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Use of expert system software for life monitoring of power plant components

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Abstract : *Life management of primarily high temperature components in power/process plants is a very involved task. Various components in a running power plant are subjected to different loading cycles, temperature, pressure and environmental conditions. The dependence of running power plant on various components as well as interdependence of various components on each other adds to the enormity of the task and requires different maintenance/repair/ replacement schedules. A systematic and smooth functioning of the plant necessitates a step-by-step analysis for each components based on its operating parameters, material. In present days, various commercial softwares are used for life monitoring, deciding different schedules in these plants. In the present paper an effort has been made to show the use of ALIAS (Advanced Life Assessment System) and its effectiveness in handling problems related to plant life monitoring, risk analysis, preparing maintenance/repair/replacement schedules.*

Key words : Service exposed; Residual life; ALIAS software; Low cycle fatigue.

INTRODUCTION

Remaining life assessment (RLA) of aged power plant components in the highly competitive industrial scenario has become very popular for economy and safety reasons. In India it has become all the more important since out of total thermal power capacity of 100,000 MW, about 12,000 MW capacity power plants as well as many of the petrochemical industries have become older than 25 years. and RLA of these plants has become imperative task. In real life situation both premature retirement and life extension (in relation to design life) can be encountered. The decision for retiring a component is not purely technical but also considered from point of view of economic and safety^[1-19]. This has attracted a few multinationals for RLA studies and the broad purpose are :

- Evaluation of parts on the degree of aging and remaining life
- Replacement of parts that failed
- Improvement in the construction of components through material substitution, shape alteration and reinforcement
- Development of an on-line diagnosis system to monitor aging of the components and to assure proper functioning of the unit within a fixed period of time.

The consequence of failure can be tragic and expensive. There are many cases of engineering disasters resulting in loss of life and property. For boiler components utmost attention is a must to ensure that such incidents should not take place. These components have finite life because of prolonged exposure to high temperature, stress and aggressive

environment. However past experience has showed that for a variety of reasons these may have significant remaining life beyond the design specification. This is best estimated by conducting a systematic life assessment exercise during a planned shutdown. In most cases damage accumulation starts from the outer surface. It manifests itself as surface cracks. Therefore careful visual examination and non-destructive tests (e.g. Dye penetration tests, MPI etc.) carried out on the outer surface can give a fair idea about the health of the component. In addition use of ultra sonic flaw detector can also detect nucleation of defects within the material. In order to arrive at a quantitative estimate of the remaining life of such ageing components, it is necessary to have some creep and stress rupture data.

A power plant has various components. And there are many power plants where RLA is necessary. The above-mentioned experiments are very voluminous when carried out for each individual component in various power plants. In order to reduce the experimentation by taking into consideration.

- Already existing database for life assessment
- Development of different analytical models for life assessment

Different softwares are being developed. This reduces the number of experiments significantly and the approach becomes more systematic.

This paper presents a case study of how a RLA problem is handled using ALIAS software step-by-step.

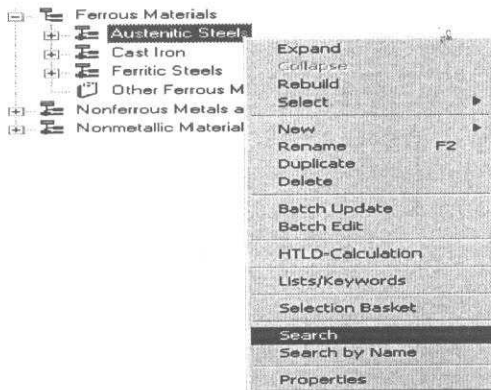
CASE STUDY

Calculate the total damage due to low cycle fatigue of a component made from X5 CrNiMo 18 10 with 900 cycles at a

strain rate of 0.7% and operating at 600°C. The analysis has to be performed using strain based approaches (total strain curve).

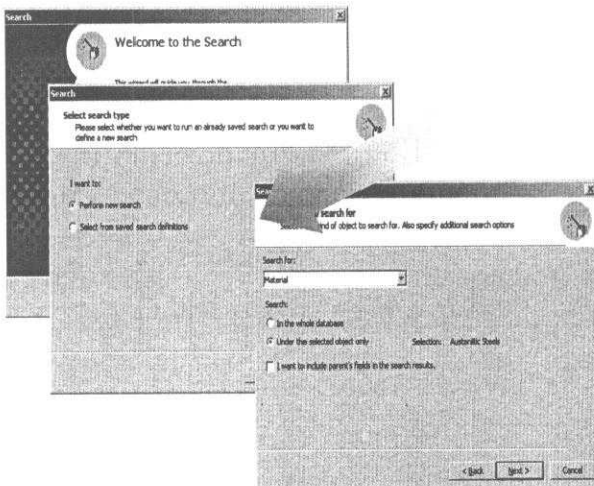
Step 1

- Expand Ferrous Materials
- Select Austenitic Steels
- Right-click on Austenitic Steels and choose the entry Search in the pop-up menu



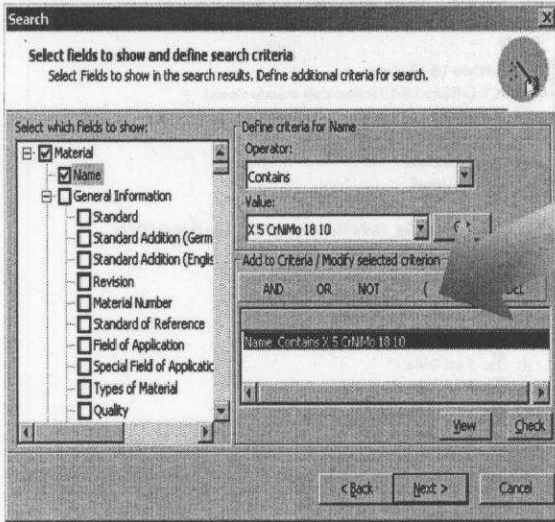
Step 2 (Search for the material -X5 CrNiMo 18 10)

- Search for the material



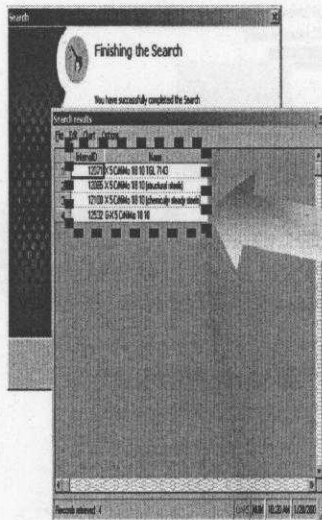
Step 3 (Search for the material -X5 CrNiMo 18 10)

Search criteria Material Name contains X 5 CrNiMo 18 10



Step 4 (Search for the material -X5 CrNiMo 18 10)

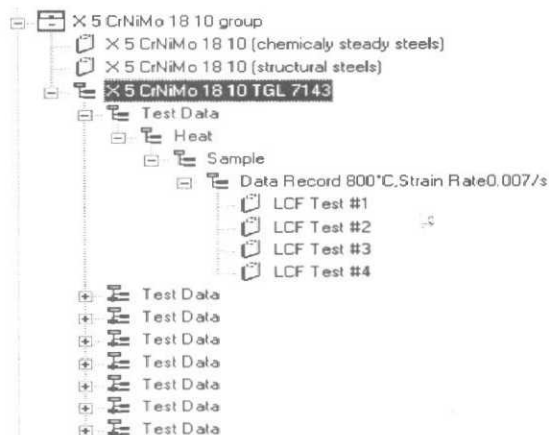
Search results Double click on the InternalID field of any found material



Step 5 (Search for the material -X5 CrNiMo 18 10)

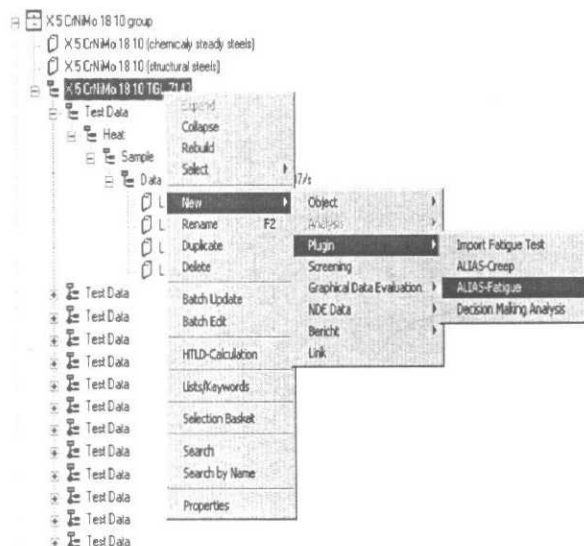
Material with LCF tests :

- X 5 CrNiMo 18 10 TGL 7143



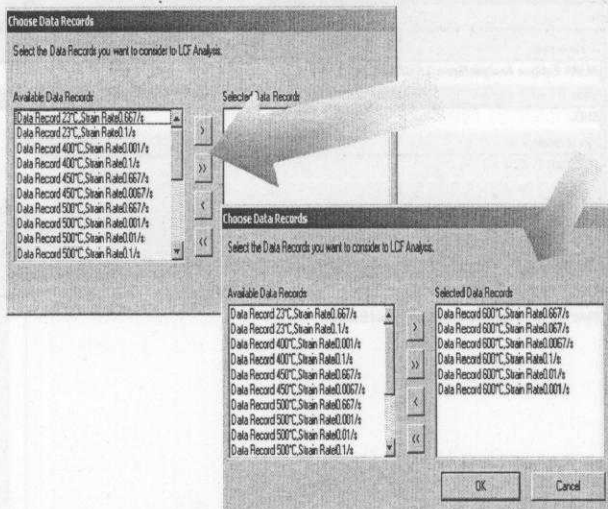
Step 6 (Start ALIAS-Fatigue)

- Select X 5 CrNiMo 18 10 TGL 7143
- Right-click on X 5 CrNiMo 18 10 TGL 7143



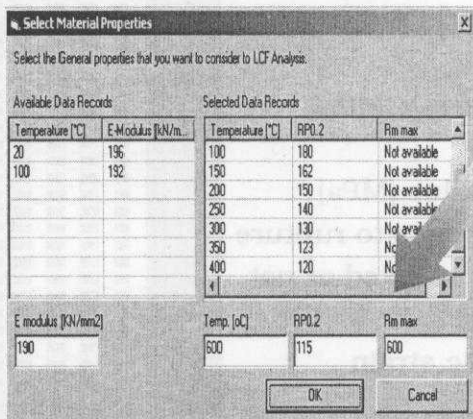
Step 7 (Selection of Data Records)

- From the Available Data Records select those ones at a temperature of 600°C



Step 8 (Selection of Material Properties)

- Elastic modulus [KN/mm²] = 190
- Temperature [°C] = 600
- $R_p 0.2 = 115$
- $R_m \text{ max} = 600$



Step 9 (Data Input)

- Edit analysis Info (e.g. title, editor, description)

The screenshot shows the 'ALIAS-Fatigue - [Analysis Data]' window. The 'General' tab is active, displaying the following information:

- Title of analysis:** ALIAS-Fatigue AnalysisName 1/20/2003 11:22:13 AM
- Editor:** BHEL
- Date of creation:** 1/20/2003 11:49:48 AM
- Last updated:** 1/20/2003 11:51:24 AM
- Description:** Example of Low Cycle Fatigue analysis. Material: X5 CrNiMo 18 10 (Note: LCF test results taken from ALIAS Material Database)

Navigation buttons at the bottom include 'Data', 'Chart Type', and 'Analysis'. A large white arrow points from the description field towards the right.

Step 10 (Data Input)

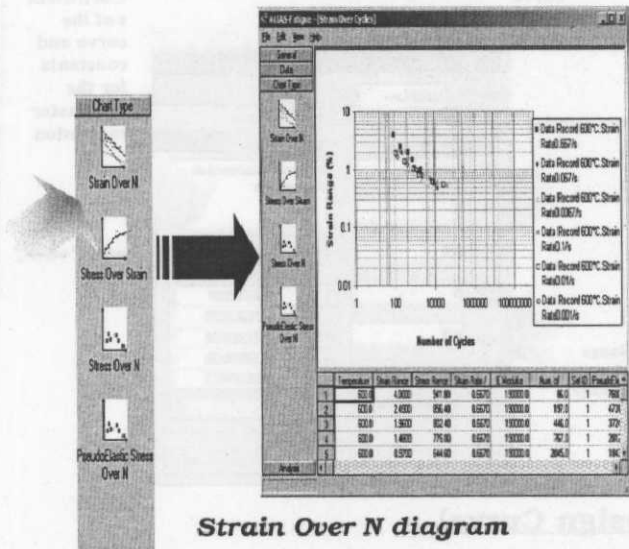
- Edit test data :
 - Temperature [°C]
 - Strain [%]
 - Measured stress [MPa]
 - Strain rate
 - Elastic modulus [MPa]
 - Number of cycles to rupture
 - If the test is selected or not
 - ID of the test
 - Pseudoelastic strain

The screenshot shows the 'ALIAS-Fatigue [Data Sheet]' window. It displays a table with the following columns: Test, Temperature, Strain, Measured Stress, Strain Rate, Elastic Modulus, Max. σ, Selected, Set ID, PseudoStrain.

Test	Temperature	Strain	Measured Stress	Strain Rate	Elastic Modulus	Max. σ	Selected	Set ID	PseudoStrain
1	600.0	0.000	901.00	0.0670	193000.0	86.0	✓	1	2000.00
2	600.0	2.490	895.40	0.0670	193000.0	197.0	✓	1	4720.00
3	600.0	1.920	902.40	0.0670	193000.0	446.0	✓	1	3720.00
4	600.0	1.480	775.00	0.0670	193000.0	707.0	✓	1	2812.00
5	600.0	0.970	644.00	0.0670	193000.0	2045.0	✓	1	1840.00
6	600.0	1.990	821.00	0.0670	193000.0	230.0	✓	2	3700.00
7	600.0	1.000	677.00	0.0670	193000.0	1520.0	✓	2	1900.00
8	600.0	0.030	524.00	0.0670	193000.0	6200.0	✓	2	1211.00
9	600.0	0.920	560.00	0.0670	193000.0	9000.0	✓	2	1064.00
10	600.0	0.900	534.00	0.0670	193000.0	12933.0	✓	2	950.00
11	600.0	2.020	794.00	0.0657	193000.0	114.0	✓	3	3030.00
12	600.0	1.010	691.00	0.0657	193000.0	585.0	✓	3	1919.00
13	600.0	0.800	527.00	0.0657	193000.0	1930.0	✓	3	1520.00
14	600.0	0.700	522.00	0.0657	193000.0	2100.0	✓	3	1230.00
15	600.0	0.900	591.00	0.0657	193000.0	2072.0	✓	3	1102.00
16	600.0	2.000	674.00	0.1000	193000.0	186.0	✓	4	2671.00
17	600.0	1.540	762.00	0.1000	193000.0	474.0	✓	4	2520.00
18	600.0	1.110	765.00	0.1000	193000.0	956.0	✓	4	2020.00
19	600.0	0.770	620.00	0.1000	193000.0	2377.0	✓	4	1460.00
20	600.0	0.700	594.00	0.1000	193000.0	5247.0	✓	4	1230.00
21	600.0	0.900	520.00	0.1000	193000.0	12400.0	✓	4	1102.00
22	600.0	0.920	591.00	0.1000	193000.0	4100.0	✓	4	1037.00
23	600.0	1.940	794.00	0.1000	193000.0	114.0	✓	5	2696.00
24	600.0	1.370	774.00	0.1000	193000.0	311.0	✓	5	2601.00
25	600.0	1.030	691.00	0.1000	193000.0	870.0	✓	5	1957.00

Step 11 (Chart Type)

- Click on the Strain Over N button



Strain Over N diagram

Step 12 (Add Curve)

The 'Toolbox' button is clicked, opening the 'Add curve dialog' window. The 'Add curve' button is also clicked. The 'Add curve dialog' window shows the following parameters:

- Select curve type: Total Strain Curve
- Name: TotalStrainCurve1
- Min: 0.5
- Max: 0.110
- MinVal: 0.5
- MinVal2: 0.110
- MinVal3: 0.5
- MinVal4: 0.110
- MinVal5: 0.5
- MinVal6: 0.110
- MinVal7: 0.5
- MinVal8: 0.110
- MinVal9: 0.5
- MinVal10: 0.110
- MinVal11: 0.5
- MinVal12: 0.110
- MinVal13: 0.5
- MinVal14: 0.110
- MinVal15: 0.5
- MinVal16: 0.110
- MinVal17: 0.5
- MinVal18: 0.110
- MinVal19: 0.5
- MinVal20: 0.110

The 'Description' field contains: 'Total Strain curve calculated numerically with chosen regression type'. The 'Coefficients' table is as follows:

	A	B
1	256.174328038	
2	0.118822208175	
3	0.103284231718	
4	0.288294432354	
5	0.0841281482271	

Edit the Parameters of the curve

Step 13 (Add Curve)

Type of curve

Plot options

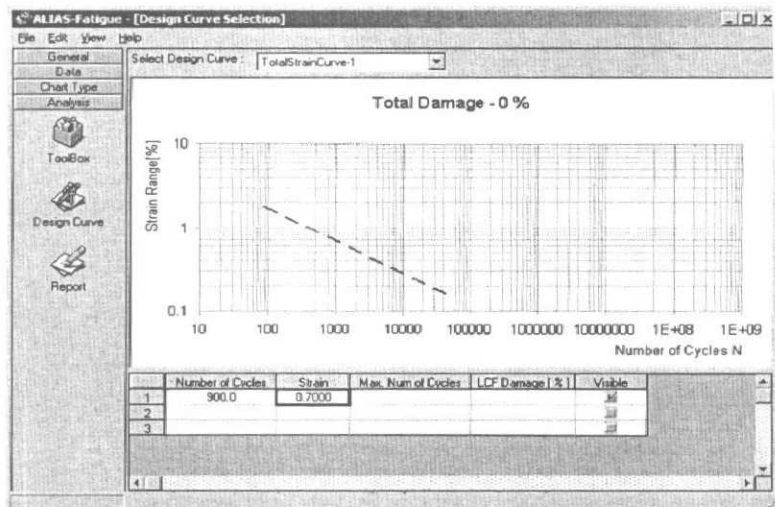
Range of validity

Coefficients of the curve and constants for the parameter regression

$\Delta \epsilon = e_1 \cdot N_A^{m_1} + e_2 \cdot N_A^{m_2}$

Step 14 (Design Curve)

- Number of cycles = 900
- Strain = 0.7
- Check the Visible button



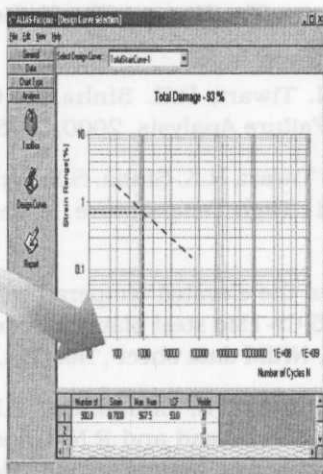
Step 14 (Design Curve)

- Right click on the data sheet and select the Refresh entry

	Number of	Strain	Max Num	LCF	Visible
1	900.0	0.7000			<input checked="" type="checkbox"/>
2					<input type="checkbox"/>
3					<input type="checkbox"/>

Step 15 (Design Curve)

- At the given operating conditions:
 - Maximum number of cycles ≈ 968
 - Damage [%] = 93



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