Tube International

January/February 2001

The journal for metal tube and pipe production and processing

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Körner builds fully automatic **encapsulated pickling plant** for Hermann Forster AG Stahlrohrtechnik

D.I. Friedrich Nerat studied mechanical engineering from 1983 to 1990 at the University of Technology, Graz. His thesis was on the modernisation of machine tools (from conventional methods to CNC technology) and he has written numerous publications on this topic. After leaving university, he was project manager at Maschinenfabrik Andritz in Graz, specialists in plant construction and paper making machines, until 1994, when he joined Körner Chemieanlagenbau GmbH in Wies, Austria. Since 1996, he has been head of the sales and project management departments, with special responsibility for automatic enclosed pickling plants.

For more than 25 years Körner (KVK) Chemieanlagenbau has been working actively in the metal pickling plant industry. Initially, robust pickling tanks were almost exclusively manufactured for pickling individual product, but over the past 10 years the Körner company has evolved from a tank manufacturer to a systems developer.

For many years KVK tanks have been successfully used in pretreatment plants by the hot-dip galvanizing industry and have also put their high quality to the test at pipe pickling plants the past few years. The evolution from tank manufacturer to systems developer goes hand in hand with the increasing demand for tank designs as per the customer's specifications, or ancillary requests regarding their facilities. Körner plants are designed in cooperation with the customer in conjunction with their specific needs.

Preliminary stage of the project

In initiating a recent joint project for Forster Stahlrohrtechnik, a company in the Arbonia-Forster-Group, to build a fully automatic, encapsulated pickling plant, this situation also came about in much the same manner. Initial contacts were already made in 1995 when modernising a pickling plant was under consideration.

Immediate concerns were based on local separation of tubing production and the pickling plant. A distance of about 3 km caused major logistical problems: the plant had already been in operation for a few decades and the applied technology was no longer in compliance with state-of-the-art technology and environmental standards. A profile on required standards as well as technological issues was worked out in intensive project talks where layout designs based on traditional facilities were presented. Project engineers from Forster Stahlrohrtechnik and Körner Chemieanlagenbau together have analysed the basic concept of the future plant.

Forster Stahlrohrtechnik outlined the original situation in very detailed reports in which the planned quantities of material, procedural steps and timelines were systematically described. As a next step, it was essential to analyse this fundamental data and integrate it into a new design. The first step in this action plan was to prepare a grouping from the materials mixture of product that is to be produced, allowing the various products to be condensed into a similarly categorical sequence of procedures. The outcome of this analysis was various process groups, for which the chemical treatment operating sequence was similar each time.

The next step was to structure these procedural sequences for the respective material grouping so that on the one hand a uniform direction in production without bottlenecks could be guaranteed, and on the other, an optimum arrangement for incorporating automatic transport systems could be found.

Result of these findings

The result of these findings was to arrange process baths in such a way as to ensure that the shortest conversion times would be met and that the chemical process in pretreatment could be optimised in terms of turn-around times.

This fundamental data was then incorporated into the Körner design and the final system design was coordinated with Forster Stahlrohrtechnik after intensive project workshops.

Experiences were integrated into this new design after visiting several facilities for reference. The final design was realised on the basis of these findings and experiences from both Körner and Forster Stahlrohrtechnik.

The final design was determined after specifying the interfaces to other industries, such as neutralising plants or prepara-

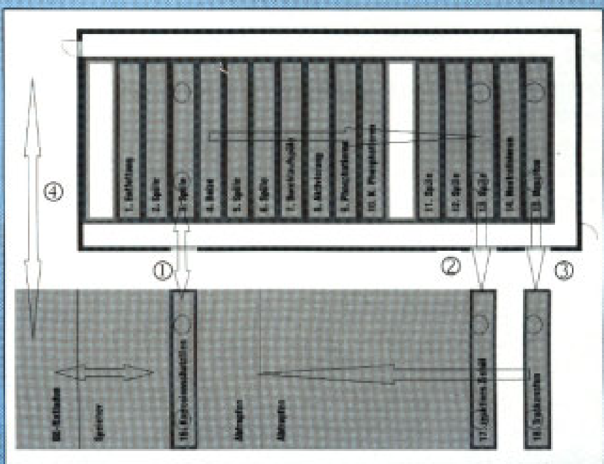

Figure 1. Explanation of code: 1 - access and exit gate; 2 - exit gate; 3 - exit gate; 4 - conveyor from and to tube stock

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Figure 2. Encapsulated pickling area

tion facilities for chemical processing. The flow of materials is outlined in a schematic drawing in Figure 1. Bundles of tubing are transported by a conveyor system to the loading and drop-off stations. Bundles of pipe measuring up to 800 mm in diameter are attached to jigs secured with a harness strap. These jigs sit on specially prepared pick-up points and can be operated fully-automatically by the transport system.

Material identification as well as processing sequences are defined at the beginning of the operational procedures and sent over to the respective transport unit by means of a process control system. This process control system optimises the operating sequence for chemical pretreatment in order to ensure optimal turn-around for various products as well.

Chemical pretreatment is divided into two areas. Area 1 (where most of the processing baths are arranged) is located in the encapsulated pretreatment area which is fed through an access gate 1 or through exit gates 1, 2, or 3 (Figure2).

The second part of pretreatment essentially consists of oil baths, storage and dripping stations and is set up outside the encapsulated system. A dryer is also located in this area.

After the carrier support beams were automatically transported from the loading and drop-off points to the storage positions, transport technology will then take them from there as specified by the downstream processing control system and lead them through a sliding door into the encapsulated pretreatment area. The advantages of the longitudinal and transverse movement of the bundle of pipes are made best use of in this set-up. In opening gate 1, the smallest possible surface in the casing is opened up and no emissions can escape.

Individual processing steps are processed in the pretreatment which were specified in the processing control system. The jigs with the bundles of tubing can either be laid down in the pretreatment baths (processing times longer than five minutes) or remain hanging in the transport units (for shorter processing times, eg rinsing). The bundles of tubing are automatically set on a cycle corresponding to the specific process through the processing baths and are taken out of the encapsulated pretreatment fully-automatically either through gate No. 2 or No. 3. After that, the drying, oiling or dripping processing steps are started-up fully-automatically. Then the jigs return through the storage area to the loading and drop-off points.

The reason for installing three gates in the pretreatment area is that the various processes can be run in the optimum amount of time. For product that only needs degreasing, the tubing bundles are taken in and out through Gate 1.

Product that needs to go through the last processing step of phosphatising is taken out through Gate No. 2. This design is crucial for optimising turn-around time.

Description of parts of the plant

Pretreatment tanks (15 units) are set up end to end along the wall in an installation pit. A protective KVK coating was applied to the installation pit in order to be in compliance with all governmental regulations with respect to the protection of ground water. This plant is situated near Lake Constance where a great deal of attention is given to protecting the quality of ground water. The tanks are constructed in various material variants depending on the chemical process and the temperature and have all the required connection flanges in order to ensure optimum chemical handling on the one hand and optimum processing on the other.

The bottom of the tank is built with a gravity slope. The phosphatising tanks were manufactured in a special shape, particularly taking into consideration the accumulation of solid waste. All the tanks are installed in this installation pit on a 500 mm high base so that the catwalks are high enough to walk around the tanks (also see later in maintenance catwalks).

In order to prevent mishandling at the contact points between the pipes, the tubing bundles are separated by a so-called bundle separator as they are immersed into the respective processing baths. Bundle seperators were developed especially for this project, ensuring that only like modules are used so that storing spare parts is not problematic. The bundle seperators are simply hoisted out of the tanks and are able to be interchanged very easily.

The degreasing bath and the greasing bath, which run at temperatures up to 95°C, were also fitted with hoods that are opened or closed via the central control. Advantages of these hoods are that savings on energy and an optimised air circulation. All of the tanks are equipped with jig supports which facilitate the jigs in moving to the exactly defined positions, thereby making it possible to automatically lift and lower the product carrier with the bundle of pipe.

Chemical processing can be operated at temperatures up to 95°C. A heat exchanger, integrated in the tanks, heats the baths. The transfer of heat is done indirectly. Super-heated water at an inlet temperature of 120°C is used as a heating medium. The central processing control system

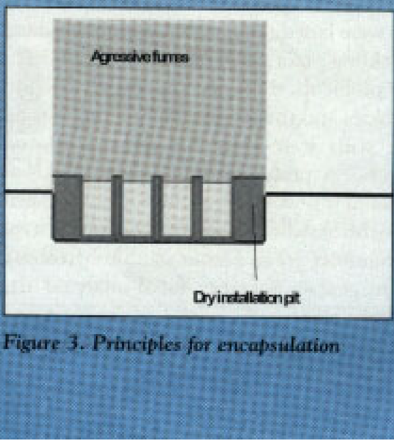

Figure 3. Principles for encapsulation

monitors the temperature as well as the specifications for the holding temperature. The heating elements are mounted in such a way that they are also protected against mechanical load by the pipe bundles. All of the pretreatment baths are set up end to end along the wall and are connected in the transfer areas.

KVK floor panels have been installed around the upper edge of the tanks: they are fastened to the tanks at one end and to the enclosure panels on the other end. The encapsulated area has been subdivided into an emissions area and into a dry cellar as a result of this installation (see Figure 3).

As stated above, the entire pretreatment area is completely closed off by KVK panels from the rest of the processing area in the plant. KVK enclosure is made up of 40 mm thick styrofoam structural sandwich panels furnished with an additional fibre-glass-reinforced plastic laminate on the side (inside panel) facing the aggressive fumes.

An optimum seal is one of the essential requirements for the encapsulation to prevent emissions from escaping. A fully-automatic, pneumatically-operated sliding door, guaranteeing short opening and closing times, takes the bundle of pipes in and out of the enclosure.

Fume extraction system

It is necessary to create a partial vacuum in the encapsulation in order to prevent emissions from escaping. This partial vacuum is guaranteed by using an extraction system that continuously discharges a certain amount of exhaust air. A pressure differential control system regulates the amount of exhaust air, thereby ensuring that emissions cannot leak out into the immediate environment when the sliding doors are open. The pressure differential control system makes an essential contribution to optimising energy on the exhaust air design. A massive amount of exhaust air must be extracted only when the sliding doors are open.

Once the gates are closed again, the amount of exhaust air can be reduced. If one takes into consideration that a reduction in the amount of exhaust air from 100% to 60% reduces power consumption from 100% to roughly 20%, then one will recognise the cost-effectiveness of this design very quickly.

Air circulation in this encapsulated system was incorporated according to one of Körner's patented designs. A great deal of attention is given to a minimal formation of mist at processing temperatures in the given range.

The air extracted from the enclosure, which shows a high level of energy, is driven back over a waste heat recovery facility before it is released into the environment. This air-to-air cross flow – glass tubing heat exchanger also comes with a fan that is interlocked electrically to the exhaust fan. This means that the quantities of air are automatically coordinated to each other: once the amount of exhaust air is reduced by the exhaust air facility, the flow through the heat exchanger is also reduced.

In taking this action, the exhaust air will cool off by at least 5°C. Conduits for the facility were laid based on jointly prepared flow charts. Solution preparing tanks were equipped with agitators for various chemicals from which the prepared chemicals are fed directly into the processing baths (see Figure 4). In-feeds and over-flows were realised for rinsing tanks which are partly done in a cascade fashion.

Safety monitoring and interlocks with level controls in the neutralisation facility were merged together. Monitoring the level of fluid in the processing baths is done by using capacitive level sensors, rendering analogue values, and being able to visually display the level either in cm or in mm.

Outside the enclosure are two oil baths and a dryer. The dryer was constructed in a new type of design that is operated at a lower operating temperature and includes a dehumidifier as well. The dryer is only set into operation whenever a signal is given per the process control system that a bundle of piping is to be cured. The time required for starting the process is specified per the control system so that the material can be dried immediately after being put into the dryer.

The entire plant operates fully automatically and is controlled by two independent control systems that are nonetheless connected to each other.

One processing control system controls the transport technology. At this point, chemical processing parameters are set-up for individual material groups and are processed fully automatically after being defined at the start of the pretreatment process. Parameters (dwell time, dipping speed, extraction speed, skew angle, etc) can be selected freely. This downstream processing control system analyses the production steps and optimises the entire sequence based on this process.

This program is interconnected to a second program by defined interfaces. The second program fully automatically monitors the chemical process and the chemical parameters.

The sliding doors as well as the hoods of the pretreatment tanks and the curing furnace are automatically opened and closed. A module is integrated in the control system ensuring that vapors found between the surface of the liquid and the hood can be appreciably discharged before opening the hood.

A special drying program was integrated out of economical considerations since the complete line of products cannot be run through the dryer.

The dryer is set into operation using a specific lead time so that the material, when it reaches the curing furnace, can be dried immediately. This information is passed on from the

Figure 4. Chemical preparation area

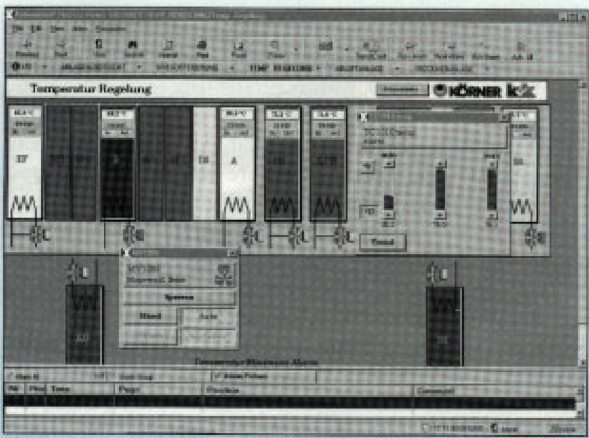

Figure 5. Temperature control system

processing control system of the transport system to the control system for pretreatment. The fume exhaust facility, being the core unit in the encapsulated system, is controlled by a pressure difference controller. The vacuum regulator guarantees that no emissions of any kind can be released from the encapsulated casing and that a high economical efficiency can be met. The fume exhaust facility only extracts a large volume whenever the access gates are open. For the remainder of the time, it is run at a relatively reduced exhaust capacity.

All of the essential parameters in the chemical process are monitored by the central control system and can be programmed there.

The fully-automatic level control system ensures that all tanks are run at the equivalent level and monitors the rinsing processes by flow meters. Monitoring elements between pretreatment and neutralisation in the respective control systems were merged together.

Processing temperatures are monitored and specified by the central temperature control system. They can be freely predefined by a central computer (see Figure 5). All of the parameters are stored via the timeline and can be archived at a later point in time in a computer file. There are also interfaces using ERP Software (Enterprise-Resource Planning) used by Forster Stahlrohrtechnik.

Summary

Forster Stahlrohrtechnik and Körner KVK Chemieanlagenbau have jointly developed a design for a new steel tubing pickling plant. This design is made-to-measure for the line of product by Forster Stahlrohrtechnik and was developed through numerous technical meetings. The central point of this new design is an encapsulated pretreatment facility that ensures that emissions originating from the chemical process or from heating cannot be released into other production areas. In doing so, it may be possible to set-up a warehousing area directly adjoining the pickling plant, in turn, assuring optimum logistical accessibility to the pickling plant.

As no corrosive vapors of any kind appear outside of the casing, it is possible to use a fully-automatic transport system with which all the sequences can be predefined by the input parameters. The tanks were constructed as per specification (chemicals and temperature) in various designs.

A heat exchanger incorporated directly in the tanks heats the baths (superheated water at 120°C is the heating medium). Some of the tanks have a hood in the casing, guaranteeing substantial savings in power and preventing excessive flashing in the baths. The bundles of pipes are loaded onto the bundle seperators in order to prevent defects on the contact points between the pipes. The bundle seperators are designed as modules so that the same module can be used for the entire plant (optimum storage of replacement parts).

The fume extraction facility and its air circulation were realised from a patented design developed especially for high temperature pickling plants. Chemicals are supplied exclusively through a piping system. The central processing control system monitors and controls the complete chemical process. This design excels in a high degree of automation as well as in optimising the whole process. This fully-automated, encapsulated pickling plant was customed designed and developed for Forster Stahlrohrtechnik according to the Körner system and will show the way for pickling technology into the steel tubing industry's future (see Figure 6).

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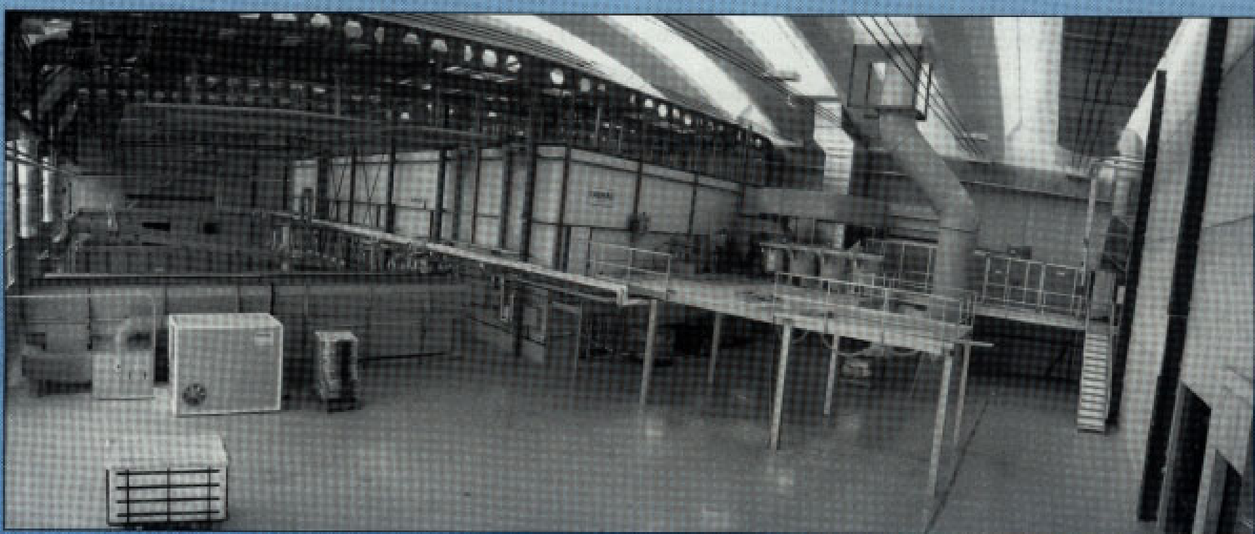

Figure 6. Overall view of the KVK pickling system