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Induction Heating Tube Extraction (IHTE) for Generating Bank Replacement

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ABSTRACT

Over time, fireside tube wastage typically results in the need to replace generating bank tubes, including the tube stub ends, which are rolled into the tube seats of the steam and lower drums. When removing tube stubs, it is important to minimize job cost and boiler downtime in addition to preserving the integrity of the drum shell.

Induction heating is a technique for rapidly heating metal through the interaction of high-frequency current and magnetic flux. This technology permits the selective, rapid, concentrated, local heating of metal without contact. The induction heating process allows for the generating bank tube stubs to be quickly heated in-situ, to 1000C, which causes the tube to undergo plastic deformation due to thermal expansion under restraint by the tube sheet (drum). The process is safe, clean and eliminates the risk of tube seat and ligament damage, often caused by the traditional tube removal methods of carbon arc air gouging or acetylene flame/torch cutting. One of the key benefits of induction heating is reducing or eliminating the need for subsequent drum shell repairs.

This paper describes the technology, the process and experience in removing tubes during a recent power boiler generating bank replacement.

OVERVIEW

- Review of traditional generating bank replacement methods
- Induction heat tube extraction technology (IHTE)
- Project review
- Safety features
- Benefits

TRADITIONAL METHODS

Traditional methods of boiler generating bank tube removal are time consuming and highly labor intensive. They create a poor work environment (smoke, sparks, fumes, heat and noise), demand extraordinary safety precautions, and carry significant risks to schedule, cost and drum shell integrity.

Carbon arc gouging is extensively used in the demolition phase of all generating bank replacements, both for the splitting of tube stubs in the drum seats of steam and mud drums, and the general cutting of the straight lengths of tubes between the drums into manageable lengths for removal from the boiler.

Although the arc gouging process is effective, it has several limitations and safety implications. If not performed by a skilled tradesman, it can result in significant repair and rework to the drum tube seat area. Due to the nature of the process, special protective clothing and breathing apparatus may be required along with ventilation equipment for the fumes generated from the work area. While gouging is in progress, very limited activity is permitted in the immediate area because of the associated work hazards, making stub removal a critical path for the project.

INDUCTION HEAT TUBE EXTRACTION (IHTE) TECHNOLOGY

The induction heating tube extraction process is an entirely computer controlled methodology aimed at effectively removing tube stub ends in a safe, simple and clean manner from the boiler drums without damaging the tube seats. The induction hardware consists of a high-frequency power unit, induction heating coil, output-matching transformer, remote on-off switch, interconnecting coaxial cables and cooling water hoses, and an auxiliary closed loop water cooling unit, meant to cool the coil and the high-frequency power unit. There are two methods of IHTE.

Heat and Shrink

Induction heating is a technique for rapidly heating metal through the interaction of high-frequency current and magnetic flux. This technology enables the selective, rapid, concentrated, local heating of metal without contact. The tube stub heats rapidly to approximately 1000C, but because the heated area of the tube stub is constrained by the drum seat, it expands beyond its elastic limit. The stub can then be rapidly cooled causing the stub to shrink to a smaller outside diameter, where it can then be removed with a specially machined anvil and hammer. This process is known as the Heat and Shrink method. (See Fig. 1.)

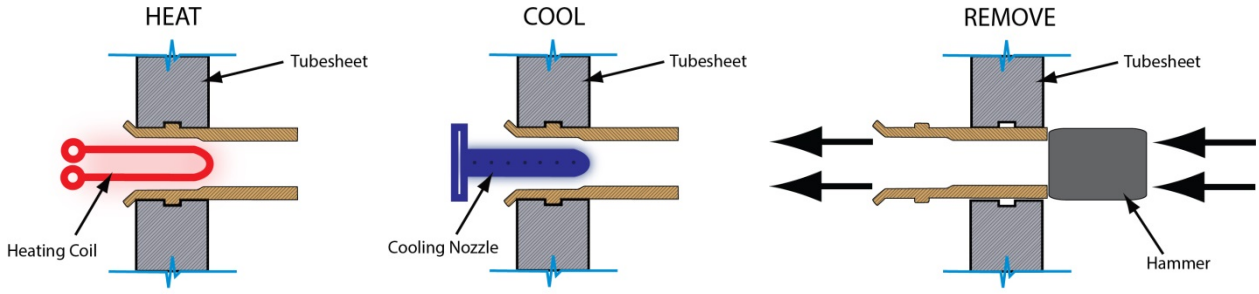

Fig. 1 Heat and Shrink IHTE method.

Heat and Pull

The Heat and Pull IHTE method (Fig. 2) is an alternate but strongly preferred extraction method especially for heavily over-expanded tubes. It is particularly effective for tube stubs installed in tube sheets with seating rings. The tube stub is rapidly heated from inside the drum while being extracted from outside the drum with a pre-installed hydraulic jack on the tube stub. Prior bell removal is not required, as the bell collapses and is pulled through with the stub.

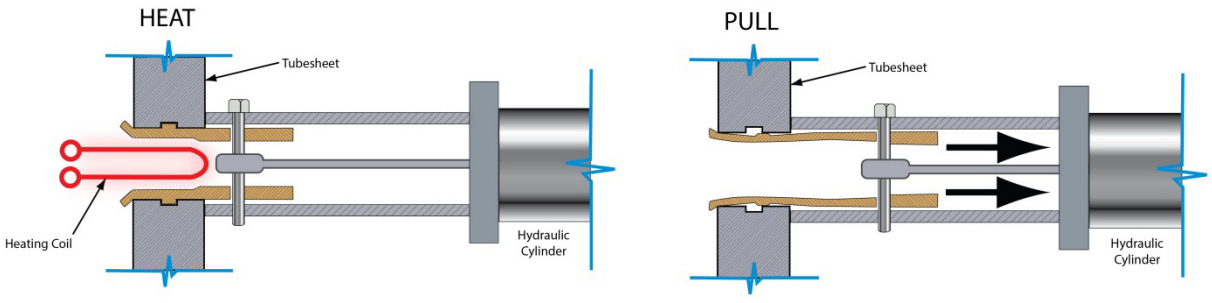

Fig. 2 Heat and Pull IHTE method.

PROJECT

The customer requested support for a generating bank replacement on two bottom-supported Combustion Engineering VU60, D-style corner-fired units. There were 672 generating bank tubes and 288 screen and wall tubes (1920 tube stubs) at 2.5 in. OD x 0.095 in. thick made from SA178A. The steam drum shell was 3.25 in. thick and the mud drum was 1.75 in. thick. The schedule was for January 2015 and November 2015, respectively.

The schedule and space that was available for the first removal called for the use of two IHTE units, one on the steam drum and one on the lower drum for approximately eight 10-hour shifts to complete the removal. The scheduled

was later revised to reflect removing approximately 25% of the tube stubs in four stages. Once the new tubes were installed the next removal stage would begin. The second removal called for two IHTE units, one on the steam drum and one on the lower drum for three stages of removal (approximately three 10-hour shifts per stage).

The boilers are located outdoors, which left the project vulnerable to the elements, especially with the area having several flooding events in recent years. Although the plant was not directly affected during the project, any potential weather-related issues are mitigated when the heat induction equipment is to be located outdoors by having the equipment set-up area enclosed.

Like many recent projects, this one provided labor that has never worked with the induction heating process. With a safety orientation, brief video and minor supervision, crews were able to quickly master the process and work effectively in a safe manner. Positive feedback from the work crew indicated a preference for the IHTE technology as opposed to traditional tube stub removal methods due to the reduction in man-hours for the stub removal and elimination of tube seat repairs with minimal cleaning of the tube seats.

SAFETY FEATURES

Safety features include a digitally controlled power unit with touch screen and remote on/off switch with integrated interlocks to prevent dangerous situations to the operator and to protect the equipment. The equipment is fully grounded. Sparks, flames, fumes, molten metal or intense light are no longer threats to safety and productivity, and ventilation requirements associated with these environments are eliminated.

BENEFITS

Primary benefits of the induction heat tube extraction methods include:

Reduced project cost and schedule

Man-hours are reduced through faster tube stub removal compared to conventional methods. Tube seat repairs are virtually eliminated (old damage from previous retubing may need to be addressed) with minimal tube seat cleaning, increasing the success for a dry hydrostatic test. Tube stub removal does not require specialized trade skills.

Improved quality

Low heat input to the drum shell means that the material grain structure is unaffected. There is no hardening of the tube seat surface and no risk of damage to the ligaments as proven by comprehensive metallurgical laboratory testing.

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