TCR Advanced Engineering P. Ltd

Experts in Metallography, Failure Investigation and RLA

Metallurgy for Industries

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Heat exchanger tube inspection

An introduction

Heat exchangers are devices used to transfer heat energy from one fluid to another. Typical heat exchangers that are normally used include condensers and evaporators installed in air conditioning units and refrigerators. Boilers and condensers in thermal power plants are examples of large industrial heat exchangers. They are also abundant in chemical and process industries. There is a wide variety of heat exchangers for diverse kinds of applications. Hence the construction also would differ widely. Periodic inspection of heat exchanger tubes is inevitable to regulate heat transfer phenomenon and to avoid forced shut downs.

Selection of inspection technique depends upon the damage mechanisms expected in heat exchanger vis-a-vis its capability to detect the flaw.

The newsletter intends to highlight advantages and disadvantages of different inspection techniques.

1) Eddy current testing for non-magnetic materials

Eddy current testing is widely used in heat exchanger inspection for following damages

1. ID/OD Pitting - This is the most common form of damage
2. ID/OD Cracking - Can be present in any tube material
3. Erosion - Caused by flow
4. Inlet End Erosion - Caused by turbulent flow at the Tube Inlet
5. Vibration Damage – Occurs between supports
6. Cracks at Tube-sheet - Caused by high stresses
7. Defect at support – This can be pitting/cracking

It is very difficult to detect tight SCC cracks by eddy current testing.

Eddy current testing indicates the location of flaw with respect to the distance from the end of tube but cannot provide the circumferential location of flaw and its nature with respect to

Microstructure of the Month

Magnification: *100X*

Etchant: *- As polished condition*

MOC: *SS 304*

Component: Gear box anchor bolt

Cause: The failure of anchor bolt of SS 304 is on account of mechanical fatigue that was initiated at the susceptible location of the root of the thread profile as the steel was found to be dirty having high level of inclusion rating and rolling defects.

Useful hints: It is recommended to use good quality of steel with minimum inclusions content. Following guidelines is provided to keep inclusion control. Type A- thin and thick: maximum rating allowed is 1. All other inclusion maximum rating is allowed is 1.5 however total rating sum should not exceed sum of 5.

the morphology.

2) RFET/NFT for magnetic materials

Remote field eddy current testing (RFET) and near field testing (NFT) are used in combination or individually depending upon the capability of testing machine. Remote field eddy current testing has better sensitivity to small defects away from structures, such as support plates and tube sheets than near field testing. Near field testing signals are easier to analyze than remote field signals, which has much better sensitivity and ease of analysis for defect signals close to structures such as support plates and tube sheets. So if one needs to know the location of flaw whether it is from OD or ID, one has to inspect a bundle with near or remote field technology or just inspect the bundle twice.

Now one can inspect a ferromagnetic tube bundle with near field and remote field simultaneously using the combination of probes from Eddy current technology incorporated.

By combining a near field sensor with a Remote field one, following capabilities can be added to the remote field probe alone.

1. An ability to accurately measure defects close to support plates and tube sheets.
2. An ability to detect a hole under a support plate.
3. The ability to distinguish between inside and outside defects.
4. An ability to inspect fin fan tubes (ferrous tubes wrapped with external aluminum fins)

RFET will not detect cracks and is used for volumetric defects like pitting or wall loss.

Like Eddy current testing, RFET gives the location of flaw with respect to the distance from the end of tube but cannot provide the circumferential location of flaw and its nature with respect to its morphology.

3) Acoustic pulse reflectometry (APR)

Acoustic pulse reflectometry is a patented technique with a trade name acoustic eye.

APR can test up to 4”inner diameter of any shape or tube material. It is ultrafast, non-invasive inspection; time required is less than 10 secs. per tube- 5sec for less than 6m tube . It is ideal for 100% inspection and emergency situations. It can detect blockages apart from pitting or punctures- useful for detecting extent of cleaning, to increase efficiency of heat exchanger. Defects under tube sheet or baffles can also be detected by this technique.

The major disadvantage of this technique is that only defect originated from ID can be detected. Cracks cannot be detected.

4) Internal rotary inspection system (IRIS)

IRIS is an ultrasonic method for the nondestructive inspection of tubes. The IRIS probe is inserted into a tube that is flooded with water, and the probe is pulled out slowly as the data is displayed and recorded. The ultrasonic beam allows detection of metal loss from the inside and outside of the tube wall.

IRIS can provide the location of flaw along the length as well as circumference of tube.

Defect detection capability for IRIS is better than RFET (in ferrous materials) but it is inferior to ECT (in non-magnetic materials)

IRIS is not as capable of detecting smaller defects when compared to ECT. The major disadvantage is that it is very slow technique (scanning speed @ 1 inch per second), but accurate in wall measurement of ferrous tubes in range of 0.15mm. IRIS inspection requires a better cleaning of surface than eddy current testing.

5) Videoscopy

Remote visual inspection by a videoscope will provide a qualitative analysis on the results of one of the above techniques. Videoscopy may be carried out after one of the above suitable techniques to know the nature of flaw.

Judicious selection of **combination of inspection techniques** helps the user to assess the condition of tubes of heat exchanger and avoid forced shutdowns. It helps to increase profitability of plant in a long run though it may appear high in initial cost.

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