

Nondestructive Evaluation of Weld seam Failures in Tubes and Other Structures for Thermal, Wind and Nuclear Power Applications

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ABSTRACT

The paper gives inspection and maintenance practices being followed in an important Tube manufacturing plant (Bundy India Limited, Baroda) where the first author (R. M Joshi) worked. Advances in the eddy current technique of on line surface and subsurface inspection along with some unconventional modern methods and their scope of application have been highlighted. The inspection techniques contribute to improved customer confidence.

Introduction

State-of-the-art non destructive testing (NDT) and condition monitoring techniques help in total customer-acceptance of production lots in a tube manufacturing unit. Timely preventive action is enabled as a result. Probable tube failure may be accurately predicted by using conventional and non conventional non invasive inspection techniques. Such techniques ensure health of equipment/component, enhance their reliability for uninterrupted operations. Different condition monitoring techniques detect in-operation defects/abnormalities of an equipment/component. Vibration monitoring, bearing condition monitoring and infrared thermography / thermometry are prominently applied non invasive industrial NDE techniques.

Overview of Inspection and Maintenance Activities

The inspection process (both on-line and off-line) can be directed as follows: (a) for work piece/product, (b) equipment, (c) raw material and (c) Condition monitoring. In the following sections, explanations are provided through typical examples.

Raw Material:

Physical characteristics

The raw material physical characteristics were 0.2 mm thick mild steel strip with 2.5 micron copper coating on both sides, slit width of the copper coated strip depended upon the tube size.

Chemical characteristics

Chemical characteristics of the raw material were, Carbon: 0.12% max., Manganese: 0.50% max., Phosphorous: 0.04% max., Sulphur: 0.045% max.

Tube Product Mix and Other Mandatory Test Requirements

- * Nine types of tubes with sizes from 3/16" to 5/8"; in three thicknesses namely 0.7 mm, 0.85 mm and 0.89 mm;
- * 25 micron yellow chrome coated, with 0 white rust for 72 hours in salt spray test; 13 micron olive green coated, with zero white rust for 96 hours in salt spray test;
- * ultimate bursting strength varying from 1155 Kg / mm² min. to 435 Kg / mm² min.
*Bend test,
- * flare test,
- * internal cleanliness inspection,
- * residual moisture,
- * 100% leak proof testing and
- * inspection.

Process Flow

In this process M.S. strip is procured and copper coated in-house /Copper coated M. S. strip is procured, slit in-house / copper coated, slit M.S. strip is procured. The slit strip is cold rolled around a mandrel in tube rolling mill. Tubes are passed length-wise through furnace kept at 1050°C under reducing atmosphere and at -80°C dew point. The tubes are inspected on-line to check for 360° circumferential brazed bonding of copper to steel surface by on-line eddy current testing. The tester accepts a tube if circumferential braze is found to be bonded 100%. Otherwise, the tube is destroyed by crimping. The accepted tubes are sent to condenser fabrication shop/electro galvanizing line for yellow chrome or olive green coating. Painted condenser assembly, yellow chrome coated tubing, olive green coated tubing are dispatched to customer.

Inspection

The on line inspection is done to ensure bonding of the tube flaps by using on-line eddy current tester, on-line hygrometer (-800 C, hydrogen) along with on-line data logger connecting 25 numbers of Cr-Al thermocouples for temperature measurement and condition monitoring of the surface of tubes of Inconel 600. Visual inspection of the mandrel is done. Off - line equipment inspection, in-process inspection, finished material inspection and laboratory testing is done as per relevant Indian standards during shut downs. Off - line inspection of tube assembly is done by leak test, inspection of in process material in tube bending area, inspection of finished painted condenser assembly for the refrigeration market in salt spray chamber as per relevant Indian standard to check

for red rust for 24 hours. Off - line visual inspection of finished material is done to ensure cosmetic appearance of the product.

Specialized Off-Line Inspection

Non destructive inspection is done as follows

- (a) welded components and assembly of wind turbine generators and turbine blade assembly of thermal power plant [1] by using a coordinate measuring machine,
- (b) magnetic particle inspection for wind turbine generator (shown in Fig. 1(a)),
- (c) liquid penetrant inspection,
- (d) Ultrasonic testing of steel plate for Nuclear Power Corporation of India Limited (NPCIL) (shown in Fig. 1(b)),
- (e) visual inspection of welds on stator (shown in Fig. 3).

Apart from the above evaluation of results is done manually/visually.

Unconventional Inspection Techniques

Some of the modern ND evaluation techniques [2] are (a) Gamma Ray Scanning, (b) Radio Isotope Tracer Technique, which uses radioactive tracers, (c) Acoustic Emission technique [3], which detect and evaluate active defects in solid material structures

Advantages of On-Line Inspection

Online inspection and maintenance techniques may be divided into two broad categories (a) monitoring technique, which indicates that changes are occurring within equipment and (b) techniques that can be applied to repair of equipment, which cannot be isolated without loss of production. Such techniques help initiate (i) suitable preventive actions, (ii) prolong plant operation with online corrective actions, (iii) keep break downs to a minimum, (iv) provide inspection guidelines during shutdowns permitting decision making for immediate shutdowns to avoid any catastrophic failure, (v) help decide the severity of damage to decide extent of work involved for repairs and (vi) plan minimum operational costs during repair-planning.

Advantages of Off-Line Inspection

Off- line component/equipment inspection by visual / boroscopic inspection, LPT, MPT, UT, and RT respectively enables thorough health monitoring of static and rotary machine parts by substantiating findings of on-line inspection thereby enabling precise action for repair and modifications, minimal total breakdown time, reduced secondary damages, safe equipment life, assurance of safe and reliable operation with increased equipment availability [4], lowers excessive spare parts inventory leading to higher profits and a higher return on investment.

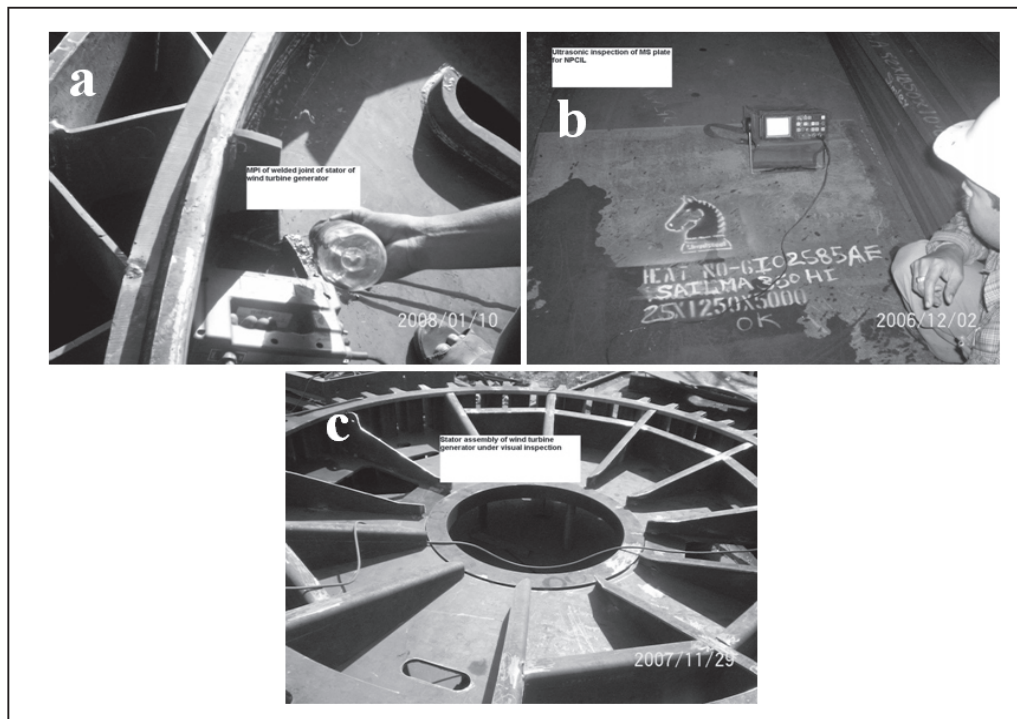


Fig. 1: Showing (a) magnetic particle inspection, (b) ultrasonic inspection and (c) visual inspection

Conclusion

Nondestructive inspection and evaluation techniques are significantly unavoidable in any industrial unit like a tube manufacturing plant. The role of ND evaluation and its relationship to almost all the functional areas of such a plant becomes acutely indispensable in the current heavily competitive techno legal industrial environment the world over.

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