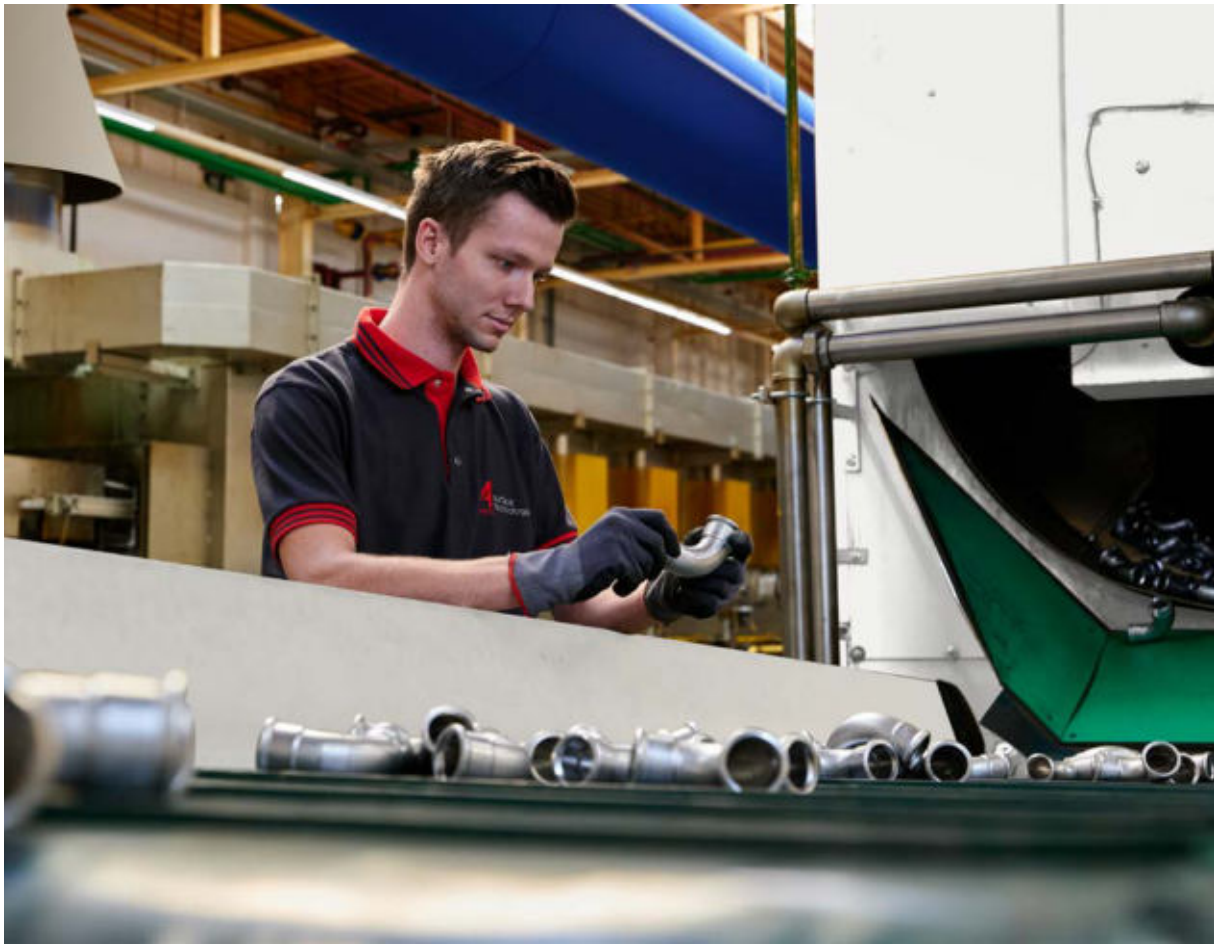
aalberts surface technologies

Annealing and brazing in continuous furnaces

whitepaper

INTRODUCTION

In this white paper we will be discussing the annealing techniques used by Aalberts Surface Technologies Venlo on products from a variety of industries. We explain the options and advantages of performing thermal processes in continuous furnaces. From order intake to final delivery, all aspects within the procesflow will be illustrated. We will also be providing a unique look at how Aalberts Surface Technologies Venlo and Aalberts Integrated Piping Systems work together in manufacturing VSH products.



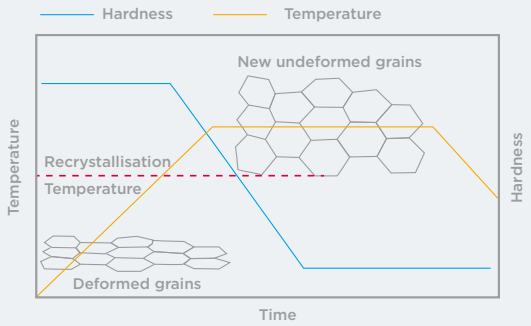
From conception to delivery we ensure that even the smallest components are absolutely perfect

What is annealing?

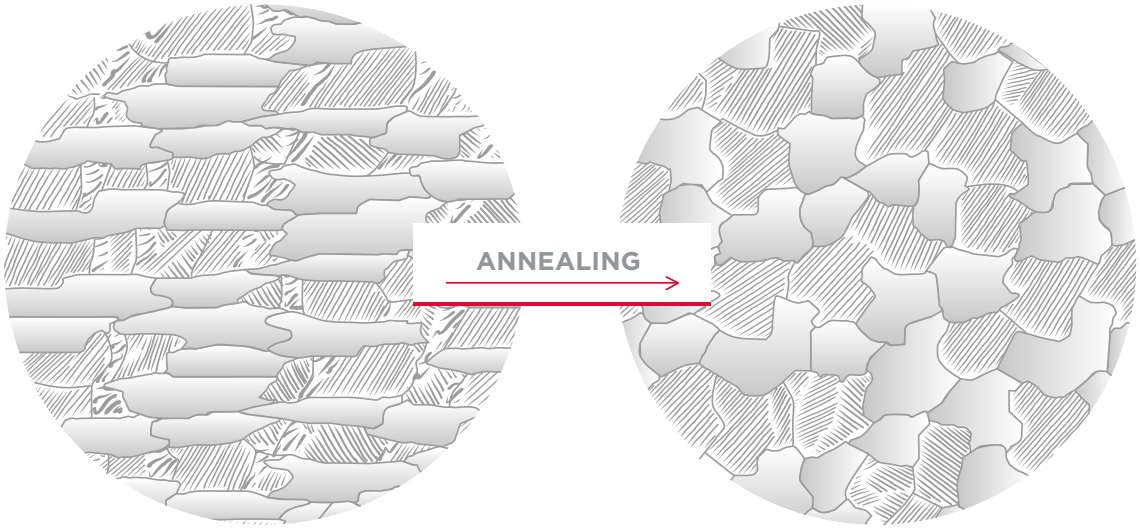
Annealing is a controlled heat treatment process that changes the microstructures and the properties of a material. In general the annealing process requires the material to heat up above the recrystallization temperature during a specific soaking time and subsequent cooling down. In order to achieve specific properties and the desired surface quality after heat treatment, numerous essential process parameters like: duration, temperature, atmosphere and cooling rate need to be controlled. The purpose of this heat treatment process is to recrystallize or normalize the microstructure, to increase ductility and reduce the hardness to make it more workable.

Annealing may be required at different stages of the processing of parts, after deep-drawing, pressing, bending, welding and machining. The cold deformation in the manufacturing process results in residual stress and recrystallisation annealing is required to soften the material to enable further cold deformation. Recrystallization improves the microstructure of the metal and eliminates the stresses. Furthermore, annealing can change the magnetic properties and improve corrosion resistance.

Figure illustrating recrystallization by annealing.



The left part of the figure shows the microstructure with elongated grains with high deformation. The hardness is high. After annealing grains are renewed. The hardness is then lowered.

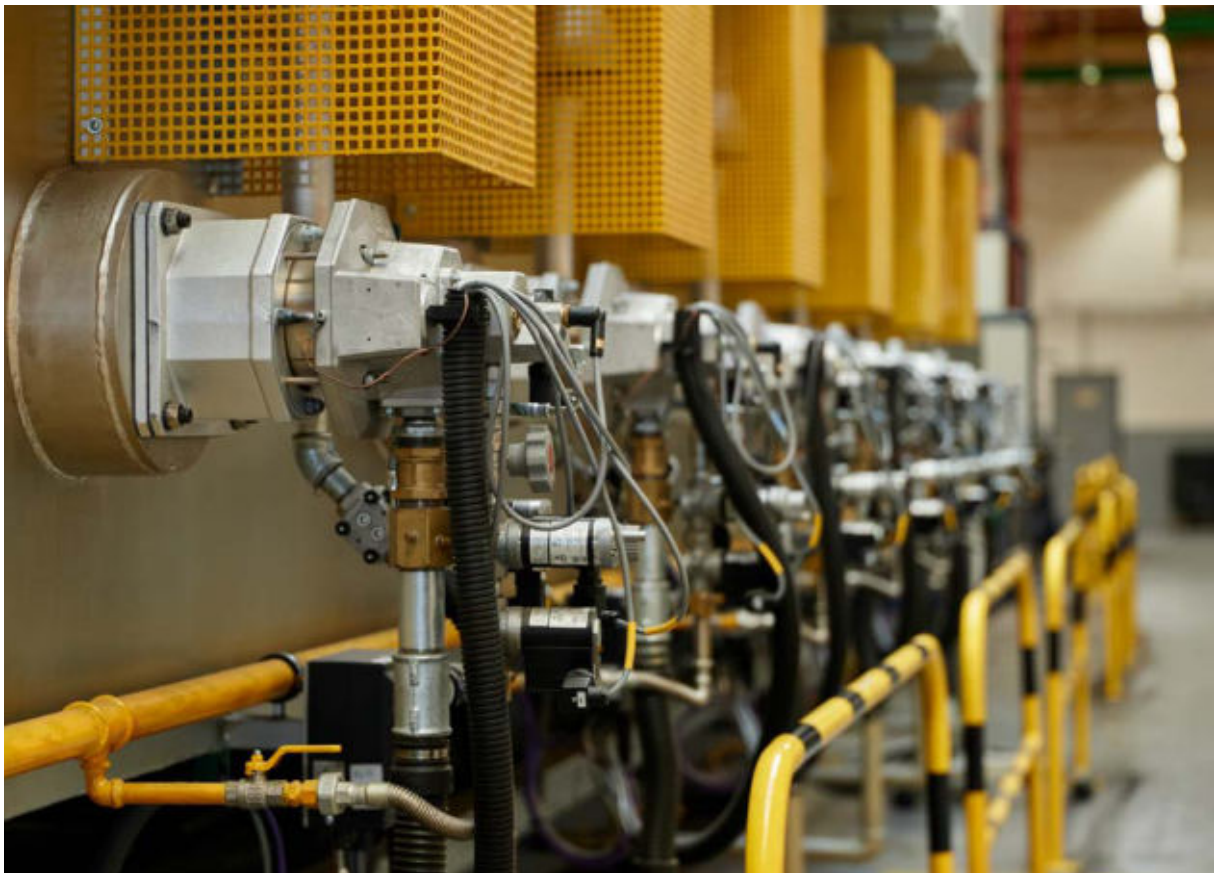


Microstructure: deformed, elongated grains produced by cold forming.

Strength/hardness ↑
Ductility/toughness ↓

Recrystallizing annealing reduces or repairs the effects of cold-formed deformations.
Elongated grains are changed into more spherical ferritic grains.

Strength/hardness ↓
Ductility/toughness ↑



Annealing: markets and applications
Annealing is an indispensable link in a wide variety of production processes that use steel. This is because annealing improves several properties such as; the machinability, structure and ductility of the material. This form of heat treatment is already widely used in markets such as:

- Building materials
- Piping systems
- Automotive
- Semiconductors
- Tooling
- Aerospace
- Mechanical engineering
- Consumer goods
- Food industry
- Medical industry

Brazing and annealing metal components at a single site
One of the specialist fields of Aalberts Surface Technologies in Venlo is annealing metal parts in what are known as 'continuous furnaces'. Using this type of furnace has several benefits, especially for larger production runs, and the technique can be widely applied. Composite parts can also be brazed during the annealing process, for example. The knowledge of materials and exceptional temperature and atmosphere control that we have available make it possible to offer this extra service to our customers.

" Our processes are fully set up to let us control the duration, temperature and atmosphere to anneal components correctly. Brazing requires the same factors to be managed, with just the one additional aspect of the braze alloy."
- René Achten, Plant Manager, Aalberts Surface Technologies Venlo

The combination of brazing and thermal treatment at a single location is higly benifitial. This not only in regards to cost savings and lead time but also considering energy consumption and emission levels. it's a one stop shop.

Capabilities of the furnaces in Venlo
The Aalberts Surface Technologies facilities in Venlo have all the equipment needed to anneal all low-alloy and high-alloy steels (including stainless steel), cast iron and non-ferrous metals. The company has a wide range furnaces, but the key feature of the production site are the continuous furnaces. Both the continuous furnaces and vacuum furnaces are suitable for the combination of annealing and brazing, there are pros and cons to each. Manufacturability and of course costs are always the decisive factor here: differences in the technology mean that some products can only be processed in a continuous furnace and others only in a vacuum furnaces.

The continuous furnaces are for example suitable for articles up to 800 millimetres wide and 150 millimetres high. In addition to its dimensions, though, the wall thickness also plays an important role: the maximum wall thickness is about 25 mm pending on material and its condition. The speed of the mesh belt within the furnace determines the holding-time at a certain required temperature. If a part has cross sections thicker than ca 25 mm, it would have to go through the furnace so slowly to get to the right temperature that the furnace would come virtually to a standstill.

Copper or nickel is commonly used for brazing the products, depending on the requirements and the conditions that the product will be exposed to. Another advantage is that no flux is needed for brazing in a continuous furnace. The experts at Aalberts Venlo will be pleased to help you think through the choice of braze filler.

“ The choice between nickel and copper brazing depends in particular on the basic material, the design and the application conditions, such as temperature, corrosive media and mechanical stresses. We don’t have a preference for copper or nickel, because we can use either alloy in our processes. But we’re happy to think the manufacturability and costs of components through with our customers. Nickel is a very pricey alloy, so we recommend copper brazing unless the application demands otherwise.”
- René Achten, Plant Manager Aalberts Surface Technologies Venlo

Annealing in a continuous furnace is a very uniform, efficient and flexible process
By far the majority of components are treated in the continuous furnaces, which are more than 30 metres long and kept up to temperature 24 hours a day, 7 days a week. The temperature and gas composition in the furnace vary depending on the component or part and processes required, but its temperature almost never falls below 800°C.

This means that significantly less energy is required for a single production process. Keeping the furnace at a constant high temperature actually uses quite a lot less energy than bringing it up to temperature for a single specific process and then letting it cool down again. As an effect the carbon foodprint is significantly lower as well as the Nitrogen deposition.

Annealing metal parts in a continuous furnace offers several advantages in the production process:

- Reliable process
- High uniformity
- Cost-efficient
- Rapid turnover times
- Sustainability

Reliable process
The furnace is divided into separate zones where the temperature, atmosphere (gas flows) and conveyor speed are controlled and monitored separately. This creates various zones that allow the entire heat treatment to be carried out in a single oven cycle. The accuracy of both the control and the monitoring is very high; each zone has high-quality Type S thermocouples (platinum-rhodium). As a result, the furnace temperatures for each zone are accurate to better than one degree.
The furnace instrumentation and classification meet the highest standards of the aerospace and automotive industries: AMS2750 and CQI-9.

The process reliability is monitored using these measurements and linked to the specific product run through the product code.

"The quality manager's role is to ensure a robust, reliable and reproducible production process. The key in creating a robust process is to start at the earliest stages of process design and continue throughout the complete process and supply chain of the product. That lets us create the optimum production process conditions with high capability and reduction of variation. This is essential to benefit effectiveness and efficiency, and of course customer satisfaction."

– Pascal Snijder, Quality and Project Manager, Aalberts Surface Technologies Venlo

Very consistent quality
The reliability of the process plus the way the components are annealed in the continuous furnace ensures very uniform quality for the annealing process itself and the heat treated components. The continuous furnace is in fact one long tunnel with a conveyor belt that all the articles lie on. Each product on the belt gets exactly the same treatment: the same number of minutes at the same temperature and under the same atmosphere. This makes annealing in a continuous furnace more uniform than in any other furnace type, where several pieces are put inside a single batch and the positioning of the piece can affect the annealing process.

Cost-efficient
A continuous furnace is always at a high temperature so that bringing it up to the right temperature for a single heat treatment process requires much less energy. This makes annealing in a continuous furnace a very cost-efficient process. Compared to annealing in a vacuum oven, where the entire annealing process has to be done in sequence for each batch, annealing in a continuous furnace only ever requires adjustment of the continuous process.

Rapid turnover times
Annealing in a continuous furnace is highly suited to rapid production and can be used both for small runs of a few articles and large series (thousands of kilograms). Aalberts Surface Technologies Venlo handles tens of thousands of kilograms of steel, stainless steel and non-ferrous metals every day. This high capacity lets us respond quickly and produce rapidly. In practice, it often means that articles can be on their way to the customer or the next supplier in line after just one day in Venlo.

Sustainability
One aspect that is weighing ever more heavily in customers' processes is sustainability, especially carbon dioxide and nitrogen emissions. Annealing in a continuous furnace is a production process that fits in well here, because keeping a furnace at continuous temperature requires less energy than restarting it for each individual annealing process. The advantage of a continuous furnace consuming less energy to reach the correct temperature for a specific annealing process means not only a cost-efficient production process but also a relatively sustainable one.

Sustainability comparison	Annealing in a vacuum oven	Annealing in a continuous furnace
Energy in MJ per ton of production	5700	3800
CO2 emissions in kg per ton of production	364	242

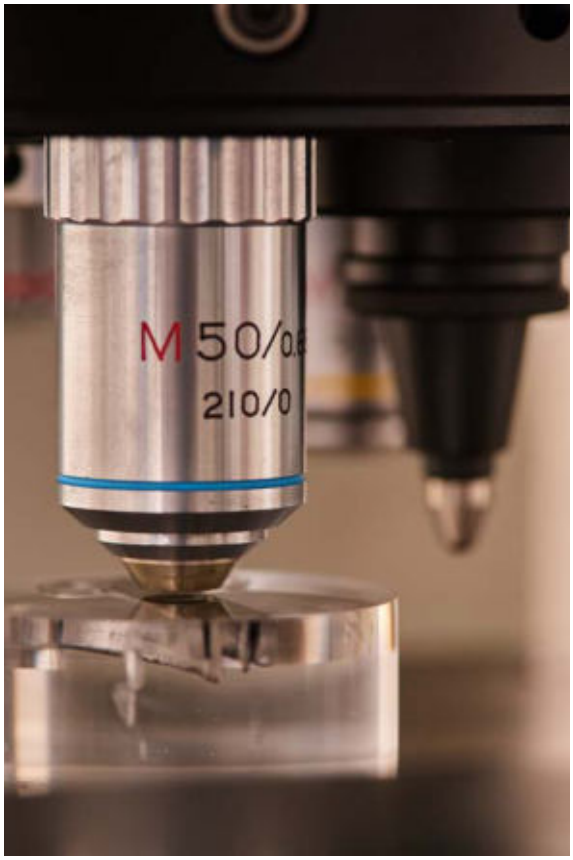
Energy and CO2 emission figures

QUALITY PLANNING PROCESS

Production processes are defined and validated for every product brazed and/or heat treated in Venlo. Process design is needed because each component has its own requirements that have to be met, making other demands on the assembly and heat treatment in Venlo. Defining this process starts with the customer's product drawings and specifications.

Our engineers and quality manager always see room for improvement – ways of using our processes to improve the product – but there are also cases where our customer's production process is already fixed. After reviewing the drawing, specifications and the application, the procedure for defining and validating the production process always goes like this:

- Analysis of the material
- Defining the scope of the production process
- Visual check of cleanliness
- Setting up and testing the annealing process
- Hardness measurements
- Destructive testing
- Reporting (in digital format)



Analysis of the material

The process is mainly determined by the material, which is why process design starts with an analysis of the material. How will the items be supplied and how should the treated parts be delivered to the customer? We investigate the hardness and micro structure of the materials supplied and determine the parameters for e.g. the desired hardness, mechanical properties and cleanliness of the part after heat treatment.

Advanced product quality planning
During this phase, we analyse what the requirements are, check that we understand the customer and whether the requirements are complete and feasible. The requirements generally include hardness, micro structure, grain size but may also include time, temperature or atmospheric conditions. We also determine how the articles should be packaged and transported after the production process. Common packaging methods are:

- Wooden containers
- Steel or plastic containers
- Pallets
- Pallets with edges
- Pallets with trays
- Wire mesh boxes

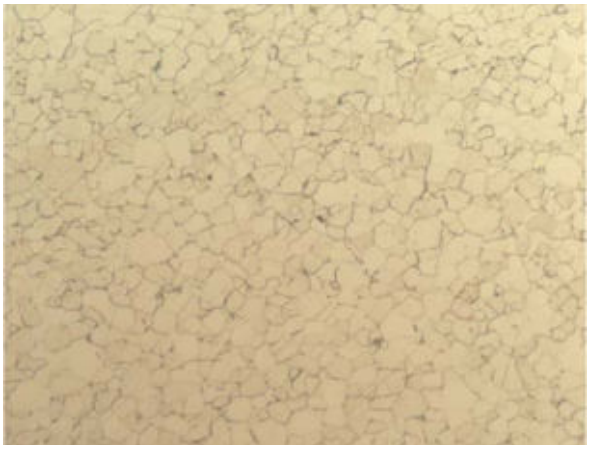
Visual check of cleanliness
How clean the parts are is decisive for the end result, which is why the cleanliness of the incoming components is assessed. Some components are provided in a suitably clean condition, but we have to clean the majority first.

The annealing process: design and validation
The type of material, further applied processes, the application, the brazing material. To be used (where applicable) and the quality of the items provided largely determine the parameters needed for annealing the components. In addition, there are several variables for the annealing process:

- Duration
- Atmosphere
- Positioning
- Dosing and jigging
- Cooling rate

During this phase, we determine the parameters for the annealing process and their tolerances. It starts with the way that the pieces are to be positioned in the furnace and then progresses to the temperature they should be heated to, how long they remain at that temperature and how they are then cooled. We test this process to determine whether it gives the desired result or whether adjustments are needed.

Hardness measurement
The hardness of the material can be measured both in the untreated condition and after the annealing process. The hardness of a material is its resistance to permanent deformation and is related to the strength, elasticity, toughness and ductility of the material. The hardness is measured using the Vickers hardness (VH) method, involving pressing a pyramidal diamond indenter into the material being tested. This leaves a pyramidal impression in the material. The length of its diagonal is measured optically with a microscope. The Vickers hardness can be calculated (ISO 6507-1) from the length of the diagonal and the load on the diamond.



Microstructure after annealing

Destructive testing
After the hardness measurements, destructive testing of the part is also done. We take a cross-section through the part, cutting out a piece of it that is then embedded, in a specimen that is ground flat, polished and etched using an acid. We look at the specimen's grains under a light microscope and assess the material's micro structure, grain size and grain orientation.

Reporting (in digital format)
The findings of all tests are reported to the customer in a digital format and appended to the work order. How often we carry out this process of testing and validation depends on the wishes of the customer.

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"Our advanced product quality planning vision aims to ensure that new parts and processes genuinely meet the application's needs and the customer-specific requirements. We are happy to meet up with customers at an early stage to advise them about the choice of materials, properties and processes. This enables us to design and perform reliable and reproducible production processes for our customers. The basic for this is most often a well performed and fully detailed feasibility study that covers not only the processes but also the part and its application."
– René Achten, Plant Manager, Aalberts Surface Technologies Venlo

THE ANNEALING AND BRAZING PROCESS

A wide range of components are annealed in Venlo and the volume of parts in each run is also highly variable. But one factor is constant: from the moment of intake, each order follows a streamlined process of cleaning, brazing if required, and then annealing, quality inspection and packaging. What does this process look like? And how do our operators, production manager, project manager and quality manager make sure that the entire process is exactly aligned to your requirements and specifications? We'll happily go through our process flow with you.

Intake and incoming inspection

Every article that arrives in Venlo is received by our logistics department, who start the process by registering the parts and giving it a barcode. Once the order has been logged in our system, the internal orders are planned and the parts are assigned a temporary location in the production department, where they are kept until the production process actually starts.

Every order and component is given an internal roadmap and a router that lists all the barcodes, processes and process parameters. The router is at each and every production step scanned, making the process and all the conditions fully traceable for the individual batches.

Cleaning
Cleaning is most often the first step in the production process, making sure that the parts are clean and degreased in order to prevent chemical reactions in the furnace process and and contamination of the part which may cause issues further down the proces chain or in the application itself. The products can be cleaned in one of three ways:

- Alkaline degreasing
- Vapour degreasing
- A combination of the two

There is a wide choice of cleaning systems available, depending on component properties and the substances to be removed, such as an automated multi-bath, in-line system filled with reverse osmosis water and neutralization with an integrated dryer. The pieces then go straight from the dryer into the furnace.

Vapour degreasing is a high-quality cleaning method that uses modified alcohol, both in the vapour phase and in full immersion. The big benefit is that the cleaning agent is always pure because it is being continuously distilled. This type of cleaning is used for products that are not suitable for any other type of cleaning, for instance because of their geometry.

The cleaning method used is determined primarily by the requirements and properties of the components as specified in the process design.

Assembling products that are to be brazed
Products that are assembled for brazing always consist of two or more parts. Two factors are critical when assembling: correct cleaning and the fit. Every component is degreased individually, as a grease-free area is essential for the flow and adhesion of the braze alloy itself.

The fit is also critical for assembling the parts correctly: there must not be too much play and it must not be too tight. After degreasing the parts, they are assembled and the brazing material is applied. The products are then placed in the baskets.

Bringing up to temperature, annealing and cooling in the furnace
After cleaning, parts are placed in the furnace; the router specifies whether this is done manually or whether pieces can be fed in on the conveyor. The products are then annealed as specified in the process design.

Products that have been assembled for the brazing process are stored temporarily and then put in the furnace in larger runs, so that the parts go through the furnace process as efficiently as possible.

Quality assurance
The annealing process is followed by quality checks. The level of checking needed is defined in consultation with the customer; this can vary from hundred per cent checks to random sampling. The leak-tightness of specific components can for instance be one hundred per cent checked, guaranteeing zero defects.

Packing
After quality control, articles are repackaged and they are then handed over to our logistics department, who make sure that the products are returned to the customer as quickly as possible or (if previously agreed) shipped to the next supplier where the components are processed further.

Some parts or better components can move between suppliers and the production site in Venlo several times because the component requires several annealing moments.

COOPERATION WITH AALBERTS INTEGRATED PIPING SYSTEMS (VSH)

Aalberts Integrated Piping Systems manufactures among other brands VSH, a well-known piping system brand, and is therefore one of the partners that Aalberts Surface Technologies Venlo does a great deal of annealing and brazing work for. Both companies belong to the Aalberts group, but that is not the main reason for the collaboration. We spoke to Sjaak Rademaker, Purchasing Director for Western Europe at Aalberts Integrated Piping Systems, about the main cornerstones of the excellent cooperation between the two companies.

Involvement in the chain

"First and foremost," says Rademaker, "it is important that people understand the end product and its application – not only the people in our own factory but also the employees of our regular suppliers. Showing the end product that they are contributing to, to all the people involved in the production process and explaining it to them lets them understand why the process is set up in a certain way. This adds not only to their satisfaction but also to the involvement that helps us improve the process further every time."

Continuous quality assurance

The metal components of VSH press fittings and compression fittings are made in the company's own production facility in Hilversum. At given points in the production process, the components are annealed in Venlo To prepare them for further processing in Hilversum, or the components may even be assembled, annealed and brazed to create the end product. It then either is shipped to Hilversum or on to the next supplier in the chain. With so many transport movements, quality control is a key aspect, and the commitment of the various employees is a major factor.

"When our parts arrive in Venlo, the intake and incoming inspection process starts, making sure that the parts receive the right treatment and can be tracked throughout the process. Each step has so many scans and sensors that the system itself serves as a continuous quality control mechanism: if anything isn't right, we see it straight away.

In practice, though, our own logistics staff or the operator, production manager or quality manager at our sister company in Venlo are the key quality assurance element. They'll already be working on a solution before we even get a signal that something has changed. In practice, we get a message telling us what's been happening and how it's been resolved. This gives us a lot of confidence in the process and lets us focus on our own processes."

“ Our knowledge of materials, heat treatment and the final application makes the difference for many of our customers because the critical factors for manufacturability and serial production runs can then be taken into account as early as the design stage. We can then set up the process in whatever way is needed.”
– René Achten, Plant Manager, Aalberts Surface Technologies Venlo

Far-reaching integration within the supply chain with customers and other suppliers
In addition, Aalberts Integrated Piping Systems has created a link between their own ERP system and those of their suppliers using the EDI system.
“We work with Aalberts Surface Technologies Venlo as a single team for producing our components. The transitions are frictionless and the connection minimizes the administrative overheads. The whole paper trail has been digitized, not only with our sister company in Venlo but also with other suppliers. It’s led to enormous efficiency gains and has become an important condition when selecting our suppliers.”

Far-reaching supply chain integration offers certainty and opportunities for innovating together
“As a brand, VSH is continually innovating. But we still very much need our suppliers too. A lot of research and experimentation is required to get from design to serial production, and the knowledge at Aalberts Surface Technologies Venlo is indispensable. They don’t only carry out feasibility studies – we also work together closely to determine the optimum production process. We also look beyond pure heat treatments. For instance, Venlo invested in an in-line cleaning system that improves the efficiency of our production process even further.”

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