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 shut-down 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.

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 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.

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 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 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.

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.

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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 EQ, in sizes 12 to 21, type GR covers intake volume flows from 100 to 500,000 cubic metres per hour. Type EQ, 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.”

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 EQ 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 coke 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.
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 CO₂ 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.

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 216 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

Fina1ly, Andreas Koschorrek, of equa, presented information about government funding programmes in respect of CO₂ 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 equa, 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.
Under pressure: tunnelling in groundwater

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 Ettingtor and Marktplatz. Due to its special geological formation, excavation work on the 300 metre long-tunnel underneath the tram route was done under pressure. 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. “The air bubbles stabilise 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. 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 Ettingtor 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 containers 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 compressors from 120°C to 20°C. “If we blow 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 m³ per minute into the tunnel. This is also the reason for the foamy road when it rains. “The air bubbles make the tunnel. This is also the reason for the foamy road when it rains. “The air bubbles make the air outlet temperature at the compres- sors from 120°C to 20°C. “If we blow the hot air directly into the tunnel, it would not be possible anymore to work down there,” notes Schweitzer.

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