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A Comparison of Welded & Seamless Heat Exchanger Tubing

SCOPE:

It is the intent of this HEI Bulletin to identify and compare two common methods of tube production for Closed Feedwater Heaters, Steam Surface Condensers, and Shell & Tube Heat Exchangers (balance of plant {BOP} heat exchangers). These methods would include a welded and seamless process. Both are commercially available to the designer/producer and can be directly compared on their merits and disadvantages. Many factors enter into the product selection equation on whether to use a welded or seamless product and indeed, compelling arguments can be made either way. Not in any order, most comparisons include the following.

- Cost
- Product Availability
- Service suitability
- Structural integrity (Code requirements)
- Severity of service
- Corrosion resistance
- NDE testing
- Dimensional Factors
- Delivery requirements

Additionally, each product can be processed and tested in a variety of different ways. On a welded product, this could include no cold working of the weld, in-line cold working of the weld with OD and ID tooling, or cold drawing of the tube. Seamless hollows are being made by either extrusion or rotary piercing. The seamless product is usually cold finished using pilger mills and/or cold drawing.

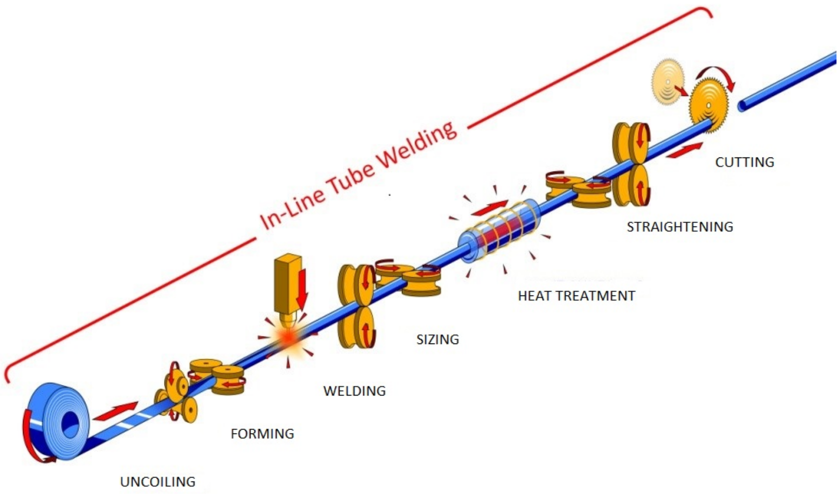
The guideline will identify basic fundamentals of each of the various products, explore process differences and outline the advantages and disadvantages of each process/product. The successful selection and use of either product largely depends on the clear understanding of the application and a thorough cost-benefit engineering analysis of all factors entering into the evaluation and selection process.

DISCUSSION:

Welded Tubing

Welded heat exchanger tubing is typically manufactured by roll forming coiled flat metal strip into a tubular shape and joining the edges together by welding to form a longitudinal seam. The operation is a continuous process with forming and welding taking place on the same equipment.

Strip can be supplied in coil form and slit to required width. The strip is then continuously formed using multiple rolls to shape it into a tube and then welded. The thickness of the tube wall is a function of the thickness of the strip used to make the tube. If a smaller diameter or thinner wall tube is desired, additional reduction operations may be required. Common welding processes include gas tungsten arc (GTAW), also known as tungsten inert gas (TIG), plasma arc, electrical resistance, high frequency, and laser. Tubing produced under the scope of this document does not permit the use of filler metals. The weld is formed by melting or joining the strip edges.



Typical Welding Process Flow

Advantages

◊ The majority of the tubing used in power generation condensers, feedwater heaters, and BOP exchanger applications is welded, making the tubing more easily accessible.

◊ For many heat exchanger applications, welded tubing may have a cost advantage.

◊ Most welded tube specifications require multiple NDE tests.

◊ More precise dimensional controls provide a more consistent product:

  - More consistent OD for integral finned tubes
  - Uniform wall thickness
  - Improved Concentricity

Disadvantages

◊ When austenitic stainless steels or nickel alloys are not effectively cold worked and heat treated, the weld can exhibit lower corrosion resistance than the parent metal (see HEI Tech Sheet #134, ***Heat Treatment of Tubes for Condenser, Feedwater Heater and Shell and Tube Heat Exchangers***.).

◊ For ASME pressure vessel tubing, the joint efficiency factor may require increased wall thickness vs. a seamless material

Cold Working and Heat Treatment of Welded Tubing

ASTM/ASME does not require cold working of copper alloys, titanium, and carbon and alloy steels. Alternatively, the stainless steel specifications may require cold work and do not address specific requirements for cold working and heat treatment. For example, some specifications require that the tubes be cold worked after welding, but do not specify the degree or method of cold work required.

Types of cold working include:

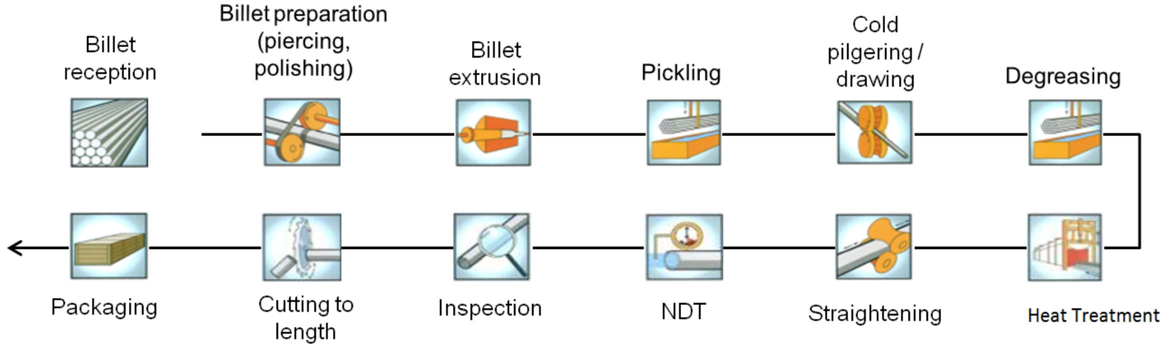
- ◊ Roll Sizing – After forming and welding the tube at a size slightly above the specified diameter, the tube has a final sizing pass that reduces it to the specified diameter. No ID tooling is utilized with this process.
- ◊ Weld Bead Forging/Rolling – In this process, the weld will be cold worked by either a rolling or forging process using both OD and ID tooling providing a weld that is blended into the base metal.
- ◊ Cold Drawing – Cold drawing is a process that reduces the OD and often the wall thickness of the tubing by pulling the tube through a die. Optimally, the ID dimension is also controlled either with a plug or a bar.

The method and amount of cold working shall be agreed upon by the Purchaser and the manufacturer.

For guidance on testing versus the cold working and heat treatment, see HEI Tech Sheet #134, ***Heat Treatment of Tubes for Condenser, Feedwater Heater and Shell and Tube Heat Exchangers***.

Seamless Tubing

The manufacturing process for seamless tubes is initiated by manufacturing a starting “hollow” from a round bar by either one of two methods, hot extrusion or rotary piercing. Extrusion, the preferred method for stainless steels, titanium and copper alloys, involves pushing a hot metal block (starting extrusion billet) with a hole in it through a die and over a mandrel.



Typical Process for Seamless Tube Production

The rotary piercing method is quite effective for carbon and alloy steels. However, the higher Cr content of stainless steels may result in defects, making it a less desirable method for stainless steel starting hollows.

Typically, only a few standard hollow sizes are made from the billet. Further reduction of the tube hollows down to the required tubing sizes is done cold using drawing, rocker pilgering or swaging. The tubes are then cold drawn down to final finish and size.

Although hot finishing (rolling to final size at high temperature) is common in larger diameter tubing, the final product has larger tolerance ranges and rougher surfaces. For these reasons, hot rolled product is rarely suitable for exchanger service.

Advantages

- ◊ The entire cross section of cold-finished product is cold worked.
- ◊ The ASME joint efficiency factor is 100%, which may result in reduced walls compared to a welded product..
- ◊ Alloy materials typically exhibit nearly consistent corrosion properties throughout the entire tube.
- ◊ Heavy wall product may have a cost advantage.

Disadvantages

- ◊ Seamless tubing can experience more wall variation, both circumferentially and longitudinally.
- ◊ Seamless tubing can have more eccentricity.
- ◊ Thin-wall seamless tubing is not commonly used for these applications.
- ◊ Due to eccentricity, finning becomes more difficult.
- ◊ Seamless tube specifications often have limited NDE test requirements.
- ◊ Product tolerance and surface finish may restrict the installation of hot finished tubular products in heat exchangers.

Finishing Operations

Both seamless and welded heat exchanger tubes may be used in the cold finished condition for these applications. Finishing operations include cold working, heat treating, cleaning and non-destructive testing.

The types of cold finish include:

- ◊ Roll sizing in ambient temperature
- ◊ Cold drawing
- ◊ Tube reducing

Further finishing operations may include:

- ◊ Heat Treatment & Pickling (see HEI Technical Sheet #134 ***Heat Treatment of Tubes for Condenser, Feedwater Heater and Shell and Tube Heat Exchangers.***).
- ◊ Straightening
- ◊ Testing
    - ◦ NDE see HEI Technical Sheet #129 ***Common NDE Tube Test Methods***

These processes can significantly affect the surface finish, mechanical properties, and corrosion resistance of the final tube product.

ASTM/ASME specifications are negotiated using the consensus process and because of that are relatively broad to allow flexibility of quality level for various markets. They should be considered to be minimum requirements, and if solely used for purchasing requirements, may not include sufficient needs for a product expected to have a 40 to 60 year reliability. It is the responsibility of the Purchaser to include additional requirements necessary for their specific application.