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Review Article

A Case Study on Procedure Standardization of Heat Exchanger Retubing in KSA Oil and Gas Industries

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Abstract

Plant shutdown also known as "turnarounds", is one of the most critical period in the oil gas refineries in the Kingdom of Saudi Arabia. Shutdowns have the ability to affect the plant's financial future and commitments either in positive or negative way. A heat exchanger is crucial and important equipment in the oil gas refineries used for various processes and heat transfers. It also affects the duration of plant turnaround. When the operation of the plant starts the after turnaround, a failed heat exchanger within short duration of normal plant operation even though warranty of contractor exists, can create major loss in terms of money due to reduced downtime or production loss. Heat exchangers are subjected to different repairs including partial or full retubing by various methods or by simple plugging. Heat exchanger repair during the turnaround helps to reduce the down time loss (repair) of heat exchanger and will ensure the integrity for smooth running of plant. After studying the retubing of more than 75 heat exchangers, standardized procedure was incorporated to satisfy all the standard codes like ASME, TEMA, SAES, SES, NBIC and all the end users like Aramco, Sabic & its affiliates.

Keywords*:* Shell & heat exchanger maintenance, heat exchanger retubing, tubesheet cutting, tube expansion.

INTRODUCTION

In oil gas field heat exchanger playing a vital role during the turnaround. They are used transfer the heat by inlet/outlet nozzles without mixing in different manufacturing processes and help to function the plant more efficiently with profit. In many industries, the heat loss is not utilized properly and it was wasted. Because of this, heat exchangers were created to arrest and reuse heat that would otherwise it would be lost to the environment. A heat exchanger is a device built for efficient heat transfer from one medium to another in order to carry and process energy [1]. Another crucial factor is safety during the repair and reinstallation. It is essential to confirm that heat exchangers must remain in good working condition at always. Systematic periodic maintenance, infrequent repair and retubing services during turnaround, cleaning of service deposits.

Shell and tube heat exchangers are commonly found in all the Saudi Aramco Plants, SABIC its affiliates plants in Kingdom of Saudi Arabia. When the tubes leak, efficiency of the shell is reduced. Tube heat exchangers then are restored through tubes plugging by tapered plug temporarily. When the number of tubes plugged or the impact of plugging decreases the efficiency of the heat exchanger, retubing needs to be done. Replacing the complete heat exchanger is expensive also, it requires preplanning. On the other hand, retubing is a cost effective option to increase the efficiency without replacing heat exchanger

LITERATURE REVIEW

After reviewing the Literature, it can be concluded that only limited work has been done in the field of Retubing of heat exchanger.B.I. Master *et al*. in 2006 found that more than 30% heat exchangers are used of shell and tube type. Shell and tube heat exchangers can be custom designed by considering its operability, maintainability, flexibility and safety. This makes it very robust and serves major reason to be used widely in industries [2] Yokell discussed some practical aspects of the expanded and welded-and-expanded tube-to-tubesheet joints and reviewed elastic-plastic tube expanding theory [3]. Pramod S. Purandare et al. carried out experimental analysis to study the heat transfer phenomenon in conical coil heat exchanger with cone angle 90 degree [4]. Bouzid and Kazeminia conducted an analytical study to investigate the effect

of reverse yielding on the contact pressure of hydraulically expanded tube-to-tubesheet joints [5]. Gajanan P Nagre 2016 studied the factors affecting the performance of shell and tube heat exchanger. The research focused on the design of small shell and tube heat exchanger with counter flow arrangement. The parameters of the thermal analysis considered such as baffle inclination, baffle spacing, flow rates of fluids, tube diameter by using CFD [6]. Merah *et al*. measured the tube-to-tubesheet joint strength in terms of residual contact pressure between the tube's outer surface and the tubesheet whole surfaces. The joint integrity is affected by several design parameters, including the type of material and the initial radial clearance [7].

In this paper, full retubing is carried out by two methods. First method is by tube sheet cutting method along with bundle pulling and second method by without cutting the tube sheet. Depending upon the end-user application, duration requirements any one of the method will be selected. If an end user want to conduct thickness study and inspecting the internals of heat exchanger like baffles, tie rods, spacers etc. Then tube sheet cutting method was applicable.

DOCUMENTS REQUIRED FOR RETUBING

Once job or po was confirmed, it's compulsory to go through assembly drawing, tube bundle drawing, nozzle detail drawing, name plate drawing are required to submit the below quality/inspection related documents.

- Method statement (Repair procedure)
- Inspection Test plan(ITP)
- Welding Procedure Specification (WPS) &Procedure Qualification Record(PQR)
- Welder Qualification Test Record (WQTR)
- Tube Expansion Procedure(TEP)
- NDT Procedures
- Hydro Test Procedures & Pneumatic Test Procedures

From the drawing resulting details tube like expansion ratio, expansion dimensions, NDT requirements, hydro test pressure details, method of expansion, welding details was identified and tools arranged accordingly. Tube to tubesheet welding qualification and its material needs will be identified and arranged accordingly.

HEAT EXCHANGER RETUBING BY TUBESHEET CUTTING METHOD

Following steps involved in Heat Exchanger retubing by tubesheet cutting method

1. Identify the Equipment by verification of name plate and drawings provided by end user and prepare receiving inspection report.
2. Visual inspection of equipment shall be carried out prior to re-tubing. Dimensional check shall be done during inspection (i.e. overall length of the equipment).
3. New materials shall be inspected and MTC shall be reviewed prior to use.
4. Remove the channel cover and its end flange on both sides (Blinding)and Carry out visual inspection and record areas of damage, corrosion effects on the tube sheet surface, gasket areas, and any other affected areas.
5. Cut and remove old Plugs (If available) and remove the weld metal where required for welded tubes using standard cutters and clean the hole.
6. Perform the sweep blasting on both corroded Tube sheet faces before tube removal. Take precaution on Gasket surface area.
7. Remove the existing weld metal using tube facer / bevelling tool and Cut all the tubes at Floating side tube sheet with the correct specification of cutting tools (i.e. internal tube cutter).
8. Cut the shell to tube sheet weld joint on Fixed side tube sheet hard stamped tube sheet orientation prior to cutting (Refer Figure 1). Dimensional inspection (tube sheet to tube sheet length in prior to cutting the tube sheet). If any dispensary found against drawing, inform to end user.
9. Perform cleaning of shell internals after pulling out bundle and carryout sweep blasting on bundle skeleton. The internal visual inspection report after cutting the tube sheet (with photographs) shall be supplied to end user for review and record. UT thickness measurement record for shell after cleaning (sweep blasting or hydro jetting) as applicable.
10. Re-groove or reaming of Tube sheet/s holes of required. Bevel the External tube sheet holes and clean the tube sheet holes ensure that dirt or foreign material are not present.
11. Perform 100% Dye Penetrant Testing on tube sheet holes after machining contour radius(R3).
12. Assemble the tube bundle skeleton with new tie rods/spacers (if required) and tubes. Visual inspection and dimensional inspection of tube sheet/s holes. Record tube sheet/s hole diameter to determine tube wall thinning (10% tube quantity)
13. Machining and inspection of both top and bottom tube sheet contour radius (R3) for carrying out strength weld.
14. Insert New Tubes; new tubes to be inserted must be clean and free from oil and dirt. Extra care shall be observed during tube insertion to avoid tube and tube sheet damage.
15. Assembly, Fit-up and welding of tubesheet/s to shell. Welding to be done as per approved WPS and qualified welder.
16. Perform 100% PT on shell to tubesheet joint/s after root pass and final weld completion. Perform UT on shell to tubesheet joint/s after final weld

completion where applicable, Use MT if UT is not possible.

17. Dimensional inspection to ensure the tube sheet to tube sheet length (as same as before cutting). Set the tube projection as per drawing.
18. Weld first pass on tube to tube sheet joints as per approved WPS and qualified welder.
19. Perform 100% Dye Penetrant Testing after completion of 1st pass welding.
20. Weld second pass tube to tube sheet joints as per approved WPS and qualified welder.
21. Perform 100% Dye Penetrant Testing followed after completion of 2nd pass welding.
22. Carry out tube expansion after completing of tube to tubesheet welding activities.
23. Percent of tube wall thinning for light expansion shall from 1% to 3% and verified by three point bore gauge (% may vary according to plant standard). Refer Figure 2
24. Air leakage test (Pneumatic test) for tube-to-tube sheet joint after expansion with soap air at 0.35 BarG or design pressure whichever is smaller.
25. Final Visual Inspection after completion of re-tubing activities.
26. Carryout hydro test on shell side tube side as per required test pressure (Deblinding).
27. Complete draining of water and dried out of the shell and tube side shall be ensured after hydro testing / in prior to N2 purging. Dry-out and Nitrogen purging/blanketing of both tube and shell side @ 5 psig. Welding grade nitrogen (99.9%pure) shall be introduced. Purging would have to repeat for several times to get the purest N2.
28. All Inspection points shall be as per approved Inspection and Test Plan (ITP) All Inspection points shall be as per approved Inspection and Test Plan (ITP)

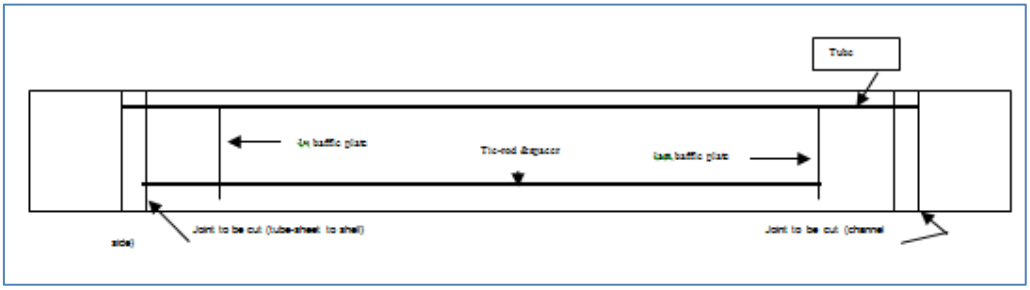

Fig-1: Tubesheet Cutting

HEAT EXCHANGER RETUBING BY WITHOUT TUBESHEET CUTTING METHOD

The main difference between both the method was time duration and internal inspection. If we did not cut the tubesheet means we can't inspect the internals of heat exchanger like baffles, tie rods, spacers etc. and also time duration will be reduced 50% less than tubesheet cutting method.

Following steps involved in Heat Exchanger retubing by without tubesheet cutting method

1. Identify the Equipment by verification of nameplate and drawings provided by end user and prepare receiving inspection report.
2. Visual inspection of equipment shall be carried out prior to re-tubing. Dimensional check shall be done during inspection (i.e. overall length of the equipment).
3. New materials shall be inspected and MTC shall be reviewed prior to use.
4. Remove the channel cover and its end flange on both sides (Blinding) and Carry out visual inspection and record areas of damage, corrosion effects on the tube sheet surface, gasket areas, and any other affected areas.
5. Cut and remove old Plugs (If available) and remove the weld metal where required for welded tubes using standard cutters and clean the hole.
6. Perform the sweep blasting on both corroded Tube sheet faces before tube removal. Take precaution on Gasket surface area.
7. Remove the existing weld metal using tube facer / bevelling tool and Cut all the tubes at Floating side tubesheet with the correct specification of cutting tools (i.e. internal tube cutter).
8. Cut the tubes from one end fixed side using tube internal cutter.
9. Pull out the tubes from fixed side by tube pulling ma-chine.
10. Remove the stubs from another end fixed side tube sheet.
11. Re-groove or reaming of Tube sheet/holes of required. Bevel the External tubesheet holes and clean the tube sheet holes ensure that dirt or foreign material are not present
12. Perform 100% Dye Penetrant Testing on tubesheet holes after machining contour radius (R3).
13. Visual inspection and dimensional inspection of tube sheet/s holes. Record tubesheet/s hole diameter to deter-mine tube wall thinning (10% tube quantity) Machining and inspection of both top and bottom tube sheet contour radius (R3) for carrying out strength weld.

14. Insert New Tubes; new tubes to be inserted must be clean and free from oil and dirt. Extra care shall be observed during tube insertion to avoid tube and tubesheet damage.
15. Set the tube projection as per drawing.
16. Weld first pass on tube-to-tube sheet joints as per approved WPS and qualified welder.
17. Perform 100% Dye Penetrant Testing after completion of 1st pass welding.
18. Weld second pass tube-to-tube sheet joints as per approved WPS and qualified welder.
19. Perform 100% Dye Penetrant Testing followed completion of 2nd pass welding.
20. Carry out tube expansion after completing of tube to tubesheet welding activities.
21. Percent of tube wall thinning for light expansion shall from 1% to 3% and verified by three point bore gauge. (% may vary according to plant standard). Refer Figure 2
22. Air leakage test (Pneumatic test) for tube-to-tube sheet joint after expansion with soap air at 0.35 BarG or design pressure whichever is smaller.
23. Final Visual Inspection after completion of re-tubing activities
24. Carryout hydro test on shell side tube side as per required test pressure (Deblinding).
25. Complete draining of water and dried out of the shell and tube side shall be ensured after hydro testing / in-prior to N2 purging. Dry-out and Nitrogen purging / blanketing of both tube and shell side @ 5 psig. Welding grade nitrogen (99.9%pure) shall be introduced. Purging would have to repeat for several times to get the purest N2.
26. All Inspection points shall be as per approved Inspection and Test Plan (ITP).

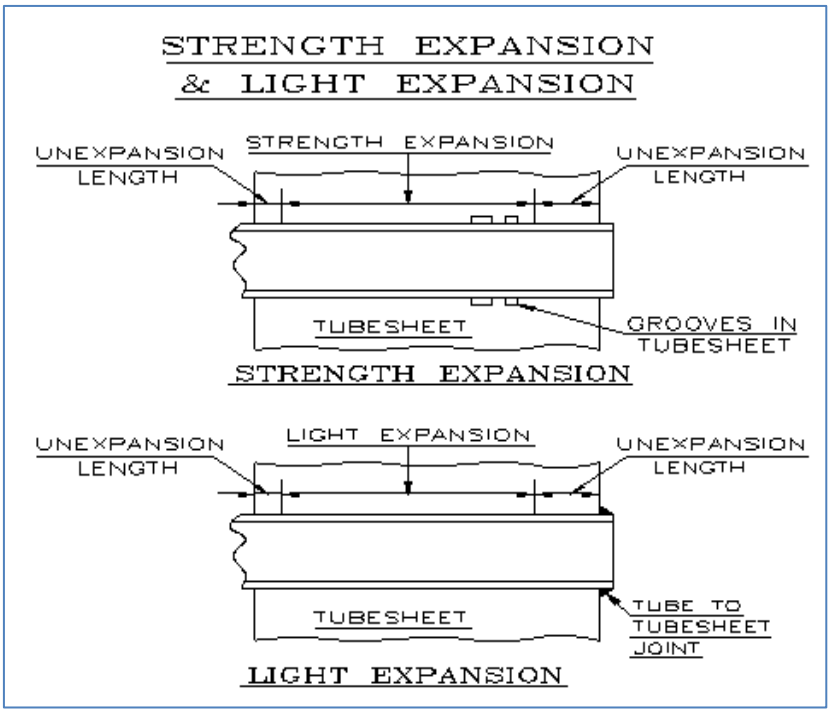

Fig-2: Strength Expansion & Light Expansion

CONCLUSION

Based on the existing condition, there is no standardized procedure or steps available in heat exchanger retubing. Procedures may vary according to plant, inspectors, contractors etc. Above procedure was prepared based on study carried out on more than 75 heat exchangers retubing in Aramco & Sabic affiliates plants. This paper describes standardized procedure for retubing of both methods of heat exchanger, which satisfies all the inspection criteria standards. This procedure was acceptable in Saudi Aramco Plants, SABIC its affiliates plants in kingdom of Saudi Arabia. This standardized procedure can also be modified for heat exchanger retubing which does not require Tube to tubesheet welding. The Practical retubing of heat exchanger for both methods (First method by tube sheet cutting method pull out bundle and second method by without cutting the tube sheet) is systematic and is perfect enough.

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