1/2010
ISSN 0934-934 X - K 30285
F VULKAN-VERLAG
ESSEN

SPECIAL EDITION
Plant engineering and Power piping technology

3R
Journal for piping practice

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Offprint from "3R international", 49th year - special edition - 1/2010, pages 34-40

VULKAN-VERLAG-HUYSSENALLE52-56-45128ESSES

Impulse rinsing process for industrial applications

The pulse-flushing method for industrial applications

By Dr. N. Klein

The patented impulse flushing process has proven itself for over ten years in the cleaning of public drinking water distribution networks. Hammann GmbH has further developed this process into the Comprex® process for other applications. In this way, raw water pipes can be effectively cleaned and upgraded. Even large pipelines up to a nominal diameter of DN 1200 are successfully freed from deposits. Wastewater pressure pipes are another area of application. During operation, air pigs remove unwanted deposits and restore the pipes to their original cross-section. The latest developments are small Comprex® systems. These can be either mobile or stationary and can be used to clean thin endoscope tubes, lines in medical devices or lines and systems in agriculture, such as drinking lines in livestock farming. Pipes and heat exchangers in industrial plants are another area of application. Here, the Comprex® process can be used for a wide range of applications. This article is intended to provide information about the new possibilities offered by this process in the industrial sector.

The patented pulse-flushing method has now proven its capabilities in cleaning of public drinking-water systems across a period of more than ten years. To permit further applications, Hammann GmbH has refined this method into the Comprex® technique. Raw-water lines can, for example, also be effectively cleaned and rehabilitated; even large-caliber pipelines, up to DN 1200 nominal diameter, are successfully freed of depositions. A further field of application includes waste-water pressure lines. Pneumatic pigs remove disruptive depositions during operation, restoring the pipelines' original cross-section. Mini Comprex® systems are the latest development; these can be used either as mobile or as stationary units. Their applications include the cleaning of thin endoscope tubes, pipes and tubes in medical devices, and pipes and complete systems in agriculture, including liquid feed lines in cattle rearing. A further application covers pipelines and heat exchanger arrangements in industrial plants; the tasks involved here are many and diverse. This article provides information on the new potentials provided in industry by the Comprex® technique.

A modern and efficient cleaning process

The Comprex process [1] is based on a controlled, pulse-like addition of compressed, clean air within a defined, pressure-reduced flushing section. **Figure 1** schematically illustrates the Comprex® cleaning of a pipe section. According to the flushing program, air bubbles of a defined size are formed. They fill the entire pipe cross-section and move through the flushing section as air blocks alternating with water. Cleaning takes place at the interfaces between the air bubbles and the water and pipe wall. This is where turbulent swirls occur at flow velocities of over 10 m/s. Local cation phenomena cause the detachment of all mobilizable deposits from the pipe walls. The air blocks in the water flow ensure that the detached substances are discharged. The Comprex® process keeps the impulse pressure below the resting pressure of the pipe network so that the pipe system is not subjected to higher pressure loads than during normal operation. Damage is therefore practically impossible.

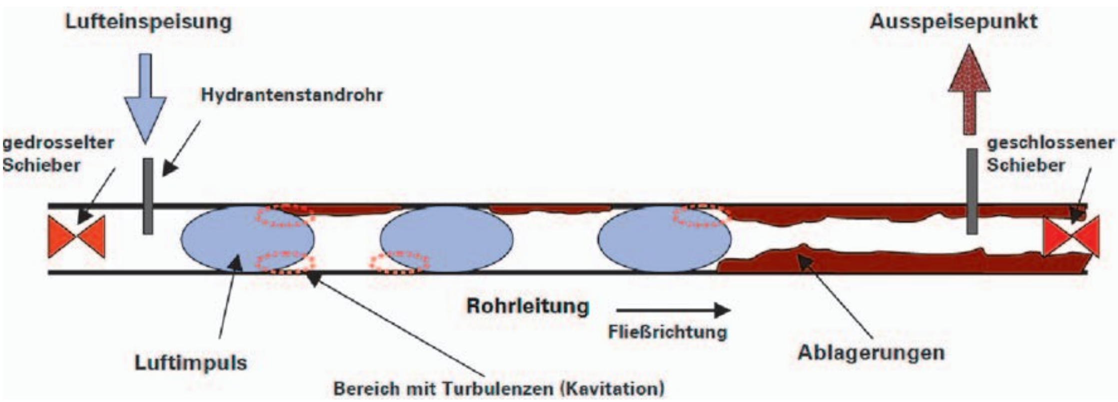
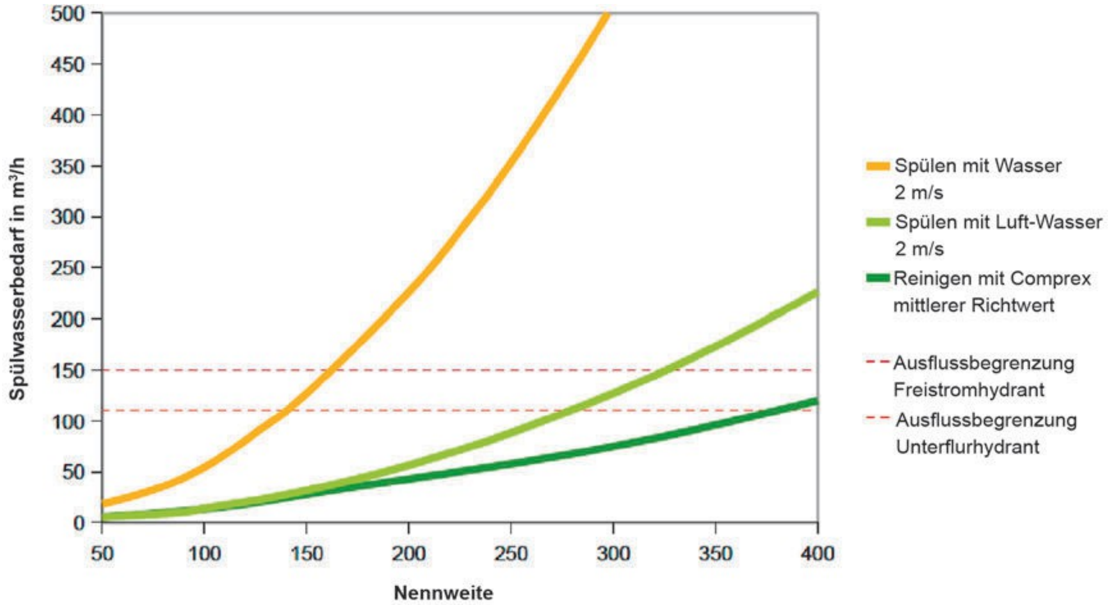


Figure 1: Schematic representation of the Comprex® pulse rinsing process

Fig. 1: Schematic view of the pulse-flushing method

Figure 2: Flushing water requirement during flushing and flow limitation by underfloor hydrant

Fig. 2: Flushing water requirement for flushing and outflow limitation by means of underground hydrant



Air pigs adapt to any geometry and do not get stuck, so that even complex networks with different nominal widths and branches can be cleaned. Existing inlets and outlets can be used for the cleaning process. Adapters to standard connections are sufficient to feed in the air.

The water that flows through the system is often used for cleaning. In the case of drinking water pipes, hygienically safe drinking water is always used for flushing. When using non-drinking water - for example when cleaning pipes carrying service water or well pipes with cooling circuits - hygiene sluices prevent contact with the high-quality Comprex units.

The advantage over water flushing is high efficiency with low water consumption, **Figure 2**. Based on the low water consumption, side effects such as turbidity or pressure drop in the neighboring network are avoided.

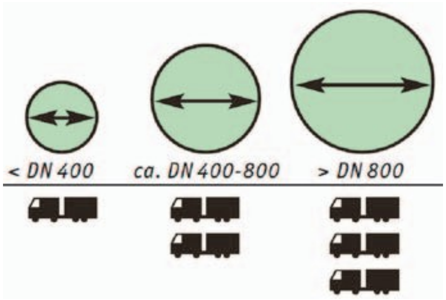


Figure 3: Technical units required for cleaning pipes of medium and large nominal diameters using the Comprex® process

Fig. 3: Examples of the use of the Comprex® technique for cleaning of industrial pipelines

avoided. By combining several Comprex units, pipes up to DN 1200 can be cleaned, **Fig. 3**. In pipes with large nominal diameters, cleaning is often only possible with the Comprex process due to the water content. However, the cleaning is so effective that disinfection measures are often unnecessary.

Comprex can be combined with other processes. This makes it possible to increase the cleaning performance for stubborn contaminants.

by adding solids,
z. e.g. pieces of ice.

Standard applications

The main application of the Comprex® process is pipe network flushing [2]. It is used to maintain the pipes and ensure clean distribution networks. Using as little water as possible, not only can the pipes be thoroughly cleaned, but also the pipes can be flushed after the inspection of valves and valves.

Table 1: Predominantly existing deposits and impairments in pipes and heat exchangers

Table 1: Depositions and impairments primarily present in pipelines and heat exchange systems

Applications	Deposits	Impairment
Drinking water pipes	Biofilms Corrosion products	Contamination, hygiene, hydraulics, pumping energy, water quality
Pipes for well water or raw water	Reaction products such as iron and manganese sludge	Hydraulics, pump energy
Piping for River water or process water	Biofilms Settling of particles	Hydraulics, pump energy
Pipes and heat exchangers in closed cooling circuits	Corrosion products	Hydraulics, pump energy Heat transfer
Pipes and heat exchangers in open cooling circuits to cooling towers	Deposition of particles Corrosion products Biofilms	Hydraulics, heat transfer, immission of microorganisms
Sewage pressure pipes	Settling of particles Sieve skin	Hydraulics, pump energy
Fire extinguishing lines	Blockages due to detached particles / corrosion products	Fire protection, safety
Product or process water lines	Reaction products Crystallization products Corrosion products Settling of particles	Hydraulics, pump energy Heat transfer

Table 2: Examples of the use of the Comprex® process for cleaning pipelines in the industrial sector

Table 2: Examples of the use of the Comprex® procedure for cleaning of industrial pipelines

Piping for	Problem definition Impairment due to	Effects Impairment of	Problem solution Discharge of
Well water	Cross-sectional constriction, turbidity with increased flow rate	Flow rate, pump capacity, energy requirement	Iron and manganese slurries
Cooling water in a closed circuit	Corrosion products	Flow rate, heat transfer at heat exchangers	Corrosion products
Cooling water in open circuit	Cross-sectional constriction, immission of microorganisms	Flow rate, Function of the cooling tower	Sludge Biofilms
River water	Cross-sectional narrowing, temporary mobilization of deposits	Flow rate, Function of downstream units	Sludges Biofilms Shellfish
Process water	Cross-sectional narrowing, temporary mobilization of deposits	Flow rate, product quality	Sludge Biofilms
Fire extinguishing water	Corrosion products, temporary mobilization of deposits	Flow rate, Function of the fittings, safety in case of fire	Corrosion products

Hydrants rehabilitate valves that are difficult to use as well as non-functioning gate valves.

In recent years, the cleaning of drinking water pipes in buildings using the Comprex® process [3] has become increasingly important because an effective process is required to remove deposits and biofilm, particularly in connection with the legionella problem. During systematic cleaning, cold and hot water lines are flushed individually. The Comprex® process has proven its worth. It extends the time window between cleaning measures prior to sanitation and creates lasting hygienic conditions after the renovation of the drinking water installation.

Applications in the industrial sector

The standard applications of the Comprex® process are also used for water supply and distribution in the industrial sector. In addition, new interesting possibilities are opening up in the industrial sector [4], with the process offering decisive advantages. Air pigs also adapt to complex geometries. In contrast to other processes

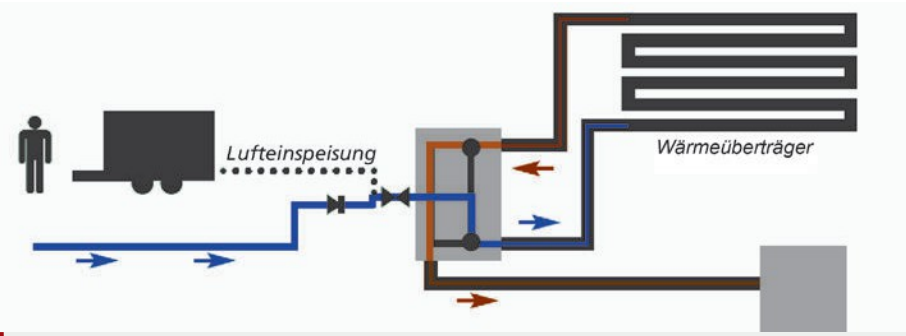


Figure 4: Scheme for cleaning a heat exchanger using the Comprex® process via a changeover station

Fig. 4:

Clean systems without time-consuming disassembly and assembly work, thereby reducing labor costs and downtimes. Cleaning is carried out mechanically and normally without chemicals. As a result, the removed deposits can be easily separated and disposed of, for example by decantation. **Table 1** provides information on the most common deposits and impairments in pipes and heat exchangers. **Table 2** gives examples of problem solutions using the Comprex® process in the industrial sector.

While pipelines are designed for several bar of pressure, the load limits of heat exchangers are often only a few bar of pressure due to the large surface area for heat transfer. Cleaning processes must therefore also be effective at these low pressure ratios.

Recent investigations have shown that new components and control systems can be used to achieve a pressure curve with peaks in the negative pressure range. Waves of pulses in the pressure range above and below the flushing pressure, but always below the maximum pressure permitted for the system, mobilize deposits even from areas with poor flow. These findings lead to new developments for cleaning complex systems, such as heat exchangers with associated piping.

Unlike pipes, heat exchangers cannot be calibrated. It was therefore necessary to develop special flushing programs. Adapted to the respective system, it is thus possible to efficiently clean heat exchangers on both the medium and heat transfer medium side. All that is required are adapter connections at the inlet and outlet (**Fig. 4**). Other costly and time-consuming separation points can be omitted, as can the subsequent leak tests of the system. The inlet and outlet of heat exchangers are not far apart. It has therefore proved advantageous to flush alternately in and against the flow direction via a changeover station (Fig. 4).

The following examples serve to illustrate the new areas of application of the Comprex® process. After describing specific problems, measures are taken to show how the process can be used effectively to clean heat exchangers. New fields of application for the Comprex® process are constantly emerging in the industrial sector. The examples described here show the current status and are intended as suggestions for further possible applications.

Example 1: Pipes for well water

Problem definition

Well water can be compared with raw water that is treated to produce drinking water. Both types of water often contain elevated levels of iron and manganese. These elements are dissolved in the water in the reduced form as divalent ions [5].

During the water treatment of raw water, these ions are oxidized with atmospheric oxygen, precipitated as insoluble hydroxides and removed via filters. If the filters are loaded and the flow rate is no longer sufficient, it is necessary to backwash and regenerate the filters.

Depending on the mode of operation and type of raw water, traces of oxygen may be introduced during water extraction. This means that the oxidation of the bivalent ions and the precipitation of the resulting sparingly soluble iron or mangene compounds take place before the water is treated. Wells that have to be regenerated at regular intervals are known to be blocked. Less attention is paid to these deposits in the pipes. The deposits occur regardless of the pipe material (**Fig. 5** and **Fig. 6**) and have a detrimental effect in two main ways:

- Narrowing of the cross-section: Deposits reduce the cross-section of the pipe; the pipe becomes too narrow.
- Turbidity with increased flow rate: sedimentation impairs water quality with high water demand and increased flow velocities due to turbidity.

Measures

Compared to conventional pigging technology [5], the Comprex® process impresses with its simplicity. Based on pipe parameters, purified air can be easily added via connections, for example to existing air vents. The computer-generated air pigs adapt to the pipe cross-section - even when the nominal diameter changes - and do not get stuck. With a low flushing water requirement, the pipe regains its planned capacity after a short cleaning time (**Fig. 7**). The process works economically, effectively and sustainably.

Example 2: Cooling water pipe in a closed circuit

Problem definition

Cooling circuits often contain components made of different materials. While the main lines are available in larger nominal widths While most of the heat exchangers are made of welded steel pipes, the distribution pipes contain components made of other materials, such as stainless steel or copper pipes and brass or gunmetal fittings. The heat exchangers are normally made of stainless steel.

The cooling water in industrial cooling circuits is often treated well water and contains corrosion inhibitors. The temperatures vary depending on the application, but are often between 10 and 30 °C. The pressure can be kept constant via expansion tanks. If necessary, treated water is added. In many places, important parameters such as temperature, pressure and flow rate are monitored at machines and other important points.

Closed cooling circuits are comparable to the heating circuit in buildings in terms of the behavior of the materials in relation to the cooling water. Corrosion products form during operation. The water in steel pipes is often greenish or contains black turbidity caused by divalent iron ions. After taking water samples, the color changes on contact with the air. The divalent iron ions oxidize to form brown trivalent and poorly soluble iron compounds.

Corrosion products can impair the function of cooling circuits. As deposits on the heat exchangers, they restrict heat transfer and as plugs they block critical supply lines. Filters are of little help. They reduce the volume flow with the load and are difficult to clean in closed circuits.

Measures

Corrosion cannot be completely avoided in closed cooling circuits, but measures can be taken to significantly reduce the processes. For example, certain treatment substances with a biocidal effect reduce microbiological corrosion. The use of gas-tight materials in components and connections reduces the corrosion rate due to oxygen permeation. Certain plastic parts, rubber seals or rubber hoses should be viewed critically.

As the risk of corrosion cannot be ruled out in practice, cleaning measures are used to maintain and, if necessary, upgrade the cooling water systems. The Comprex® process has proven itself in this application and enables cleaning at fixed intervals, for example during maintenance work on the units or even when required, whereby the necessity and urgency of the cleaning measure can be identified by checking the temperature, pressure and flow rate.

Figure 5: Iron sludge in plastic pipe

Fig. 5: Iron sludge in a plastic pipeline

Figure 6: Manganese sludge in stainless steel piping

Fig. 6: Manganese sludge in a stainless steel pipeline

Figure 7: Iron sludge, discharge from well pipe during Comprex cleaning

Fig. 7: Iron sludge, carried over from a well line, and following separation of flushing water

Figure 8: Mussel shells removed from river water using t h e Comprex® process

Fig. 8: Mussel shells removed from river-water lines using the Comprex® method

Using the Comprex® process, first the main pipes and then the distribution pipes can be cleaned quickly and effectively. Finally, it is also possible to clean the heat exchangers. Coordinated flushing programs are used for these applications. Work instructions are provided if required.

Sampling during flushing provides information on the type and quantity of turbidity and deposits. Further examinations of the samples aim to determine their composition and obtain information on necessary water treatment or remediation measures.

Example 3: Cooling water pipe in open circuit

Problem definition

In contrast to closed cooling circuits, cooling towers in open circuits allow the entry of atmospheric oxygen, dust and other particles. The consequences are corrosion and the proliferation of microorganisms. Finally, deposits and biofilms impair the function of the systems and the emission of microorganisms into the environment.

Measures

As with closed cooling circuits, these processes cannot be completely avoided. Although they can be significantly reduced by treatment measures and controlled by modern analysis methods, e.g. based on bioluminescence [6], cleaning measures are necessary at some point. While the cooling towers are accessible for these measures, the pipes require other cleaning strategies. The Comprex® process offers decisive advantages here. In addition to the mobilization and removal of deposits and biofilms from the supply and return lines to the cooling tower can also clean areas with poor flow, for example at shut-off valves. The air pigs do not get stuck in the pipes. The entrained solids can be collected, the microorganisms from the exhaust air can be retained by filtering and disposed of properly.

Example 4: River water pipe

Problem definition

River water is used for various industrial purposes. It is transported in pipes made of different materials. Over time, substances contained in the river water are deposited in the pipes. These include not only turbidity but also microorganisms and crustaceans. The deposits therefore not only consist of sediments and biofilm, but can also contain mussel shells, for example, which adhere more or less firmly to the inner wall of the pipe. As in many cases the colonization cannot be prevented, cleaning measures must restore the original pipe cross-section.

Measures

The cleaning of river water pipes is an interesting application for the Comprex® process. Typically, sludge-like deposits are removed, but in certain cases mussel shells are also removed. **Figure 8 shows mussel shells** that have been removed from river water pipes using Comprex®.

Depending on the water requirement, river water pipes can have medium to large nominal diameters. Large volumes of air are required for cleaning using impulse flushing technology. The combination of two or three technical units is necessary to provide these air volumes, as shown schematically in Fig. 3.

mated. Synchronizing the technical units makes it possible to generate large air bubbles in the pipe so that large pipes can be cleaned even over long distances.

Compared to other cleaning methods, the simplicity of the Comprex® method is also advantageous here. No openings for cleaning equipment are required. Aeration or venting devices, hydrants or other existing fittings, for example on branches, are sufficient to feed in the compressed air. The flushing technology tried and tested with raw water pipes can also be transferred to river water pipes.

Example 5: Process water pipe

Problem definition

In the industrial sector, pipelines that transport aqueous solutions or suspensions are frequently encountered. The mode of operation is often intermittent, so that substances can settle during the stagnation phases. This situation is comparable to that of pressurized wastewater pipes. Examples include sludge pipes or pipes for contaminated process water. In many cases, these pipes transport the process water for treatment. Deposits lead to a narrowing of the cross-section, the effects of which are described in example 1 above.

Another example of process water lines are pipelines in painting lines. Water-based coating materials are increasingly being used there. Demineralized water (demineralized water) is used as a solvent. A disadvantage of this method is the potential for contamination. Contamination can be significantly reduced using biocides and analyzed using modern analysis methods. z. The possibility of biofilms forming on the inner surfaces of pipes can be controlled, e.g. based on bioluminescence [6], but cannot be completely ruled out. Biofilms form on the inner surfaces of pipes. If they reach a certain size, parts of them can detach and get onto the painted surfaces. The consequences are complaints due to imperfect surface quality.

Measures

For process water pipes, the Comprex® method can be used both for basic cleaning and, more recently, for stationary prophylaxis. In many cases, the process water is used instead of expensive drinking water, similar to the Comprex® cleaning of wastewater pressure pipes with wastewater. If a water treatment or sewage treatment plant is available, cleaning can often be carried out during operation.

Example 6: Fire extinguishing pipes and sprinkler systems

Problem definition

Many fire extinguishing pipes are made of steel pipes and are constantly filled with water. Due to the mode of operation, the water stagnates in the pipes for a long time. This causes deposits to form. They can mobilize in the event of a fire and impair the discharge valves and nozzles. Sprinkler systems or emergency showers in warehouse buildings in particular can lose their function or, in the worst case, fail. It is therefore necessary to regularly maintain fire extinguishing systems and equipment. Although the usual water flushing mobilizes particles that can lead to malfunctions in the event of a fire, this is not only in the fire extinguishing pipe but also in the upstream network. The water remains cloudy for a longer period of time. This effect is also known in drinking water networks when large quantities of water are withdrawn as required.

Measures

The Comprex® process offers significant advantages in the gentle but sustainable cleaning of the fire extinguishing pipe and -systems. Initially, only a small amount of water is required for pulse flushing (Fig. 2). Turbulence and short-term cavitation only mobilize deposits in the pipe section to be flushed and not in the upstream network. The conditions correspond to flow velocities of around 15 m/s. They are therefore much more effective than water flushing at 2 m/s to 3 m/s, limited by the outflow via the flushing hydrant (Fig. 2).

Example 7: Tubular heat exchanger

Problem definition

Tubular heat exchangers are used as reactors in the chemical industry. Certain reactions only take place at several hundred degrees. Steam is used to supply heat, which is directed through the shell tube of the tubular heat exchanger to initiate the reaction of the reaction mixture in the inner tube and allow it to proceed in a controlled manner. Over time, deposits grow on the partition wall between the inner tube and the jacket tube, increasing the heat transfer resistance and thus the energy requirement. The deposits must be reliably removed during regular maintenance work. In the past, this was only possible after dismantling the system components. After cleaning, the parts had to be reassembled with the help of expensive special seals.

Problem solution

Cleaning using the Comprex® process only requires adapter connections at the inlet and outlet of the heat exchanger. As shown in Figure 4, it is advantageous to flush in and against the flow direction with coordinated flushing programs. In some cases, heat exchangers connected in series can be cleaned together. If the heat exchangers are designed for high pressures, it is possible to use the water pressure specified by the existing network to intensify the cleaning with correspondingly increased compressed air. There is now also experience of using solid injection to increase the cleaning work.

Example 8: Spiral heat exchanger

Problem definition

Spiral heat exchangers are often used in industry as coolers. Well or river water, for example, is used to dissipate heat. These cooling waters deposit deposits on the surface of the heat exchanger. In the case of well water, these are iron or manganese sludges. In the case of river water, layers of turbidity and biofilm form. Previously, the deposits were mainly removed using chemical cleaning agents. The contaminated rinsing water had to be disposed of properly.

Problem solution

Cleaning using the Comprex® process is characterized by the fact that it removes the deposits in a short time without the need for additional aids. The rinsing water can be disposed of via the sewer after the removed solids have settled in decanting tanks or containers. The deposited solids are of natural origin and therefore easy to dispose of.

In many cases, it is possible to clean the spiral heat exchangers together with the supply and return lines (see example 2). This is another advantage of Comprex® cleaning. As air pigs adapt to the nominal diameter of the pipes and heat exchangers, even in complex systems several spiral heat exchangers can be flushed one after the other by controlling the shut-off valves without loosening the connections.

Example 9: Plate heat exchanger

Problem definition

Plate heat exchangers are often used in industry in either welded or bolted form. They are usually designed for low pressures. Various processes have been used for cleaning used for cleaning. Chemical cleaning agents are normally used. In the bolted form, the partition walls can be dismantled and sometimes cleaned with high pressure. If refrigerants such as ammonia are used in plate coolers, the corresponding chambers must be dry after cleaning, which in turn means extra work.

Problem solution

The Comprex® process can also work at low pressures [7]. It is important to take precautions to ensure that the pressure permitted in the heat exchanger is not exceeded. The flushing program must be adapted accordingly. It has been shown in many cases that deposits can be effectively removed from well and river water.

Conclusion

The Comprex® process has already proven itself in many industrial sectors. The advantages of the process are its simplicity, design and high cleaning efficiency. The process can be used to clean pressurized systems in practically all nominal sizes. Foreign matter that impairs the function of the pipes is mobilized and removed. The pipelines are restored to their original hydraulic design. Extended pumping times or increased energy requirements due to cross-section constrictions are eliminated. This also makes cleaning worthwhile.

Comprex® cleaning can be combined with other work such as maintenance work on shut-off valves and hydrants. Cleaning fire extinguishing pipes increases safety in the event of a fire. Cleaned cooling water pipes to cooling towers contribute to lower emissions. These examples show the safety-relevant aspect of regular cleaning, which can be achieved easily and effectively with the process.

The process has also proven itself in the cleaning of heat exchangers. Compared to other methods, it is characterized above all by its simple handling and effective cleaning. Only inlets and outlets are required for flushing. These can be advantageously connected to a distributor station so that flushing can be carried out in and against the direction of flow. There is no need for time-consuming loosening and reconnecting of other connections. Ideally, the heat exchanger is equipped with T-pieces, for example, to feed in the flushing air and drain the flushing water for disposal. This reduces system downtimes. In some cases cleaning can even be carried out during operation.

Comprex® cleaning is normally carried out as a service. The system operator only needs to plan the cleaning work, e.g. make the feed-in and feed-out openings accessible, provide a supply of fresh water and disposal options for rinsing water, provide safety instructions. The service provider takes on other tasks in addition to cleaning. If necessary, the service provider prepares special work instructions, documents the work and points out special features. The service provider provides trained personnel and maintained equipment, thus relieving the system operator.

Only water and air are used for cleaning. If necessary, the use of solids, e.g. pieces of ice, can reinforce the mechanical cleaning work. This enables simple rinse water preparation by decantation. In some cases, the sediment can be reused.

Comprex® cleaning can be scheduled for system maintenance. It can be cyclical,

In the case of pipes, this is caused by longer pumping times and reduced pump efficiency; in the case of heat exchangers, it is caused by increased heat transfer resistance.

Recently, Comprex® technology has also been installed in stationary systems. This enables regular cleaning at the desired intervals. The units can be operated both manually and automatically. In automatic operation, the cleaning step is triggered by the above-mentioned control parameters.

The advantages of Comprex® cleaning are:

- Short cleaning times, short system downtimes
- Discharge of mobilizable substances of various sizes even at low pressure
- Efficient cleaning without chemicals and low water consumption
- Optimal preparation before chemical treatment measures such as disinfection

i.e. according to certain fixed intervals or demand-oriented, i.e. over a period of time. control of parameters. Control parameters are, for example, pressure, temperature or energy requirements. While the pipe characteristic curve (pressure/volume flow) is of interest for pipes, the heat transfer plays the decisive role for heat exchangers. Increasing energy requirements in all

- Easy processing of the deposited materials and reuse if necessary
- Service provided by trained staff and maintained equipment
- Stationary systems possible in certain cases
- Cost-effective contribution to the safe operation of the systems

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