		●	●	
Atlas Copco Energas GmbH, Gas and Process Division www.atlascopco-gap.com				●		●		●					●	●	●	●	●	●								
Atlas Copco Kompressoren und Drucklufttechnik GmbH www.atlascopco.de	●	●	●			●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Gebr. Becker GmbH www.becker-international.com	●					●	●	●	●	●	●													●		
J. A. Becker & Söhne GmbH & Co. KG www.jab-becker.de				●			●	●	●	●	●		●	●	●	●	●	●						●	●	
BEKO TECHNOLOGIES GmbH www.beko-technologies.de		●				●	●	●	●	●	●		●		●	●	●	●		●	●	●		●	●	
BlitzRotary GmbH www.blitzrotary.com	●	●																		●	●	●		●		
BOGE KOMPRESSOREN Otto Boge GmbH & Co. KG www.boge.de	●	●	●			●	●	●	●	●	●		●	●	●	●	●	●		●				●	●	
BORSIG ZM Compression GmbH www.borsig.de/zm				●									●	●	●	●	●									
M. Braun Inertgas-Systeme GmbH www.mbraun.de										●																
Dr.-Ing. K. Busch GmbH www.buschvacuum.com/de/de/				●		●	●	●	●	●	●			●	●		●			●				●		
Cejn-Product GmbH www.cejn.de			●			●	●		●	●	●		●	●	●	●	●	●		●	●	●		●	●	
CVS engineering GmbH www.cvs-eng.de	●												●		●		●			●	●	●				
Deprag Schulz GmbH & Co. www.deprag.com			●			●	●	●	●	●			●	●	●	●	●	●		●	●			●		
Donaldson Filtration Deutschland GmbH www.donaldson.com		●				●	●	●	●	●	●		●		●	●	●							●	●	
FST GmbH Filtrations-Separations-Technik www.fstweb.de		●				●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Gardner Denver www.gardnerdenver.com	●	●				●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Gardner Denver Deutschland GmbH, CompAir www.compair.com	●	●				●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	

●	●	●	●			●				●		●	●	●	●			●	●		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
							●		●												**Plastic production/processing**
		●	●						●												**Hydrogen technology**

Applications Process & Compressed Air Technology

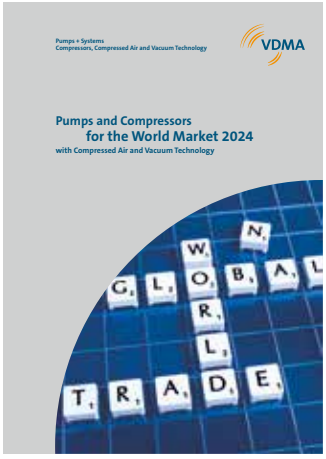
	Products				Fields of application																					
	Compressed air generation	**Compressed air treatment**	**Compressed air distribution**	**Process compressors**	**Hygiene**	Breweries	Medical technology	Food industry	Packaging (except Food)	Laboratory	Cleaning (Purging)	**Oil/Gas**	Natural gas industry	Oil fields	Petrochemical industry	Refineries	Biogas	Gas stations (natural gas, LPG)	**Handicrafts/Workshops**	Workshops	Handicrafts	Garages	**Pneumatic**	Mechanical engineering	Switchgear	
Gardner Denver Deutschland GmbH, Elmo Rietschle www.gd-elmorietschle.com	●					●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Gardner Denver Deutschland GmbH, Robuschi www.robuschi.com	●					●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Gardner Denver Deutschland GmbH, Nash www.gdnash.com	●												●	●	●	●	●									
GEA Group Aktiengesellschaft www.gea.com		●				●		●					●		●	●										
HAUG Sauer Kompressoren AG www.haug.ch				●		●	●	●	●	●	●		●	●	●	●	●							●	●	
Andreas Hofer Hochdrucktechnik GmbH www.andreas-hofer.de				●				●		●			●	●	●	●	●	●								
Ingersoll-Rand GmbH www.ingersollrandproducts.com	●	●	●			●	●	●	●	●	●		●	●	●	●	●			●	●	●		●	●	
KAESER Kompressoren SE www.kaeser.com	●	●	●			●	●	●	●	●	●		●	●	●	●				●	●	●		●	●	
KNF Neuberger GmbH www.knf.com						●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Körting Hannover AG www.koerting.de				●		●		●					●		●	●										
MAN Energy Solutions SE www.man-es.com				●									●	●	●	●	●							●		
MANN+HUMMEL GmbH www.mann-hummel.com		●																								
Mattei Kompressoren Deutschland GmbH www.matteigroup.com	●	●				●	●	●	●	●	●		●	●	●	●	●			●	●	●		●	●	
Mehrer Compression GmbH www.mehrer.de				●		●	●	●	●		●		●	●	●	●	●	●						●		
MTA Deutschland GmbH www.mta.de		●				●		●	●								●				●			●		
Neuenhauser Kompressorenbau GmbH www.nk-air.com	●									●	●		●	●	●	●								●		
NEUMAN & ESSER GROUP www.neuman-esser.com				●		●		●		●			●	●	●	●	●	●						●		
Parker Hannifin GmbH www.parker.com		●	●			●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●	
Piab Vakuum GmbH www.piab.com						●	●	●	●	●	●				●									●	●	
ITT Rheinhütte Pumpen www.rheinhuette.de						●		●					●		●	●	●							●		
RKR Gebläse und Verdichter GmbH www.rkr.de	●			●		●	●	●	●	●	●		●	●	●	●	●							●		
MultiAir Germany GmbH www.schneider-airsystems.de	●					●	●	●	●	●	●									●	●	●		●	●	

●	●			●	●	●		●	●				●	●	●		●			●	●	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
			●		●						●					●						**Plastic production/processing**
			●		●			●			●		●			●	●					**Hydrogen technology**

Applications Process & Compressed Air Technology

	Products				Fields of application																						
	Compressed air generation	**Compressed air treatment**	**Compressed air distribution**	**Process compressors**	**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	
Siemens-Energy AG www.siemens-energy.com				●									●	●	●	●	●										
SMC Deutschland GmbH www.smc.de		●	●			●	●	●	●	●	●														●		
STASSKOL GmbH www.stasskol.de				●		●	●	●					●	●	●	●	●	●						●			
Ultrafilter GmbH www.ultraair.de / www.ultra-filter.de		●				●	●	●	●	●	●		●		●	●	●	●		●	●	●		●	●		

	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	**Plastic production/processing**	**Hydrogen technology**
				●	●																●	●														●	●	●
	●	●		●	●		●	●	●		●	●	●	●											●	●							●	●	●		
	●	●		●	●		●		●		●	●	●	●		●	●			●	●	●			●	●		●	●	●			●	●	●	●	●
	●	●		●					●																●	●		●	●	●	●		●	●			



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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[1]	Vacuum Heat Treatment[2]	Laser Technology	Electron Tubes	TV Tubes	Lamps and Bulbs
ABN Apparatebau Nittenau GmbH www.abn-drucklufttechnik.de		●						●		●		●	●	●	●	●	●	●	●	●							
Aerzener Maschinenfabrik GmbH www.aerzener.de		●	●	●	●	●				●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Apex Tool Group GmbH & Co. OHG www.apexpowertools.eu				●																							
Atlas Copco Kompressoren und Drucklufttechnik GmbH www.atlascopco.de		●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●		●	●				
Gebr. Becker GmbH www.becker-international.com		●	●	●	●	●	●	●					●	●	●	●	●		●					●			●
M. Braun Inertgas-System GmbH www.mbraun.de										●		●												●			●
Dr.-Ing. K. Busch GmbH www.busch.de		●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
CVS engineering GmbH www.cvs-eng.de						●																					
Flowserve-Sterling SIHI GmbH www.flowserve-sihi.com		●	●	●		●		●		●	●	●	●	●	●	●	●	●	●	●		●	●				●
Gardner Denver www.gardnerdenver.com		●	●	●	●	●	●	●		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●	●
Gardner Denver Deutschland GmbH, Elmo Rietschle www.gd-elmorietschle.com		●	●	●	●	●	●	●		●	●	●	●	●	●	●		●	●	●		●	●	●	●	●	●
Gardner Denver Deutschland GmbH, Robuschi www.robuschi.com		●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●			●		●	●	
Gardner Denver Deutschland GmbH, Nash www.gdnash.com		●	●			●				●	●	●	●	●	●	●	●	●	●	●		●					
GEA Group Aktiengesellschaft www.gea.com										●	●	●	●	●	●	●	●	●	●	●		●					
HERMETIC-Pumpen GmbH www.hermetic-pumpen.com										●	●	●	●														
KAESER Kompressoren SE www.kaeser.com		●	●	●	●	●				●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Körting Hannover AG www.koerting.de										●	●	●	●	●	●	●	●	●	●	●		●					
Leybold GmbH www.leybold.com		●	●			●		●		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●

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

●		●				●	●	●			●					●		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[3]
●		●				●										●		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[4]
●						●												Focused Ion Beam systems
●																●		Electron Beam systems
●																		X-Ray Analysis
●																		MRI and NMR
●											●							Sample preparation[5]
																		R & D
●							●	●			●	●	●	●				Universities
●											●	●		●				Government Labs
●											●	●	●	●				Scientific Research Laboratories
●	●			●							●			●				Space Simulation
																		Plastic production/processing
																		Hydrogen technology

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[1]	Vacuum Heat Treatment[2]	Laser Technology	Electron Tubes	TV Tubes	Lamps and Bulbs
MAN Energy Solutions SE www.man-es.com				●							●						●										
MANN+HUMMEL GmbH www.oe-products.mann-hummel.com		●	●	●	●	●		●		●			●	●	●	●	●			●							
MTA Deutschland GmbH www.mta.de		●		●																							
Pfeiffer Vacuum GmbH www.pfeiffer-vacuum.com						●		●		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Piab Vakuum GmbH www.piab.com		●	●	●	●	●		●								●											
ITT Rheinhütte Pumpen www.rheinhuette.de											●		●				●										
RKR Gebläse und Verdichter GmbH www.rkr.de		●	●	●	●	●		●		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
SBS Metalltechnik GmbH www.sbs-metalltechnik.de						●														●		●	●		●		
SMC Deutschland GmbH www.smc.de		●		●	●	●	●	●		●	●	●	●	●	●	●	●							●			
STASSKOL GmbH www.stasskol.de		●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●		●	●				

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

		●	●		●	●				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[3]
●				●		●				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[4]
						●				Focused Ion Beam systems
						●				Electron Beam systems
						●				X-Ray Analysis
						●				MRI and NMR
						●				Sample preparation[5]
										R & D
	●	●			●	●		●		Universities
	●	●			●	●		●		Government Labs
	●	●			●	●		●		Scientific Research Laboratories
						●				Space Simulation
●	●				●					**Plastic production/processing**
●	●				●					**Hydrogen technology**

Brand name & trade fair register

Alltech Dosieranlagen GmbH
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IFAT, Munich,
13–17/5 2024, Hall A2, Booth 438

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- Centralized air supply systems

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

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ACHEMA, Frankfurt,
10–14/6 2024

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Petrochemical & Refining Congress Europe 2024, Amsterdam, Netherlands,
13–15/5 2024
ACHEMA, Frankfurt,
10–14/6 2024
Hydrogen Technology & Carbon Capture Expo Europe, Hamburg, 23–24/10 2024
ADIPEC, Abu Dhabi, UAE,
4–7/11 2024

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Pumps & Valves, Dortmund, 21–22/2 2024
EDS, Sharm El Sheikh, Egypt, 6–9/5 2024
EXPONOR, Antofagasta, Chile, 3–6/6 2024
ACHEMA, Frankfurt, 10–14/6 2024
MINEXPO, Las Vegas, USA, 24–26/9 2024
IDA World Congress, Abu Dhabi, UAE, 8–12/12 2024

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HMI, Hanover, 22–26/4 2024, Hall 13
IFAT, Munich,
13–17/5 2024, Hall B1, Booth 422
ACHEMA, Frankfurt,
10–14/6 2024, Hall 8, Booth D76
Hydrogen Technology Expo Europe, Hamburg, 23–24/10 2024,
Hall A3, Booth 3F12
All exhibition dates: **www.edur.com**

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analytica, Munich, 9–12/4 2024
HMI, Hanover, 22–26/4 2024
drupa, Dusseldorf, 28/5–7/6 2024
ACHEMA, Frankfurt, 10–14/6 2024
MEDICAL FAIR ASIA, Singapore, 11–13/9 2024
ADIPEC, Abu Dhabi, UAE, 11–14/11 2024
COMPAMED, Dusseldorf, 11–14/11 2024

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ANUGA FoodTec, Cologne, 19–22/3 2024, Hall 10.1, Booth D040
StocExpo, Rotterdam, Netherlands, 12–13/4 2024, Booth E40
ADIPEC 2024, Abu Dhabi, UAE, 11–14/11 2024, Hall 6, Booth 6210

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Pumps & Valves, Dortmund, 21–22/2 2024, Hall 05, Booth H04
ANUGA FoodTec, Cologne, 19–22/3 2024, Hall 4.1, Booth A088-B089
IFAT, Munich, 13–17/5 2024, Hall B1, Booth 451/550
ACHEMA, Frankfurt, 10–14/6 2024, Hall 8.0, Booth C27
SMM, Hamburg, 3–6/9 2024

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IFAT, Munich, 13–17/5 2024, Hall B1, Booth 414

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IFAT, Munich, 13–17/5 2024, Hall B1, Booth 414
SMM, Hamburg, 3–6/9 2024, Hall A2, Booth 137

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Achema, Frankfurt, 10–14/6 2024
The Battery Show Europe, Stuttgart, 18–20/6 2024
SMM, Hamburg, 3–6/9 2024
SOLIDS, Dortmund, 9–10/10 2024
Hydrogen Technology Expo Hamburg, 23–24/10 2024

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SHK-E, Essen, 19–22/3 2024
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ANUGA FoodTec, Cologne, 19–22/3 2024, Hall 04.1, Booth B-078
IFAT, Munich, 13–17/5 2024, Hall A2, Booth 318
ACHEMA, Frankfurt, 10–14/6 2024, Hall 8.0, Booth H12
EuroTier, Hanover, 12–15/11 2024

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ACHEMA, Frankfurt, 10–14/6 2024
Kraftwerkstechnisches Kolloquium, Dresden, 8–9/10 2024
Valve World, Dusseldorf, 3–5/12 2024

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Lyoner Str. 18
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vf 800324-e