CUSTOMER JOURNAL · EDITION 4·2016

AERZEN COM·PRESS

In the steel industry, AERZEN positive displacement blowers are in operation all over the world, for example in the production of reduction gas.

Dear Readers,

Klaus-Hasso Heller, Chief Executive Officer

You have in your hands the fourth and last edition of the 2016 customer journal AERZEN COM.PRESS. Please read about the versatility of our products. Learn about the latest news from steel producers - more and more frequently, coke is being replaced by reduction gas. AERZEN positive displacement blowers are operating very successfully in steel plants for gas supply all over the world.

Read about new trends in the wastewater sector. How does a wastewater treatment plant turn from energy consumer into energy producer? The solution is energy-efficient aeration systems combined with energy-efficient blowers "made by AERZEN".

Learn more about our new concept Performance³ with the innovative control system AERsmart. These are exciting innovations which can help optimise energy efficiency in your plant.

Do you need machines on a temporary basis? If so, it's possible to rent them. In such cases, please contact our colleagues at Aerzen Rental. They will be happy to assist you. For further details about all of these developments, please enjoy reading this edition of our customer journal.

I wish you and your families all the best for 2017!

Cordially yours,

Iron smelting below the smelting point

Direct reduction with AERZEN positive displacement blowers - the gas is what matters!

Steel without coke - is it possible? Current developments in iron smelting and steel production are heading in exactly this direction. Instead of reducing the iron oxide in the ore with coke to elementary iron, steelworkers are more and more often going another way. Instead of coke, reduction gas is used, mostly generated from natural gas. In many plants all over the world, positive displacement blowers made by AERZEN are taking over the gas supply of the reduction towers.

It was only this autumn that the world's biggest direct reduction plant was commissioned in Texas. Iron sponge is the substance generated from direct reduction - also called the Midrex-procedure. While the generation of raw iron is usually connected with fiery images, direct reduction plants go quite another way as far as process technology is concerned. First of all, this technology has been designed for smaller lots and smaller dimensioned plants, which can be started up and shutdown more flexibly compared with traditional blast furnaces. There is another difference between direct reduction and "steel making": the independence from coke - and thus from coal. The background: as reducing agent no fixed carbon as bulk material is used - instead, there is a gas mixture consisting of carbon monoxide and hydrogen. Accordingly, the material flow for the combustible material differs: conveyor belts and screw conveyors in traditional steel mills; blowers and compressors in direct reduction plants. In this field of application, AERZEN has a market presence all over the world, mainly with its positive displacement blowers.

Before natural gas can be used to reduce the positively charged iron ions in the iron oxide to molecular iron, methane has to be treated in a so-called reformer. For the chemical steam reformation, natural gas with water and oxygen injection is modified into carbon monoxide and hydrogen in an endothermic reaction and using heat. Both gases are perfectly suitable for dissolving out the oxygen retained in the iron oxide. The reaction products are iron, water and carbon dioxide.

Iron sponge briquettes with high purity

Large multi-stage blowers made by AERZEN convey the initial gases with a volume flow of up to 300,000 cubic metres per hour into the reformers. From there, the separated gas is channelled in the counterflow into the shaft furnace also by means of positive displacement blowers. Reduction of iron ore to iron sponge begins. This is then cooled down immediately, to prevent the hot material, which has a temperature of approaching 1,000 degrees C, from oxidising immediately in the air. Furthermore, it is processed mechanically, in a hot state, into briquettes or pellets. The intermediate product, on the way to becoming high-grade steel, now has the quality of raw iron and can be processed accordingly in the steel works.

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Exhibition dates (first half of 2017)

PlastIndia,Mumbai/India	19th to 23rd January 2017
NEWA, Boston/USA	22nd to 25th January 2017
NYWEA, New York/USA	6th to 8th February 2017
Water NI, Belfast/Ireland	23rd February 2017
AWWOA Banff, Alberta/Canada	13rd/14th March 2017
Americana, Montréal/Canada	21st to 23rd March 2017
Aqua Nederland, Gorinchem/Netherlands	21st to 23rd March 2017
Propak Vietnam 2017, Ho Chi Minh/Vietnam	21st to 23rd March 2017
Water Phillipines 2017, Manila/Philippines	22nd to 24th March 2017
Wasser Berlin, Berlin/Germany	28th to 31st March 2017
Water Ireland, Ashbourne/Ireland	28th March 2017
Maintenance, Dortmund/Germany	29th/30th March 2017
Maintenance, Antwerp/Belgium	29th/30th March 2017
WEAO/OPCEA, Ottawa/Canada	2nd to 4th April 2017
SC Environmental Conference, Myrtle Beach/USA	6th to 9th April 2017
NeftegazExpo, Moscow/Russia	17th to 20th April 2017
Florida Water, Palm Beach/USA	23rd to 26th April 2017
Hannover Messe/ComVac, Hanover/Germany	24th to 28th April 2017
CWEA, San Diego/USA	29th April to 1st May 2017
AWEA, Orange Beach/USA	30th April to 3rd May 2017
IE EXPO 2017, Shanghai/China	4th to 6th May 2017
Arizona Water, Glendale/USA	6th to 8th May 2017
AISTech Show, Nashville/USA	8th to 11th May 2017
Schüttgut, Dortmund/Germany	10th/11th May 2017
Pump Centre, Telford/UK	10th/11th May 2017
Expo Apa, Bukarest/Rumänien	15th to 17th May 2017
Power Gen, Delhi/Indien	17th to 19th May 2017
Missouri Water, Missoula/USA	21st to 24th May 2017
BCWWA, Victoria/Canada	28th/29th May 2017
ACODAL, Cartagena/Columbia	31st May to 2nd June 2017
Oil & Gas Show, Puebla/Mexico	7th to 10th June 2017
Congreso Mexicano Del Petroleo, Puebla/Mexico	7th to 10th June 2017
Texas Water, Corpus Christi/USA	22nd to 25th June 2017

Five years of Aerzen Turbo

Aerzen Turbo in Korea had a double anniversary this year, marking: five years in existence and five years of production – definitely a cause for celebration. At the beginning of December, all employees, as well as Vice President Asia Pacific - Chuck Lim, Product Manager Turbo - Steffen Helmert, Vice President Marketing & Product Management/ Director Turbo Business - Stephan Brand, as well as H.J. Lee and C.Y. Kim of the local representative HC Corporation, were invited to a joint Company Dinner. As part of the celebrations, other anniversaries were honoured: 17 of the 58 employees of Aerzen Turbo have been present since the day the company opened.

Aerzen Turbo has been producing the core components of AERZEN Turbo Blowers – Turbo stage, frequency converter and control unit, as well as complete packaged units. Turnover has increased to more than EUR 8 million over the last five years.

The team at Aerzen Turbo in Korea celebrated the company's 5th anniversary.

Different process, different requirements, depending on the location: Midrex plants are suitable for smaller locations, and their requirements for raw materials are different. In its heyday, the Ruhr area benefited from access to coal as an energy source and redox agent for its ironworks, but for the Midrex process the key element is access to cheap natural gas. Therefore, it is hardly surprising that the currently biggest direct reduction furnace was commissioned in 2016 in the U.S.A. The capacity of the plant in Texas is two million tons of iron sponge, processed into briquettes while hot.

Durable and reliable

In view of the importance of gas availability in such plants, demands for durability and operational reliability of the blowers are high. For conveying and compression of process gases, AERZEN developed positive displacement blowers series GR and GQ. In sizes 12 to 21, type GR covers intake volume flows from 100 to 50,000 cubic metres per hour. Type GQ, with sizes between 17 and 22, covers the volume range between 1,500 and 100,000 cubic metres per hour. Both performance classes convey the gas based on the positive displacement principle.

"Our machines are among the biggest available in the market," explains Pierre Noack, Head of Process Gas Division at AERZEN. Their size, in connection with a high performance density, offers the advantage that fewer machines need to be installed to handle the required gas volume. Thus, Midrex-plants can be specified more easily and commissioned faster. Another advantage is availability. In engineering, and the evaluation of the most suitable technology, calculations of the medium default probability play an increasingly important role - particularly for plants which work continuously. If bigger compressors are used, fewer of them are required, which means that less piping needs to be built, fewer connections need to be installed, and less sensor technology and actuator technology needs to be integrated into the overall control system. Against this background, higher acquisition costs may play a subordinate role - in the evaluation of the technical components, it is MTBF figures, average maintenance intervals and lifecycle costs which play the key role. "Our packaged units still have a longer service life," says Noack, and he mentions "very satisfied customers."

Picture: Wikimedia/Borvan53

In direct reduction processes, briquettes of sponge iron are being made.

Water injection for maximum washing effect

Their long working life and operational reliability result primarily from the fact that the oil-free conveying process gas blowers have been designed as robust high performance machines. Types GR and GQ are able to withstand contaminations in gas very well, and are also highly resistant to iron dust. In addition, water can be injected into the packages. This detail has a significant impact, particularly in the conveying of aggressive process gases. With the specific injection of water, both gas and blower package can be cooled very efficiently. Another advantage is the washing effect of the water. During operation, this prevents positive displacement blowers from sustaining damage from the deposits of highly viscous residues of process gases. The two-lobe design of the machine allows an additional self-cleaning effect.

This may not be important when conveying pure natural gas into a reformer, but it is a significant aspect when primary energy sources are blended with other gases. Here, coke oven gas is first on the list. The by-product of the pyrolysis of coal and coke contains, depending on the quality of the coal, about 55% hydrogen, 25% methane, 10% nitrogen and 5% carbon monoxide. Except for nitrogen, the mixture is excellent for reducing iron ore. However, the coke oven gas also contains minor components, including tar, hydrogen sulphide, ammonia, benzene, as well as aromatic compounds, such as naphthalene. In general, in Midrex processes, it is worthwhile to use the volatile components of coal for direct reduction of iron ore, as its share of coal is 25% of the initial weight. One tonne of coal produces 280 cubic metres of pure gas from coking plant and approximately 55 kg of sticky coal tar.

Gas treatment is not necessary

Positive displacement blowers made by AERZEN are always capable of conveying fail-safe the indicated contaminations. Thus, users of Midrex plants do not need separate gas treatment. This would be necessary if turbo compressors were used instead of positive displacement blowers. However, due to the high rotation speeds, this technology does not tolerate any foreign particles, no matter how small, in the gas flow. Thanks to the different operating principles of forced displacement, positive displacement blowers operate at considerable lower surface speeds. Just to recap: The working principle of positive displacement blowers allows maximum tip speeds which are 7 - 10 times lower than the tip speeds of turbo compressors. Thus, the injection of water leads to low erosion of the positive displacement blowers, whereas turbo compressors are not equipped with continuous water injection.

Easy modernisation with Positive Displacement Blowers

In order to apply major industrial blower solutions in other application fields of raw iron production, Pierre Noack explains that "our machines have a broadband design." During operation, when the capabilities of the displacement machines are not being fully utilised, either calculated theoretically or facturing in optimum characteristic curves, they nevertheless work quite efficiently due to the speed control of frequency converters. In comparison with centrifugal compressors, which have a relatively small control range at constant back pressure, positive displacement blowers adapt perfectly to changing working conditions. Their speed variance creates flexibility. It makes a difference that AERZEN positive displacement blowers can operate in highly variable modes. Existing plants can be retrofitted easily, and modernised, thanks to these machines. ○

www.aerzen.com

International websites relaunch has started successfully

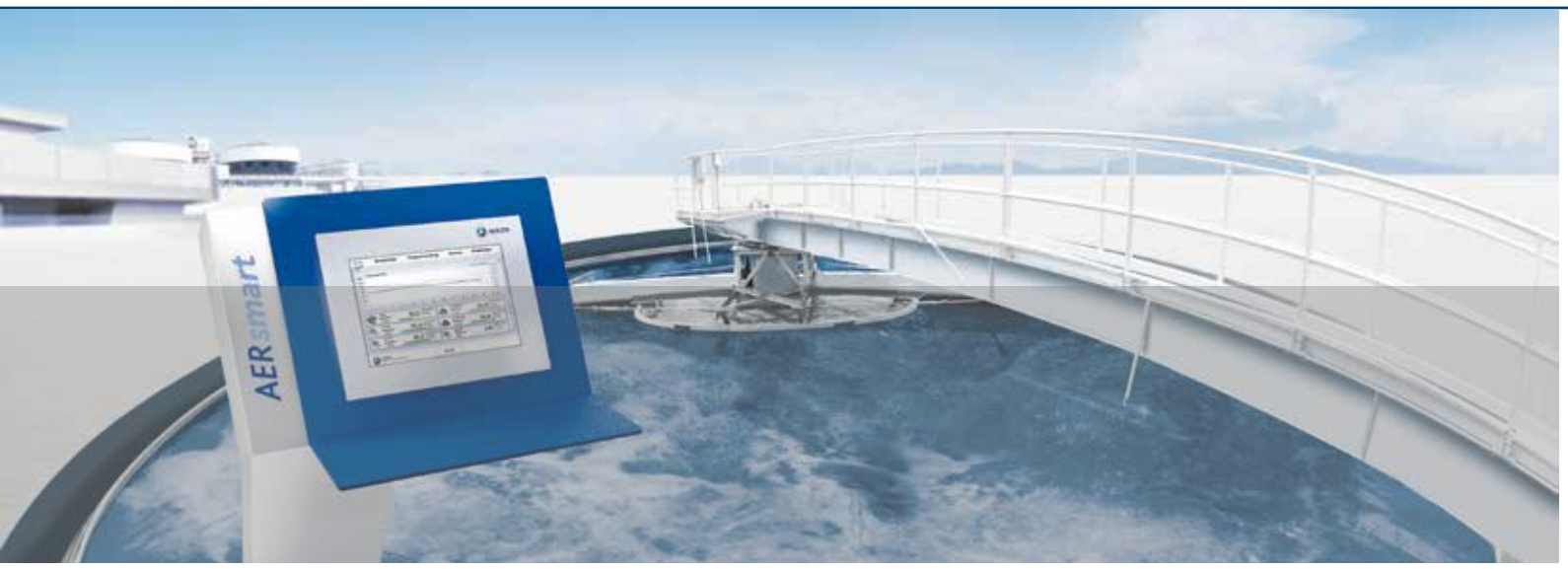
Since the middle of December, the websites of the AERZEN subsidiaries in Great Britain, the U.S.A., Australia, Asia, India, Taiwan, Austria, South and North Africa, and the United Arab Emirates, have all been shining in new splendour.

With the changeover to a new Content Management System, international visitors to the AERZEN website now benefit from new content and functions:

- Thanks to the Responsive Design, users can reach AERZEN on all types of devices, anywhere and at any time.
- By means of the product search function, users can find individual product solutions with just a few mouse clicks.
- New application overviews provide detailed information and practical references.
- In the AERZEN CustomerNet, new tools and information are available:
  - AERSELECT - a calculation tool
  - A flexible performance directory tool - for preparing flexible performance directories
  - Technical documentation in the web configurator

In 2017, the remaining country websites will be implemented. With content available in more than 20 languages, country-specific content and local contact persons, AERZEN ensures closeness to its customers. ○

The CustomerNet offers new tools and information.



Implementation by means of AERsmart and Performance³

AERZEN wastewater forum

(Waste)water 4.0

In early October, AERZEN held a two-day wastewater forum in co-operation with the Rheda-Wiedenbrück Wastewater treatment plant.

Energy efficiency is becoming more and more important in the German wastewater treatment sector. From a technical point of view, the focus is on CO_2 minimisation and digitalisation (Water 4.0), as well as on the A 216 rulebook of the German Association for Water and Waste Water Technology (DWA). But the requirement for optimal use of government funding is also gaining in importance. As a result of these developments, there are opportunities as well as new challenges. Accordingly, the wastewater forum offered operators, engineering offices, system manufacturers and blower suppliers a platform to combine theory with practice.

Wastewater treatment plant as energy producer

The first day of the event was dedicated to the press and addressed the following question - which new technological approaches and concepts are currently being tested around Europe which could ultimately result in a wastewater treatment plant changing from being a municipality's biggest energy consumer into an energy producer?

Wolf-Uwe Schneider, Plant Manager of municipal wastewater drainage operation Rheda-Wiedenbrück, presented current operational activities at the Rheda-Wiedenbrück wastewater treatment plant. Using the example of his current "POWERSTEP" project, promoted by the EU (www.powerstep.eu), Christian Loderer presented the wastewater treatment plant of the future. The useable chemical energy in the activated sludge is discharged right at the beginning of the wastewater purification process, in order to produce a higher biogas return and ultimately more heat and more energy. Technologies such as carbon extraction, mainstream deammonification, ammonium stripping, and also power-2-gas and heat-2-power technologies, are being tested at six European wastewater treatment plants.

Christian Loderer,
Project Manager, POWERSTEP

The path towards Water 4.0 must be laid down today.

Energy-efficient aeration

The second day of the event involved around 40 industry practitioners. First of all, Schneider gave a brief historical overview of the individual construction measures at the Rheda-Wiedenbrück Wastewater treatment plant. The focus of the actual reconstruction measures was on optimisation of the biggest energy consumer of the wastewater treatment plant, i.e. the biology. A new energy-efficient aeration system, including a newly designed compressed-air station made by AERZEN, was installed, and this resulted in tremendous savings in operating costs.

During his presentation, Markus Haverkamp, who is responsible for projects at the consulting and engineering company aqua consult GmbH, pointed out how important it is to observe and implement correctly the DWA-A 268 rulebook and stressed the advantages that this brings. Using the example of the Rheda-Wiedenbrück project, forum participants could see the implementation of the new design and automation of the single-stage aeration basin by applying the DWA-rulebook in practice.

Afterwards, Rüdiger Vrabac, of UD Umwelt-Dienste, gave a lecture on the topic of aeration. He not only presented the new membrane strip ventilation technology, but also demonstrated how optimal oxygen entry into the aeration basin can be guaranteed with a skilled allocation of basins by means of diffusers.

Besides energy-efficient aerators, an optimised aeration system needs energy-efficient blowers. With positive displacement blowers, DELTA HYBRID rotary lobe compressors and turbo machines, AERZEN offers all three machine technologies (Performance³) from a single source. Markus Leidinger, AERZEN wastewater manager in the EMEA division, presented the successful upgrade of the blower station to the new Performance³ concept with AERsmart: a turbo for covering the base load, a Delta Hybrid, on the one hand for exclusively covering the weak load and in combination with the Turbo for covering the air consumption during full load operation. In this way, it is possible to dimension the required oxygen volume for any load by means of the most efficient machine. Thanks to the comprehensive data provided by the AERsmart control system, energy analyses of the machines currently running can be prepared and displayed. These give systematically detailed information about the energy consumption of the blowers, and provide a comparison between the current actual value and the plant-specific ideal value, so that, if necessary, suitable energy optimisation measures can be taken. As a result, the recommendations of the DWA A 216 rulebook which refer to meaningful performance values of a compressor station, are available at the push of a button.

The principle behind AERsmart is that it optimally distributes the required air volume at all loads to the individual degree of efficiency of the installed machine combination, and can be connected to master control systems. As a result, the installed machinery is able to operate at an efficiency level which is very close to the highest level theoretically possible. Another major advantage: blowers made by other manufacturers can also be integrated into the control system. The engineering office, the system manufacturer and the operator receive a consistent concept from a single source for the visualisation, communication and optimisation of process-relevant machine data, thus enabling them to manage the best possible energy concept.

At the Rheda-Wiedenbrück wastewater treatment plant they have had enormous success: the new machine technology Performance³ with AERsmart has resulted in savings of approximately €40,000 per annum being made. The costs of the upgrade will be fully amortised after just four years.

Financing options

Finally, Andreas Koschorrek, of e.qua, presented information about government funding programmes in respect of CO_2-minimisation which elicited great interest among the specialist audience. Start-up funding costs of up to 50 per cent, and development funding costs of up to 90 per cent, depending on the individual federal state involved, can be claimed. Therefore, AERZEN has developed, together with e.qua, network energy recovery and resource management, a customer-specific, and very streamlined, way to apply for corresponding funding when using energy-efficient compressors and seeking possible heat recovery. ○

Application managers for Europe, Middle East and Africa

Markus Leidinger

In January 2016, **Markus Leidinger** took over the new function of Application Manager Wastewater Treatment Plant for the Europe, Middle East and Africa regions. He had previously worked for nine years as a sales engineer in our sales office South-West. In his role he gained a considerable amount of practical experience, particularly as far as applications around sewage treatment plant technology are concerned.

First internal system audit completed

Since the beginning of 2016 AERZEN has achieved the certifications according to DIN EN ISO 9001 (quality management), 14001 (environment management) and 50001 (energy management), as well as according to OHSAS 18001 (occupational and health protection management system). These certifications are completed by DIN EN ISO 80079-34 (quality management for machines for ATEX-applications), NSQ-100 (quality management for machines for nuclear-applications) and the MID 2014/32/EU module D (quality management for the production of rotary piston gas meters). In September 2016, the quality assurance department has now carried out the first internal system audit for the integrated management system in Aerzen. Successful: All departments fulfill the management requirements.

Meeting of the Customs and Import expert forum

The Customs and Import expert forum of the IHK Hanover held a meeting at Aerzener Maschinenfabrik GmbH on 23rd November 2016.

After a company presentation, which included a tour of the company premises, the around 40 participants concentrated on the first item on the agenda, the intensification of air safety rules by the Federal Aviation Authority. An exchange of information and opinions on other current topics followed. Topics included the list of goods for external trade statistics with changes for year 2017, the new preferential agreement of the EU with the Ivory Coast and the southern African states, the survey of the IHK Stuttgart regarding supplier's declarations, and the EU-customs tariff 2017.

Further meetings have already been scheduled for 2017 – these will be on 15th February/21st June at Johnson Controls Autobatterie, Hanover, and on 21st September/29th November at Lenze Operations GmbH, Aerzen.

Stephan Brand, Vice President Marketing & Product Management/Director Turbo Business, presented the company to the participants of the IHK Hanover.

Questions, Suggestions, Ideas?

We are looking forward to all your queries, comments and suggestions on our customer journal and we are at your disposal for further information on AERZEN products and services. Give us a visit on our website:

www.aerzen.com/news

AERZEN Style icon

While shopping in Hamburg one of our colleagues discovered an AERZEN product in an unusual place: in the entrance area of the Stilwerk Design centre, in the middle of a café, an old AERZEN blower was exhibited. The GLa 14.18 blower, manufactured in the 1960s, had been running in a malt factory where it had been used in a silo plant.

AERZEN blower at the 'Stilwerk' Design centre in Hamburg

New manager of Process Gas Division Hungary

Dr. Imre Pesthy

On 1st September 2016, **Dr. Imre Pesthy** took over the management of Process Gas Division Hungary from Rolf Heinemeyer. Dr. Pesthy has been awarded a post-graduate degree in metallurgical process engineering, special field metallurgy and welding technology, and completed his Master's degree in business management. He has long-term experience with leading positions in small and larger production segments of international companies.

Besides supporting PGD Hungary further, Rolf Heinemeyer will focus in future on PGD business at AERZEN.

IMPRINT

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The tunnelling project in Karlsruhe is located in the centre of the ground water table. The compressed air provided by our compressors ensures that, during propulsion, the site I not immediately filled with water.

Compressors made by Aerzen Rental for preliminary application

Under pressure: tunnelling in groundwater

Construction work is usually temporary in nature. Therefore, it is sufficient to rent the necessary equipment required for pressure application instead of buying it. At present, Aerzen Rental Division is providing equipment for a tunnelling project in the city centre of Karlsruhe, together with the company Pressluft-Frankfurt.

Expansion of the regional public transport network is under way in Karlsruhe. A new tunnel for cars will improve mobility and quality of life. This car tunnel will relieve pressure on the transport network by taking commuters and visitors to the city more quickly and more safely to their destinations. An underground tram route is available between Ettlinger Tor and Marktplatz. Due to its special geological formation, excavation work on the 300 metre long-tunnel underneath the city is quite demanding. To prevent water penetrating into the construction site, the company Pressluft-Frankfurt relies on AERZEN compressor technology.

Demanding geological conditions

When it rains on Karl-Friedrich-Straße, and you look at the asphalt, you will notice a road with fine bubbles. The reason for this: The tunnel underneath, with its 15-metre footprint below street level, loses air. "Here, we have to deal with a lot of sand, gravel and loose rock. These are materials which are not useful in tunnel construction," says Robert Schweitzer, Construction Manager, describing the challenges he faces in the centre of Karlsruhe. On one side, due to the geological conditions, BeMo Tunnelling GmbH is forced to stabilise the walls by propelling shotcrete at them, as otherwise the ground would behave like a sandcastle. On the other side, the pores are so big that groundwater would penetrate through the walls if the corresponding back pressure is not provided.

This means that the work between Ettlinger Tor and Marktplatz is literally being done under pressure. In the first construction phase, the pressure has a delta/atmosphere rate of from 0.75 to 0.85 bar. Therefore, the project is subject to German compressed-air regulations, which define the relevant rules regarding job safety. For this reason, appropriate briefings and the corresponding health certificates are mandatory to get into the pressure lock. To get out, decompression is inevitable.

More losses due to gravel and sand

The pressure lock is part of a control room, where the lock operator always keeps an eye on the operational state of all compressors on a display panel. Twelve packaged units have been installed - four machines have been installed underground and eight of them directly above (at ground level).

"We have integrated the compressors with Delta Screw packages as core within container frames. This way they can be transported easily and combined on site as a space-saving unit - thanks to cartridge/multilevel design," explains Peter Link, who is responsible for the German rental business. The headquarters of Aerzen Rental is at Duiven in the Netherlands. In Karlsruhe, the compressors, type CVO4400, are combined with water coolers, which cool down the air outlet temperature of the compressor from 120°C to 20°C. "If we blew the hot air directly into the tunnel, it would not be possible anymore to work down there," notes Schweitzer.

Sufficient reserves are required

For work which is not so deep below ground, the packaged units from Aerzen Rental pump a daily average amount of air of between 100 - 140 m^3 per minute into the tunnel. This is also the reason for the foamy road when it rains. "The air bubbles to the top slowly and steadily. The shotcrete stabilises the walls, however, it is not as tight as the inner shell at final completion," says Schweitzer. In order to limit the pressure experienced by the construction workers further down, the tunnel is driven into the ground in layers - from top to bottom, until the base is reached. The deeper the construction site is, the more the pressure increases from the groundwater. Schweitzer expects a pressure delta of up to 1.3 bar by the end of the structural work. Therefore, the pressure losses will increase exponentially and a higher volume flow will be required. For this reason, and according to the compressed air regulations after sufficient redundancy, the equipment supplied by Aerzen Rental covers adequate reserves. "We have to cover the complete demand by two thirds of the installed machine performance. Four of the twelve packaged units serve as spare machines," explains the mechanical engineer of the Austrian company, specialised in tunnelling.

"The specific performance of the packaged units is unrivalled," emphasises Peter Engelke, Project Manager of Pressluft Frankfurt, describing the start of cooperation between AERZEN and Pressluft-Frankfurt more than 30 years ago. "In all these years, I have never had a broken machine - this signifies long working life and reliability." Operational reliability is essential with tunnel projects, as breakdowns may have devastating consequences. In case of a breakdown, the construction workers would have enough time to get safely outside, although the penetrating water would cause massive damage to the tunnel. "It is mandatory to prevent this by all possible means," advises Schweitzer. "The machines must run," he adds. If all machines are in operation, the available volume flow is 700 cubic metres per minute - minus the stated reserve, which makes 420 cubic metres during standard operation.

As the required reserves are synonymous with undesired oversizing, the question of energy efficiency arises. After all, the compressors have an installed power output of 200 kW each. "The efficient use of electrical energy is what counts - even in terms of preliminary construction projects," emphasises Link. Engelke has also observed that electricity costs are always an issue. Considering twelve compressors with a capacity of 200 kW each, every digit behind the decimal point is important," he says. The single stage, oil-free screw compressors of series Delta Screw Generation 5 plus are universal tools and have been optimised to provide maximum energy efficiency. They can be controlled by means of a frequency converter as needed.

In Karlsruhe, the speed of the compressors is pressure-controlled and adjusted, so that their actual performance corresponds exactly with the pressure losses from the tunnel - these measure 15,000 cubic metres from Marktplatz to Ettlinger Tor. In addition, it is economical for BeMo Tunnelling and Pressluft-Frankfurt to rent these compressor packages in such special application cases, instead of buying them. And the independent rental service of the manufacturer of the blowers and compressors, located in Lower Saxony, takes care of all the maintenance during the time that the equipment is in operation. If all goes as planned, in about one year's time the compressor packages will be returned for general maintenance before a second rental period is required. By that time, the tunnel in Karlsruhe should be free from groundwater, so that the actual station and line upgrading work can start. ○