

Ultrasonic Examination Of Tube To Tube Sheet Weld Joints In High Pressure Heat Exchanger For The Urea Process

*Jigar Prajapati, Subhas Ghosh, Subrata Bera, Hardhan Pal, Mitesh Panchal
ISGEC Hitachi Zosen Limited, Dahej-Gujarat, India
+91 9998814547, jigar.prajapati@isgechitachizosen.com*

Abstract

Urea stripper and Carbamate condenser are two main key and critical equipment in any Urea plant. Both the equipment's are operated at elevated temperature (182-250°C) and high pressure (150-220 Bar) with aggressive corrosive fluid inside. Tube to tube sheet welding(duplex stainless steel) is one of the most critical joint in these types of high pressure and high temperature heat exchanger, hence quality of all the welds are very important from service point of view.

Effective Non-destructive testing is needed for the volumetric examination of Tube to Tube sheet weld joints. In general we perform Visual Examination& Penetrant Testing for this type of joints, but some of the customers ask for the Ultrasonic Examination. Ultrasonic Examination of this type of joints is very difficult to perform because of very small size of the joint and coarse grain material structure.

This paper describes the main challenges for development and implementation of Tube to tube sheet joints Ultrasonic Examination in Urea stripper and Carbamate Condenser.

Introduction:

Urea stripper and carbamate condenser are two main key and critical equipment in Urea plant. These units consist of large shell and tube heat exchangers with tubedimensions(19mm ODx2mm thickness) and more than 1500 tubes .Tube to tube sheet welding of high pressure exchangers operating in urea plants has to be carried out with outmost care in order to obtain high quality of welds. A number of issues come into play when perfecting the welding process for the tube to tube sheet welds. These includes

- Welding penetration must not be higher than limits
- Fusion depth must be consistently present within the tube wall
- Uniformity of the welding bead
- No defects should be present on the weld

In order to achieve high quality of welds, it is necessary to use an automatic GTAW process with a programmable computerized welding machine.

Duplex stainless steel material due to the presence of Nitrogen is prone to develop defects such as pores during welding. In addition to the selection of proper weld parameters, pure argon gas was used as a shielding gas.

Considering all the above factors, the requirement of NDT for Tube to Tube sheet joint is very critical. Visual Examination and PT Examination is generally performed in Tube to Tube sheet joint of Heat Exchanger to access the soundness of weld. However Tube to Tube sheet joint in High pressure urea service demand Ultrasonic Examination in addition to Visual examination and PT Examination. Because of size, thickness and material,Ultrasonic Examination is very difficult to perform, so we have developed special technique, probes, fixtures to perform Ultrasonic Examination. This paper discuss about the specification requirements, technique developed, fixtures developed to perform Ultrasonic examination of tube to tube sheet weld joints.

Objective & Plan:

Our aim is to achieve the best quality levels along with safe handling and reduced cycle time. The journey begins with the feasibility study and selection of suitable UT Technique.

To achieve the same, following steps were taken.

1. Feasibility study
2. Development of mockup block
3. Arrangement of required equipment and accessories
4. Procedure development and validation
5. Training to the NDE personnel
6. Application on the equipment/welded joint in production

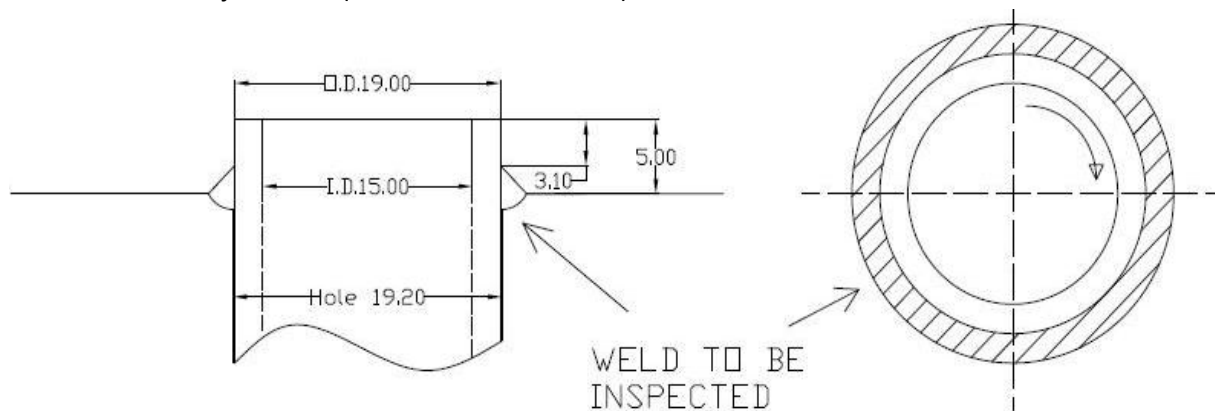
1) Feasibility study:

Tube Material : DP28W – Duplex Stainless steel

Diameter of Tube: 19mm

Thickness of Tube: 2mm

No of tubes in one job: 1585 (Total 3170 Weld Joints)

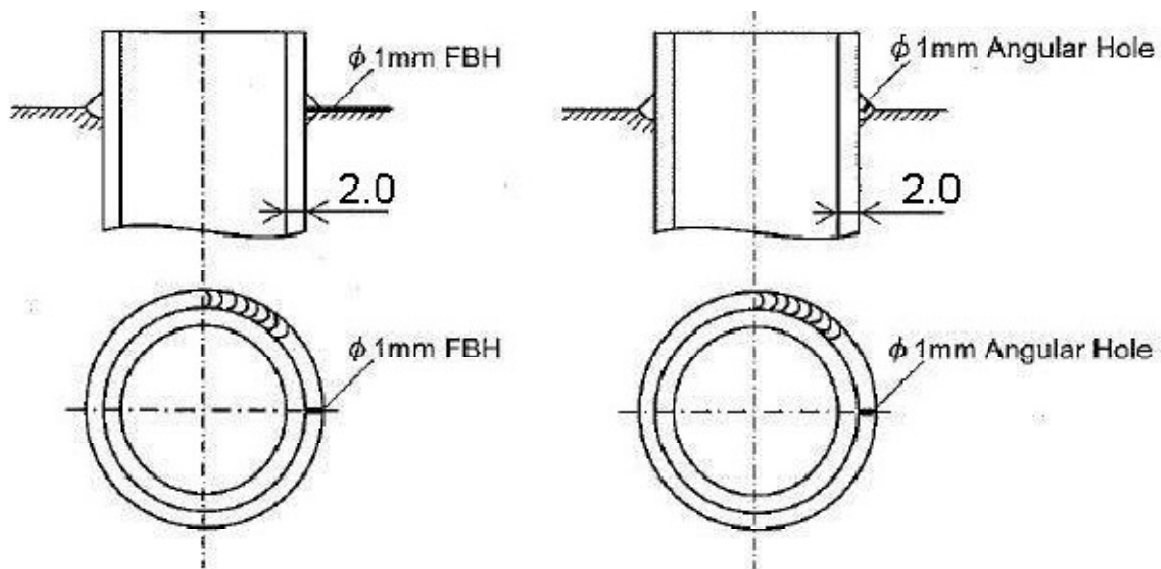


Sketch-1

To perform Ultrasonic Examination of above joint, Normal beam scanning is required to be done from ID of the tube. Standard probes are available with flat contact surface, which cannot sit on the ID of the tube; moreover our hand is also not able to hold the probe inside the tube. So using conventional probes and accessories, Ultrasonic Examination of above joint is not feasible. To make it feasible, special probes fixtures are designed to make it feasible.

2) Development of mockup block:

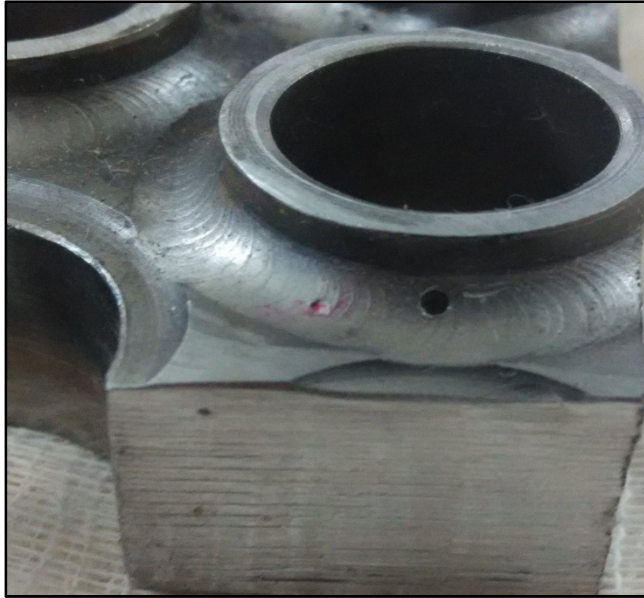
Ø 1mm Flat bottom hole at the fusion zone of tube OD and Ø 1mm Angular hole (45°) in the weld is required to be made as per specification requirement. So, same material, same joint type and same welding process was taken for mockup block. Drilling had been done as per the requirement.



Sketch-2



Calibration Block with 1 mm Flat Bottom Hole



Calibration Block with 1 mm Flat Bottom Hole-Angular

3) Arrangement of required equipment and accessories:

Holding the probe by hand is not possible due to very small size of the tube, so special probe and fixture has been designed. 10 MHz, \varnothing 15mm, OD-14.5 mm, Dual crystal probe has been designed and manufactured which can be inserted in the tube easily. The fixture is also designed and manufactured to facilitate the probe holding and indexing of the probe. Olympus make Epoch XT Ultrasonic Flaw detector was used. Glycerin was used as a couplant.



UT probe – Dual crystal, 10 MHz, \varnothing 15 mm



UT probe with Fixture Arrangement

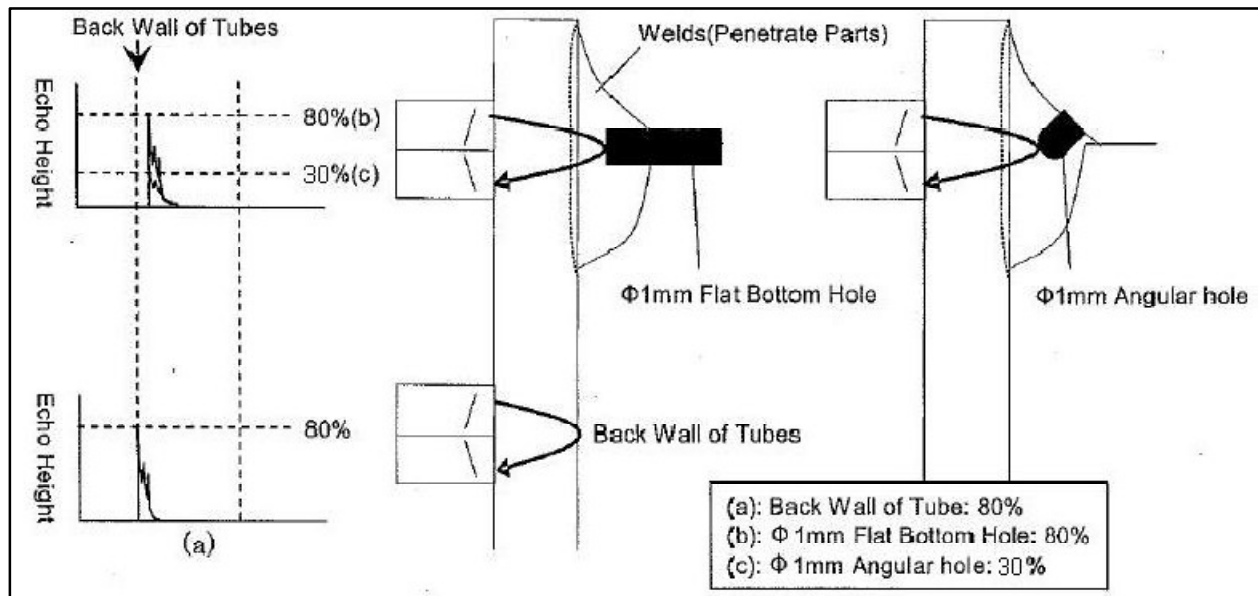
4) Procedure development and validation

Probe was set on 1 mm flat bottom hole. Indication echo was set on 80% of Full screen height.

With the same instrument setting, probe was set on angular Hole. That echo height was 30% of Full screen height. Acceptance criteria were set based on 1 mm flat bottom hole.

Acceptance criteria :

- Echo level more than 80% is rejected regardless of length.
- Echo level 30% to 80% and length is more than $\frac{1}{4}$ of weld circumference is rejected.



Calibration on 1 mm Flat Bottom Hole

5) Training to the NDE personnel

NDE Procedure, operation of probe & fixture explained to all the operators. Practical tests were conducted on the mockup block.

6) Application on the equipment/welded joint in production:

Total 6340 Nos.of Tube to Tube sheet weld joints were UT tested and demonstrated to customer.



Actual UT of Tube to Tube sheet Weld Joint
Total – 6340 Weld joints

Conclusion:

We at ISGEC Hitachi Zosen limited have developed the procedure, technique, calibration block & fixture; and successfully completed Total 6340 Nos. of Tube to Tube sheet weld joints.