Revista Facultad de Ingeniería Universidad de Antioquia
ISSN: 0120-6230
revista.ingenieria@udea.edu.co
Universidad de Antioquia
Colombia

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Revista Facultad de Ingeniería Universidad de Antioquia, núm. 64, septiembre, 2012, pp. 195-199
Universidad de Antioquia
Medellín, Colombia

Technological aspects of assembling and processing narrow tubes (Short paper)

Aspectos tecnológicos del montaje y procesamiento de los tubos delgados (Artículo corto)

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(Recibido el 16 de septiembre de 2011. Aceptado el 17 septiembre de 2012)

Abstract

The paper presents the assembling, welding and processing of narrow tubes made of austenitic stainless steel used for the manufacturing of syringes and of food industry parts.

At the same time, the paper discusses the various phenomena occurring during the processing of the materials previous to assembling and welding as well as during the welding operation proper.

Following these studies and experiments, a suitable welding technology has been homologated for the respective tubes.

--------- *Keywords:* assembling, control, welding, stainless steel

Resumen

En la ponencia se presenta la experiencia del colectivo de investigación con respecto al montaje, soldadura y procesamiento de los tubos delgados fabricados por acero inoxidable austenítico. Asimismo se presentan los problemas que aparecen durante el calentamiento y resfriamiento (enfriamiento) del material en el proceso de soldadura, los constituyentes estructurales que aparezcan en este caso también las medidas que tengan tomadas para disminuir el volumen de estos constituyentes.

En continuación los autores presentan también los problemas con respecto al procesamiento de los materiales para montarles y la modalidad (el modo) de resolver estas situaciones (estos problemas). En el final de la ponencia se presenta el modo de control del producto (tubo delgado) también unas recomendaciones tecnológicas finales.

--------- *Palabras clave*: montaje, control, soldadura, acero inoxidable

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Introduction

The narrow tube manufacturing process comprises a series of specific requirements pertaining to the assembling, welding and processing operations, as these tubes are meant to be used in corroding media.

The steel used for the manufacturing of the tubes must have the following characteristic features: high resistance to corrosion, high tenacity, high mechanical strength , high plasticity (40-50%), strain–hardness, high coefficient of linear expansion (50% higher than the coefficient of plain unalloyed carbon steels), low thermal conductibility (2,5 times less than that of the unalloyed carbon steels).

The experiments carried out have tried to eliminate the following negative phenomena, [1, 2]:

a) The intergrain corrosion that occurs due to the precipitation of the chrome carbides on the margins of the austenitic grain during a 600-800° C heating interval.

b) The precipitation of the δ phase.

In the case of the analyzed steel due to its high content of chrome, the precipitation of the δ phase occurs during the 600-800° C heating interval. This precipitation results in a decrease of plasticity and resistance to corrosion.

c) The seam of the steel band occurs following the wear of the cutting rolls or the incorrect positioning of the materials.

The experimental part

Materials used

The following groups of materials have been used, [3]:

AISI 304L Austenitic steel having the following characteristics: chemical composition: 18% Cr, 0,04%C, 1% Si, 2% Mu, 10% Ni.

The chosen material conforms to the conditions imposed to the product, its physical and chemical properties are not influenced and do not have any influence on the substances that are being injected, and it is not toxic in any way for the human body. Other features of this steel are: toughness (152 HV), resistance to breakage (600 ÷ 620 N/mm^2), and elongation before breaking (56 ÷ 60%).

The stainless steel used is introduced into the manufacturing process as a 15,24 mm wide, 0,2 mm thick and 36 m/kg heavy calibrated band. The band needs to be degreased, and spooled without any dents or jagged ends, and its surface needs to be neat.

Protective gas: argon

Tungsten electrode

The equipment

The welding equipment comprises, [1, 2, 4]:

the profiled roll train used to turn the steel band into a tube via a process of deformation;

– the WIG welding chamber with fixed welding head and a positioning device which positions the tube below the welding head;
– coolant chamber with water jet ;
– heat treatment equipment
– the system for control and marking of flawed areas
– the draw-plate for drawing and spooling of the welded tube

Figure 1 shows the block diagram of the equipment used.

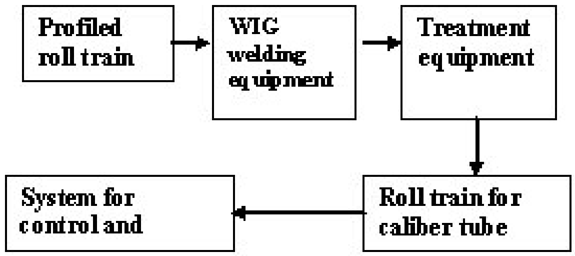

Figure 1 Block diagram of equipment

The welding technology used

As a working principle the authors chose a welding technology and a mechanical processing procedure that insert small linear and quantifiable energies. These energies have to generate structural constituents that ensure the required operating features of the steel.

Preparing the steel band for the welding operation

The quality of the steel band is very important for the welding operation. It has to be perfectly plane, without ridges.

For the manufacturing of cannula tubes a floating mandrel is used without lubrication.

The major stages before the welding operation are as follows:

– the stainless steel spool is fixed on a draw-plate or on a spool support.

– the wound band passes through a train of rolls which turns the band into cannula tubes.

Welding the tube generatrix /side

Once the material has been transformed into a tube it passes to the welding chamber. The welding chamber contains four compression groups (rolls) which close the tube before welding.

The welding operation is performed by means of a WIG welding head mounted on a device which has the possibility to adjust the head position by three degrees of freedom, [4, 5] . The tube is positioned via two prism-shaped parts with circular grooves and two guiding rolls which prevent the opening of the tube.

The welding performed is a flat gapless butt welding with a maximum gap width of 0,5 mm. The protective gas used during welding is argon blown both on the root of the joint and on the welding area. The welding operation is carried out without addition of material.

The electric arc obtained is a d. c. impulse arc which has to generate a stable bath. Any disturbance that may generate vibrations in the bath will lead to flaws in the weld.

Figure 2 shows the welding chamber

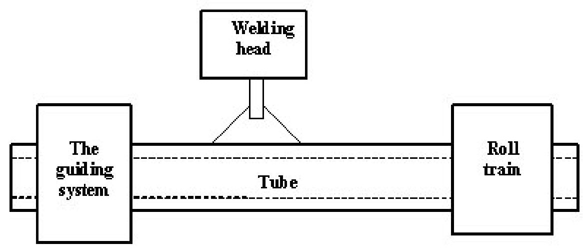

Figure 2 The welding chamber

Checking the welding

The welded tube passes thorough a control system that marks the defective areas after which by means of a floating mandrel it undergoes four drawings in order to reduce wall thickness and twelve passes in order to reduce tube diameter.

A high quality product requires a check between phases as well as a final check of the tubes.

The final checking of the tube is carried out on the manufacturing flow by means of single frequency magnetic induction equipment fitted with a microprocessor and controlled circuits, suitable for the detection of surface and in-depth defects.

The following defects can be determined: overlapping of welding strata, scratches, external or internal deformations, welding cracks. The equipment is provided with an ink spray nozzle that marks any tube defect.

Results and discussions

Following the experiments carried out the quality of the welded material has been analyzed and the occurrence of the following phenomena has been noticed:

a) The seam of the steel band has a negative effect upon the weld both on the external and internal side of the tube, in the following way:

- In the case of butt welding it does not allow for a suitable gap;
- if an irregular seam is positioned towards the electric arc , it determines a change in the tension of the arc and consequently in its length;
- if the seam is positioned opposite to the electrical arc , it generates fluctuations of the molten material due to the surface tensions

Figure 3 shows the negative effect of the seam whose size is sometimes bigger than the thickness of the band

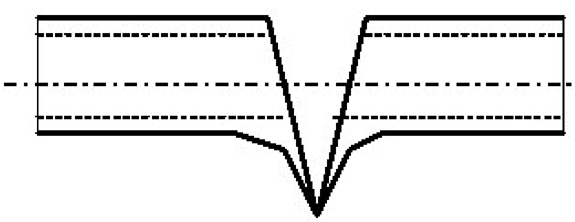

Figure 3 The steel band seams

b) It has been noticed that if the steel band is not clean (even if it is touched by hand) the stability of the electric arc and of the molten material is disturbed.

c) Certain flaws kept repeating, due to an impurity on a roll, which marked a side of the welding gap, thus creating an unbalance of the components. When studying this area, one could observe under a magnifying glass how the bath went through a buffered oscillatory movement, after about three periods. This movement of the bath led to flaws, which in the drawing position which resulted in the breaking or cracking of the tube.

d) The guiding system of the tube for the welding operation

If the tube is incorrectly guided the bath is not stable and at the end of the welding operation flaws appear which result in the waste of the tube.

The guiding system of the tube in front of the electric arc consists of :

- A pair of parallelepiped pieces with a semicircular groove through which the tube passes.
- A pair of profiled rolls.

Both components may be tightened with a fine screw, which allows for a fine calibration; the degree of wear is thus checked periodically. After charging the electric arc and starting the system, the operator has to correct the position of the tube until a stable bath is obtained and maintained.

Conclusions

In order to obtain high quality products the following have to be observed:

a) The elimination of intergrain corrosion.

The welding cycle and gap is selected so that the heating and cooling of the material should be made quickly during the 600 - 800 °C interval. The carbon content has to be as low as possible. If the carbon content cannot be reduced very much after the final processing operation the product has to undergo a heat treatment of dissolving the chrome carbides in solid solution at a temperature of 1200 °C followed by a quick cooling.

b) Avoidance of δ- phase precipitation.

An increase in the content of Mn to at least 2% is recommended for the used steel, as well as the use of low linear energies and a stabilizing heat treatment at 1100 °C.

c) The use of steel bands without seams and their thorough cleaning in order to avoid the appearance of cracks in the welded tubes.

d) The technological parameters for welding that have produced the best results are:

Welding speed: 18 m/min.

Protective gas: argon

Electrode: tungsten

Welding power: P = 10 Kw

Primary:

U = 380 V

I = 70 A

Secondary:

U= 62 V

I = 300 A

Is ech = 13 A

fpulse = 450 Hz

QAr = 4 l / min

Sharpening of the electrode is done with a tip diameter of 0,65d, which is recommended for high speed welding.

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