Dear Technology Fans,

Our customers choose Sulzer because we deliver with our products and services exceptional performance and value. But in today’s world, that is no longer enough. We also need to offer the shortest lead times, whether it is for a standard product or something highly engineered. And the highest quality, because our solutions are often mission-critical for our customers. This is the essence of what Sulzer is striving to achieve: to always be faster and better than other suppliers.

How do Sulzer engineers shorten the time needed to take a product from the development phase to being commercially available? Experience, teamwork, knowledge — and digitalization. Every engineer has access to our digitalized designs, iterations are made, and rapid prototypes produced. Our subject matter experts around the company, who share their expertise across several departments, are consulted to define the right materials, coatings, or appropriate production technologies. For example, our engineers developed a new way of producing large impellers, which led to better quality and performance for our customers.

Sulzer has many applications for additive manufacturing, one of them being fast prototyping. Our customers save time and money because they can judge and test 3D-printed mascara brushes. Being agile and innovative is essential, and Sulzer is a frontrunner in using new materials for selective laser sintering.

Speeding up repairs has always been a key focus for the Sulzer service centers around the globe. Over the holiday season last year, our service team in Indonesia was busy repairing a large generator whose failure had taken a power plant in Malaysia offline. The call came on Christmas eve, and we responded immediately. The original equipment manufacturer could not make the customer’s timing. Sulzer could and, with a little help from the world’s largest cargo plane, got the generator back in time and the plant back up and running. With Sulzer quality, second to none. Faster and better — for the sake of our customers.

Nevertheless, take your time when reading this edition of the Sulzer Technical Review.

Greg Poux-Guillaume
CEO Sulzer
Faster and Better

4 Better Pump Capacity Calculation
Smart pump control ABS PC 441

7 Increased Separation Capacity with NeXRing™
Expanded family of superior random packing

10 Flow Optimization in Large Gas Ducts
Efficiency boost for firing systems

14 Precise Production for Large Impellers
New manufacturing method to achieve higher quality

18 Faster Development Process With Additive Manufacturing
Laser sintering for mascara brushes

21 Flying Generators for Fast Repair
Accelerating with transport and parallel workflows

24 Rapid Repair of a Solo Hydro-generator
High-voltage generator overhaul in Scotland

26 Survival Relies on Speed
Hunt and flight strategies in nature

28 News and Events

31 Imprint
Better Pump Capacity Calculation

Data-driven pump control and maintenance is getting more and more important. With the smart combination of high-resolution input data, the Sulzer pump control ABS PC 441 calculates real-time pump capacity and efficiency with extreme precision. The ability to monitor these values — for Sulzer pumps and pumps from other manufacturers — helps customers to make better service decisions.

1 Sulzer enables smart volumetric flow calculations for pump stations that process municipal sewage water.

Municipal sewage water stations (Fig. 1) run a full network of pumps. Collecting data from these stations is becoming increasingly important. Knowing the water inflow and outflow volumes is significant for the operating personnel, especially when heavy rainfalls occur.

Not every station is equipped with a flowmeter to measure the water volumes, but most of the stations have level sensors. Sulzer looked for a smart way to use these level sensors in combination with a pumping station control to deliver this important information.

For terminal and stormwater pumping stations
The pump control ABS PC 441 is a monitoring and controlling device for one to four pumps. The pump control can be used for Sulzer pumps, but pumps from other brands can also be connected to the ABS PC 441. It is designed for use in municipal wastewater pumping stations — mainly in terminal pumping stations or stormwater pumping stations. It allows pumps to be started, stopped, or regulated to increase availability, minimize energy use, and reduce stress on the water network downstream. In addition, the system allows the surveillance of pumps and pumping stations, and
Continuous volumetric calculations!
No fixed volume cross sections needs to be defined, only break points!

Level 0
Area 0
Level 1
Area 1
Level 2
Area 2
Level 3
Area 3
Level 4
Area 4

The unit continuously re-calculates the momentary surface area for an accurate measurement.

Up to 9 different level points can be used to define the shape!
Only the relevant levels needs to be entered!

2 The volume definition of the basin and required data for the software program.

- The control detects a reduced outflow volume quite quickly. The lower outflow is often caused by a decline of the pumping efficiency, which indicates that a pump should be serviced. This maintenance can be planned in advance and done before a breakdown occurs.
- Because pumps with a lower efficiency are switched off, the pump control helps to save energy.
- The accurate overflow measurement does not require a sensitive, external flow meter.

Calculation principles and sensors
To enable the pump control ABS PC 441 to measure automatically, initial programming is required. For accurate calculations, it is necessary to enter into the controller the shape and volume of the basin where the pumps are installed (Fig. 2). Either float switches or hydrostatic sensors with 4 to 20 mA signals can be connected to the PC 441 control device. A hydrostatic sensor is necessary to calculate the flow.

Traditional flow calculation
The “drop test method” has been used for many years by customers to calculate the capacity of the pump station manually. The method is also used to check the condition and pumping capacity of each pump. This time-consuming method has a large margin of error because it is based on assumptions and not on measurements. Sometimes, these assumptions are incorrect.

The three assumptions are:
1. The level change in the fluid sump is directly related to volume change in the sump.
2. The inflow rate during pump operation is the same as the inflow rate between pump operations.
3. The pumping rate is constant.

How does the drop test calculation work? Customers literally place a bucket with a known volume under the inlet in the station and measure how fast the bucket fills up. Based on this, they can roughly estimate the inflow rate.

It is possible to use another method if customers know the volume of the basin and can check two marked level points. The inflow is calculated by measuring the time it takes to fill the basin from level point 1 to level point 2. When the pump starts working, the same level points are used to determine the outflow.

Automated calculation method
Based on the basic principles of this method, Sulzer developed a more automated and accurate way of doing these calculations. The ongoing and precise calculation method of Sulzer has several benefits:

3 Water-level measurement with analog level sensor and other controls.
4 Exact water-level measurement with two-wire level sensor and ABS PC 441 control.

The logging of hydraulic and electrical data. The pump control offers a wide variety of functions: Settings, alarms, pump status, level information, and trends can be accessed instantly. Customers can see those values on-site or remotely via the AquaWeb software.
Inflow calculation with high-resolution input signals

For the pump control ABS PC 441 to be able to measure the inflow, first, the pumps have to stop operating to bring the water to a standstill. The pumps are then brought up to full operation. At that point, the water inflow is continuously monitored and memorized during a defined time interval set by the customer. The controller continuously adapts the calculations to the current level, speed of level change, and volume of the basin. Not all pump controls on the market are able to measure and store input signals with such a high resolution as the pump control ABS PC 441.

High-precision measurement in practice

Just to understand how precise the measurements and calculations are: Imagine a two-wire level sensor (4-20 mA, 0-5 V) is installed in a pit with a surface area of 15 m². When the sensors measure a change of 0.19 mm of the water level, this equates to a calculated volume flow of 2.86 liters. This high-resolution water-level measurement, combined with a smart and extremely precise calculation algorithm allows to calculate the inflow much better. The resulting digital measurement resolution consists of small steps (Fig. 4, page 5). It allows the system to deliver the volume flow calculations extremely precisely, in contrast to the analog measurement (Fig. 3, page 5).

Precise pump capacity calculation

The pump capacity calculation takes into consideration the inflow stored in the memory. To allow the pumps to run up to full speed, a small time delay is set before the capacity calculations are started. Entering the pump curve into the ABS PC 441 control supports precise calculations as well (Fig. 5). The corrected calculated outflow (green line) bases on the pump curve.

By entering the pump curve (for one pump) or the system curve for a set of pumps (Fig. 6), the capacity and outflow calculation is even more accurate. If more than one pump is running, there is higher pressure built up in the sewage water pipe resulting in a higher friction loss. This is why the system shows a decrease in efficiency when two or three pumps are in use. If the system curve is not available, an estimated percentage value is entered to compensate for the capacity loss that occurs when two, three, or four pumps are running.

Benefits in practice

A customer in Norway conducted a test to compare the Sulzer pump control ABS PC 441 with an inductive flow meter. After trimming all the parameters, the value Sulzer calculated differed less than 1% from the flow meter. For detecting trends and pump efficiency, the calculated values have a sufficient accuracy.

Another customer in New Zealand refurbished its installation with new pumps, controllers, and level sensors. The installed pump control ABS PC 441 immediately detected a capacity difference of 20% between the two pumps. The detailed inspection showed that pump and pedestal did not fit properly. After fitting, the leakage between pedestal and flange was eliminated and both pumps worked properly with similar capacity. Sensors and smart algorithms are the basis for data collection and remote control systems like AquaWeb.

The outstanding capacity control of the ABS PC 441 system is highly valued by customers in the fields of water and sewage water because it enables them to make better decisions more quickly.

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Increased Separation Capacity with NeXRing™

Do you know how to increase the separation capacity inside a column? The secret is to fill up your column with NeXRing™ — the patented high-performance random packing of Sulzer. The demand for NeXRing is growing constantly. Sulzer extended the application range of the NeXRing family, which now consists of seven members.

Two years after being launched, the NeXRing™ has become the top seller of Sulzer ring products. Random packings are used in conjunction with specially designed column internals. Collectively, they are used for fractionation, absorption, and stripping operations in gas, refinery, and chemical plants.

The use of columns with random packing has been well established for decades. The random packing has a big advantage: it can be easily replaced in the column. If you need to improve the separation capacity in your columns, you can just exchange the column internals.

1 Sulzer NeXRing™ — the best seller product for random packing.
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Development of random packing
Sulzer continuously develops and improves the performance of its random packing products. The better performance of the NeXRing is achieved by:

- An increased surface area of the ring where the separation process can take place.
- The specific form of the rings (Fig. 2), which allows an increase in the overall packing density and thus the available surface area.
- The open design of the rings (Fig. 2), which lowers the pressure drop by 50% compared with conventional rings.

A strong design
NeXRing packing is spaced evenly throughout the packing volume inside the column. The mechanical structure of the rings ensures a uniform fluid flow through the column. The shape of the NeXRing looks fragile, but the ring structure cannot be deformed. Thanks to the end flanges combined with strengthened ribs (Fig. 2) the NeXRing is extremely strong.

For a wide application range
The smaller the rings are inside the column, the higher the surface area available for the separation process is. At market launch in 2015, only three NeXRing versions were available (NXR #2, NXR #1.5 and NXR #1).

The NeXRing family has meanwhile grown to seven members (Fig. 2). Now four more ring sizes are available on the market: NXR #0.6, NXR #0.7, NXR #1.2 and NXR #3.

Comparison of different rings
Before launching a product on the market, Sulzer’s R&D engineers conduct in-house tests to define the application range reliably. These tests have been cross-checked at an independent institute in the US and can serve customers as a basis for decisions. The results confirm that the new product will meet the required demands. Sulzer tested three different ring types (Fig. 3) with different liquids and gases.

Application areas of NeXRing
NeXRing random packing is often used for the removal of CO₂ and H₂S from natural or biogas by contacting the feed gas with amine-based solvents. The solvents have a strong tendency to foam. With the much lower pressure drop of NeXRing, the hydraulic impact of the foam is minimized and thus the efficiency is increasing.

The NeXRing is used to guarantee the gas purity requirements in the process of gas recovery from natural gas liquids (NGL).

In Butadiene production with a high specific liquid load, the large surface area of NeXRing offers a higher capacity.
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Three ring types were tested and compared: P-Ring, I-Ring, and NeXRing. The graphic (Fig. 4) shows relative efficiency values and relative capacity values for different versions of P-Ring, I-Ring, and NeXRing. The P-Ring #2 is a standard in the industry. That’s why it was set as a reference point (100% efficiency and 100% capacity).

The size of the rings influences the flow rate and, thus, the capacity. The larger the rings are, the lower the resistance to the flow. A more open ring structure (I-Ring and NeXRing) increases the flow rate. With a smaller ring size, the efficiency of the separation process increases. With a smaller ring size, more surface area is offered for the separation process inside the column. A high surface exposure to liquid and vapor enhances the process efficiency and, thus, the quality of the process. NeXRing clearly shows much better efficiency than P-Ring and I-Ring.

Benefits of using NeXRing
What are the benefits in using NeXRing? Customers who replace conventional rings in an existing column (Brownfield project) can increase the separation capacity of their column. Sulzer recommends the use of NeXRing especially in cases where the separation process is a bottleneck at the customer’s site. If customers are building a new column (Greenfield project), they can plan a smaller, slimmer column when using NeXRing packing.

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Flow Optimization for Large Gas Ducts

Huge amounts of fossil fuels are burnt in large combustion plants such as power plants, refineries, or cement works. The flue gas generated in these combustion processes needs to be cleaned to protect our environment. Sulzer offers technology for flue gas ducts to make these flue gas cleaning systems more economical and efficient.

Blowers are used to transport streams of gas in large combustion plants. Powering these blower devices is energy-intensive and cost-intensive. A minimized flow resistance in the system lowers the operating costs remarkably. Sulzer is constantly developing new methods and products to optimize flows within the ducts.

With the help of computational fluid mechanics (CFD), Sulzer’s engineers calculate the flow distribution of the gas. Optimizing the flow reduces flow detachments, vortices and pressure drops. Thanks to the CFD simulation and subsequent analysis, Sulzer customers are assured that their new installations or retrofits (Fig. 1) meet the required operating conditions and legal standards.

Reasons for pressure drop reduction
The loss of blow performance in gas ducts has two main reasons. First of all, the blower devices in gas ducts have a smaller diameter than the ducts themselves, and they deliver the gas with a high speed into a large duct. In doing so, a big part of the blower performance is lost. Secondly, noise reduction devices have to be implemented into the gas duct and lead to pressure drop as well.

There is not always sufficient space inside the building to build the gas duct behind the blower for optimal flow. The building may not be large enough or other devices in the facility may be in the way. In these cases another solution is required to solve the problem.
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Gas flows can cause vibrations
If you recall how loud wind is when it blows around the corners of a house, then you’ll have some idea of how loud it can be when air does not flow optimally. In combustion plants, a splitter attenuator is often installed after the blowers so that the noise emissions comply with the legal regulations. The use of these sound absorbers directly after the blower results in an additional loss of the blower power. If there isn’t an absorber in place, the vibrations generated may damage the system.

Better blow performance without vibrations
To make the gas ducts more efficient and the work more economical, Sulzer got the license for a new, patented insert for expansion ducts called EcoSpand. This EcoSpand insert is installed in the duct after the blower or before the sound absorber, or wherever the diameter of the duct is enlarged.

The new EcoSpand duct insert tames the gasflow
Several expansion diffusers are positioned in the shape of a star on a conical internal part that tapers in the direction of the flow. These expansion diffusers (Fig. 2) divide the gas flow into several individual streams — like a ship’s keel in the water. Since their wedge shape optimizes the flow, i.e. narrow at the front and wide at the back, the expansion diffusers offer little resistance to the gas flow. Behind the expansion diffusers, the individual small gas flows swirl, and there are targeted flow detachments and hardly any vibrations. With EcoSpand, the velocity of the gas is equalized over the entire diameter of the gas duct and less dynamic blower performance is lost through the use of EcoSpand (Fig. 2).

Individual design
The reduction of the vibrations with EcoSpand is impressive, and plants could be able to operate without downstream sound absorbers.

The EcoSpand device is available in individual designs for the different areas of use:
- Standard (use without sound absorbers)
- Combined with sound absorbers (with reduced noise suppression capacity)
- Combined with dosing mixers and premixers

Premixing grid — ideal for short mixing lengths
Conventional static mixers sometimes reach their limits when mixing hot and cool streams of air or gas over extremely short mixing lengths. To mix two similarly large streams of gas homogeneously over a very short mixing length, Sulzer has designed a premixing grid. One use for this premixing grid would be to set it right in front of the biomass grinder during the
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tempering of the air in biomass power plants. The pre-mixing grid mixes the two flows through intensive pre-dispersion (Fig. 4, D). At the same time, the main flow exhibits an extremely low pressure drop during the through-flow of this mixing grid. The mixing works not only with two similar flow rates but also with largely differing flow rates.

Mixing and flow control with very low pressure drop

Selective catalytic reduction (SCR) is often used to reduce nitrogen oxides in flue gases from combustion plants, gas turbines, or internal combustion engines. The chemical reaction to the SCR catalyst is selective and preferentially reduces nitrogen oxides (NO, NO₂). For the catalytic NOₓ reduction (detail 1 in Fig. 3), it is essential to have a homogeneous admixture of ammonia and a consistent temperature for the process — that is where the mixers come into use.

Contour™ mixer for lower pressure drop

Static mixers are used more and more frequently before SCR reactors, before electrostatic precipitators, or after flue gas desulfurization. A pressure drop below 1 mbar with an excellent mixing performance can be obtained with the Sulzer Contour™ mixer. After an in-depth consultation, Sulzer engineers can adapt the Contour mixer (Fig. 4, B) to suit the customer’s specific requirements. The wing geometry is adapted to the diameter of the duct and the existing mixing line. In addition, the Contour mixer can be designed in such a way that it generates co-rotating or counter-rotating vortices. Thus, the mixing process can be optimized.

The Contour mixer is the ideal choice if ammonia water or urea solution is to be atomized through nozzles for ammonia dosing. Sulzer offers a proven, safe process method for optimized dosing ratios of ammonia after the Contour mixers. Because of the lightweight construction of the Contour mixer, there is no need to additionally reinforce the duct when it is being installed into existing ducts. This makes retrofitting easy (Fig. 1, page 11).

Dispersion of dust or ash particles with SMV™ mixers

In certain practical applications, the flue gas flow contains high levels of ash or dust particles. In some cases, these particles have to be selectively separated and, in other cases, they need to be dispersed evenly in the flue gas stream. If the SCR catalyst is positioned directly after the boiler — i.e., the dust has not been removed beforehand — it is preferable to disperse the dust in the flue gas as uniformly as possible (detail 2 in Fig. 3).

3 Flue gas cleaning in practice — example from the coal-fired power plant Block 9 (Source: GKM, Mannheim, Germany).
This prevents the expensive catalyst from being worn on one side. To meet customer requirements, Sulzer engineers know how to position the SMV mixer in such a way that a homogenized dispersion of dust particles is achieved before the flow reaches the catalyst. This increases the service life of the catalyst and improves efficiency.

**Improved separation of SO₂ with grid packings**

Normally, to separate the sulfur dioxide contaminants (SO₂) in coal-fired power plants, a limestone suspension is injected into the flue gas (detail 3 in Fig. 3). This method has proven to work well and the gypsum that is created is further processed in the construction industry. However, in cases where injections do not disperse the limestone suspension sufficiently, the level of separation of SO₂ falls short of the strict emission guidelines. Sulzer’s engineers have designed special grid packings to increase the amount of separation.

The grid packings (Fig. 3, E) provide for a very homogeneous distribution of the limestone suspension and, therefore, for very high SO₂ suspension levels (to below 35 mg/Nm³). These are required by stricter regulations in more and more countries. At the same time, the suspension on the grid packings is used to remove dust from the flue gas, so that operators can achieve even extremely demanding limit values for dust in the flue gas (less than 10 mg/Nm³). Despite this remarkable efficiency, the grid packings barely create a noticeable increase in pressure drop (pressure drop below 1 mbar). Sulzer offers a wide range of droplet separators (Fig. 3, F) that are highly efficient. For example, the droplet separators Mellachevron™ or KnitMesh™ 9797 can be installed after flue gas desulfurization so that no drops containing sulfuric acid end up in the environment.

**Individual, efficient and economical**

Since combustion plants are customized and no two plants are the same, the flow optimization shown with CFD simulations is very important in the design phase of the plants. CFD simulations form an integral part of the project-specific consultation process with the customers and the development of new products. The efficiency and cost-effectiveness of the plants can only be verified prior to construction on the basis of these calculations, and it is becoming more and more important for demonstrating the plant’s compliance with legal regulations.

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Precise Production for Large Impellers

The pump impeller is one of the most important parts with regard to pump efficiency. Impellers have to be produced with the highest geometrical accuracy. Even small geometrical deviations can impair the efficiency and, furthermore, cause the risk of a hydraulic imbalance during operation. Sulzer tested several new manufacturing methods to meet the highest quality standards for impeller production.

Sulzer offers different types of pump product lines: standardized and engineered pumps. Standardized pumps are developed with a defined configuration, produced, and delivered directly from the Sulzer warehouse to customers. Engineered pumps are individually designed, developed, and manufactured for customers according to their specific requirements. These engineered pumps are used mainly for oil and gas production, power plants, and major water projects. For an important project, Sulzer examined new methods of improving the quality and reducing lead times for individually manufactured pump impellers (Fig. 1).

Casting — the traditional manufacturing method
The common — and often most cost-effective — method to produce large steel parts of engineered pumps is to cast them in one piece. But for open impellers, a general, intrinsic problem of the casting process becomes apparent. Casting areas with thick walls cool down slowly, whereas sections with thin walls lose heat much faster. This difference results in material stresses between impeller sections with different wall thicknesses. In the worst case, it leads to significant geometric distortions or even visible cracks in the material. For impellers, this effect is observed mainly at the transition from the relatively thick impeller hub to the relatively thin blades.
Large vertical pumps

Engineered pumps are designed according to customers’ requests. The engineered SJT/SJM cooling water pumps (Fig. 2) are usually single-stage, mixed-flow vertical pumps with semi-open impellers. They are available in sizes starting from 750 mm (30”) up to 1800 mm (72”) impeller diameter (Fig 3).

They are used for water supply, such as cooling water pumps for power applications, irrigation, drainage, or desalination. The pump length and the impeller sizes are always adapted to the site conditions and the required pump curve. The capacities of those pumps can reach up to 80,000 m³/h (349,000 USgpm).

Evaluation of alternative manufacturing methods

In the search for the best method, Sulzer engineers analyzed six possible manufacturing processes. The first assessment ruled out three possibilities. In the final decision round, three manufacturing processes were checked and compared in detail. The traditional method of casting a single-piece impeller was compared with two new alternatives. Would it be better to mill the impeller from a wrought semi-finished part? Or would welding separately cast blades onto a hub be the better way for a precise and fast result?

Comparing subtractive manufacturing with the traditional method of casting, the milled variant, of course, yields the best quality and is the fastest. However, this manufacturing route is significantly more expensive than producing a cast part because of the high amount of material that has to be removed.

The method of welding single blades to a hub received only a slightly lower score for accuracy and lead time than subtractive manufacturing. Because it is far more cost-effective and feasible, this method was chosen as the solution to be tested and realized (Fig. 4).
Strength analysis of welding connections

The impeller inside an engineered water pump — such as an SJT or SJM cooling water pump — has to withstand all applied loads in different working conditions. The weld seams between blade and hub represent the most critical areas to fulfill this requirement. When building up a very large weld seam consisting of multiple layers, there is a certain risk of incomplete fusion, even with highly skilled welders. The Sulzer engineers performed a finite element analysis (FEA) on a weld seam with induced defects. The calculation showed that even with a void along the whole length of a blade, the whole impeller is durable. The defined weld seam is able to bear all static and all fatigue loads that occur within the entire operating range of the impeller (Fig. 5).

Weld qualification with a model

So that the engineers could qualify the planned welding operation, a model part was produced and welded at a designated weld supplier. The model part (Fig. 6) was designed so that it had the same measurements as the original impeller: weld preparation geometry, weld geometry, and distances between impeller blades. This way, it reflected all difficulties that were present at the real impeller. The specific shape of the impeller allows only restricted accessibility during the welding process.

Depending on their end use, pump impellers of the SJT or SJM cooling water pumps can be produced from bronze, chrome steel, stainless austenitic steel, duplex, or super duplex stainless steel. For corrosive liquids like seawater, the use of duplex or super duplex components is often required. Usually, for super duplex stainless steel, the only reasonable heat treatment is a full-solution annealing with subsequent water quenching. But that heat treatment can result in extensive part distortions. To avoid such heat treatments, the welding operator has to set the parameters very narrowly. Therefore, it is challenging to achieve superior welding quality, and only extremely reliable welding suppliers meet the demands for this task.

After it had successfully completed liquid penetrant testing, the model part had to undergo several destructive tests: corrosion tests, phase content determinations, tensile tests, and hardness tests. Macrosections were cut from the welding area to be judged later under the microscope. After all these tests, the Sulzer engineers were sure the welding zone itself and the heat-affected zone had been produced in the quality needed.

Prototype production and tests

After the positive test results, a prototype of a super duplex stainless steel impeller was manufactured. This prototype showed that the chosen welding supplier was qualified to produce such weldings — even ones with difficult geometric arrangements. The hub part and the four single blades were produced as a cast as...
A first step. The blades were manufactured at a very high geometric accuracy on the first try. A precise prediction of the blade distortion during the cooldown of the melt was possible because the wall thickness over the blade is almost constant. The dimensions of all parts were checked by 3D measurements before the welding process. All requirements for the castings were according to the quality specifications.

The second production step — the welding — was carried out subsequently according to the parameters that have been evaluated with the model part. The biggest challenge in keeping the high geometric accuracy was the correct positioning of the blades on the hub. Sulzer engineers created several templates to adjust the blades. The templates support the welding operator during this challenging process (Fig. 7). After technicians had finished grinding the weld seams, final machining, and balancing, the prototype was ready to be used and compared with the traditionally manufactured impeller.

Process evaluation
With the new manufacturing method, the major goal — to improve the geometric accuracy — had been fulfilled. All 3D measurements confirmed that — even compared with the very best conventionally cast impellers — distortions could be reduced by 40%. Indirect benefits of the improved geometric accuracy are significantly reduced machining, grinding, and balancing efforts. Impellers up to a size of 2.5 m in diameter can be produced with the new process.

In terms of cost, the welding process increases the production costs. On the other hand, the patterns for the casting process are much easier to produce and thus more cost-efficient. The reduced final machining and balancing effort saves costs and ultimately leads to a reduction of the total production cost. The lead time follows the same logic as the costs. Welding adds time but pattern manufacturing for casting is easier and, thus, faster. Final machining and balancing is much faster, which leads to a shorter overall lead time.
Faster Development Using Additive Manufacturing

When developing prototypes, Sulzer’s development departments are increasingly opting for additive manufacturing processes. Sulzer was the first company to develop and use a new plastic powder and its processing by selective laser sintering for brush production. Thanks to the elasticity of the plastic, the prototypes of Geka mascara brushes can also be used for application tests. Instead of waiting 18 weeks for an injection-molded brush, customers can have the prototypes in their hands after just one week.

Prototype of a mascara brush made using the 3D-printing process.

Sulzer has been employing additive manufacturing processes for a long time. The number of materials that can be processed using 3D-printing is constantly increasing. The new materials open up new possibilities in both development and production. The 3D-printing processes are cost-intensive and are predominantly used for producing prototypes or components in small quantities. However, additive manufacturing processes will also be incorporated on the Sulzer shop floor in the foreseeable future.

Production of prototype mascara brushes
Sulzer has been using 3D-printing methods to produce prototypes of mascara brushes since 2007. To date, these prototypes have been made using a hard plastic material based on a three-dimensional CAD drawing. Customers had the opportunity to visually assess and physically inspect the brushes. However, the bristles of these prototypes were too hard to be tested in the field.

The development team and the prototype manufacturing team of the Sulzer Applicator Systems division were looking for alternative methods and materials for producing 3D-printed prototypes. In 2015, after a long search, they found a solution. A new type of plastic came onto the market as a powder. It displayed similar chemical properties to the material that had been used in the series production of the injection-molded parts. This particular plastic
ensures that each filament has the correct elasticity and stability, i.e., the filaments are rigid enough to separate the eyelashes and yet flexible enough not to injure the user’s eyes. Considerable research has been carried out to develop the manufacturing process and to find the ideal settings for hardening the plastic for 3D-printed prototypes. Since 2016, Sulzer has been commissioning an external supplier to make all of its mascara brush prototypes using the developed selective laser sintering method.

**3D-printing process allows new possibilities**

Selective laser sintering (SLS) is an additive manufacturing process that uses a powdered material to produce solid structures. A power source is required to sinter the powder. A laser provides this power; the beam is aimed at the right point using a mirror system. The component is then built up in layers. The individual layers applied to make prototype brushes (Fig. 1) can be seen in the form of small indentations on the filaments.

**How selective laser sintering works (SLS)**

A laser sintering system (Fig. 2) spreads a thin layer of powdered material onto a building platform. A laser beam selectively fuses the material using a mirror system. After the building platform has been lowered, the next layer of powdered material is applied. This process repeats until the entire component has been built up — layer by layer — in the powder bed.

With this technique the components do not necessarily have the same surface structure as parts made using injection molding. Sulzer has advantageously used the special processing capabilities of SLS to create unique new brushes.

![Schematic view of a prototype of a mascara brush bristle tip using laser sintering (SLS).](image)

![Functional principle of the selective laser sintering process, also called SLS.](image)
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The technique of 3D-printing makes it possible to create special surface structures and topographies to enhance the wetting and/or makeup capture and storage properties of the brush. Such surface topographies are shown in Fig. 3 in which a part of the bristle tip is cut away to make the special microstructure visible through the shaded bristle core. This figure is taken from a utility model by which Sulzer has secured its intellectual property rights.

Reduced development time

The development process for mascara brushes has accelerated enormously since the incorporation of the additive manufacturing technique. Previously, the team would create drawings, produce visual prototypes using 3D-printing, and then create a pilot brush for the injection molding. This pilot brush had to be made according to the customer-specific adjustments to the drawings. It takes 12 weeks to complete a pilot brush this way, and the process is very cost-intensive. A small hollow cutout called “cavity” has to be milled into the injection molding tool for each mascara filament. It would take 18 weeks before customers were even able to carry out the first application test. Prototypes made using the selective laser sintering (SLS) technique can be produced much more quickly: these are ready in just 5 to 7 working days (Fig. 4).

Streamlined design process

Once the drawing has been created, Sulzer goes on to produce SLS brushes. The customer can then conduct application tests immediately, and if any modifications are required, the drawings are adjusted accordingly without delay. New SLS brushes are then produced and tested.

The surface of the 3D-printed brushes does not necessarily correspond exactly to the injection-molded parts. The amount of mascara that can be applied may not be exactly the same, but the customer can obtain sufficiently accurate results from the prototypes. The customer only gives permission to proceed with the production of injection molding pilot brushes or series brushes when the results of the application tests are satisfactory.

Because there is greater freedom to conduct more application tests with the brushes made using the SLS technique, the development process is that much faster, meaning the products can be launched sooner in the market. In fact, Sulzer can even use the special SLS processing capabilities to create unique new brush surfaces having advantageous properties.

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4 Up to 17 weeks can be saved in development time by using 3D-printing.
Flying Generators for Fast Repair

Power generation companies rely on turbines and generators to deliver vital power to customers. Repairs are usually required urgently when an unexpected failure occurs. To save time, a Malaysian power generation company even sent a 500 MW turbine and generator rotors via airfreight to Sulzer in Indonesia for repair.

A 500 MW turbine and generator in a power plant in Malaysia broke down during the festive season, shortly before New Year. The Sulzer engineers headed out from the service center in Indonesia on the first available flight to assess the situation. Whoever has tried to get a last minute flight at the end of December knows it is not an easy task to get a seat during this extended holiday period.

A breakdown during New Year

The initial on-site inspection of the turbine generator showed that a lubrication failure had occurred. The result was seriously damaged bearing journals and blades on the high-pressure / intermediate-pressure (HPIP) turbine rotor. It was immediately clear that the drive train of the generator would require extensive repairs. The customer as well as the insurance company were very keen to minimize the downtime, primarily due to financial losses incurred for each day of non-operation.

The most urgent of the large component repairs, the HPIP turbine rotor, was flown to the service center in Purwakarta, Indonesia, using a Boeing 747 airplane. The generator and low-pressure rotor followed via sea freight because repairing them would take less time. Once repaired, all three items were transported back using an Antonov An-124 and a Boeing 747, some of the largest cargo planes, to ensure the fastest possible turnaround.

1 The generator was transported for repair and back with one of the largest cargo planes in existence.
Parallel workflows for fast repair
Sulzer’s field service team helped to dismantle the generator drive train, which weighed 22 tons (84,500 lbs.). They made all arrangements for the HP/IP rotor to be airfreighted to the service center in Purwakarta, Indonesia. Compared with sea freight, this air-freight saved approximately 15 days (Fig. 2).

To save additional time, samples were taken from 12 rows of HP/IP turbine rotor blades before the rotor was removed from the site. The blades were sent for immediate reverse engineering and manufacturing to Indonesia. The leadtime for new blades was going to be the most time-consuming part of the repair, so it was important to produce these samples as fast as possible.

Once the rotor was in the Sulzer Indonesia workshop, the full extent of the damage became apparent.

A fluoroscopic inspection revealed a significant amount of cracking in the active thrust collar. Rebuilding the active thrust collar to its nominal dimensions required extensive machining, weld buildup, and a final heat treatment (Fig. 3).

Sailing in LPA and generator rotor
The generator rotor and the low-pressure rotor (LPA) were carefully packaged. They were shipped to Indonesia by sea freight because the damage to these two components required less time to repair. The aim of the Sulzer engineers was to minimize the rebuild time and complete the repairs of the three rotors at the same time.

The LPA rotor showed significant wear and high hardness readings on both bearing journals. In each case, the journals were undercut and prepared for welding. After that, they were encased with special ovens to deliver the correct heat treatment prior to final machining.
At the same time, the service engineers inspected the generator rotor. The findings were: damaged bearing journals, a significant bow at the coupling end of the rotor, and oil contamination under both retaining rings (Fig. 4).

One damaged bearing journal was repaired in a similar way to the LPA rotor. The bow was removed using heat treatment and stress relief. Both retaining rings were removed for non-destructive testing to confirm that there were no defects before they were reinstalled with new insulation material. After the repair, all rotating equipment needs a dynamic balancing procedure and quality tests to guarantee reliable, concentric operation. The Sulzer service center in Purwakarta, Indonesia, is equipped with a large balancing machine to complete this task before rotors were transported back to Malaysia (Fig. 5).

**Two teams of specialists involved**

While the LPA and generator rotors were being repaired, the HPIP rotor required a considerable amount of work. The suppliers of the new blades had worked around the clock to manufacture all components in the shortest possible time. Now, it was the turn of the specialists in Purwakarta. All available hands were needed — two blading teams were involved in removing and replacing the blades.

Once the new blades were in place, the teams started the process of attaching the blade shroud. This involves a hot peening process: The blade tenons are heated to a specific temperature before deforming the ends, thus binding the blades and shrouds together. This process is similar to the creation of a steel rivet (Fig. 6). Both blading teams worked in parallel to complete the task as quickly as possible. This ensured that the work on the HPIP rotor was completed at the same time as the other two rotors. The customer was regularly updated on the work progress, to be able to arrange transport efficiently for the return trip of the rotors.

**Fast return to Malaysia**

The customer booked air transport for all rotors. Because of the size and weight of the cargo, they required the services of both an Antonov An-124 and a Boeing 747. The refurbished rotors, which had been carefully packaged and loaded, were all airfreighted back to Malaysia, where the Sulzer field service team awaited them. All generator components were repaired in just 85 days, which would have been about 100 days without the use of airfreight. An alternative option for the customer would have been to replace the generator with a new unit, which would have taken much more time than the repair done by the Sulzer Service Center in Indonesia.

Sulzer’s Service Center in Indonesia

Agus Susena, Manager of Sulzer South East Asia concludes: “Thanks to our previous partnership, the customer was confident that Sulzer would complete the repair in the shortest possible time, even over the New Year period. In fact, between arrival and departure of the HPIP turbine rotor, we stayed on schedule to complete the reblanding, machining, and balancing as committed.

Our engineers delivered a very high level of professionalism and workmanship during this tight time frame. After this refurbishment, the rotors should have many more years of reliable operation ahead. As a service center, we are committed to providing an immediate and positive response to ensure customer satisfaction. This is why we are available 24 hours a day and 7 days a week.”

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Rapid Repair for a Solo Hydrogenerator

With over 50 years on its back, the hydrogenerator at Inverawe power station recently needed a thorough repair of the stator. The time for the repair was very limited because there was no other generating capacity on-site. The site’s owners, Scottish and Southern Energy (SSE), awarded the project to Sulzer, which has a distinguished history in high-voltage-generator repair.

Scotland has many hydroelectric power stations that were built in the 1950s and 1960s. These power stations continue to provide reliable service to this day, mainly to meet peaks in demand. After working so many years without a break, the Interwave power station — located in Argyll and Bute, Scotland — needed comprehensive maintenance for its hydrogenerator.

Reliability is of prime importance
Routine maintenance of hydroelectric generators is essential in order to sustain reliability of supply. These repair projects are always planned to minimize disruption. Most of the power stations have multiple generators, which produce a reduced output during the repair of single generators.

However, some power stations have only one generator, which means that the time for maintenance must be kept to an absolute minimum. Inverawe power station runs only a single generator. This is why Scottish and Southern Energy (SSE), the owner of the power station, had planned a specific maintenance project for the generator. It awarded the project to Sulzer. From its refurbishment and repair of the Lochay and Fasnakyle generators in Scotland in 2015, Sulzer is well known to SSE to be a reliable partner.

In between aqueducts and tunnels
The Inverawe power station is part of the Sloy Awe hydroelectric scheme, which is a series of stations connected by a number of aqueducts and tunnels. The site itself contains a single 25 MW generator driven by a Kaplan turbine. A 5-kilometer-long tunnel feeds it from the 18-meter-high barrage built across Loch Awe. Originally built in 1963, the Inverawe generator has been in service for over 50 years with only minor maintenance.

1 The stator was repaired in situ at the Inverawe power station.
conducted during that time. Throughout its lifetime, the Inverawe generator has been monitored for vibration and overheating, which may indicate potential failures, and it has undergone regular inspections.

During the annual routine inspection, SSE requested that Sulzer carry out a restricted visual review of the stator and rotor condition. The service center manager detected alarming defects: several wedges migrating across numerous areas of the stator core. To prevent any movement of the windings, these stator wedges, which hold the stator windings securely in position, needed to be replaced. SSE decided to briefly take the generator offline to complete the maintenance and repair as quickly as possible.

**Detailed rotor and stator inspection**

The generator was taken offline and the rotor removed by SSE engineers before the Sulzer personnel arrived on-site. This allowed a detailed inspection of the rotor while the stator was being repaired. It also allowed Sulzer to set up a repair plan. The initial inspection showed that several of the wedges had started to migrate out of position (Fig. 2). The repair process started with the removal of all of the original wedging and packing. Once the windings had been cleaned, the rebuild got underway. The Sulzer engineers installed a full set of new G11 wedges — made from glass laminate — which had been manufactured in-house. Additionally, the wedges got a new packing (Fig. 3).

After the rebuild had been completed, the stator was tested for insulation resistance as well as winding continuity under static conditions. All of the test results were recorded to ensure the highest quality standards. With a full set of satisfactory results, the stator was re-varnished — ready for the SSE engineers to rebuild the generator on-site. Though the stator repair progressed smoothly, the findings from the rotor inspection indicated that additional work would be required soon. However, since the generator had been operating without any cause for concern, it was decided to return the unit to service as soon as this project was completed. A more detailed evaluation of the rotor report would be conducted in due course.

**Experienced project coordination**

The whole project was coordinated and run by the local service center in Falkirk, Scotland. The Sulzer engineers in Falkirk have vast experience in maintaining hydroelectric generators. It also has an expert field service team that is accustomed to working in the more remote areas of the country. Additional technical support was provided by the Birmingham Service Center, which provides the design and manufacturing expertise for the engineers on-site.

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Survival Relies on Speed

In the animal kingdom, speed is not a luxury — predators and prey alike depend on it for their survival. The hunted animal literally runs for its life and can only escape death if it is faster than its hunter.

Usain Bolt set a new world record on August 16, 2009, in Berlin, Germany, by sprinting 100 m in just 9.58 seconds. He did this in the spirit of competition and for the tidy sum of prize money. The Jamaican athlete’s performance was not a matter of life or death. In the animal kingdom, things are different. When a peregrine falcon dives from the skies at a speed of over 200 km/h or a cheetah darts across the grasslands clocking in at 120 km/h, these velocities are part of hunting strategies that aid the survival of these predators. In the course of evolution, prey animals like crows and gazelles have adapted their speeds to be able to flee from their predators.

An anatomy made for hunting

The case of the cheetah and gazelle (Fig. 1) demonstrates how close the race between eating and being eaten may be. The feline manages to accelerate from zero to 70 km/h in just two seconds, which it does by bringing its hind legs well ahead of its front legs — much as a hare does. A highly flexible spine supports this motion like a tight spring, while the cat’s tail acts as a stabilizing yaw rudder. The downside to such a speed-maximized build is that the cheetah runs out of energy at no more than 400 m, at which point it needs to give up the chase. That’s why the only way for it to succeed is to sneak up to the gazelle until it is no further than 50 m away.

1 The cheetah’s tail serves as a stabilizing yaw rudder when it is hunting.
Exhaustion after the hunt
Even then, only around 40% of the cheetah’s attacks end up in a kill. And, should the prey indeed end up dead, this is by no means a guaranteed meal for the cheetah. There may be lions or hyenas nearby who are stronger than the worn-out cheetah and who can chase it away from its bounty. Consequently, the cheetah really needs to eat its prey as quickly as it can. However, after such an extreme sprint, the exhausted animal first needs to rest for at least a quarter of an hour. Once it has regained its breath, of course, it tears the gazelle to shreds and eats the best of its meat.

Confusing swarm behaviors
Speed is an essential survival tactic for prey animals as well. In many cases, they complement this with elaborate group strategies. Huge swarms of birds or fish, for example, are fascinating to watch as they race across the sky or ocean like a big living cloud. The pursuing falcon or shark is usually unable to focus on any one target in particular (Fig. 2).

Complex escape methods
Sometimes, the best way for a pursued animal to make its escape is to combine a range of different movement strategies. The field hare, for example, is a very vulnerable animal. When it senses danger, it ducks into the nearest dell or pocket and holds still. In order to betray as little motion as possible, it reduces its usual pulse of 120 beats per minute (bpm) by half.

If the predator continues to advance regardless, the hare will shoot out of its hiding place like a cannonball, attempting an escape at the very last minute (Fig. 3). In order to accelerate to 70 km/h as quickly as possible, the hare triples its heart rate from the resting level of 60 bpm to 180 bpm just before it makes its dash.

Also, instead of running away in a straight line, this escapee is known to follow a zigzag path. Thanks to a special leg technique it has evolved over time, the hare is able to push its body sideways while in full stride, and thereby suddenly change direction. Because this makes for an entirely unpredictable flight path, even the fastest fox or dog may not be able to catch this elusive prey.

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Total-patented Wash Tank Technology Licensed to Sulzer

On September 5, 2017, Sulzer’s Chemtech division was granted a license covering the Total-patented wash tank technology for oil processing. The main purpose of this technology is to enhance the removal of water, salt, and contaminants from oil and emulsions. This happens by a controlled distribution of the feed into the bottom of a hull tank of an FPSO / FSO / FPU which transforms the water-in-oil dispersion into an oil-in-water one where high-efficiency phase separation takes place more easily. The technology also involves a significant simplification of the topsides crude oil process.

Sulzer will commercialize the licensed technology along with its static mixing technology as well as patented oil / water emulsion distributors. Sulzer’s testing capabilities and CFD services form an integral part of a properly designed solution for each specific facility. The main benefits are reduced weight of the topsides, improved performance, and less energy consumption.

This wash tank technology has been in operation for many years on the USAN, PAZFLOR, and CLOV FPSO’s, as well as on the recently started MOHO Nord / LIKOUF FPU. MARTIN LINGE FSO and the EGINA FPSO are also equipped with this technology and will start up in the near future. While all these assets are operated by Total, Sulzer’s license agreement will make the benefits associated with this technology available to oil field FPSOs around the world.

Further information is available on: http://www.total.no/en/patented-oil-washing-martin-linge

Sulzer Acquired Transcodent

On September 30, 2017, Sulzer acquired Transcodent GmbH & Co KG, a leading provider of multiple-dose and unit-dose application systems, needles, tips and capsules for the dental market. The acquisition further strengthens the Applicator Systems division of Sulzer in its dental segment, where Sulzer is already a global market leader.

Transcodent, headquarterd in Kiel, Germany, is expected to achieve revenues of EUR 17 million in 2017. The company generates the majority of its revenues in Europe and the Americas, and manufactures in Kiel. Transcodent is known for its multiple-dose and unit-dose application systems with highest barrier properties and a wide range of premium-quality needles. It also offers the development and manufacturing of customer-specific injection-molded application systems. Transcodent-branded products are used by dentists in anesthetics, endo irrigation, prevention, and aesthetic restoration.

The transaction allows Sulzer to round out its dental portfolio with fine needles, unit doses, contract filling, and customized assembly. Combining the complementary product portfolios enables Sulzer to become a full-line supplier in dental applications.

1 The CLOV FPSO is using the Total-patented wash tank technology.

1 The CLOV FPSO is using the Total-patented wash tank technology.

1 Headquarter of Transcodent in Kiel, Germany.
Faster Testing Thanks to Test-Bed Extension

To ensure the highest quality and security, all pumps assembled in Bruchsal, Germany, are tested in their test-bed. Sulzer Pumps Germany started in mid-2016 with the extension of its test-bed. The new test-bed installation started operation end of June 2017, and the increased capacity allows the faster testing of customer pumps. Remarkable time savings for the delivery of a pump are possible with the enlarged test-bed facilities.

The extension of the test-bed was initiated to gain more capacity and space for testing. It includes an automatic vertical lift and storage system which is used for the storage of specific materials needed for testing different pumps. The lift and storage system consists of a storage section and two transport wagons, which supply the entire test-bed with materials, such as piping, supports, or motors. Each of the autonomous and cordless transport wagons has the remarkable transport capacity of 5 tons. The time required to erect and dismount pump packages for testing is significantly reduced with this system.

Additionally, the test-bed is equipped with two overhead cranes (Fig. 1). They are capable of handling 16 tons and 32 tons weight respectively. Thanks to a new entrance gate that is 10 m wide and 5 m high, the workflow at the new test-bed is improved. Trucks are able to pass this large gate and drive in front of the test-bed. With the crane, Sulzer operators can load the tested equipment quickly and easily to the truck. In the future, a rail system will be installed at the test bed. Then large pump packages can be moved parallel to the gate on these rails. To save additional time, the packaging of large units can be done directly in front of the test area.

In short time, the test-bed will be equipped with a new control center. This room will be located right over the test-bed (Fig. 2). Interested customers who want to participate during the test procedure of their pump are invited to this control center. There, they can monitor the pump equipment as well as the testing parameters at a safe distance from the test area.
New AGISTAR SSA Side-Mounted Agitator Range

With the AGISTAR™ SSA side-mounted agitator, Sulzer has taken a significant step to further decrease power consumption and reduce the environmental impact of its product portfolio.

AGISTAR SSA is designed for demanding applications in various industries, such as pulp and paper, biofuels, food, sludge, as well as municipal and industrial wastewater. For this agitator, Sulzer has developed high-efficiency hydraulics (patent pending) with high pumping capacity and axial thrust but with low power consumption. Customers can benefit from reduced energy consumption, and low operational and maintenance costs.

The reliable AGISTAR SSA agitator has a strong shaft with minimal deflection. The rigid construction ensures low vibration and a long lifetime of the seals and bearing — more than 200 000 hours for the bearing. The agitator is equipped with a new duplex stainless steel EX3 propeller for higher strength and wear properties. This ensures a longer lifetime than for agitators using austenitic stainless steel propellers. In addition, the performance of the agitator can be adapted with the adjustable propeller blades. The EX3 propeller is so extremely efficient, that Sulzer decided to offer it as a retrofit set for older MX4 propellers as well.

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### Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
<th>Location</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 12–14, 2017</td>
<td>46th Turbomachinery &amp; 33rd Pump Symposia</td>
<td>Houston, TX, USA</td>
<td><a href="http://tps.tamu.edu">http://tps.tamu.edu</a></td>
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</tbody>
</table>
About Sulzer
Sulzer specializes in pumping solutions, rotating equipment maintenance and services, and separation, reaction, and mixing technology. We create reliable and sustainable solutions for our key markets: oil and gas, power, and water.

Combining engineering and application expertise, our innovative products and services add value and strengthen the competitive position of our customers. Sulzer serves clients around the world through a network of over 180 locations in more than 40 countries.

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We offer a wide range of pumping solutions and related equipment. Customers benefit from extensive research and development in fluid dynamics, process-oriented products, and reliable services. Our global manufacturing and support network ensures high customer proximity.

Rotating Equipment Services
We offer a full range of services for turbines, pumps, compressors, motors, and generators. Customers benefit from reliable and efficient repair and maintenance services for pumps, gas and steam turbines, compressors, motors, and generators of any brand. Our global network ensures high-quality local service.

Chemtech
We offer products and services for separation, reaction, and mixing technology. Customers benefit from advanced solutions in the fields of process technology and separation equipment. Our global footprint ensures local knowledge and competence.

Applicator Systems
We offer products and services for liquid application and mixing technology. Our customers benefit from advanced solutions in the field of precise applications as well as one- and two-component mixing and dispensing systems. Our market focus is on the adhesive, cosmetics, beauty, dental and healthcare industry.