New Developments in Tube Pre-treatment Plants

By D.I. Fritz Nerat, Sales & Project Director, and
D.I. Jörg Papak, Process Engineer, Körner GmbH

1. Introduction

The surface treatment of tubes is necessary for many products, and the type of pre-treatment technology can vary, depending on the different materials used (carbon steel, stainless steel, non-ferrous, etc). However there are many common aspects shared by the technical equipment used in this technology for metal pickling processes.

Due to the use of chemicals – which are more or less aggressive – the demands on the materials applied in plant design are high. The resistance to chemical as well as mechanical attacks should be optimised, and in order to reduce operational cost it is necessary to also minimise maintenance costs.

A further vital aspect to consider in the design of pre-treatment lines is the role of environmental regulations, which will become more stringent in the future.

The following solutions will explain how pre-treatment lines are executed today, in order to meet the requirements of the market and the environmental regulations. The new concept of encapsulated pre-treatment plants, according to the 'KVK-System' from Körner KVK, will also be introduced. With this system, Körner aim to target a number of benefits including increased productivity, improved quality, reduction of personnel costs (through automation), material optimisation, increased bath service-life, and reduction of waste-disposal and maintenance costs.

2. Different Materials Requires Different Pre-Treatment

The following will present an overview of different pre-treatment requirements, depending on the materials and the final use of the tubes.

2.1. Galvanised Tubes

Such plants need a special type of technical equipment, especially for the process of galvanizing. The pre-treatment of the tubes is done by degreasing (in most plants), pickling and fluxing. The pickling chemicals, that are used are mainly HCl or H_2SO_4. In most of the plants the pre-treatment line is a traditional open system: mostly without any, or with poor, measures for environmental protection.

2.2. Carbon Tubes

Tubes that are manufactured according to DIN 2391 or DIN 2393 require chemical pre-treatment prior to cold drawing. Pickling is only one step of the pre-treatment, which normally consists of degreasing, pickling, and phosphating soap. The pickling chemicals are mainly H_2SO_4, but some plants use also HCl. Temperatures can vary and depend on the pickling chemicals (H_2SO_4 at approx 70°C and HCl between 30 and 50°C), but also on the special know how of the companies.

Plants for these products are designed as either traditional (without fume extraction) or with lateral fume extraction on the pre-treatment tanks, which are operated at high temperatures and/or with aggressive chemicals.

Only few plants are designed fully encapsulated (as for example Forster in Switzerland, or TAP – Tubos de Acero de Precision in Spain).

2.3. Stainless Steel Tubes

Pickling of stainless steel tubes requires very aggressive chemicals. A mixture of a 2 or 3 component acid is used in most of the companies. Pre-treatment plants for stainless steel are equipped with fume extraction equipment as well as different types of purification systems.

In some plants the tanks are equipped with covers in order to reduce the vapours. In addition, pickling processes according to the autoclave system are used in some companies.

2.4. Non Ferrous Metals

These kind of pickling lines are sometimes very special and consist of a few tanks only. The plants for titanium tube pickling are similar to stainless steel pickling lines, whereas pickling equipment for zirconium tubes is highly specialised and not used in other industries.

3. Types of Pickling Plants

The description below focuses only on the technical key equipment of pre-treatment plants. The main difference between the types of plants is the reduction procedure of vapours and the way that the fume purification is undertaken. Other external equipment that can be used in any type of plant (by pipe connection to the tanks), such as filters and deionisers are not considered here.

3.1. Standard Type

This type of plant had been installed for decades and some of the plants are still in use without big changes. The different pre-treatment tanks are standing in a building and are not equipped with any fume extraction equipment.

The disadvantages for this type of plant are obvious. The vapours and aggressive fumes will evaporate from the liquid surface and be distributed within the building. Steel structures and electrical equipment will be attacked and destroyed, resulting in high maintenance costs.

3.2. Autoclave Systems

The main target for optimising the pre-treatment section is to reduce the amount of vapours and aggressive fumes, which cause destruction of equipment (cranes, building, stored material, etc).

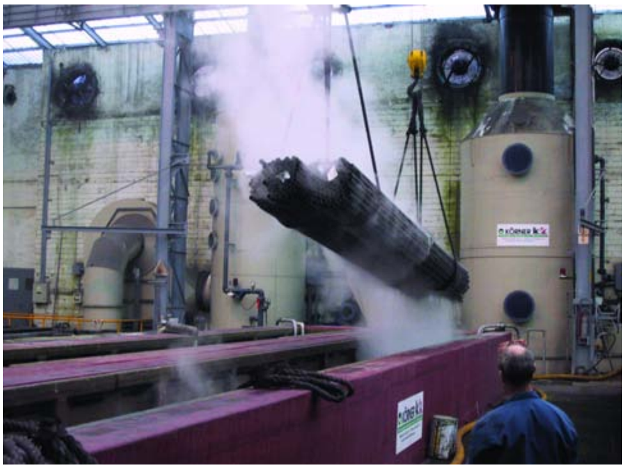
One option, which is utilised in some plants, is to use only one pre-treatment tank, where the different processes (pickling, rinsing, etc.) are carried out by pumping the chemical from storage tanks to the operating tank and vice versa. These autoclave systems are equipped with covers for the tanks and with fume extraction systems.

3.3. Plants with Lateral Fume Extraction

The most common way for reduction of fumes and vapours is to install fume extraction channels along the tanks. In principle there are two different types of fume extraction systems: extraction on both lateral sides or a 'push and pull' system, where only the air is extracted on one side. On the opposite side there is a blowing pipe, which creates an air curtain above the liquid surface.

The latter method needs approximately 20 per cent less extraction volume. If these systems are designed properly, they can catch most of the fumes while the material is immersed, or without the material. When the tube bundles are lifted after finishing the pickling process, a huge surface – which is wetted with chemicals – is exposed to the atmosphere. In this position, no lateral fume extraction system can catch the emissions coming from the tube bundle. The surface of the tube bundles is more than twice as large as the liquid surface of the pre-treatment tanks.

Picture 1: *Pre-treatment tank with lateral fume extraction channels: fumes are caught, when tubes are immersed*



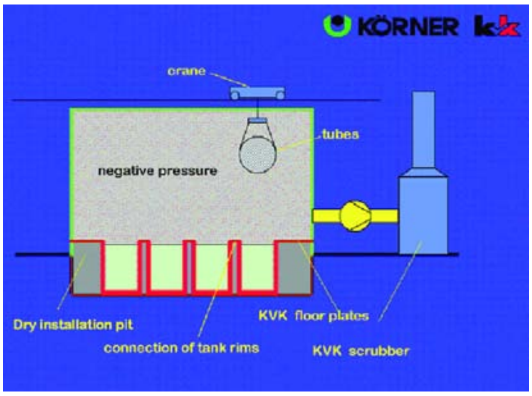
Picture 2: *When tubes are lifted, lateral fume extraction channels cannot catch aggressive fumes*

The required extraction volume is rather high and cannot avoid the scenario where aggressive fumes can attack other equipment and the building. For most pickling chemicals it is necessary to clean the extracted air. The size of the purification systems (scrubbers in most cases) depends mainly on the volume of decontaminated air.

3.4. 'KVK System': Fully Encapsulated Pre-Treatment

Encapsulated pre-treatment plants are a rather new technology for tube pickling plants. The main advantages of this system include no corrosion at the building and on equipment around the pre-treatment area (cranes etc), space-saving (reduces building costs), high environmental standards, low maintenance costs, perfect working conditions for operators, high quality and economic viability.

3.4.1. Basics of the 'KVK System'



Picture 3: *Schematic illustration of the 'KVK-system'*

3.4.1.1.KVK Tanks

The tanks used today are all free-standing and are installed in so-called installation pits (concrete troughs), which collect the chemicals in the event of a tank leak (caused by mechanical damage from falling parts). This prevents any chemicals from escaping into the ground water.

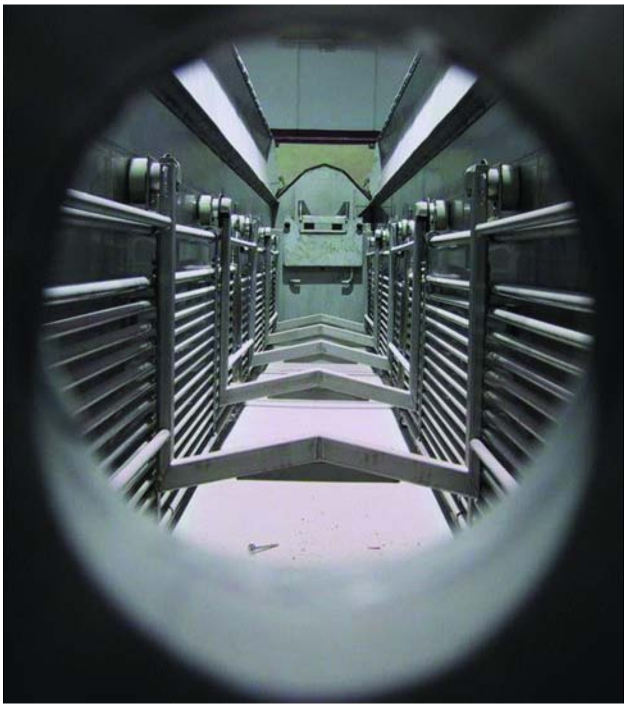
The working tanks are sturdy KVK tanks, specially designed for the tough operating conditions in pre-treatment plants. The tanks are placed close to each other in order to minimise the required space for pickling tanks.

It should be considered that it is a big advantage if the tanks can be repaired in the operating position (that is without moving the tank) in case of damages. The tanks can be equipped with additional parts, such as jig supports for exact positioning of jigs on the tanks, or tube bundle separators.

3.4.1.2. Enclosed Pre-Treatment

The greatest problem with respect to the generation of emissions is the 'steaming off' of the acid when the material is taken out of the bath. As mentioned above, channels for lateral fume extraction cannot solve this effect. The only way to solve this problem properly is to encapsulate the whole pre-treatment area.

The pre-treatment is enclosed using KVK panels. These panels are mounted on a steel or wooden substructure and coated on the working side with glass-fibre reinforced plastic to create a diffusion-tight, chemical-resistant shell isolated from the other production areas.



Picture 4: *Pickling tank with tube bundle separator and lateral heating elements*

Since the cranes are running outside the encapsulated area, the ropes or chains enter the encapsulated room through slots in the ceiling of the enclosure. These slots must be sealed tightly in order to keep the fumes inside.

Picture 5: *Encapsulated pickling area: only chains or ropes are exposed to aggressive air and crane units are running outside*

3.4.1.3. Dry Installation Pit

In the 'KVK System', the tanks are placed sidewall to sidewall, making optimum use of the space available. These sidewalls are glued together. This also ensures that spilt chemicals cannot drip between the tank walls into the installation pit.

The areas alongside the tanks are fitted with walkways made of acid-resistant, non-slip KVK floor panels. The panels are mounted at the height of the upper edge of the tank and slope inwards to the tank chamber. This ensures that any liquid drips will flow immediately back into the correct tank, thus saving a considerable amount of chemicals.

This arrangement of maintenance access panels divides the pre-treatment unit into two completely independent areas. The upper part (emission area, wet area) contains the aggressive fumes resulting from the high solution temperatures. However, these fumes are prevented from escaping from the enclosed pre-treatment unit and from entering the floor area (cellar), since the KVK casing panels and the KVK maintenance access panels form a diffusion-tight shell.

Since no chemicals or aggressive fumes enter the cellar part, the latter can be referred to as dry installation pit. This division of the pre-treatment unit into a wet emission area and a dry floor area can be exploited in order to locate any sensitive parts requiring protection against corrosion at places where they do not come into contact with the aggressive atmosphere. The dry cellar contains all the automatic valves, pumps, electronic components such as transmitters, and measuring sensors etc *(see picture 6)*.

Picture 6: *Dry cellar: no aggressive fumes attack the sensitive equipment*

3.4.1.4. Fume Extraction System

The heating of the pickling liquid creates fumes in the emission area. However, these fumes cannot escape due to the enclosed design of the pre-treatment unit. It is absolutely necessary to create a negative pressure atmosphere inside the enclosure to guarantee that no fumes will escape from the pickling area.

In the Körner system, these fumes are continuously extracted through an extraction channel and fed to a scrubber unit for purification.

The exhaust system is calculated specifically for each pre-treatment unit, since the complex interplay of casing volume, air-lock gate opening, arrangement of exhaust air lines, and the size and temperature of the bath surface make a simple design impossible.

A big difference between lateral extraction and extraction of encapsulated systems is, that the volume to be extracted is much less in encapsulated system.

For a complete pre-treatment line one needs to extract approximately only that volume, that would be necessary to extract two single tanks in open systems. This ensures the size of the scrubber can be reduced.

3.4.2. Criteria in Designing Encapsulated Pickling Systems

The principle of the 'KVK system'is very simple, but it might be very dangerous to install an encapsulated pickling line without knowing the criteria in the design and calculation. To design a modern system properly it was necessary to develop several calculation tools, which cannot be purchased on the market.

Special knowledge and the possibility to compare the theoretical results with measurements in real plants, has enabled Körner to adapt the software modules. It is essential to calculate the complex interactions very closely in encapsulated plants compared to the real situation at the very beginning of the design of a project.

The interfering aspects that must be considered in any project design are multi-faceted. The concentration of fumes inside the pickling area is vital: it is necessary to design the scrubber in the correct way and several parameters are influencing this figure.

It is essential to avoid fog inside the enclosure, and the climatic conditions need to be considered very carefully.

It must be guaranteed that no fumes are escaping and a critical time in this aspect is when the doors are opened. Due to thermal gradients and inhomogeneous flow conditions inside the enclosure, complex flow calculation programs are required. Several patented inventions are incorporated in the design of modern encapsulated plants.

4. Transport Logistics

For the design of modern plants it is necessary not only to consider new technical and technological aspects, but at least as important is the optimum material logistic.

4.1. Analysis of the Basic Data

A profile on required standards as well as technological issues needs to be developed. It is helpful if the supplier of the chemical process is also involved in this discussion. The planned quantities of material, procedural steps and timelines have to be described systematically.

The next step is to analyse this fundamental data and integrate it into a new design. The initial step in this action plan is to prepare a grouping from the materials mixture of the product that is to be created, allowing the various products to be condensed into a similar sequence of procedures. The outcome of this analysis defines various process groups for which the operating sequence of chemical treatment is similar.

These procedural sequences must then be structured for the respective material grouping so that, on the one hand, a uniform direction in production – without bottlenecks – can be guaranteed, and on the other hand, an optimum arrangement for incorporating automatic transport systems can be found.

The result of these findings is the optimum configuration of process baths with respect to (minimum) conversion times and (optimum) turn-around times.

Experiences were integrated along into this new design after visiting several facilities of reference. The final and individually customised design is realised on the basis of these findings and experiences from both the supplier and the customer.

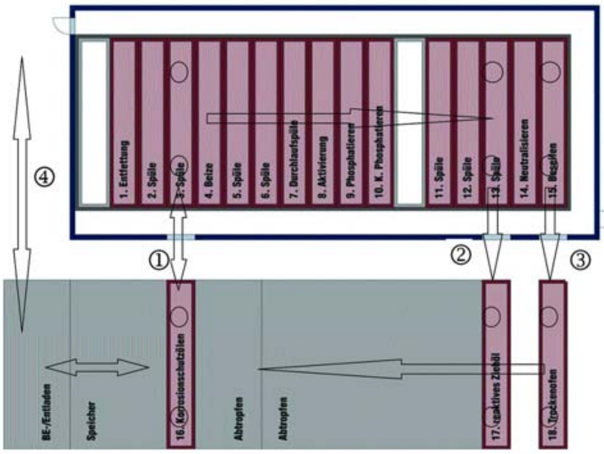
4.2. Material Flow in Encapsulated Systems

In principle there are two different possibilities for encapsulated systems to enter and to leave the pre-treatment area: crosswise or lengthwise.

4.2.1. Lengthwise Logistic

An example for material flow is outlined in a schematic drawing *picture 7*. Bundles of tubing are transported by a conveyor system to the loading and drop-off stations. The bundles are attached to carrier support beams secured with a harness strap. These carrier support beams sit on specially prepared pick-up points and can be operated fully-automatically by the transport system.

In principle, chemical pre-treatment is divided into two areas. Most of the processing baths are located within the encapsulated pre-treatment area, which is fed through an access gate 1 or through exit gates 1, 2, or 3 *(picture 7).*



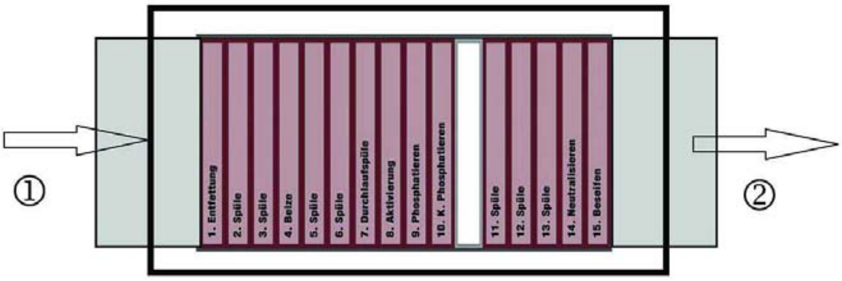
Picture 7: *Length transport logistics*

Picture 8: *Encapsulated plant with lateral material access*

The second part of pre-treatment essentially consists of oil baths, storage and dripping stations and is set-up outside of the encapsulated system. A drier is also located in this area. It is possible to bring in the material either by shuttles or with monorails, where turntables change the direction of transport.

4.2.2. Crosswise Transportation Logistic

In this system the tube bundles are taken over to hand over positions outside the pre-treatment area. A hand over system



***Picture 9**: Principle of crosswise plant logistic*

***Picture 10**: Crosswise plant in real operation*

(mainly chain conveyors) moves the material into a position where the transport unit, that works for the pre-treatment, can take them over.

The transport units used for the pre-treatment are running outside and thus not exposed to aggressive fumes at any time. After the final step of pre-treatment, the material is passed over to the exit hand over unit, which moves the material outside *(see this principle in picture 9)*.

4.2.3. Control System: Manual or Automatic

Encapsulated pre-treatment lines can be operated manually, as well as automatically. For automatic systems, the carrier support beams are transported from the loading and drop-off points to the storage positions. The transport technology will then take them from these positions as specified by the downstream processing control system, and lead them through a sliding door into the encapsulated pre-treatment area.

Material identification, as well as individual processing sequences, are defined at the beginning of the operational procedures and sent over to the respective transport unit via a process control system.

This process control system optimises the operating sequence for the chemical pre-treatment, in order to ensure optimum turn-around for various products.

Körner KVK has developed a system where standard overhead cranes can be used for the encapsulated pre-treatment. For this new development it is possible that the bridge cranes are running outside the pre-treatment area and never exposed to aggressive fumes.

If a plant should start with manual operation the savings for the initial investment can be significant, particularly if standard cranes can be used. This system enables the customers to obtain full advantage of an encapsulated pre-treatment plant, while future modification to an automatic system is possible.

5. Summary

The ever-increasing pressure of competition must be met by new ideas for system techniques and technologies. In order to reduce production costs, every stage in the production process must be optimised and all system components optimally adjusted to each other.

There are many different options to reduce problematic fumes in pre-treatment lines. Since lateral fume extraction systems on pre-treatment tanks cannot be avoided, and aggressive fumes attack buildings and equipment, further fully encapsulated systems used in pre-treatment plants need to be the design for the future.

If the plant is designed based on specific know how, there are a lot of advantages compared to other systems. By fully isolating the pre-treatment from other production areas, it is possible to operate the baths at high temperatures without corrosion in the rest of the production area.

In addition, space-saving (thus reducing building costs) is possible, while enclosing the pre-treatment unit and extraction of the emission area (permanent partial vacuum) provides the technical precondition for the use of modern automated transport systems, thus increasing the degree of automation.

These systems can be operated manually or fully automatic, which reduces labour costs and as far as possible eliminates the human factor as a source of errors. Enclosure prevents the escape of aggressive fumes from the pre-treatment unit, thus preventing corrosion on crane equipment and buildings.

The design of the encapsulated systems requires substantial special, technological knowledge in process engineering as well as thermodynamics and fluid dynamics. Consequently, the encapsulated pickling plant according to the 'KVK-System' is operational in more than 20 plants all over the world.

Körner Chemieanlagenbau GmbH
Am Bahnhof 26, A-8551 Wies, Austria
Fax: +43 3465 2118
E-mail: office@kvk-koerner.at
Website: www.kvk-koerner.at