Life Assessment Steam Turbine Components

With the increasing competition in the power generation sector worldwide, high standards of reliability, availability and safety are becoming number one requirement for successful operation of a power plant. Steam turbine equipment operates under very complex thermal and mechanical loadings and hence plant operators are daily challenged to cost-effectively manage their safe and reliable operation.

AMCO Integrity offers comprehensive ***Asset Integrity Services*** that assist plant operators in making informed decisions on the operation and maintenance of the main steam turbine components. The benefits include:

- Improved safety and reliability
- Reduced downtime
- Scheduled repair or replacement
- Cost savings

FITNESS FOR SERVICE & REMAINING LIFE ASSESSMENT

A key activity of AMCO Asset Integrity Services is in the area of fitness-for-service (FFS) and remaining life assessment (RLA) of a range of plant, including steam turbine equipment. Assessment of this type may be performed on new components just entering service or on existing components where changes in service are planned as a result of degradation during service. For performing such an assessment, steam turbine equipment is generally split in two main categories:

Rotating parts

- High temperature Rotors & blades
- Lower temperature Rotors & blades
- Discs

Static parts

- Casing
- Valves / Steam Chests
- HT Fasteners
- Piping

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As is well known the rotors are complex components with many different designs (solid, bored, welded and disked). In terms of the steam turbine equipment assessment (FFS & RLA), the rotors, and particularly those operating at very high temperatures, are the most critical components, as they are not only highly stressed but ***brittle failure*** can be a significant threat to them. The rotor critical areas at which FSS and RLA should be focused include the bore, the 1st stage blade root fixing and geometrical stress raisers. Furthermore, for the solid forged impulse type rotor, two additional critical areas should be considered; the disc balance holes and disc to body fillet radii.

The current trend towards higher plant output leads to high operating stresses within the plant components including the steam turbine equipment. To accommodate these stresses, materials exhibiting higher strength and fracture toughness are used for steam turbine components. However, rotor steels particularly those of earlier manufacture, are susceptible to ***temper embrittlement***, which is a shift in the ***brittle to ductile transition*** that occurs when the material is cooled (heated) slowly through a temperature range of 350°C to 570°C. Hence, when evaluating the remaining life of a steam turbine component (e.g. rotor, casing), it is important to assess whether it has been operating within the temper embrittlement temperature range and if it has, any impact on the material fracture toughness has to be taken into account when making an integrity assessment of such components. . It is well known that for the steam turbine equipment, the key input to the FFS and remaining life assessment is not single valued but distributed:

- through spatial changes (e.g. thickness, temperature, stress, etc.) or temporal variability (e.g. operating conditions, ageing, etc.), or,
- through the imprecision of measurements and scatter in the data (e.g. inspection, on-line monitoring data, materials data, etc.)

The deterministic approach to life assessment is based on the “worst-case scenario” and conservative values/ bounds for the inputs are generally used in the analysis. However, this may provide an overly conservative and unrealistic result.

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Thus AMCO also offers the option to perform a ***probabilistic life assessment,*** which provides a more realistic estimate of the component remaining life by statistically quantifying the variation in the key inputs in terms of a nominal value and the scatter or drift around this value. AMCO has built up valuable experience in this area and made a number of publications.

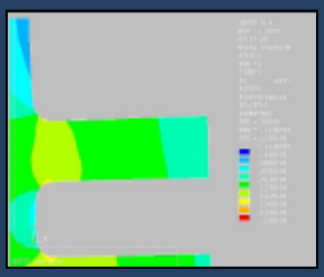
Stress Analysis

The integrity of the steam turbine equipment and hence RLA is closely linked to the stresses that key components experience during service and how these stresses compare with the design. AMCO has excellent experience in stress analysis using both traditional 'hand' calculation approach and, where necessary, advanced Finite Element (FE) methods. AMCO is well familiar with British, European and ASME standards and can provide assessment for:

- Temperature distributions
- Mechanical and thermal stress levels and distributions in structures subjected to transient and/or steady state loading
- Dynamic response of components, including natural frequencies and mode shapes
- Stress concentration factors, particularly used for assessing grind-out repair of small defects
- Life prediction under creep and/or fatigue conditions

FE Thermal and Structural Analysis of Steam turbine components

a/ Valve casing – Temperature distribution



b/ LP turbine rotor – Stress distribution in stage 1

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AMCO'S Approach to Life Assessment

AMCO adopts a staged approach to life assessment of steam turbine equipment as follows:

i Preliminary assessment (Level 1)
- Detailed assessment (FE stress analysis etc.) using average or minimum inputs
- Deterministic

ii Refined Assessment (Level 2)
- Improve operational inputs
- Probabilistic option

iii Detailed Assessment (Level 3)
- Improve material property inputs via sampling, testing and re –inspection
- Refined probabilistic option

AMCO has established expertise in performing a wide range of FFS analyses and remaining life assessment for steam turbine equipment, which includes (but not limited to):

HP/IP Rotors
- Brittle fracture,
- Bore high strain fatigue,
- Bore creep cracking due to strain exhaustion,
- Surface thermal fatigue damage, creep-fatigue interaction

LP Rotors & Discs
- Stress Corrosion Cracking
- Corrosion Fatigue

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Life Assessment Steam Turbine Components

LP Turbine Blades

- Stress Corrosion Cracking
- Corrosion Fatigue

High Temperature Casing

- Thermal fatigue
- Creep-fatigue

AMCO's Asset Integrity Services are internationally recognized in the field of ***defect assessment*** both at ambient and elevated temperatures. For assessing steam turbine components containing cracking (detected or assumed), particularly their fitness against brittle fracture.

AMCO uses a range of effective and robust in-house tools that incorporate the widely accepted fracture assessment procedures and its own practical field experience. These special purpose tools, which are based on both ***deterministic*** and ***probabilistic*** methods, enable the assessment of known defects and to determine maximum acceptable defect sizes to assist in identifying suitable inspection methods and inspection intervals. In the area of defect assessment AMCO provides expert services in:

- Crack growth under fatigue and/or creep conditions.
- Determination of necessary potential defect size to be detected by NDE.
- Defect tolerance including critical crack size or critical load.

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