

Looking at liners

In April 2006 CTI Industries Inc. was contracted by a major oil refinery in the southwestern USA to achieve a unique full length tube lining project on two crude tower overhead (OH) fin fan condensers.

Although CTI has been achieving these types of repairs for some 15 years into previously damaged or failed condensers and heat exchangers, in the USA the liners were installed into two new bundles with SA-179 carbon steel finned tubes. Adding to the uniqueness was the fact that the entire installation was achieved in-situ with the bundles approximately 40 ft above ground level. A very similar installation was achieved at four major refineries in Canada, where Hastelloy C-276 liners were installed into badly pitted Monel tubes between 1993 and 1996. These units have run trouble free since the installation. The major factor that prompted the plant metallurgist and fellow engineers to utilise this technology was the historical problems encountered with these bundles in previous years. These include:

- Excessive corrosion in the original carbon steel crude unit OH fin fan condenser.
- One in-service failure plus additional shutdowns for inspection to avoid loss of containment; unacceptable tube life.
- Undersized water wash.
- Unequal water wash distribution.
- Non-desaltable (phantom) chlorides.
- Chemical inhibition program could not manage the corrosion issue.

Terry Quinn, CTI Industries, USA, recounts a lining installation carried out at a southwestern US oil refinery.



Figure 1. A 1 ft diameter pipe was cut in half. Two boxes of Hastelloy C-276 liners (in background) were loaded into the pipe and lifted by crane to 40 ft elevation for installation by CTI crew.



Figure 2. Portable hydraulic liner expansion pump.



Figure 3. Inlet feed chuck for hydraulic expansion of liners to 7500 psi.



Figure 4. Outlet air bleed liner expansion chuck.



Figure 5. Post expansion of liners shown extending through header box.

The bundles

Once these problems were identified, the most crucial decision by the metallurgist was to select a liner material that would extend the service life of the newly retubed carbon steel bundles indefinitely, thereby preventing a recurrence of a similar attack. Having experienced a number of previous failures on the original bundles, which resulted in partial plant shutdown at excessive monetary cost and related downtime, the decision was made to manufacture the liners from Hastelloy C-276.

The original two bundles in question consisted of 389 tubes, each with a 1 x 0.120 in. minimum wall, embedded finned SA-179 tubes with a length of 40 ft. These bundles are adjacent to each other, thus enabling the refinery to have one bundle in operation while the second bundle is being retubed and lined. Both units were retubed with thinner wall tubes (0.109 in. minimum wall).

It should be noted that the original bundles do not need to be retubed before applying this technology. The majority of applications are normally installed into either tubes that have been removed from service on a preventive maintenance basis in accordance with an Eddy Current, or Iris exam wherein the wall loss was estimated at 40% or greater. Another even more common application has been to install liners into all bundles that have exceeded the 10 - 15% over design for failed tubes, as a penalty is incurred for all failures from that point forward. Rather than retube an entire bundle at excessive cost and loss of production, extracting the existing tube plugs, cleaning the tubes with a high pressure water jetting and installing liners can restore the bundle to full flow capacity and forestall a major retubing project until a future planned turnaround. As the most crucial aspect of any refinery is to remain in constant operation, when older bundles are being replaced with new heat exchangers, a number of companies are installing liners into the old bundles versus retiring them to the 'boneyard'. These backup bundles can be instrumental when newer bundles fail unexpectedly. Naturally, the installation of liners into new tubes versus eroded/corroded tubes is an ideal application and the related heat transfer on new tubes is superior. This is exactly why this specific refinery opted to hire a local company to retube the bundles prior to lining them.

The local company contracted to achieve the retubing projects worked very closely with the CTI crews to keep the downtime and related startup to a minimum. Both companies worked back to back 12 hour shifts in extremely difficult conditions, including excessive cold wind and rain. The refinery was instrumental in providing as much protection as possible, resulting in a well coordinated team effort.

Problems and solutions

One potential problem following the retubing and successful hydrostatic test of the first bundle was how to support the 42 ft long liners at 40 ft elevation, which would enable the CTI crew to slide the liners through the header plug sheets and into the parent tubes before the full length hydraulic expansion process began. After discussing various options, the plant metallurgist decided to cut a 35 ft long pipe with a 1 ft diameter in half. The 42 ft liners were then loaded into the pipe and lifted by crane to the required level adjacent to the inlet catwalk and scaffolding. The liners were hand fed from the pipe, through the header sheets and tube ID's with no difficulty whatsoever. This innovation (Figure 1) was so effective that a full shift was eliminated from the original job scope for both bundles.

Once the Hastelloy liners (0.735 in. OD x 0.028 in. AW UNS N10276 WLD ASME SB 626-03 Class III) were in place, the hydraulic pump used to expand the liners to

a pressurised fit for the full 40 ft was placed on the inlet catwalk (Figure 2). In order to determine the pressures required to expand the liners from their original OD of 0.735 in. to a final OD of approximately 0.760 - 0.765 in., thereby creating a pressurised fit against the parent tube wall, the pump was set at a relatively low pressure of 5000 psi. Following this initial expansion, a series of ID readings were then recorded with a three ball micrometer (Elliott Tube Gauge #876200- 875). Following these readings, the pump pressure was incrementally increased until the desired ID was attained. With the final determination of 7500 psi, the pump was set and the full length expansion process began (Figure 3).

A common concern and/or question by most clients at this point is whether or not the 7500 psi pressure will expand the parent tube, thereby making a future retubing either difficult or impossible. The answer is visually demonstrated in the centre section of Figure 5. As the liner wall material (0.028 in.) is substantially thinner than the parent tube wall (0.109 in.), as the pressure builds the weakest point, which is the excess liner material, will burst prior to developing pressures capable of expanding a parent tube. The resultant 'fish mouth' is illustrated here. As this does not occur until the full length expansion is completed, the process is not affected.

As these two pass bundles have header boxes with a 7 in. depth at the nozzle end and a 5 in. depth at the return end, an extra 2 ft of liner material was required in order for the inlet pump feed chuck and the outlet air bleed chuck to create the necessary seal on both ends of the liner (Figure 4). Once the full length expansion process is completed (Figure 5), the inlet and outlet chucks are removed and a tube ID cutter (Figure 6) set at a predetermined depth is used to sever the liner approximately 0.5 in. from the tubesheet inside the header box. With the excess liner material removed from both ends, a tube end facer is then used to remove the remaining

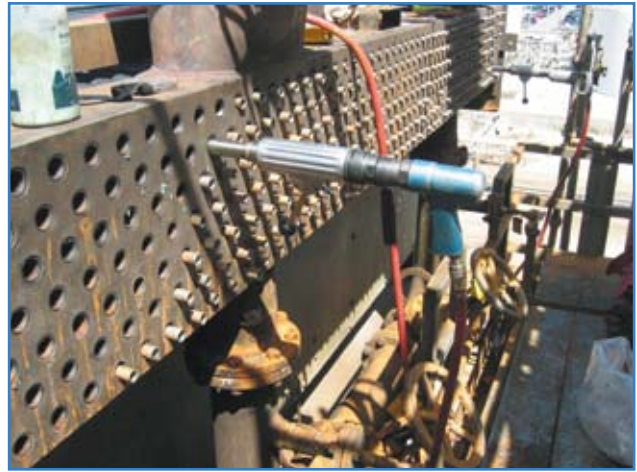


Figure 6. ID tube cutter.

0.5 in. of liner material. Upon completion of this milling process, the liners are then mechanically roller expanded at each tubesheet with a pneumatic torque controlled rolling motor to complete the expansion process. A pneumatic flaring punch sets each liner to the existing tube end and the installation process is complete. The header plugs are reinstalled and a final hydrostatic test is achieved before the bundle is returned to service.

Conclusion

This particular application was completed on budget and ahead of schedule to the delight of everyone involved. Returning these bundles to service one full shift ahead of time was of great financial benefit to the refinery. As a result of the success of this project, an additional eight Dehex OH fin fan units suffering from ammonium chloride corrosion are under consideration for an identical repair in 2007. ■