ACHEMA 2000
22. – 27. May 2000
Frankfurt am Main/Germany

The opening ceremony of the 26th ACHEMA was performed in the Congress Center at the Frankfurt Exhibitions Grounds. From Monday, May 22, 2000 the gates to the world's biggest chemical engineering Exhibition-Congress and International Meeting on Chemical Engineering, Enviromental protection and Biotechnology was opened to the public for 6 days.
The special trend reports of ACHEMA 2000 exhibition (no 1-19) were prepared for publication by authorities from DECHEMA. In this issue of Chemical Industry Journal (Hemijska industrija) trends covering the Pumps and valves, Pumps, fittings and seals, Compressors, drives and seals and Trends in Automation are given. Trends covering Process intensification, Process instrumentation and control, Process safety and Plant engineering tools were published in No 6 of Chemical Industry, while all the others, taking from the press information prepared by DECHEMA, will be published in next few issues of Chemical Industry Journals in 2000.

PUMPS AND VALVES

Pumps and valves perform quite different jobs, but they have a good deal in common. Used in their hundreds or thousands in a typical process plant, they are basic components of most fluids–handling systems. Compared to main process items such as reactors and columns, most pumps and valves are unglamorous and relatively cheap. Yet collectively they can account for a large part of both the plant's maintenance budget and its fugitive emissions of volatile substances. ACHEMA 2000 showed the latest innovations in this field.

Accordingly, manufacturers of both pumps and valves are concentrating on reducing the cost of ownership by increasing versatility, reliability and ease of servicing, and on reducing leaks. Important elements of this strategy are modular construction, improved control and diagnostics, the use of new materials, and better hydraulic design – which also improves energy efficiency.

Pumps: healthy growth

By 2003, global pump sales will top $30 billion, up 20% from the 1999 figure of $25 billion, according to a 1999 report commissioned by the Hydraulic Institute, the trade association for U.S. pump manufacturers. Sales of drivers and parts will add another $17 billion to the total.

Across the world there are more than 800 pump manufacturers, but one–third of the global market is in the hands of the top ten firms: ITT, Ebara, KSB, Grundfos, IDP–Ingersoll Dresser, Flowserve, Sterling Fluid Systems, Hitachi, Wilo–Salmson and Sulzer.

Centrifugal pumps take around 55% of the market, while other rotary pumps, reciprocating pumps and diaphragm pumps add a further 8% each. The biggest growth among individual pump types is expected to be in sealless magnetically–coupled and canned–motor pumps, most of which are centrifugal. Tightening regulations on fugitive emissions in Europe, the U.S. and Japan, says the Hydraulic Institute, will increase sales of sealless pumps by 10% during the five–year period.

Among pump applications, the smallest growth is likely to be in the power generation sector, where modern combined–cycle gas–turbine plants use fewer pumps than the coal–fired plants they replace. The largest single boost will come from desalination. Increasing global demand for drinking water is producing huge growth in the market for desalination plants using reverse osmosis, which operate at pressures of 25 bar and upwards. As a result, the market for pumps – reciprocating pumps in small reverse osmosis plants and multi–stage centrifugal pumps in large plants – will grow by an estimated 6%, or nearly one–third of the total growth over the period 1999–2003. Local demand for desalination plants means that Asia is likely to see the biggest growth in pump demand, at around 8% a year compared with 4% for the pump market as a whole. The largest single geographical market for pumps will remain the U.S., with around 20% of the world total.

Lowering the cost of pump ownership

For run–of–the–mill chemical and refinery pumps, the biggest single challenge to pump manufacturers is to cut the total cost of ownership over the pump's lifetime. There are many ways to achieve this, but typical approaches are: compliance with international standards; reducing spares inventories, by rationalizing pump families and using common parts across a range of pumps; designing for greater reliability and easier servicing; improving energy efficiency; and more involvement with the customer in specifying, installing and operating pumps.

For pump users, the benefit is a reduction in the estimated 85% of the pump's lifetime cost that is spent on operation and maintenance (the initial purchase price accounts for around 5%, and installation for a further 10%). For manufacturers, the payback is in market share

Note: This press release can also be downloaded from the Internet http://www.dechema.de

and customer loyalty. Organizations such as Europump and the Hydraulic Institute are lobbying the International Organization for Standardization (ISO) for a full set of international pump standards.

Although this ideal remains some years in the future, some manufacturers are already managing to produce machines that comply with U.S. (ANSI) and Japanese (JIS) standards as well as existing ISO standards. For a pump user with plants around the world, the resulting savings in design and purchasing effort can be significant. Pump manufacturers, meanwhile, are realizing that lower costs for manufacturing and stockholding offset the increased effort needed to design a pump that meets multiple standards.

Along with standards comes the rationalization of design. Many manufacturers now use identical parts, especially seals and bearings, in more than one pump model, with consequent reductions in spares inventories. Just as important is the rationalization of complete pump ranges and an increase in the versatility of individual designs.

Thicker shafts, better mechanical seals and ceramic bearings are typical of the measures being used to increase pump reliability, both in normal operation and under abnormal conditions such as dry running. Many manufacturers now also offer electronic monitoring systems that detect dry running and shut down the pump before the bearings can be damaged. Another reliability strategy that also cuts capital and installation costs is to do away with maintenance–hungry external cooling and lubricating systems. Alternatives to cooling water and lubricating oil include product–lubricated ceramic bearings, and air cooling for high–temperature pumps. Overall cost savings for a single pump can be as high as $10,000/year, says one manufacturer.

Hydraulics and efficiency

Manufacturers seeking to widen the economic operating ranges of their pumps face difficult design challenges. Small centrifugal pumps typically have a maximum efficiency of 60–70%. This figure could be improved, but the real problem is that most small pumps operate so far from their design points that their real efficiency may be 10% or less. Good specification procedures help ensure that every pump is sized correctly to meet the job in hand. However, manufacturers are increasingly realizing that a typical real–world pump sees many different flow conditions over its lifetime or even in the course of a working day. The solution is to redesign the pump to give a flatter efficiency curve, even if this means some reduction in performance at the best efficiency point.

The need to operate across a range of different flow and pressure conditions is also a problem for specialist high–energy pumps such as boiler feed pumps. For such pumps, which typically have dimensionless specific speeds above 0.3 and pressure rises of 40 bar or more per stage, operation at the design point is generally well–understood. Away from the design point, however, cavitation, instability and reversed flows can wreck a pump in a short time.

Computational fluid dynamics (CFD) is now helping pump designers come up with better designs for high–energy pumps. Successful approaches include reshaping the leading edges of impeller blades, to reduce cavitation; bigger gaps between blade rows, to reduce pressure pulsations; and smaller gaps between the impeller and the diffuser shroud, to control axial thrust.

Variable–speed drives, now reasonably common as stand–alone accessories for pumps, are also beginning to appear as integral parts of the pump motor itself. For most small pumps there is still no guarantee that fitting a variable–speed drive will save money over the lifetime of the pump, and the savings must be calculated for each application. Integrated variable–speed drives, however, are cheaper to buy and install than stand–alone units, so they can only increase the popularity of speed control.

A refinement of variable–speed pumping has produced dedicated pump control systems. These use "smart" technology to improve control, especially of multiple large pumps in complex networks such as those found in water supply and power generation.

Talking to the customer

The biggest cost saving of all comes from buying and installing only enough pumping capacity to meet the plant's needs. This means installing the correct number of units as well as sizing individual pumps correctly. Pump manufacturers now realize that, by helping their customers save money, they can generate loyalty and guarantee future sales. A pump user may specify, say, three operating pumps plus a spare, when two somewhat larger pumps and a spare would do the job. The three large pumps cost less than four small ones, but more importantly the costs of installation and maintenance over the lifetime of the pumps are considerably lower.

Individual pumps, too, are commonly oversized because extra capacity creeps into each stage of the design process. First, the engineer adds a safety factor of 15% to the calculated design flowrate. Next, the plant manager adds a further 20% to cover future expansion. Finally, after the pump manufacturer has supplied the next–largest pump size, the plant ends up with a pump that is considerably oversized from the moment it is installed. Any oversizing will lead to a drop in pump efficiency. It is also likely to increase vibration and shorten the life of seals and bearings, if the pump has not been specifically designed to span a wide range of flowrates. As a result, some manufacturers are making

efforts to become more closely involved in their customers' processes for specifying pumps. This partnering approach can cut both maintenance and capital costs, say the manufacturers.

Valves: technical progress despite flat market

Like most pumps, most valves are small items costing relatively little to buy and install, but with the potential to absorb large amounts of money in maintenance and unplanned shutdowns. As with pumps, manufacturers have recently been concentrating on improving valve reliability, reducing the total cost of ownership and working more closely with their customers. In contrast to pumps, however, the emphasis has been on control and communications as much as on improved design and materials.

Control and diagnostics

Valve users aware of the latest developments in process control have come to expect a lot from their valves. In the past, a refinery typically had a major shutdown every two years, at which time every valve was serviced. Now, reports one valve manufacturer, the shutdown interval has been extended to four years. Even then, only 20% of the valves may be removed for servicing.

A prime method by which vendors are helping users to manage their valve assets is by building intelligence into the valve. Embedded microprocessors in valve positioners provide improved positioning accuracy, diagnostics and datalogging facilities, digital communications and, in some cases, direct control of flowrate or pressure drop. Especially in the last year, several major manufacturers have extended this functionality to allow users to interrogate their valves from a web browser, across a company intranet or the Internet.

Valve design for better performance

Progress in the basic design of valves has been steady, if undramatic. Ceramics and engineering plastics continue to grow in popularity as alternatives to expensive high–performance alloys for corrosive applications. New designs of metal–seated butterfly valve provide tight sealing, and thus eliminate the traditional need to choose between leak tightness (with resilient seats) and robustness (with metal seats). New ball, globe and butterfly valves are often easier to clean and service than their predecessors.

Valve manifolds, originally a space–saving idea for instrument connections, are now starting to become available in larger sizes. Biotech, food and other industries with strict hygiene requirements were the first to realize the potential of close–coupled and multi–port solenoid and diaphragm valves, which are designed to minimize the dead volume between adjacent valve nozzles. A similar principle is the close–coupled branch valve machined from solid metal, eliminating the need for fabrication welds.

More recently, the double–block–and–bleed valve long favored for instrument manifolds has started to appear as a more compact and reliable replacement for networks of discrete valves. One design has a tapered plug incorporating two independent resilient seals, with secondary metal–to–metal contact for fire safety. The primary seals do not rely on line pressure for their effect, so the valve is suitable for low as well as high pressures. This valve is available in diameters from 50 mm to 900 mm.

Manufacturers of safety interlock systems have been busy with new designs specifically for valves. Some allow users to create complex operating sequences, while others aim to provide compact, one–size–fits–all protection for a wide variety of valve types.

Actuators: increased safety, improved convenience

Actuators, too, have seen some developments aimed at increasing safety and ease of use. Two recent new designs, for instance, aim to make electric actuators more reliable under emergency shutdown conditions.

For valves in remote locations, electric actuators tend to be more convenient to install than their pneumatic counterparts. Until now, however, it has been difficult to make them fail–safe in emergency situations when the electric power may fail. Many users do not consider either local battery backup, or a spring–operated emergency closing mechanism, to be reliable alternatives.

Instead, one butterfly valve and actuator package uses a cylinder of compressed nitrogen to close the valve in an emergency. But the manufacturer has gone one better, by controlling the system through a "thermal fuse" made from low–melting–point alloy. If the valve temperature reaches 140C the fuse melts, allowing the nitrogen pressure to disengage the electric actuator and drive a pneumatic actuator to close the valve. The second manufacturer has designed a spring–return electric actuator in which the spring forms an integral part of the actuator mechanism, instead of being a bolt–on extra. Because the spring is tested every time the actuator operates, it is more reliable than conventional actuator designs in which the spring is called upon only under emergency conditions.

Another new actuator–positioner package for quarter–turn valves simplifies equipment selection and installation by doing away with the need for extra linkages, drive shafts, couplings and enclosures. The all–in–one package features single connection points for air and electricity, and is more compact than traditional actuator–positioner combinations. A version for electric actuators is also available.

Steam traps: venturi is a new concept

Steam traps, designed to remove condensate from steam pipelines and heat exchangers while blocking the escape of live steam, are really a specialized kind of valve. Like other valves, they are relatively cheap to buy and are easily overlooked, yet they can require a lot of maintenance and are an important source of energy losses.

The market sees a steady trickle of new steam trap models, especially in stainless–steel crevice–free designs for hygienic applications. But rather than developing any radically new trap designs, manufacturers have invested most of their efforts to improve performance in developing contract maintenance schemes and hand–held steam trap testers. These electronic devices, which combine the functions of a datalogger and a trap tester, eliminate much of the drudgery of a traditional steam trap survey. The result is that for many years the choice of steam trap has been limited to a handful of basic types: bucket–type, float–type, thermostatic, bimetallic and so on.

Since Achema 1997, however, a new steam trap based on entirely different operating principles has emerged. The venturi steam trap has no moving parts; instead, its active element is simply a narrow orifice. When the condensate in contact with the trap is cold, steam pressure forces condensate – and any air present – through the orifice. Once hot condensate reaches the trap, the pressure drop across the orifice produces flash steam that effectively blocks the flow of live steam.

As the load on the steam system falls, the condensate temperature increases and so does the amount of flash steam. As a result, the device is self–regulating. Made from a single piece of stainless steel, the venturi trap needs no maintenance apart from occasional cleaning. It is now being used by a number of well–known companies, who report steam savings of 12–55% and faster warm–up of steam systems.

PUMPS, FITTINGS AND SEALS:

From component manufacturers to fluid management systems

ACHEMA 2000 showed that manufacturers of pumps, fittings and seals are departing from the pure product: fluid management systems as a service is just around the corner. Reliable plant operation has a higher priority than investment costs which, only at first glance, are lower. The aim is often a product tailored to a particular plant.

The future lies not in individual components, but in individual solutions – this is the conviction of many suppliers of pumps, fittings and seals. Fluid management will be the focus of the development and service efforts of many manufacturers at ACHEMA 2000. Although this commitment to customer requirements takes place locally, manufacturers must, for cost reasons, look further afield for manufacture and acquisition: global players, in particular, prefer to concentrate certain manufacturing capabilities in low–wage countries; the international outsourcing of components is now standard, even for smaller companies. External and internal logistics are, of course, more complicated as a result – the customer will not accept lengthy delivery times, whether in the USA or Europe.

Is pump manufacture on demand possible?

According to the study 'Pumps: World Market 1999–2004' from the Hydraulic Institute (HI), Parsippany, N.J., USA, 800 pump manufacturers are controlling around 90 percent of the world market. The three large manufacturers alone – ITT, Ebara and KSB – account for 20 percent of the turnover. The Hydraulic Institute is predicting a turnover potential of 15 billion Euro in this sector by the year 2003, compared with the current figure of 12.5 billion Euro – an increase of around 20 percent. According to predictions, leakage–free aggregates (magnetic pumps, canned motor pumps) will show the greatest growth (10 percent). Manufacturers of these pumps are profiting from environmental legislation in the USA, Europe and Japan. It will become that the efficiency of these hermetically sealed pumps leaves room for improvement: with new canned box materials, which reduce loss through eddy currents, as well as the use of optimized rotary seals which are lubricated with the transport medium, which also improve the dry running properties.

The products described somewhat cautiously as the "light" variation of the previous construction series are also of interest: reduced technology which evidently fulfills the needs of the customer better than the previous heavy–duty series. Many providers are opting for worldwide product platforms and structures, at the same time they are reducing the complexity. ACHEMA 2000 will show further steps in this direction.

Specific solutions are in demand

The plant operator expects solutions adapted to his specific problems, not a pump equipped with every feature thinkable. Manufacturers are reacting with innovations, in market niches too, with different types of service and with the offer of long–term supply agreements. Operators are also demanding quite clearly that manufacturers take more into consideration than the very specific, sometimes unique process requirements, for example optimization of material selection. This is an important aspect for the many chemical providers in market niches. Although the concentration process among manufacturers will continue, there will still be room for smaller pump manufacturers.

The customer's request for individual solutions demands an increase in know–how of the manufacturer

and an increase in the variety of products. This will force the manufacturers to make commitments in terms of production and logistics. Will pumps or fittings on demand become a standard requirement in the chemical industry as it is already in the energy industry?

From standard pumps to pump monitoring?

No great advances have been made in the area of standard pumps, but developments are apparent. Improvements in plates, optimization of bearings – the constructive improvement of models continues, also with a view to standardizing the pump design, for example the use of the same bearing supports for entire construction series. The integration of surveillance systems in the pump for the early recognition of unexpected operating conditions will be another point of emphasis. Although pump manufacturers are forcing the development of pump monitoring, they need to provide the customer with more information about the advantages of pump surveillance. In practice customers often admit that they prefer to carry on using a redundant pump than to switch to an expensive surveillance system.

This emphasizes that, compared with other process engineering components, pumps fall into the category "peanuts" when investment costs are being discussed. They only become expensive when they break down, where the downtime or delay in production is more costly than the pump itself. The difference in price between pump supplier A and pump supplier B is rapidly becoming minimal. In fact this is one of the main requirements of the operator: a reduction of downtimes – not because of the repair costs, but because of the delay in production (and the decrease in productivity which results) which is an order of magnitude greater than the repair costs.

BOT (Build Operate Transfer) models, which are well–known in the energy sector, are apparently more common in the chemical industry than was first thought. BOT means that the pump manufacturer supplies the pump and operates it, for a fee, until the full price of the pump has been paid. The pump is then the property of the operator. This idea could of course be taken one step further: the customer does not buy the pump at all but pays for the transfer of his process medium from point A to point B, according to the motto: "The customer doesn't need a pump he just needs to transfer his process medium from point A to point B ". It is the responsibility of the pump manufacturer to do that. However, the obvious fear from the operator's perspective is that he could lose the process know–how in his own plant. However since this model works in other branches, the chemical industry will follow sooner or later.

Saving potential in electric drives

In the industry, two thirds of the electrical energy consumption is used for drive systems. Thus electric drives are receiving the most attention in attempts to cut back on electrical energy consumption and increase efficiency. However, energy costs are often not given sufficient consideration in investment decisions, although the cost of a year's operation in terms of energy consumption are often several times higher than the price of the drive. In the case of pumps, the use of a more expensive economy motor with electronic speed control often pays off after only a short period of time. The use of variable–speed aggregates is becoming more common, as ACHEMA 2000 showed. However, some manufacturers are no longer opting for "home–made" constructions and instead prefer to buy SPS–controlled standard modules. They will only produce the software themselves.

Volumetric fluid dosing is profiting from the favorable price trend of variable–speed electric drives – this applies to all types of rotary positive displacement pumps, e.g. peristaltic pumps, rotary vane, rotary piston and spindle design. Peristaltic and gear pumps in particular are available in compact form which can be controlled both digitally and analogue and integrated into the dosing flow control circuits with flowmeters or weighing systems.

Dosing pumps as automated components in process and equipment technology are increasingly being miniaturized and are capable of greater output. Interesting new developments can be expected here. Fine mechanical membrane pumps with internal volumes of only a few milliliters, magnet– and motor–driven membrane pumps with compact microprocessor control and modular process dosing pumps for a wide spectrum of applications and very high pressure usage are the characteristics of the products on offer. In addition low–pulsation twin–headed membrane pumps, valveless rotary piston positive displacement pumps made of high–tech ceramics as well as gas– or air–driven pumps for niche applications. The success story of direct compressed air–driven membrane pumps continues, because the functional principle is compact and economical for many applications with infrequent periods of operation.

Innovative system solutions are in demand

Economy motors are also being developed for wastewater pumps in order to increase efficiency and reduce energy costs. The attractive concepts was presented at ACHEMA 2000. Surveillance and control systems are gaining significance. Many manufacturers are, together with their customers opting for BOT models, which force system solutions from one source. Manufacturers are meeting the requirements of the operator with hydraulic pumps which have a consistently high efficiency, lower energy costs and reduced maintenance requirements. They have designed peripheral technology with modern supervisory remote control and innovative solutions for self–cleaning,

odorless pump shafts which maintain plant safety and reduce maintenance.

In the field of wastewater pumps, the trend is now away from wet–operating pumps and more towards dry–operating, floodable aggregates which function even in flooding conditions. The reason: when the pump is repaired maintenance personnel do not come into contact with the wastewater, and even if the pump is damaged there is no risk of contamination (e.g. risk of hepatitis). With dry–operating pumps these problems are less common.

How leaktight does it have to be?

Industrial emissions arise not only from defined sources such as waste gas stacks, but also to a not inconsiderable amount from various other diffuse sources distributed across the factory premises. For example, an enormous proportion of industrial emissions of organic gases and vapours comes from sources such as the flanges, shaft seals and spindle seals of fittings. This recognition has led to a demand for precautionary measures, in particular when handling the environmental pollutants emitted from the spindle seals of shut–off valves. Thus according to the German technical instruction air (TA Luft) for gaseous emissions when handling liquid organic substances, the spindle connections on fittings must be "sealed using bellow–sealed isolating valves and downstream valve glands or similar". It remains to be seen how "similar" will be interpreted by manufacturers.

In the field of rotary seals more products along the lines of gas–lubricated rotary seals are expected at ACHEMA 2000 – after their successful use for compressors they are now likely to be used increasingly for pumps as well. The background to this is as follows: larger batches and improved manufacturing techniques have forced the prices down and made them more readily available. The plant manufacturer will also be able to choose from many more products which offer complete tightness. The approach: the seal manufacturer analyses the customer's complete system and based on this analysis suggests alternatives. The result should be an optimal, complete solution for the tightness of all the pumps, fittings and pipelines belonging to the system in question – the aim is tightness as a function, the focus is no longer on a single seal. Condition monitoring via integrated sensors is also becoming more important.

Flanges, screws, seal: the sum makes the difference

Rotary seals of varying complexity are no longer seen as the only solution to the problem of tightness in rotary shafts. Flanged connections are common in the chemical industry – and in addition to tanks, pumps and fittings they are the main source for diffuse emissions.

In the case of plant failure or atypical operating conditions flanged connections are vital, because if they fail large amounts of product are often released spontaneously: flange, screw and seal have the joint responsibility for making sure that this does not happen. The German technical instruction air, however, contains no specific tightness criteria for flange connections; values for the maximum permissible leakage rates are not given. In order to provide definite criteria, some working groups have developed their own ideas. Tightness requirements, demanded by the drafts of the German VDI 2440 Guidelines, are, according to engineers, very difficult to measure.

Fittings which can communicate

The components of a control valve – in other words the valve itself, the drive and the valve positioner – have undergone different developments in recent years. The throughput and sound emission of the valve have been optimized. In the case of drives, which are predominantly still pneumatic, simple assembly and corrosion protection are paramount. The most development can be expected with valve positioners, due to the intensive use of microprocessor technology: self adjustment of edge contacts, selection of control parameters, bi–directional fieldbus communication and diagnosis systems are no longer foreign words any more and will be further refined. In all actuators the trend is towards smart technology: the electrical periphery of the drive system is increasingly being transferred to the device itself – even to the extent of integration into the fieldbus technology.

Whether valve, slide, baffle or ball cock: all fittings have one thing in common – the seal is achieved by a tight fit between a mobile shut–off valve and an immobile base mounted in a housing, but that is the only thing they have in common. When the user should use which fitting depends very much on the application. Both the user and the manufacturer have to search for the fitting which is best suited to the temperature and pressure conditions and the media with which it will come in contact, and which has acceptable pressure loss, dimensions, etc.

That is easier said than done: the chemical industry is conservative – anyone who has had no problems with a particular baffle for a number of years will not be easily convinced by a ball–cock. Of course, the same applies in reverse. Usually the motto "Never change a running system" applies.

In addition to hand fittings automatic fittings are also in demand, particularly in process engineering and chemistry: avoidance of expensive manual work is one reason, the other is the networking of all fittings in the central control systems of large plants. The different operating types differ clearly in terms of purchase price, operating and energy costs. Thus the purchase price of electromotively–driven valves, which is double that of pneumatically–driven valves, is rapidly recovered. The operating costs of pneumatically–driven valves on the

other hand, are several times higher. Fail–safe drives are important. More advanced concepts in this area were presented at ACHEMA 2000. For example, if the electricity supply fails, a fail–safe switch is activated and an emergency energy in the form of potential energy (stored in a spring) becomes available.

The membrane valve still plays a special role. This design with only two components which come into contact with the media, the housing and the membrane itself, is the solution to technical problems, especially in the chemical industry. As a result of efficient internal streamlining it achieves a favorable zeta value (loss–coefficient). The materials used for the housing (and sometimes the cladding) and the membrane are chosen so that use in corrosive and abrasive media is possible. ACHEMA 2000 showed that the market for membrane valves is growing in the sterile equipment sector.

COMPRESSORS, DRIVES AND SEALS

Compressors, blowers and vacuum pumps for process gases are essential to most chemical plants and refineries, while air compressors are to be found in practically every plant. Large compressors and other rotating machines are also a good place to look for developments in seals and drives – motors, gearboxes, speed controllers and bearings. The high investment cost of compressors and turbines, and the need for reliability in these critical items, means that new technology in seals and drives often appears first in large rotating machines, before filtering down to smaller items such as pumps and mixers. Exhibitors at ACHEMA 2000 saw the latest developments in this field.

Process compressors: higher reliability

Commercial pressure in a mature market means that overall sales of compressors and vacuum pumps are growing at most by 5% a year. According to marketing consultancy Frost & Sullivan, the U.S. market for compressors in 1999 accounted for 193,000 units worth a total of $1.0 billion, while for vacuum pumps the corresponding figures were 264,000 units and $645 million. Many of these machines, however, are at the small end of the spectrum – as indicated by the average unit values of $5200 for compressors and $2400 for vacuum pumps.

For process–gas compressors the emphasis is on lower leak rates, increased reliability through better design and in–service monitoring, oil–free operation and higher efficiency. Centrifugal and reciprocating compressors continue to dominate, while axial compressors are used for very large flowrates and low pressure ratios.

For large centrifugal compressors, better seals and bearings (see below) are probably the biggest sources of increased reliability. Removing contaminants from the inlet gas stream, however, can also cut downtime significantly. In reciprocating compressors, liquid droplets and solid particles damage the valves and seals; one user attributes 20% of reciprocating compressor failures to this source. In centrifugal machines, contaminant buildup on the rotors ("salting") can lead to loss of efficiency and increased vibration. The latest purpose–designed coalescers, made up from multiple grades of glass fibers treated with fluorocarbons, can reduce contaminant levels to 0.003 ppm and offer much better turndown than traditional mesh pads or cyclone separators.

Air compressors and vacuum pumps

Suppliers of air compressors are concentrating on higher reliability, greater efficiency and user–friendliness through "intelligent" control systems, and oil–free operation. Centrifugal machines are important for larger sizes, while the compactness of screw compressors makes these the most popular choice in small sizes. New coating materials such as vapor–deposited amorphous carbon help screw compressors adapt to oil–free and reduced–oil operation, and to more environment–friendly lubricants such as vegetable oil esters.

The move towards pollution–free dry–running vacuum pumps continues wherever their considerable investment costs can be justified. The original lobe–type pumps have now been joined by several screw designs. One of the latest of these offers maintenance intervals of up to 20,000 hours, maximum internal surface temperatures of 135C and the ability to run completely full of liquid. In this twin–screw machine, each rotor is driven by its own motor, synchronized by an electronic control system that protects against overload. Because the motors are located inside the pump casing, there are no shaft seals to wear or leak. Another manufacturer offers a sealless claw–type dry vacuum pump, again with a canned motor.

Looking for a better bearing

Dry gas seals (see below) are now very common on compressors because they increase reliability and eliminate the need for seal lubrication systems. Most compressors, however, still require oil to lubricate their bearings. In normal operation, seals prevent the oil from contaminating the process gas, but oil–sensitive processes such as polypropylene manufacture may have to be shut down in the event of seal failure. In addition, some users blame lubrication systems for 80% of their compressor problems.

Active magnetic bearings, in which the compressor shaft runs without contacting the stationary parts of the machine, have been available to special order for more than a decade. Because they support the compressor rotor on a magnetic "cushion", magnetic bearings are completely oil–free; they also produce less friction than conventional bearings. Since they increase

both cost and delivery time, however, magnetic bearings have so far generally been confined to large machines.

Now for the first time both magnetic bearings and dry gas seals are available as standard on a centrifugal compressor available in power ratings of 10 MW and below. Cost is claimed to be competitive with that of a compressor with oil–lubricated bearings. As well as increasing the compressor's operating efficiency by 1–2%, the magnetic bearings are said to reduce vibration by up to 90%.

Variable–speed drives continue to spread

Variable–speed drives continue to grow in popularity as their price/performance ratio falls. Also important are features such as increasing user–friendliness and digital communications. A recent development of the variable–speed drive is the variable–speed motor, in which the control electronics are housed in a box attached to the motor itself. Variable–speed motors were beginning to make an appearance at ACHEMA 97. Since then they have increased in popularity and prices have fallen, though few suppliers are yet offering power ratings higher than 7.5 kW.

Frost & Sullivan estimates that in 1999 around 40 manufacturers of variable–speed motors supplied 39,700 units to a European market worth $46.4 million, giving an average price of $1200. More than half of these sales went to Germany, where the technology is already well accepted, while Italy was in second place with 17% of the market. Market growth, which has been above 100% annually for the past few years, is expected to level out at around 10% by 2005.

Turning from variable–speed drives to switchgear, a modest development that will nonetheless save considerable downtime is a circuit breaker designed especially for motor control. If the motor overheats and draws too much current, ordinary circuit breakers trip out and need to be reset manually. The new circuit breaker has a relay that simply removes power from the overloaded motor and restores it once the motor has had a chance to cool, so the motor restarts automatically.

New motor for speed and low inertia

A centrifugal compressor rotor designed for, say, 30,000 rpm is generally driven by an electric motor running at 3,600 rpm. Between the two is a gear chain that takes up space, generates noise, consumes oil and reduces reliability. A high–speed motor that could run at the same speed as the compressor wheel would be a distinct advantage. Such motors are not yet commercially available, but we already have the technology to build them.

At least one company has now developed a commercial high–speed alternator that runs at up to 60,000 rpm, and says the same technology could be used to build a high–speed motor. In contrast to the drum–shaped rotor of a conventional motor or alternator, the new machine uses a stack of disk–shaped rotors made from carbon fiber composite and aluminum, and carrying permanent magnets. The windings fit between the rotor disks, instead of around the outside of the rotor. A 50–kW version of the alternator is on sale coupled directly to a small gas turbine. Efficiency is 91–92%, a high figure for a machine of this size.

Another new device, this time of interest to manufacturers of synthetic fibers, films, paper and board, is a lightweight web roller with a built–in motor. The roller's low inertia improves the control of web tension, while the ability to do away with a gearbox saves weight and makes possible a wider range of operating speeds.

The self–powered roller is made from carbon fiber composite loaded with up to 20% by volume of powdered neodymium–iron–boron magnet material. Inside the roller are the field coils and control electronics needed to turn the whole thing into a brushless D.C. motor. In tests, a roller 106 mm in diameter accelerated from rest to 2000 rpm in just 0.1 s. Now at the prototype stage, the self–powered roller is forecast to cost no more than a conventional steel roller, motor and gearbox when it is available in production quantities.

For conventional electric motors, a relatively simple design modification promises to extend the life of drive–train bearings. Electric currents induced in the drive shaft by the motor windings often flow to earth through the bearings. This produces arcing which, over time, can cause the ball races to become scored and pitted, especially in large, high–frequency motors. By dividing the motor windings into two balanced halves, researchers at one large motor manufacturer have managed to greatly reduce these circulating bearing currents.

Mechanical seals: gas lubrication

Almost every drive shaft in the chemical process industries has a seal attached to it somewhere. Frost & Sullivan divides the European market into three sectors: seals, gaskets and packings. The largest sector is gaskets, which with sales of $1,600 million account for just over 50% of the market. Seals and packings each make up 25% of the market, or around $800 million. Germany has the largest geographical share of the market, at 24%, with the U.K. in second place (17%). In total there are more than 30 significant manufacturers.

Cartridge–type mechanical seals continue to become more popular as users realize that poor installation of conventional mechanical seals is responsible for a lot of expensive failures. For conventional mechanical seals, modular design is helping to cut the cost of stocking spares.

The most significant technical change, however, has been the move towards non–contacting

gas–lubricated seals. The first applications for these were in compressors, where they improved reliability and eliminated the need for seal lubricants and barrier fluids. Gas–lubricated seals have been available for pumps since around 1993, but they have only become popular quite recently.

Gas–lubricated seals use a series of spiral grooves on the seal face to "pump" a thin film of air or nitrogen towards the rotating shaft, generating a pressure 1.5–2 bar higher than that inside the seal chamber and so preventing the escape of process fluids. Because during normal running the seal faces do not touch, there is no wear. The gas used as a barrier fluid contaminates the process fluid less than is the case with a liquid–lubricated seal. It is also cheaper: a large hydrogen compressor with oil–lubricated seals, for instance, can consume up to 2,000 l/d of oil. Modern gas–lubricated seals can handle process pressures up to 40 bar and solids concentrations of up to 40% by volume in the pumped fluid.

In cases where it is impossible or uneconomic to eliminate seal leaks, an alternative course of action is to install a secondary extraction device. Such a system may be fan–powered, or it may use a venturi driven by pressurized gas to suck up contaminated air from around the primary seal. If the venturi is powered by compressed air, the exhaust is fed to a flare or scrubber; if it uses process gas taken from the compressor discharge, the exhaust can be returned to the compressor inlet. A new variant of this system uses the Coanda effect – the tendency of a jet of fluid to follow a curved surface – to amplify the flowrate of entrained gas by a factor of up to 30 compared to a conventional venturi. As a result, it collects pollutants more effectively.

Focusing on static seals

Alongside mechanical seals and packings are static seals such as

O–rings and gaskets. In recent years, emphasis on reliability and increasingly severe process conditions has transformed the image of

O–rings from low–priority items to often–critical engineering components. Seal users are now generally prepared to pay for perfluoroelastomer

O–rings wherever the increase in reliability justifies their considerable cost. Encapsulated O–rings, in which a chemical–resistant such as PTFE protects a resilient elastomer core, are also becoming more common.

At the cheaper end of the market, ethylene–propylene (EPDM) rubber and Viton are making inroads into markets traditionally occupied by chloroprene and nitrile rubbers. For compressor seals, new elastomer compounds specially developed to resist explosive decompression are helping to improve reliability at operating pressures of 130 bar and upwards.

In the world of gaskets, the ban on asbestos has forced vendors to develop alternatives to compressed asbestos fiber (CAF). The choice of gasket materials based on carbon and other fibers, graphite, metal and PTFE can be bewildering, and gasket users must take care learning to use these new materials correctly. The new gaskets can often out–perform asbestos, point out the vendors, but they are not generally as versatile, or as forgiving of sloppy specification or installation.

Magnets for seals and couplings

Ferrofluid seals are an interesting alternative to conventional mechanical seals. At the moment they are suitable for only modest pressure differentials – typically less than 0.5 bars – but they have the advantage of simple construction and the ability to run at shaft speeds of 20,000 rpm and upwards. Emission levels of volatile substances can be as low as 3 ppm.

A ferrofluid consists of tiny particles of magnetic material carried in a base fluid. The solids concentration is high enough to cause the entire fluid to exhibit strong magnetic properties, allowing it to be confined as a liquid "O–ring" by permanent magnets positioned around the shaft to be sealed. Because the sealing medium is a liquid, it conforms easily to shaft irregularities and deflections. Wear is almost non–existent, so maintenance consists simply of replacing or topping–up the ferrofluid as required. Gas–purged versions are available for process fluids containing solid particles.

Another application of magnetism is in sealless magnetic couplings, which use permanent magnets to transmit torque through vessel walls, eliminating the need for dynamic seals. Although pumps using this principle have been growing in popularity for some years, magnetic couplings for reactor agitators, mixers and other process items have been slower to catch on. In the right circumstances, though, they offer many benefits.

For example, one manufacturer offers maintenance–free magnetic couplings for shaft diameters up to 40 mm and power up to 11 kW, suitable for agitators in process vessels sizes of up to 1,000 l. Maximum operating pressures range from 70–400 bar, depending on size, and the maximum operating temperature is 340°C.

TRENDS IN AUTOMATION

First, the good news: the chemical industry is booming again after the cut–backs of recent years. This has opened the way again for new investment in process control systems, which are still the key to successful and efficient production. Frost & Sullivan for example predict growth from US$ 7.65 million in 1998 to US$ 9.20 million in 2004 in the European market. This is an average annual growth of 3.1 percent.

Whereas a few years ago products were being produced in large quantities in the chemical industry, today many companies are producing tailor–made products for market niches. In the face of tough competition, only companies which can react quickly and flexibly to the demands of the market have a chance. However, this often conflicts with the aim of continuous, highly automated production that is much cheaper. The design process for new plants has also changed considerably. The time available for planning and commissioning new plants is constantly decreasing, and, at the same time, the amount of capital required and the developing and operating costs must be reduced. Despite all the cost aspects the plant designer cannot afford to neglect process reliability. Manufacturers of process control systems have to adapt to these demands and produce systems which meet the new requirements, if they want to survive in the marketplace.

In addition to the economic changes, there are also technical aspects that have led to the transformation of automation in the chemical industry. For example, the first promising projects in the area of field buses have begun, which show that the digital world is slowly but surely making an impact on the chemical industry. The previous hesitation in the chemical industry was based on a lack of readiness to invest in this technology and, above all, the fear of technically incomplete systems. The new field bus concepts will, in the big projects of the future (for example in Asia or the USA), give added impetus to the development of this technology.

New solutions to global communication problems

In addition, manufacturers of process control systems cannot withstand the increasing effect of communication solutions, such as a company–specific Intranet or the Internet, any longer. With the link–up of communication systems in the automation based on field buses and administration sectors company–wide or even worldwide access to different parameters and important information is now possible. Another example of the impact of the Internet on process control systems: most manufacturers are now providing field equipment and process control systems with functions such as remote diagnosis, commissioning, maintenance and surveillance. Furthermore, the virtual planning office has now become reality in instrumentation and control technology. Different parts of a project can be designed and revised in different locations simultaneously via the Internet.

Field devices and sensors are gaining importance

The shift in workload is apparent not only on a global level, within the plant the demands are also changing. Many tasks, which until recently were performed by the control system, are now being taken over by field devices. This will have unknown consequences: Measuring devices and sensors are the unsung stars of the plant. They are becoming more and more "intelligent", because the trend is towards integrating as many control functions as possible from the process control system into these devices, to save costs and increase availability. These devices are becoming an integral part of process and information technology. One example of the increasing intelligence of these devices is online diagnosis and preventive maintenance of the entire unit. Several companies are presenting different functions of process control, maintenance and plant economy, under the umbrella term "asset management". The field instruments provide indentfication and status information and thus enable the diagnosis of their functions. With the aid of this information they can then be configured and calibrated.

Since the workload of process control systems is being relieved by field devices, control technology is facing new challenges. For example, new software functions, such as higher level control algorithms. In process modeling the competition between mathematical and knowledge–based methods is increasing, although both are often combined in order to control complex, non–linear processes. Modern simulation solutions are also helping to train plant operators.

Interface solutions are in demand

On the other hand, some process control systems now allow vertical integration into ERP systems (Enterprise Resource Planning). Thus process control is becoming part of production technology as a whole, but its significance both as a user interface to the intelligent field level, and as a platform for the optimization of business processes is increasing. The boundaries between real–time–oriented process control and plant management data systems are merging. Integrated process control is not only capable of regulating the process, it can also take the logistics into account.To archive entire production data from several plants provides additional advantages for the control and planning of aproduction process. However, large databases are required to combine process–relevant data and information about turnover or planning in one system.

Ever–increasing amounts of data must be analyzed and fed through the right channels, if we are not to drown in digits. For developers of process control systems this means: both horizontal and vertical interfaces to plant and materials management systems are required for data exchange between different sectors. At ACHEMA manufacturers demonstrated how this could be achieved in practice.

Data transfer more versatile than ever

Many users are convinced that these interfaces enable a constant flow of information between

temperature sensors in the field and the company balance sheet. The reality in the chemical industry is quite different. Only a few sectors actually exchange data. However, the interfaces required for a "system world" have already been created. As recently as a few years ago, the desire of many users to integrate numerous Windows applications into everyday production led to considerable problems. The situation changed however, with the OPC (Object Linking Embedded for Process Control) standard. This standard is based on the OLE/COM and DCOM technology (Component Object Model/ Distributed COM) and enables simple, standardized data exchange between control applications, field instruments and office programs. Nowadays, more and more machines are fitted with this interface, which allows easy communication, for example between different field bus protocols. Thus the foundations for PC–based automation in the chemical industry have been laid – in other branches it is already commonplace.

The free exchange of data required does not end with the engineering process. Construction software, such as CFD (Computational Fluid Dynamics), CAD (Computer Aided Design) or FEM (Finite Element Method), is closely associated with the design process of a chemical plant and would be unthinkable without simulation software. Even so, many documents are produced in duplicate during the conception and design phases. Whereas with CFD and FEM it is mainly the construction diagrams of the apparatus to be calculated which have to be embedded, in the case of flowsheet simulators it is the flowsheets of the process. To date neither the CAD construction diagrams nor the flowsheets of the process can be used as the basis for calculation programs. For some users electronic data transfer causes an unacceptable amount of problems and shows clearly the poor integration into the entire engineering process.

Intrinsically safe field bus systems

For many years, the question remained as to which field bus would become established in the chemical industry and accepted as the standard internationally. The answer to this question has now been found, but in a different way than was expected by some manufacturers. All organizations are required to register their bus system with the IEC (International Electrotechnical Commission), so that it can be published as an international standard. Meanwhile, it has been generally recognized that different users have different requirements.

Whereas mechanical engineering, robotics and the automobile industry all require fast buses which can achieve reaction times of 1 ms, users in the fields of process engineering, petrochemistry and in the pharmaceutical and chemical industries are happy with transfer speeds of 100 ms. Many of their production plants are located in explosion hazard areas. In the manufacturing industry the buses are often several meters long, the number of users accessing the same bus is high and the amount of data from a single user is low. In the process industry the bus length is, on average, 200 m, but distances of 1000 m to the tank depot are not uncommon and the amount of data transferred is considerable. In addition to high–resolution measurement values, status signals, limits, configuration data and other information need to be transferred.

The decision of the International Electrochemical Commission in June 1999 has paved the way for a uniform field bus concept. Instead of blocking each other, the different field bus manufacturers have abandoned this policy and accepted the coexistence of different models. As a result of the recommendations of the IEC Task Force and the decisions of the Committee of Action, the field bus organizations ControlNet International, Field bus Foundation and PROFIBUS International as well as the companies Fisher Rosemount, Rockwell Automation and Siemens AG have reached an agreement. They have formed a strategic alliance and will actively support the IEC experts.

Ethernet is increasingly calling the tune

However, it remains to be seen whether these efforts are too late. In the meantime, almost unnoticed, a new transfer medium has made the headlines – Ethernet. Ethernet has proved to be the communication standard of the office environment in the last 15 years. Its advantage is its simplicity. Many users have their doubts. They say it is too slow and the transfer of data is too unreliable. However, Ethernet has, in the meantime, had an impact on industrial automation, and several manufacturers speculate that it could, in future, replace the field bus.

How and when this will happen will not be determined by automation technology but rather by commercial data processing, the multinational software houses and the Internet. Initial solutions to this problem were presented at ACHEMA. The future of automation technology will not take place without Ethernet as the uniform network architecture, TCP/IP (Transmission Control Protocol/Internet Protocol) or XML (Extensible Markup Language) as the transfer protocol and a Windows derivative as the operating system, because the Internet and the Microsoft environment are well–established in field instruments, for example as web servers.

According to the press informations
prepared by DECHEMA e.V.
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ACHEMA 2000
26th Exhibition-Congress • International Meeting on Chemical Engineering, Environmental Protection and Biotechnology • Frankfurt am Main 22 - 27 May 2000
DECHEMA