Press Release

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Pumps & Compressors: App in the Cloud

- Modular system design creates challenges for component manufacturers
- Rotating equipment: Message from the digital twin
- Resource efficiency: Retrofits save time and money

Industry 4.0 and digital transformation solutions are a priority for many pump, vacuum equipment and compressor manufacturers. The race to develop new business models has just started. 3D printing has a special role to play, and it will revolutionize the spare parts market.

How can the process industry increase production speed and flexibility and also deliver greater product customization? Conventional single-output systems are not really suitable and remain the domain of commodity production. Modular design is needed to meet the need for increased speed, agility and customization. The goal is repetitive execution of specific basic functions on the systems to minimize process and installation times. The fundamental concept is to define a proven solution as a standard and use it repetitively, creating a type of "copy & paste" scenario with subsequent plug & play. This also makes documentation for validation easier.

Modular system design creates challenges for component manufacturers

Suppliers who deliver equipment for key subsystems (e.g. columns, pumps and compressors) are working on modular designs (skids) for new systems and system upgrades. In the future, engineers will be thinking in terms of functions, in other words modules and system solutions. This approach has the advantage that engineers do not always have to pay attention to every detail of components such as pump, vacuum and compressor systems. Even more importantly, modularized subsystems facilitate reuse of proven, pre-designed solutions on new projects. Based on the Lego principle, new systems can be engineered by designing in modules with different functions for use with a wide variety of production technologies.

One of the characteristics of modularity is the ability to offer the same functionality on different models of a product line designed for different operating parameters, for example a

family of pumps with versions which handle different volume flows and pressure ranges. This approach requires standardization of technical components (this also facilitates qualification and validation in regulated industries).

KSB offers virtual impeller trimming which enables a user to directly change the rotational speed from a smartphone. In contrast to mechanical modification of the impeller, no intervention in the operating process is needed. This makes it possible to optimize energy efficiency if the actual flow/head point deviates from the expected value or react to a system-related change of the operating point. Pump customization can be delayed until much later in the procurement process. The number of versions can also be reduced, and in the future that will have a major impact on pump selection. With rotational speed customization, fewer model sizes will be needed to cover the entire parameter range with practically the same efficiency and NPSH. The version complexity of the hydraulics is reduced by more than 50%, and that saves time and money in engineering.

Multi-stage high-pressure pumps are a good design option for modular function blocks (e.g. Grundfos, Rheinhütte, Flowserve, Xylem). Operators can choose different combinations of pump sizes, materials, connections and features. Varying the number of pumping stages provides the flexibility to adapt the pump capacity to the chosen module size. The system manufacturer can operate the motor in the supersynchronous range to alter the pump dimensions (more compact design).

In combination with greater standardization, modularization creates the possibility to configure simple pump solutions on the manufacturer's homepage. Similar to the way in which engineers can now use a configurator to design a pump, users have access to virtual tools which initiate the actual production process (pump on demand).

Pumps & Compressors: App in the Cloud

In response to rapidly increasing energy costs, more and more electronic components and sensors are being installed on rotating equipment. However that in itself is not enough to make the components Industry 4.0 ready. Data generation (big data) must be followed by data analysis and interpretation (smart data). Sensors provide data, microchips with on-board software interpret the data and actuators initiate the appropriate response.

Practical implementation of Industry 4.0 means that a system no longer operates exclusively under the guidance of a central process control system. Intelligence migrates to the field level. Smart field devices execute specific functionalities and optionally may monitor and control other technical equipment.

The next step is the digital counterpart in the cloud. The digital twin can access other data sources or communicate over a network with other digital twins, e.g. as an active element in a cyber-physical system.

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Connectivity and interactivity are essential for Industry 4.0 readiness. The compelling benefits for plant operators are enhanced transparency and higher system availability together with increased productivity.

Here are three examples. KSB offers a Pump Operation Check app. This service allows the user to generate load profiles using the PumpMeter monitoring unit and derive action recommendations for increasing system efficiency and availability (to be executed with the PumpDrive variable speed system).

A chemicals app is available from Grundfos which was developed in response to problems encountered by customers in the water treatment and chemical distribution industries. Mix-ups can occur when containers are connected to dosing pumps. The chemicals app ensures that the dosing pump will only accept containers which have been released for use via the cloud. Not only that, the app monitors the fill level of the container and can control replenishment with a new container.

Boge Kompressoren and Aventics have developed Smart Pneumatic Grid as a pathway to digitalization. Intelligent networking of air compressors and compressed air consumers based on the OPC UA communications protocol supports monitoring, control and optimization of the entire system topology. The Smart Pneumatic Grid captures energy demand data right down to the individual consumer level and provides a transparent visualization of the results, according to Aventics. Demand-based regulation parameters for boge compressors can be derived from this information with minimal effort. The device also provides notification of increased air consumption (leakage).

The big data to smart data business model

Smart Data provides an opportunity to generate business models which in the past were not feasible. Manufacturers have been selling hardware, but what they are really selling is conveyance of the medium. Customers could conceivably pay for conveyance of a medium from A to B without actually investing in the hardware. It is up to the manufacturer to design a material flow process which is as efficient as possible. This approach generates additional value-add for conventional solutions.

In the future, rotating equipment suppliers will offer products that have a higher service ratio. KSB has set up a dedicated Business Innovation Lab task force to explore the opportunities. 15 - 20 internal and external employees have been organized into four teams. Their task is to develop services based on technical customer data as well as to identify and expand services available on Internet platforms such as additive manufacturing (3D printing) for spare parts.

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News from the analogue world

Hybrid technologies are currently being hyped by the automotive industry. The combination of electric motors and internal combustion engines appears to be a good transition technology. Hybrid solutions are also a talking point in the pump industry. TPS series single-stage pumps made by GEA Hilge combine the conventional impeller of a non-self-priming centrifugal pump with an upstream screw rotor stage (inducer). This hybrid technology makes the pump self-priming. It is particularly suitable as a CIP return pump and for conveying media which contain gas, and it is a low-cost alternative to side channel pumps.

The Egger TEO vortex pump with hybrid impeller combines the advantages of a semi-open impeller with that of a Turo vortex impeller. The pump is ideal for conveying media with a high gas content (up to 10%) and large diameter solids.

Hybrid compressors combine the advantages of piston machines and membrane machines. They are particularly effective at very high pressures (1500 bar and more) for compressing technical gases and gas mixtures without oil lubrication in applications which require high availability. Hybrid compressors are a safe investment in the future to ensure compliance with the expected environmental regulations. To exploit the strengths of both compression technologies, it seams reasonable to combine them in the same housing. Because the compression principle is the same, combing the two does not create thermodynamic problems. The process components which need to be installed between the stages (e.g. coolers, vessels, separators) do not create different requirements for the two compression principles. Using piston compressor stages for low-pressure compression and membrane stages for high-pressure compression is the ideal choice for unlubricated high-pressure compression of gases, according to Neumann & Esser (NEA Group).

The temperatures should be as high as possible to maximize heat storage efficiency. Up until now, no technology has been available to do that, but researchers have recently developed a pump based on ceramic materials. The seals are made of graphite which also withstands high temperatures. The prototype pump worked with molten tin and temperatures up to 1400°C for around 72 h. $3.6 million in funding was provided by ARPA-E, the research agency of the U.S. Department of Energy for highly ambitious projects. In the journal Nature, the researchers reported that the pump could be used to develop reliable storage systems for the electricity grid to make energy from renewable sources such as wind and solar available as cheaply and easily as energy from natural gas power stations. No doubt about it, production of pumps for high-temperature applications requires very well coordinated material selection, product design and intelligent systems technology. It is however well worth the effort. Solar power is a clean, renewable energy source which has great potential, claims pump manufacturer Sulzer. Worldwide energy demand continues to rise, but conventional energy sources are being depleted and their impact on the environment is causing increasing concern.

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Resource efficiency: Retrofits save time and money

Erosion corrosion is the removal of material due to mechanical stress (erosion) and corrosion. Destruction of protective layers as a result of erosion exposes the surface to corrosion. The company SICcast Mineralguß describes this phenomenon as a combination of chemical and abrasive attack by media which contain solids as well as acids and alkalies. The manufacturer recommends a material made of 82% SiC and 18% epoxy resin.

The material is (nearly) as hard as diamond, not susceptible to corrosion, anti-magnetic and extremely resistant to abrasion, temperature and shock. The parts are molded in a mineral casting process and then heat hardened to give them their strength and endurance. The fits are subsequently machined with diamond tools.

Given its characteristics profile, the high-resistance cast material is suitable for all wetted pump parts (casings, impellers, wear plates, casing covers) which are exposed to extreme stress caused by corrosive and abrasive media.

Düchting Pumpen and Klaus Union are well-known users. If the material is used for re-engineering (coating) of parts like impellers, the cost is only 1/3 that of a new part.

When will 3D printing revolutionize the spare parts market? It will probably happen sooner rather than later due to the increasing popularity of metal printing. A laser selectively melts areas in a fine layer of pulverized metal. These areas harden following contact with the laser. Then another layer of metal powder is deposited which again is melted with the laser and subsequently hardens. The process is repeated until the hardened areas have the desired shape.

So why should it not be possible to use this technique, for example, to revitalize the impeller in a centrifugal pump or piston pump nozzles? The "cloud producing" concept developed by agricultural and construction machinery manufacturers Caterpillar and John Deere indicate a possible future direction of 3D technology. The idea is to store spare parts data in a database which any authorized user anywhere in the world can access. If a service center anywhere around the globe needs a spare part, it can download the data and print the part locally.

KSB sees itself as the industry leader in 3D printing and expects to achieve massive cost savings which however are not possible to quantify at this point in time. This will only be possible after the products have been re-designed. When that happens, material consumption will decrease and fewer steps will be needed in the production process. At the present time, the company uses 3D printing mainly at the research stage but some 3D printing takes place in production. This is the case when spare parts are needed with extremely short turnaround times or in small quantities.

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Service is becoming an increasingly important factor in the machinery manufacturing industry. Many pump suppliers clearly intend to expand their service and spare parts business. Large manufacturers generate 30-35% of turnover in the aftersales market.

Safety & Security: Ciritcal infrastructure?

Despite all of the euphoria about the digital transformation, security must not be neglected. A hacker recently gained access to the system which controls the waste water pumps in a large German city. Fortunately, the control system crashed.

BASF is convinced that the risk posed by cyber criminals is manageable. The system controller is not connected to the Internet. In 2015 together with Bayer, VW and Allianz, BASF founded DCSO (German Cyber Security Organization) in Berlin to protect against Internet crime. The organization is a repository of information, knowledge, best practice and operational effectiveness at top German companies and makes this expertise available to members.

Namur has introduced the NOA (Namur Open Architecture) concept. Its purpose is to provide secure access to data for monitoring solutions without putting equipment availability and safety at risk. The idea is to export data from the current core automation world via open interfaces such as OPC UA to the systems world for monitoring and optimization tasks and leave core automation largely unchanged. Alternatively, existing field devices can be accessed directly using a second communications channel.

Summary: The need for flexibility, a higher level of product customization and faster product introduction continues to grow in the process industry. How pump and vacuum equipment manufacturers reconcile all of these demands remains at least for the time being something which the companies have to deal with on their own. Exotic solutions are probably not the best choice. Users in the chemical industry and particularly in the pharmaceutical industry tend to make conservative choices when they select equipment that plays a central role in the process such as pumps and compressors. A proven track record is more assuring than abstract claims.

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The future of industrial pumps at a glance:

- Products without sensors and connectivity will not be a significant factor in the future world of Industry 4.0.
- Conventional products will be supplanted by products with sensors and on-board monitoring capability. Cyber-physical systems (CPS) will become the standard.
- Manufacturers and service providers will set up platforms (cloud) for CPS communication via gateways.
- The challenge is to filter out relevant data streams and develop modules which generate real customer benefit.
- CPS, the cloud and data analysis will provide the basis for tailored services.

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