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Rebuilding Feedwater Heaters
The Cost Effective, High-Quality Alternative

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Abstract

Feedwater heaters with 10 to 30% of the tubes plugged have traditionally been replaced with new heater. Today with the focus on keeping capital cost to a minimum, rebuilding existing heaters is becoming an increased trend. During the past two years alone, metals used for making heater components have gone up 30 to 40%. Reusing all of the components that do not need to be scrapped can save significant costs. Rebuilding an existing heater can be successfully completed for 50 to 75% of the cost of an installed new replacement heater. The quality of the rebuilt heater is as good or better than that of a replacement heater because prior to and during the rebuilding process, a failure analysis is performed to determine why the first heater failed and the failed components are redesigned and replaced or modified. This paper talks about the key factors in making the decision to rebuild or replace and about how to insure a high quality rebuilt heater that will last 30 or more years by eliminating future potential problems in the existing heater.

Keys to making the best decision

Whether buying a new heater or rebuilding an existing heater, an understanding of the past heater operation and it's failures is important. Without an understanding of the reasons for the existing heater failure, a new heater design or a retubing of the existing heater will only be somewhat of a guess.

If the existing heater has been in operation for 30 to 40 years and the tubes have simply eroded away, you can be relatively assured that using the same design will likely result in another 30 to 40 years of good reliable service. If the existing heater has had some premature tube failure, it is very important to find out the root cause of failure. These past failures should be considered and incorporated into the specification of a new heater or rebuilding the existing heater to prevent premature failure of the new or rebuilt heater. The root cause of failure and the resulting associated damage to the heater may have damaged major components beyond repair. If the heater has been operated for long periods of time with tube leaks, the damage to major components could be more serious.

If a change in tube material or increasing the heater performance is a consideration, a rebuilt heater can still be considered. There are bundle diameter limitations in rebuilding an existing heater with an existing tube sheet, however, modifications to the zones and the bundle length have often achieved the increased design or change in tube material performance.

If venting is a problem with the existing heater, a new venting system can be designed into the rebuilt heater. If there are design problems with the original heater's desuperheating or subcooling zones, modifications can be made during the rebuilding process to eliminate the original design problems. On a number of heaters, after a condition assessment was conducted, the need for a complete replacement or rebuilt heater was changed to a less expensive alternative of a partial retubing with some modifications to the steam inlet, desuperheating zone flow or drips inlet impingement to correct the problem.

On-going heater maintenance should include locating and identifying the tube failure mechanism when plugging a tube leak whenever possible. Locating the tube failure along the length of the tube will help diagnose the cause of failure and what design modification or redesign should be incorporated into the rebuilt or new heater. This tube failure information along with any past eddy current test results or tube sample analysis should be taken into consideration in the new heater design or rebuilt heater redesign.

Economic Analysis

Once a decision is made to replace or rebuild an existing heater, a economic evaluation of the alternatives should be conducted between the cost of an installed new heater, the cost to rebuild the existing heater in place and the cost to have the existing heater rebuilt in a qualified contractors shop. The following cost factors should be considered:

<u>New Heater Cost:</u>

1. The cost of the new heater as specified.
2. The cost to ship new heater to the plant.
3. The cost to cut the feed water heater lines.
4. The cost to cut the steam inlet and condensate outlet.
5. The cost for any structural steel or supports to rig the heater out.
6. The cost to remove any interferences in the way to rig the heater out.
7. The cost for any crane rental and operator.
8. The cost of labor to rig the heater out.
9. The cost of labor to rig the new heater in to position.
10. The cost of labor to fit up, pre-heat and weld the feedwater lines.
11. The cost of labor to fit up and weld the steam inlet and condensate outlet lines.
12. The cost to perform NDE and stress relieve for all connections.
13. The cost for Authorized Inspection of the piping connections.
14. The cost to reinstall all interferences.
15. The cost to ship the old heater to the scrap dealer.
16. The credit from the scrap dealer for the old heater.

<u>Rebuilt Heater Cost On-site:</u>

1. The cost of the new replacement tubes.
2. The cost to ship the new tubes to the plant.
3. The cost of the replacement internal components which may include a new end plate, new or replacement support plate(s), tie rods, spacers, zone shroud, shell spool piece extension, impingement plate(s) and venting system.
4. The cost to ship the internal components to the plant.
5. The cost for skilled technicians and welders to rebuild the existing heater in place.

6. The cost for specialized tooling, technical support, on site engineering and quality control.
7. The cost for Authorized Inspection of the rebuilt heater and the shell connection piping and shell spool piece if needed (the steam inlet, condensate outlet and feedwater piping connections will not need to be cut, fit up, welded, NDE tested or stress relieved).
8. The cost to remove any interferences to pull shell or rig in new tubing.
9. The cost to rig out the scrap tubing and any required internal components.
10. The cost to rig in the new tubing to the heater elevation.
11. The cost to reinstall any removed interferences.
12. The cost to ship scrap tubing to the scrap dealer.
13. The credit from the scrap dealer for the scrap tubing.

Rebuilt Heater in Contractor's Shop:

1. The cost of the new replacement tubes.
2. The cost to ship the new tubes to the contractor's shop.
3. The cost to cut the feed water heater lines.
4. The cost to cut the steam inlet and condensate outlet.
5. The cost for any structural steel or supports to rig the heater out.
6. The cost to remove any interferences in the way to rig the heater out.
7. The cost for any crane rental and operator.
8. The cost of labor, supervision and engineering if needed to rig the heater out.
9. The cost to ship the existing heater to the contractor's shop.
10. The cost of the replacement internal components which may include a new end plate, new or replacement support plate(s), tie rods, spacers, zone shroud, shell spool piece extension, impingement plate(s) and venting system.
11. The cost to ship the internal components to the contractor's shop.
12. The cost for skilled technicians and welders to rebuild the existing heater at the contractor's shop.
13. The cost for specialized tooling, technical support, shop engineering and quality control.
14. The cost for Authorized Inspection of the rebuilt heater in the contractor's shop.
15. The cost of labor to rig the new heater in to position.
16. The cost of labor to fit up, pre-heat and weld the feedwater lines.
17. The cost of labor to fit up and weld the steam inlet and condensate outlet lines.
18. The cost to perform NDE and stress relieve for all connections.
19. The cost for Authorized Inspection of the piping connections.
20. The cost to reinstall any removed interferences.
21. The cost to ship scrap tubing to the scrap dealer.
22. The credit from the scrap dealer for the scrap tubing.

If you are not sure about which of the three alternatives may be most cost effective, ask the new heater manufacturers and the rebuilding contractor's for a budget proposal to include all of the above items. After securing their budget proposals along with their estimated time to complete each alternative, evaluate the cost, the time to complete and the lead time for delivery of the heater and the tubes and compare it with the outage dates and time frame. If more than one alternative is feasible, write a specification that allows for all feasible alternatives and send it to all experienced manufacturers/contractors.

Procedures for performing the on-site rebuilding of HP FWH with small hemi-head:

1. Arrive on-site and set up tools and equipment, move pumps and equipment next to heater and wire pump motors.
2. Open head man-way and pass partition plate.
3. Inspect and replace pass partition plate assembly if needed.
4. Machine cut and bevel hemi-head dome to allow full access to the tube sheet front face of small heaters with hemi-heads.
   Field on-site machining of the hemi-head on small heaters will save time on a number of steps during the rebuilding process:
   a. Removing the tube plugs,
   b. Removing any installed inserts,
   c. Machining the tube to tube sheet TIG welded joints,
   d. Removing the tube stubs,
   e. Reaming the tube sheet holes,
   f. Wire brushing the tube sheet holes,
   g. Measuring the tube sheet holes for verifying HEI tube sheet hole requirements
   h. Inspecting the tube sheet holes
   i. TIG joint welding the new tubes to tube sheet,
   j. Hydrostatically expanding the tube the full length of the tube sheet,
   k. Measuring the wall reduction of the hydraulically expanded tubes within the tube sheet
   l. Explosively expanding the tube within the tube sheet hole
   m. Measuring the wall reduction of the explosively expanded tubes,
   n. Preparing the tube hole for insert installation
   o. Installation of the tube insert if required
   p. Inspecting and testing the tube joints for leak free seal.
5. Move tube sheet, bundle and shell back several feet to gain access to the tubesheet.
6. Machine cut shell and weld prep bevel.
7. Pull shell off tube bundle and store shell for visual inspection and NDE as required.
8. Remove desuperheating and subcooling zone shrouds for access to tube supports within the zones.
   A focus on inspecting all internal components and welds with NDE and visual methods with the Quality Control Inspector.
9. Drill existing tube plugs using new portable drill press and drills.
   New tube sheet mounted drill presses specialized and designed for HP FWH's. This tool allows plant personnel or boilermakers to be very efficient in drilling out old plugs and at the same time reduce the fatigue factor.
10. Pull stainless steel inserts out of the tube inlets.

11. Cut tubes behind tube sheet with Plasma ID tube cutter. (This is a specialty tool which has been used successfully on a number of HP FWH rebuilding jobs.) This procedure will eliminate the need to cut any of the tubes externally at the tube sheet end. If this tool was not available, it would require wafer wheel cutting of the tubes at the end of the sub-cooling zone end plate, at the end of the skirt, again cut at the first support plate within the skirt and then at the second support plate from the end of the skirt, at the third support plate from the skirt and finally at the back of the tube sheet. These wafer wheel cuts can only be done with one boilermaker as there is very little room to work and a second boilermaker would be required to pull the tube pieces out as they are cut with the wafer wheel.
12. Pull tubes from bundle through support plates using pneumatic tube tugger.
13. Machine existing TIG tube joint welds using portable drill press fixture and specialty counter bore tube sheet cutter or portable full tube sheet machining center. A specialized tube mounted drill press is used for this process. A Quality Control Inspector will be on site to inspect this machined tube sheet during and after it's completion.
14. Disassemble zones shrouds.
15. Pull tube inserts and stubs from tube sheet.
16. Ball Burr, measure and inspect support plates to assure they comply with the current HEI requirements.
17. Inspect all zone components, shrouds, welds, impact plates, etc (QC inspector).
18. A Quality Control Inspector to provide a condition assessment of tubes and internals to plant Engineers with recommendations for any corrective action.
19. Ream and aggressive wire brush all tube sheet holes for TIG joint welding preparation.
20. Measure and document 10% of tube sheet holes and repair as needed. A Quality Control Inspector will take these readings.
21. Assemble tube support cage.
22. Align cage assembly and perform final inspection of all internal components.
23. Clean tubes before installation. Each tube end must be thoroughly cleaned before it is pushed into the cage and tube sheet.
24. Install tubes with care using white gloves when handling the tubes. Boilermaker Technicians or plant personnel will not hit the U-bend end of the tube with any object which could result in denting the U-bend. A tube clamping fixture will be used for any difficult tubes to prevent damaging the tubes when pushing them into the bundle.
25. TIG Weld tube to tube sheet joints. Only trained and certified TIG joint welders will be used to weld the tube to the tube sheet/overlay. Boilermakers/welders will be tested and certified to ASME Code in reference to tube joint welding. Approved weld procedures will be followed by all certified welders and each weld will be inspected by a Quality Control Inspector. Full access to the tube sheet will

significantly improve the welding time and welding quality of the tube to tube sheet joints TIG welds.

26. Install and weld zone shroud windows with full penetration welds.
27. Install, fit up and weld shell with backing ring.
28. Perform shell side air test and a dye penetrant test of the TIG tube to tube sheet joint welds by a QC inspector. A Quality Control Inspector will perform this test and will record the results in detail so each boilermaker/welder will know the quality of their welds and the cause of any defects.

29. Hydraulically expand tube ends within the tube sheet full length. This is the first step in performing a hybrid expansion of the tube ends with hydraulic expansion followed by explosive expansion to achieve a minimum of 4% wall reduction. An analysis and mock up test may be needed to prove the best alternatives in providing the strongest leak free seal for a specific feedwater heater application. Boilermaker Technicians/plant personnel will perform this with state of the art factory equipment and authorized training instructors to train and certify all hydraulic equipment operators.

30. Explosively expand all tubes full length within the tube sheet. Licensed blasters to explosively expand tubes and a Quality Inspector will monitor and record the wall reduction to prove the quality of the expansion.

31. Specialty code welders will reinstall the hemi-head dome by fitting up, pre-heat, welding, performing NDE and stress relieving. Welding to be Flux Core MIG weld with automatic wire feed, X-ray and stress relieving to provide the highest quality.

32. Perform a shell side hydro test, a QC Inspector and ASME Code Authorized Inspector will observe and document the hydro test.

33. Install existing or a new pass partition plate as needed to allow reasonable access to the outlet tubes for testing and plugging in the future.

34. Install head man-way. A Quality Control Inspector will communicate the correct procedure in installing the man way head and inspect.

35. Install “R” stamp as required, clean up area, load tools and demobilize.

A quality control inspector will be present at all key inspection hold points and through out all Code welding, testing and stress relieving procedures.

Summary

Heaters built 20 to 50 years ago were designed with a much higher safety margin. The heaters were much heavier and most manufactures were focused on building a long lasting product. Today’s Code allows for fine tuning the new heater designs to obtain the same performance. The new heaters are designed to keep the raw material and labor costs to a minimum. Heaters that have provided good service for a long period of time should be considered for rebuilding rather than being scrapped.

Through out the past 20 years, power companies have experimented with different materials that have proven to have less than full expected life. Feedwater heater OEM's have also certain design flaws and vulnerabilities that should be addressed during the rebuilding process. Solutions for correcting those flaws should be incorporated into the redesigned rebuilt heaters.

A key to having your heaters provide reliable long lasting performance is to regularly inspect and maintain them. Document and maintain a history of tube failures and the location of the failures along the length of the tube. Every five years or so, open the heater and perform an eddy current test and cut and pull a failed tube for inspection. This information will help with the design of a new heater or with redesigning the existing heater. Correcting weaknesses in your existing heater will insure an even more reliable long lasting heater in the future.