ERA TECHNOLOGY

Steam Reformer Life Assessment

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Performance and life optimisation of steam reformers

Steam reformer units are critical to many processes in refining and chemical plant, being used in the production of ammonia, methanol, acetic acid and as a source of additional hydrogen in the oil refining process. Despite this variety of roles, there is similarity in general design, materials selection and operational conditions, allowing a common approach to integrity assessment and life prediction.

Life management of reformer units is ordinarily dominated by the service capability of the catalyst tubes; approaches to their evaluation form the main topic of this summary. However, creep-fatigue of pig-tails can be a significant operational problem and instances of thermo-mechanical fatigue of outlet manifolds, creep cracking of manifold and riser welds and support problems are known and consequently must be dealt with in an overall asset management approach.

Approach

ERA Technologys ReformPLUS package for catalyst tubes uses a creep life consumption algorithm, validated by critical experimentation and service experience, which accurately models the materials response to steady and transient conditions. The package takes as input historic operating data and standard materials properties, augmented by specific test data and condition assessment information where appropriate. Variability in all input parameters is accounted for by use of probabilistic techniques. Output is provided in terms of cumulative failure probability, increase in diametral strain and through wall damage progression, as functions of future service time and of location within the unit.

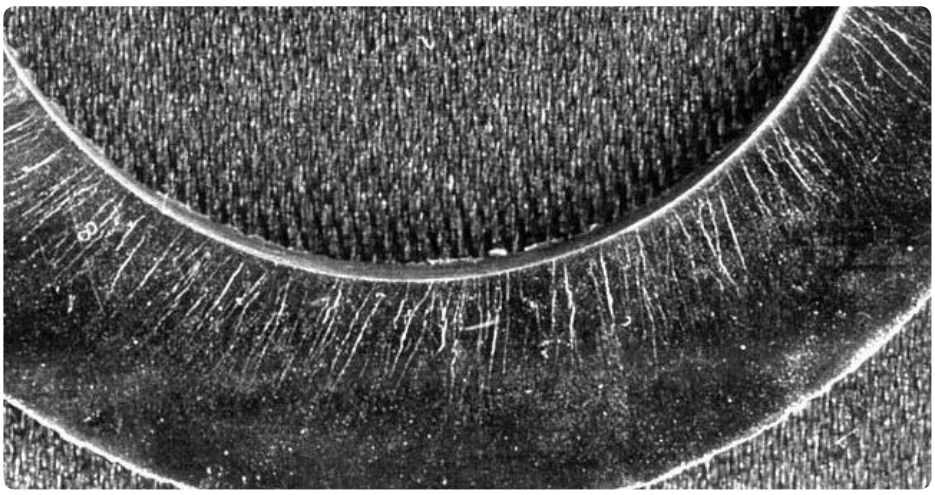
Similar models are available for other major components, such as manifolds, risers and pigtails.

Objectives

The objectives of ERA's ReformPLUS programme are:

- To establish the cumulative failure probability, expected tube failure and damage accumulation rates as a function of future service time for the subject furnace tubes.
- To make recommendations regarding future run/retire/inspection strategy.

ReformPLUS will provide a validated and realistic evaluation of future tube serviceability and remaining life, and thus clearly provides the basis for an optimised inspection/ replacement strategy.



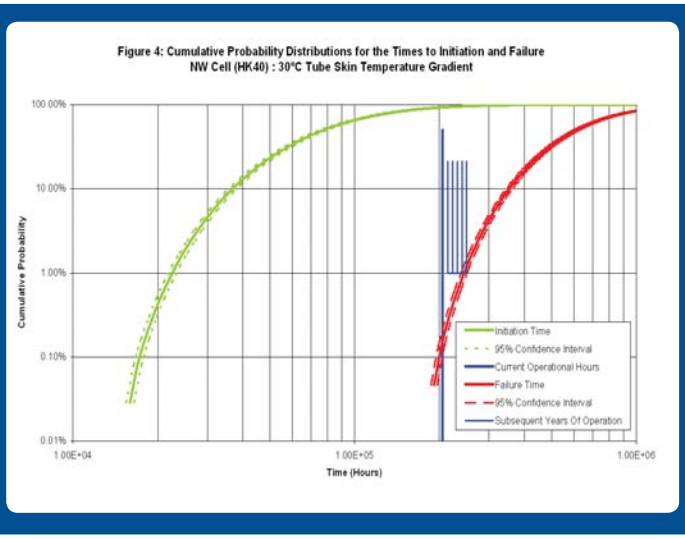
Benefits

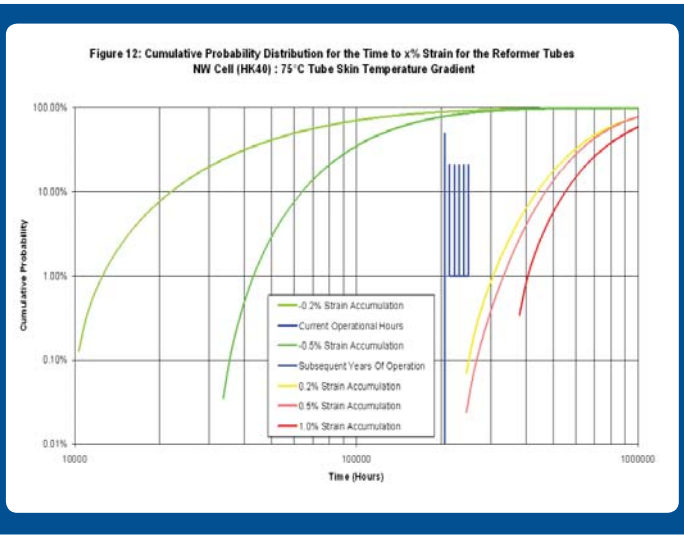
ERA's assessment of steam reformers (including reformer manifolds, pigtails, catalyst tubes, and risers) will help kpclients to:

- Save costs
- Determine remaining life
- Extend the life of existing plant
- Reduce outages and unplanned inspection/maintenance
- Improve confidence in reformer integrity
- Provide input to planned inspection and maintenance strategies
- Prioritise and schedule repairs/reorder of catalyst tubes.

The assessment route does not require access to the plant, although this can be beneficial, and may thus be carried out at any time. Frequently the maximum value from such an assessment comes from evaluation prior to a planned shutdown. In this case the actual requirement for inspection can then be assessed and the significance of the expected damage determined in advance.

The outcome of the assessment provides a quantification of future tube serviceability and as a consequence a significance to damage classification based inspections. This is expressed as the future risk of tube failure and expected tube failure rate.





The possibilities for life optimisation to suit production demands can be quantified through a review of start up and operational procedures. The life penalty for increasing throughput can be evaluated, as can the trade-off between the severities of transients against steady state operating conditions.
As the assessment is based on a mechanistic approach, alternative tube replacement materials may be easily compared.
Cost optimisation for proposed alternative operating regimes and/or upgraded replacement tube materials may be defined.

Typical results

The typical output from a ReformPLUS assessment is shown above. The left graph shows the predicted times to crack initiation and to tube failure relative to current and future service times. The right graph shows the development of diametral tube strain relative to current and future service times. This information enables inspection actions to be pre-planned at the appropriate level. For example, there is little point in doing UT examination until crack initiation has occurred. In addition there is little point in Eddy current examination until a diametral strain level equivalent to cavitation/cracking has reached the inner surface of the tube. The ReformPLUS assessment provides this information. An ERA assessment report gives full details of the data used and the interpretation of the assessment and the results.

Pigtail assessment

Pigtail life is predominantly creep controlled and thus influenced by temperature and time in service, primary and secondary loadings, internal and external oxidation and corrosion and tube materials properties. These parameters can only be adequately described by ranges appropriate to both groups of pigtails and the total population of pigtails. An ERA assessment takes existing unit inspection data into a proven pigtail creep model. Rigorous treatment of the data necessitates the use of probabilistic techniques. This procedure has the advantage that the effects of uncertainties in data accuracy can be quantified in their effect on outcome. The assessment procedure allows quantification of pigtail secondary loadings which cannot be identified by any other means. Remaining life assessment is thus based on the true state of pigtail loadings.

This avoids the assumption that these are only one half of the pigtail hoop stress, whereas in fact they can be frequently higher with appropriate deleterious effect on life.

ERA Technology

Since its foundation in 1920, ERA has evolved from its roots as a research association to become a centre of excellence in engineering technology with a strong brand and reputation, sitting at the forefront of specialist asset integrity service provision.

ERA is committed to delivering professional services to our customers across all business sectors, assisting them in reducing technical and commercial risk, improving the operational performance of their assets and developing and enhancing the competitiveness of their products and systems.

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