Better aluminium coil annealing

Utilising patented jet airflow technology, the Seco/Warwick Vortex® coil annealing system, combined with bypass cooler and SeCoil control and simulation software, offers coil producers the ability to significantly reduce the overall cycle time of their furnaces, resulting in energy savings, increased productivity, and improved surface quality.

The Seco/Warwick Group has introduced a patented Vortex® jet airflow technology for the annealing of aluminium sheet coils. This innovative design harnesses cyclonic rotation and wind speed to produce a rapid heating of the coil with minimal hot spots. The result is a faster annealing cycle which reduces energy consumption and delivers better product quality through higher surface temperature uniformity. The Vortex® furnace design is presently in use for coils ranging from 3.9 tonnes (8,500 lbs) up to 11.3 tonnes (25,000 lbs) each. Plants in North America, Europe, Asia, and the Far East are all successfully taking advantage of this technology to increase their operating profits.

Heat transfer rate

The key to the system is an increased heat transfer coefficient achieved by high speed air impinging on both sides of the coil. The intent is to transfer heat through the wound edges as opposed to only through the outside layer of the coil. By adopting this method, the heat transfer efficiency can be increased from 30% in a traditional design to 70% in the Vortex® design. The heat transfer coefficient has been calculated at 150 W/m^2K.

Three part system

The heat delivery system consists of three components. The first critical component is the air recirculation fan. One of two types of fan is used depending on the coil size being processed and the required air flow needed. The semi-axial fan has been specifically developed for use in the Vortex furnace. It is designed to optimise the flow pattern of an axial flow impeller and to achieve the higher pressures needed for jet flow. It will produce a pressure of 4-5 inches water column (WC). The second type of fan used for large coil processing is a standard centrifugal style impellor. Processing larger coil sizes necessarily requires more air at higher pressures. The centrifugal impellor produces a pressure approximately 7-8 inches WC.

The second component of the heat delivery system is the flow ducts and Vortex® plenum. The flow ducts serve to direct the flow of air to specific points within the furnace while maintaining the pressure developed by the fan. When using a centrifugal impeller, custom engineered diffuser vanes are incorporated into the ducts to compensate for the directional flow characteristics inherent with this impeller. The patented Vortex plenums are located at the exit end of the ducts. The plenums consist of inclined jet nozzles arranged in such a way as to create a multitude of vortices directed at the coil side. The air velocity generated through the plenum combined with the rotation of the air produces the higher heat transfer rate associated with impingement heating, but eliminates the hot spots typically produced by straight nozzles. A straight nozzle hits in one spot and the air rebounds sharply off the surface. This concentrates the heat at the point of impingement while the adjacent surface remains significantly cooler. The spinning motion of the vortex eliminates any sharp rebound because the air rotates outwards from the point of contact along the surface. The inclined nozzle groups are engineered to produce overlapping vortices. This results in a more uniform surface temperature. Temperature uniformity achieved at the end of soak is typically ± 5°F.


The Vortex® furnace design.


Specially developed semi-axial fan.

The third part is the heat source. Whether using electric resistance elements or fuel fired burners in radiant tubes, the heat source is placed directly within the flow ducts to maximise heat transfer to the circulating air. As the air is delivered from the fan, it passes over the heat source, then is directed out of the Vortex plenum, impinges on the coil sides and returns vertically to the fan for the next pass. Heating times for a 30 U.S. ton coil average 8 hours and 20 minutes.

Cooling of coils

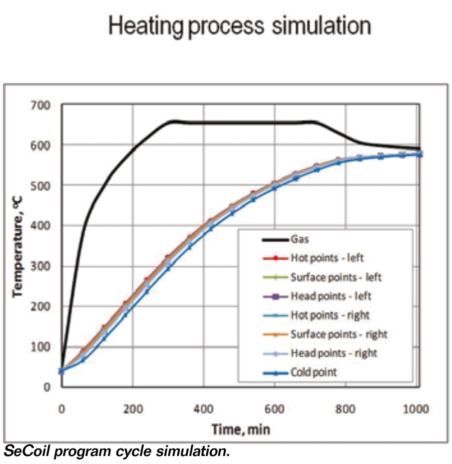
It is quite common for aluminium coil annealing furnaces to include a means for cooling the coils, under protective atmosphere, at the end of soak. Cooling under protective atmosphere reduces the chances of staining on the coil and prevents oxidation on the outside wraps. Cooling also facilitates further handling by reducing risk to personnel of elevated metal temperatures. Typically the loads will be cooled until the load control thermocouples are at 350°F or lower. At that point, the cycle is complete and the load can be discharged from the furnace.

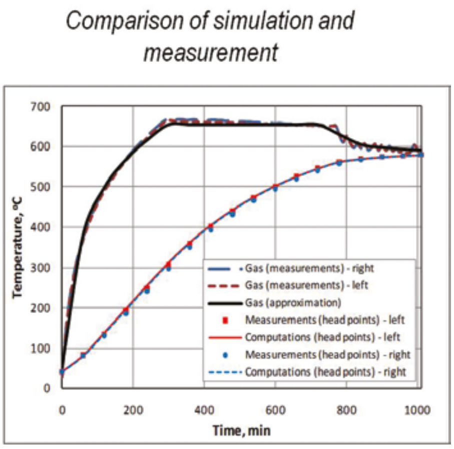

Vortex® ducts and plenum.

For aluminium coil and foil annealing furnaces, SECO/WARWICK utilises a bypass cooler. It consists of a shell fabricated of structural and plate steel and a set of low temperature cooling coils. A set of filters is located above the air-to-water heat exchangers to prevent dirt from clogging the aluminium fins on the coils. A blower near the bottom of the cooler pulls the hot atmosphere from the furnace and pushes the cooled atmosphere into the furnace. In operation, the cooler controls inlet and outlet dampers through a mechanical linkage to achieve the required cooling rate set by the temperature control system.

As the controls call for cooling, the inlet damper begins to open, allowing the cooling fan to draw hot atmosphere from the furnace and, at the same time, the outlet damper from the cooler opens and allows cooled atmosphere to pass from the cooler back into the furnace to the cooler distribution duct. The hot air that is drawn in from the furnace is mixed with atmosphere coming through the bypass of the cooler and is cooled sufficiently so that the approximate temperature of the gas is 350°F prior to passing through the filter and over the coils of the cooler.

The bypass cooler alone provides highly controllable cooling rates, but when combined with the high speed produced by the Vortex® jet nozzles it becomes a very efficient method for cooling. The concept is the reverse of the heating method. The impingement of cooled gas on the coil edges transfers more heat from the coil at a faster rate than is typical. Combined with the faster heating cycle, this faster cooling rate helps reduce the overall cycle time by 25 to 30 percent.





SeCoil program cycle simulation.

Process control

The challenge in coil annealing is to optimise the process to shorten the cycle time to the greatest extent possible, while maintaining the desired metallurgical properties of the entire load. SECO/WARWICK has developed, for use in conjunction with the Vortex® furnace, a coil annealing process control system employing an on-line simulator for the heating process.

From a metallurgical point of view, the important process parameters are the final batch temperature and the soaking time. These parameters strictly define the process of re-crystallisation annealing and must be strictly met. From an economic point of view, the most important parameter is the total process time, which directly affects the energy consumption.

Seco/Warwick vortex coil annealling installation.

The task of the SeCoil automatic regulation and control system is to keep, for the longest possible time, an adequate air to work (head) temperature to minimise heating time, and after reaching the load temperature setpoint, to reduce the head temperature to avoid any overshot of the load setpoint. Due to the procedure applied, a shorter process time can be achieved without the risk of overheating the load. The SeCoil control system and on-line simulator accomplishes this through the following steps:

First an annealing process recipe is entered into the In-Touch software which defines the basic parameters such as temperature, heating ramp, and soak time. Next the coil parameters such as the outer and the inner diameter of the coil, the width of the coil, and the thickness of the aluminium sheet are defined. The prepared recipe is uploaded to the controller and the option for the process to be controlled by the SeCoil program is selected. At this point, the data is automatically copied to the SeCoil program. The program can then simulate the temperature curve of the batch at a user-defined point and compare with data read in real time. The collected data can ultimately be used to fine tune the recipe and optimise the process.

With the new Vortex® jet airflow technology, reductions of cycle times in the 25 to 30 percent range have been achieved for a wide range of coil widths and diameters. The wiping action of the jet nozzles on the edge wraps of the coil significantly reduces the formation of hot spots and staining. The reduction of cycle time results in less utility consumption per cycle and higher productivity, with the ability to run more cycles per year.

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