Remaining Life Estimation in Boiler Pressure Parts
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Remaining life estimation in boiler pressure parts is a very important tool towards predictive maintenance of boiler pressure parts. Boilers are made up of large amount of tubing and pipes of different materials which will have to withstand high pressure and temperature.

Boilers are made up of a large amount of tubing and pipes of different materials which will have to withstand high pressure and temperature. These pressure parts undergo aging due to various reasons including internal and external deposition. Above a particular limit of aging these pressure parts start failing frequently, which leads to higher outage of the units. To understand the health condition of these pressure parts there are many scientific methods used today which can estimate the remaining life of the pressure parts.

Reason to estimate remaining life
The high temperatures to which the pressure parts are subjected at elevated pressure lead to creep stress. The starting and stopping of the unit results in fatigue stress, and the fuels burnt can cause corrosion in various areas in the boiler. The water used for steam generation leaves deposits inside the tube which increases the metal temperature leading to long term overheating. Residual stresses during manufacturing, the vibrations due to flow over the tube, mechanical vibrations, erosion due to the abrasive nature of the fuel, etc, do occur in a boiler. Operation of the boiler at elevated temperature and parameters leads to stresses higher than the design levels. All of these, individually or combined, lead to material degradations of different magnitude resulting in failure. To avoid any such forced outage, boiler owners would like to have a preventive method. Remaining life estimation of pressure parts helps this requirement by a scientific method of analysis.

Steps involved in remaining life estimation
The first and foremost requirement of remaining life estimation is to study the past data of the plant.

- The predicted performance data,
- The guarantee performance test data,
- The operating data for the period of time of operation of unit,
- Operating practice adopted
- The maintenance data,
- Failures and repairs
- Previous inspection reports
- The outage data,
- Areas of frequent failure if any,
- Inadequacy of any nature in boiler,
- Modifications carried out for achieving the performance,
- Other major modifications,
- The procedure adopted for welding during the years,
- Any special welding method used,
- Variation in water chemistry
- Any post operational acid cleaning done
- The number of startups and shutdowns of the unit
• Temperature excursions in various areas
• Any special study carried out and the reason for the study
• The owners requirement after the life extension program
• After consolidation of the data and understanding the data, the next step is to do a set of field tests. These field tests include.

• Visual inspection for
  • Erosion, corrosion
  • Swelling, scaling
  • Deposits, misalignments
  • Supports, pipe hangers etc
• Dimensional checks
  • Thickness
  • Outside diameter
• Non-destructive examination
• Penetrant testing including fluorescent type
• Magnetic particle inspection (Wet fluorescent & Dry)
• Ultrasonic tests
• In-situ hardness checks
• Eddy current testing
• Tube sampling – water walls for internal deposit analysis
• Superheater and reheater sample if needed
• Special examinations for
  • WW H2 embrittlement
  • Superheater/Reheater for oxide scales,
  • Metallographic examination of thick wall component
  • Fibroscopic inspection of headers and other regions needed
  • Spot chemical check when needed

Once when the field tests are completed, a few laboratory examinations and tests are carried out. The tube samples taken from the water walls, superheater, and reheater are subjected to microscopic examination (Light Microscopy & Scanning Electron Microscopy) to understand the microstructure of the tube material. The water wall tubes are subjected to internal deposit analysis. Both the quantity of the deposit and the chemical composition are carried out to evaluate the need to carry out post operational acid cleaning. Based on this, the solvent for post operational acid cleaning is decided. Other mechanical and metallurgical tests are also carried out for the tube samples collected. If any external deposits are collected from locations in the boiler, they are also analysed to understand the cause of the deposition. The presence of both external and internal corrosion is also evaluated based on the deposit analysis and the tube sample study. If the failure data gives a clue for any hydrogen embrittlement in the water wall tubes, a detailed field test and analysis is carried out to decide the area requiring replacement. The samples taken from the thick walled components are analysed for spheroidisation and cavitation level. Based on the level the repair and replacement strategy is arrived at.

**Remaining life prediction techniques**

There are many methods used by engineers to predict the remaining life of boiler pressure parts. The most commonly used technique is the steam side oxide scale thickness growth and life fraction rule using Larson-Miller
parameter. Every tube in service has a Larson-Miller parameter that increases with time. The oxide scale thickness is correlated by many equations which is used to arrive at the remaining life along with the life fraction rule.

The strain measurement technique is another method used, however this requires data with a large time interval.

There are advanced techniques like crack growth propagation analysis which is being tried with limited success.

Many other tailor-made techniques are used by different boiler makers to estimate the remaining life of pressure parts. However due to the large scatter in stress values of the materials used along with the safety margins and other special allowances used during design, it is very difficult to predict the remaining life with good accuracy levels.

Source: