Methodology to assess the remaining life of gas turbines components

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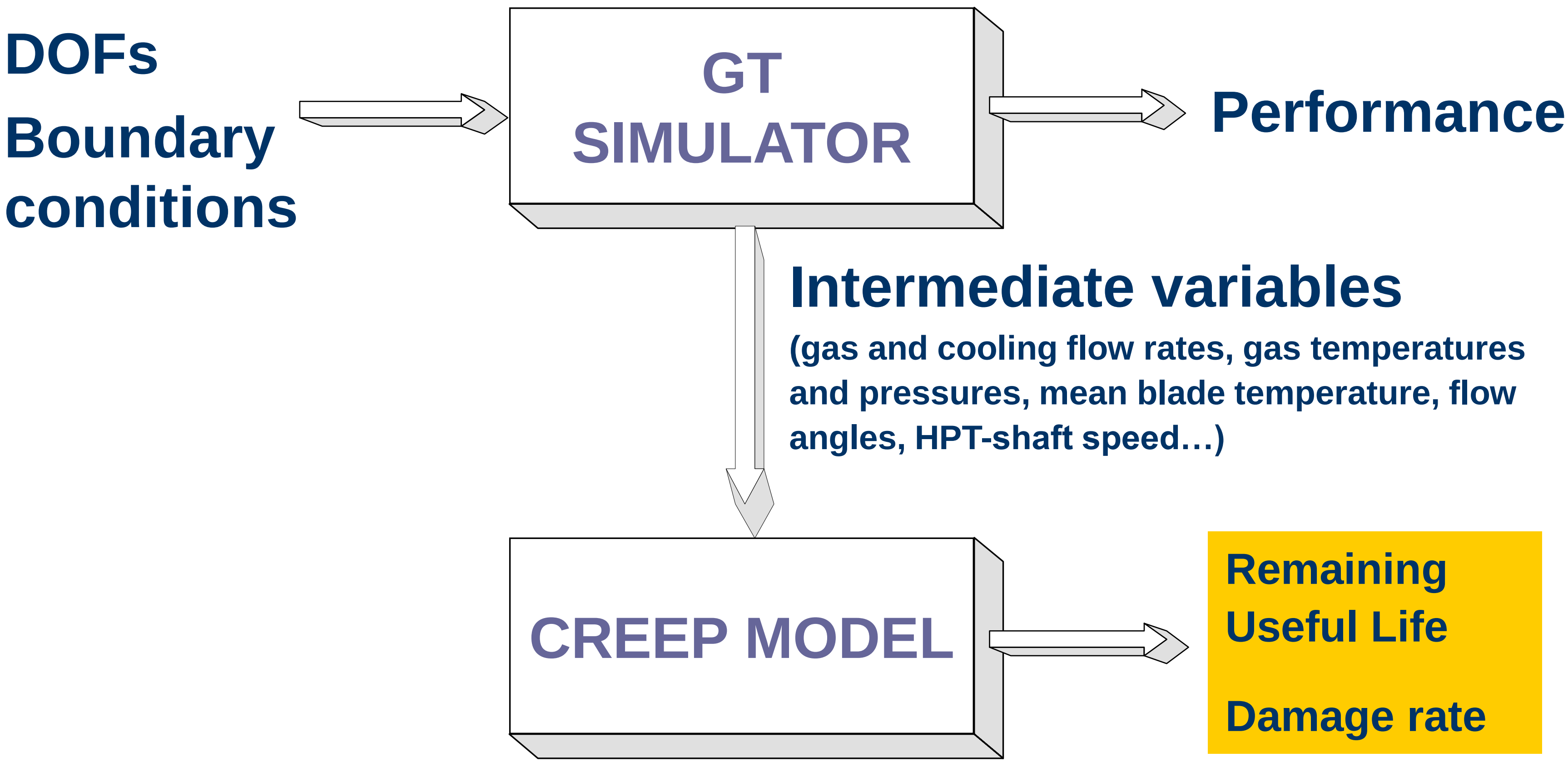
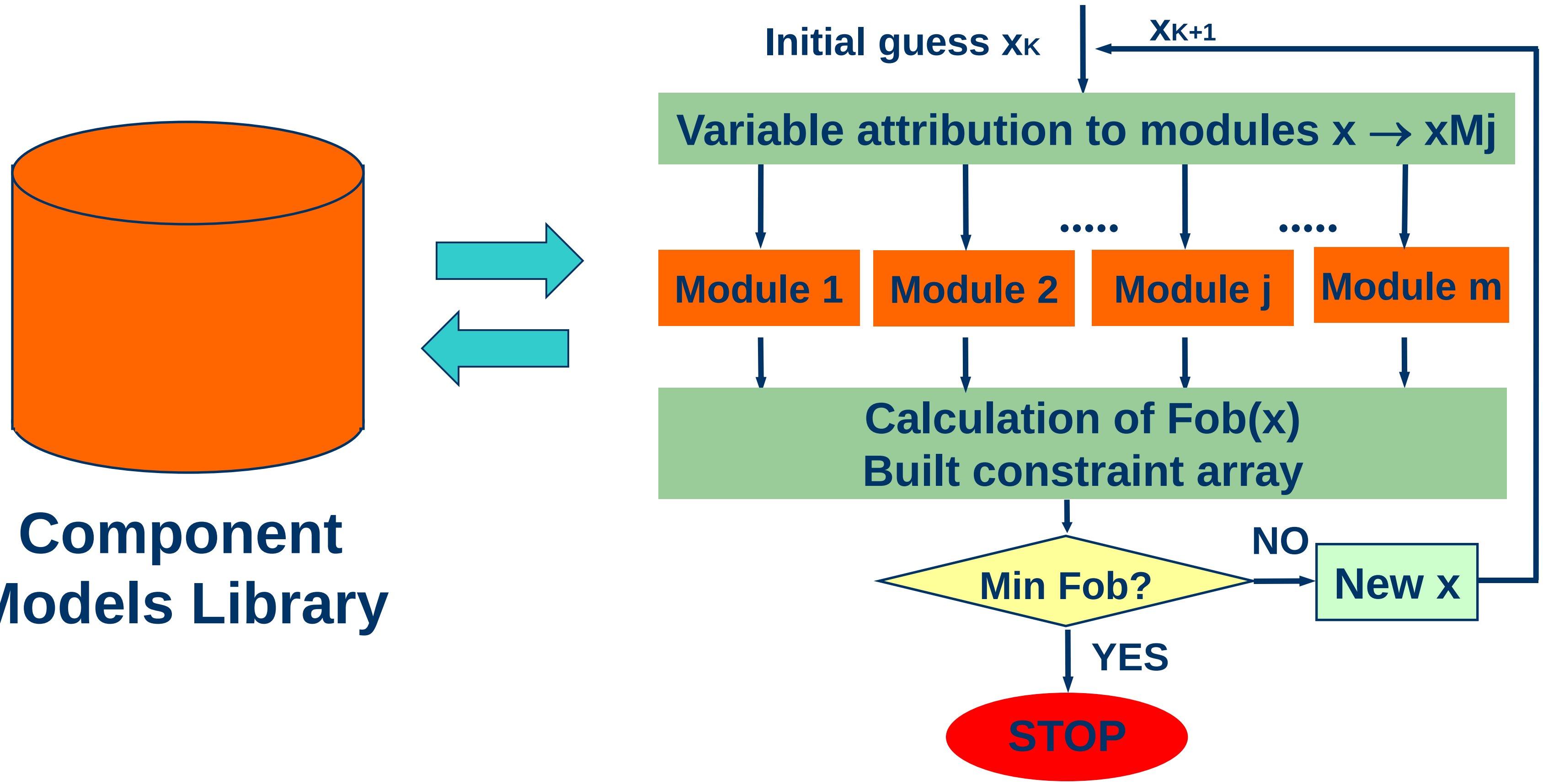
RM3 Life Assessment Tool



Gas Turbine Simulator



Component
Models Library

SIMULTANEOUS SOLUTION AND OPTIMISATION STRUCTURE

Component models

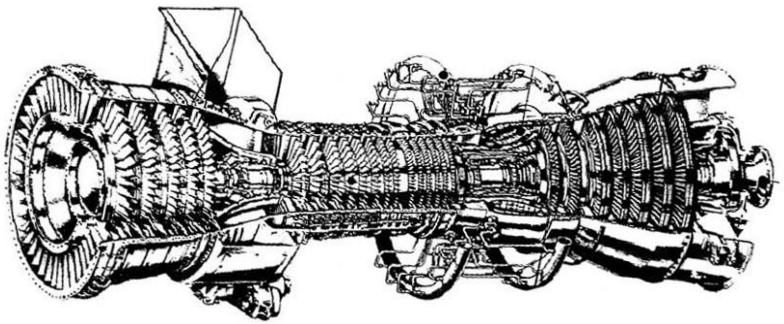
Conservation of Mass, Energy, Momentum and Entropy	Fluid properties, control rules, DB (archit., shapes, correlations …)	Heat transfer rules, Machinery behavior (empirical)

F (z, b, g, rf, af) = 0 Equations

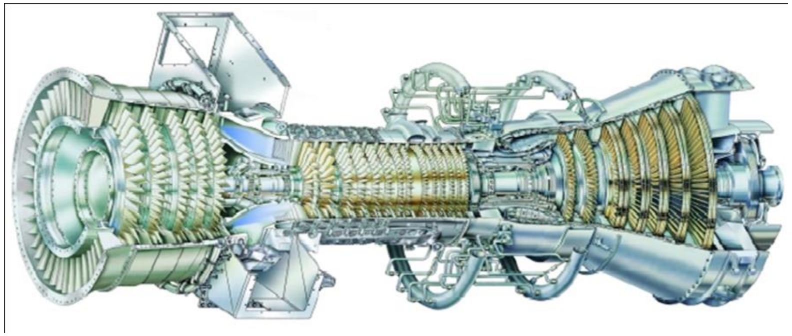
D (z, b, g, rf, af) > 0 Inequalities

z = indep. var. U unknown var.
b = boundary conditions
g = geometric data
rf = Reality Function coefficients
af = Actuality Function coefficients

Component real behaviour



Simulated Machinery



Real Machinery

COMPARISON

Search Reality Functions (RFs) values

Reality Functions (N&C)

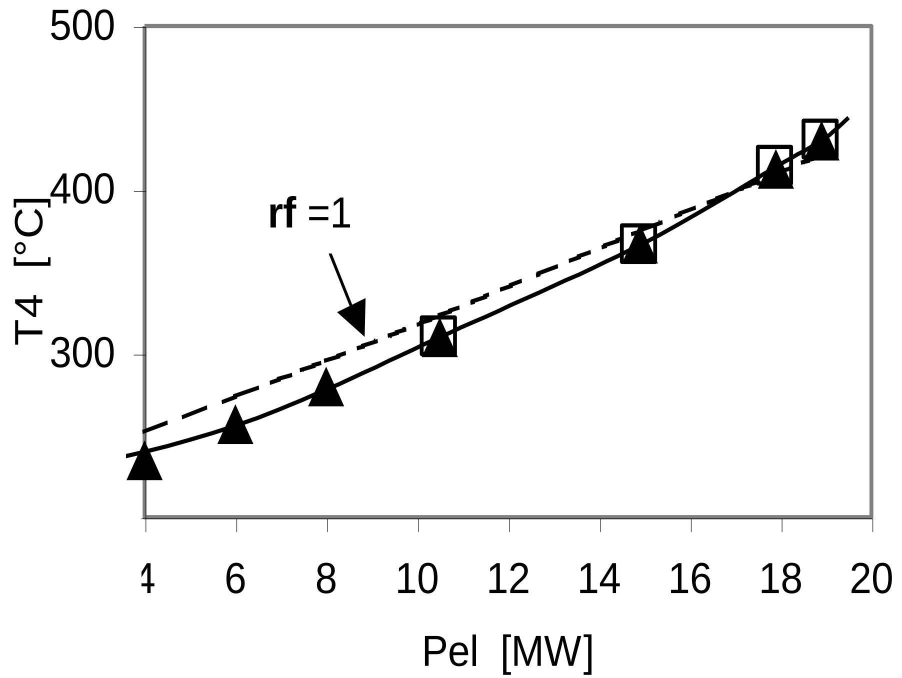
Reality Functions are introduced to adapt the model to the machine behaviour

GT Exhaust Temperature

vs

GT Power Output

Fiat Avio TG 16



Manufacturer curve

Acceptance Test Data

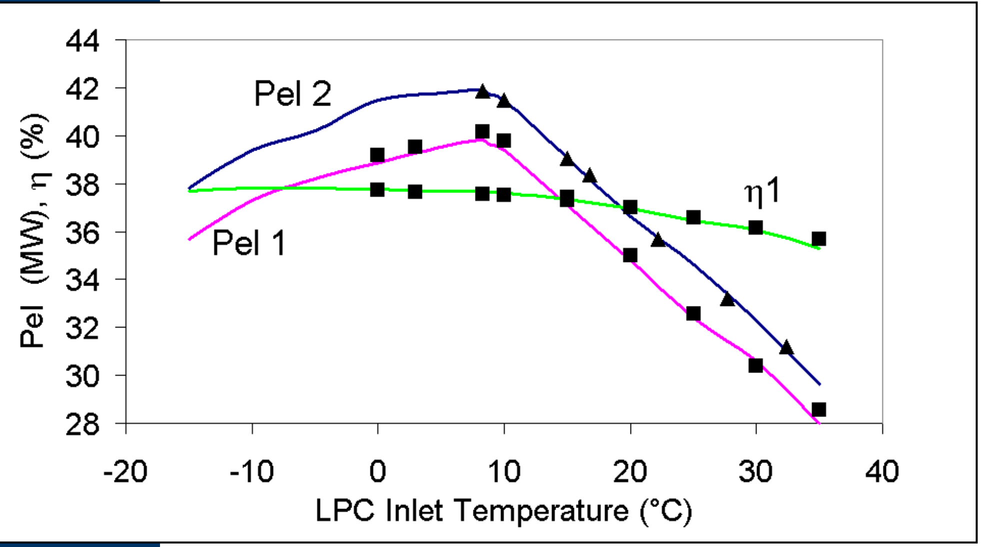
rf

Reality Functions (N&C)

GE LM6000

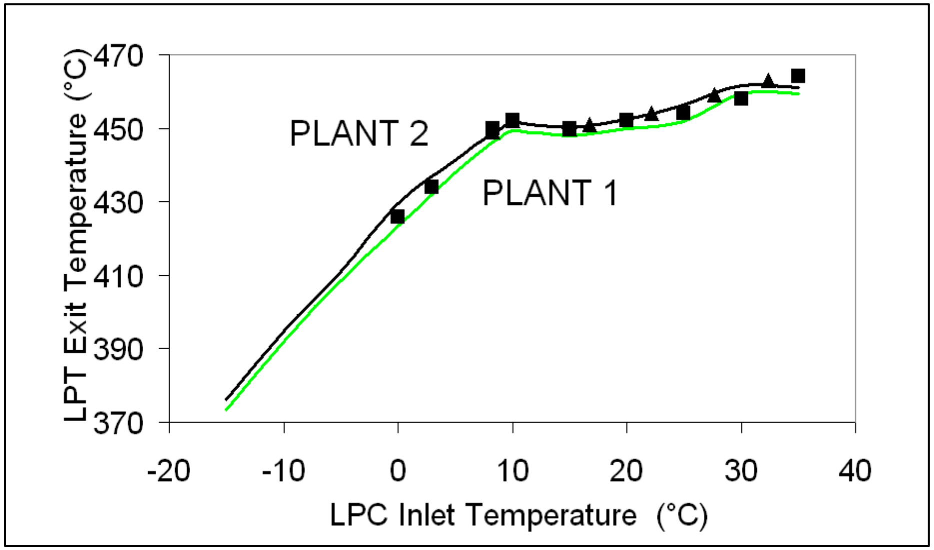
Plant #1 and Plant #2

base-load performance curves



Plant #1 and Plant #2

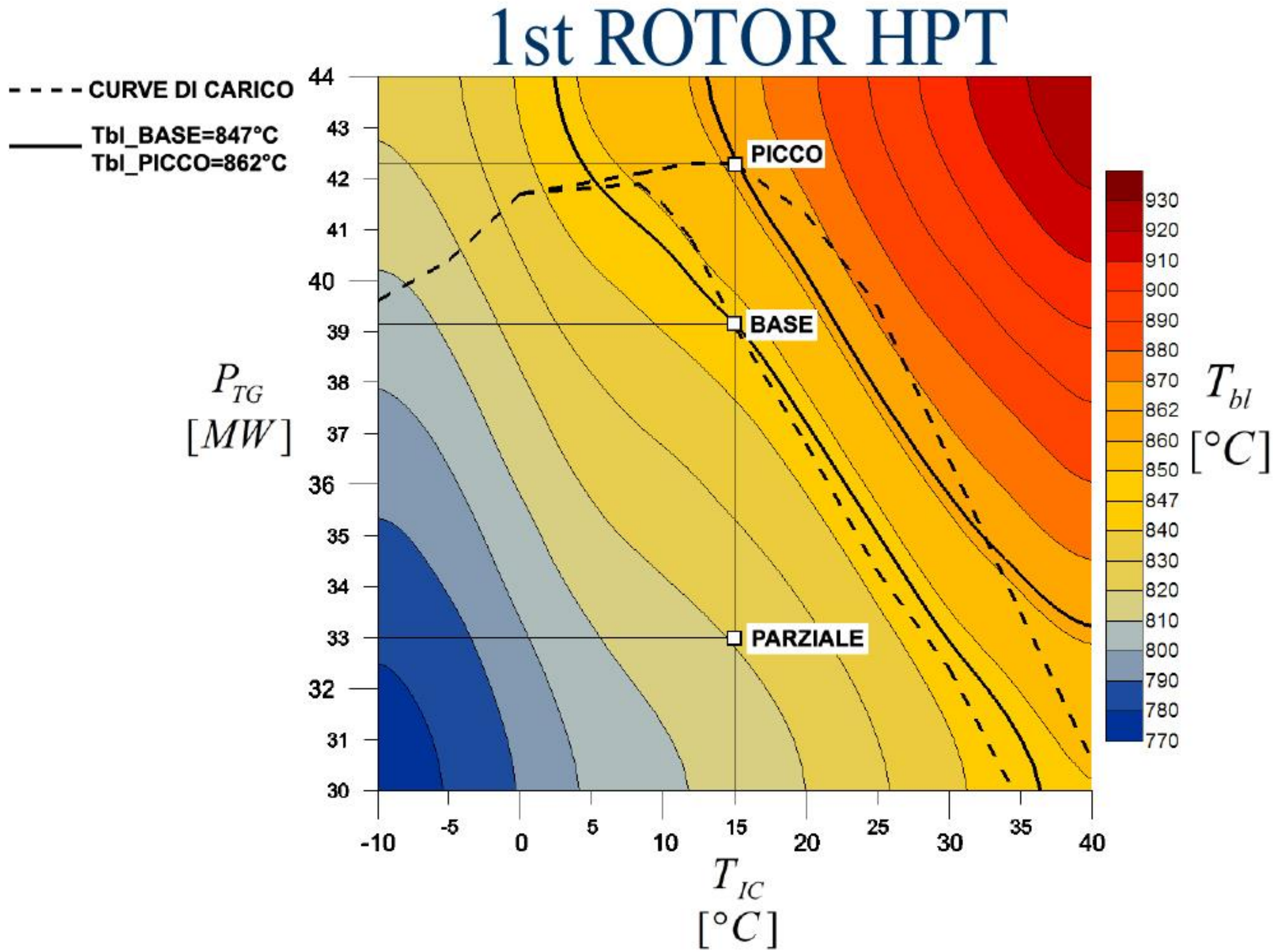
LPT Exit Temperature



■ Plant #1 ▲ Plant #2

Manufacturer Data

Simulator application: blade temperature maps related to power output and compressor inlet temperature



Actuality Functions

Plant component performance changes during their life due to phenomena affecting actual behaviour of plant units

↓

Characteristic curves of components and performance maps change continuously

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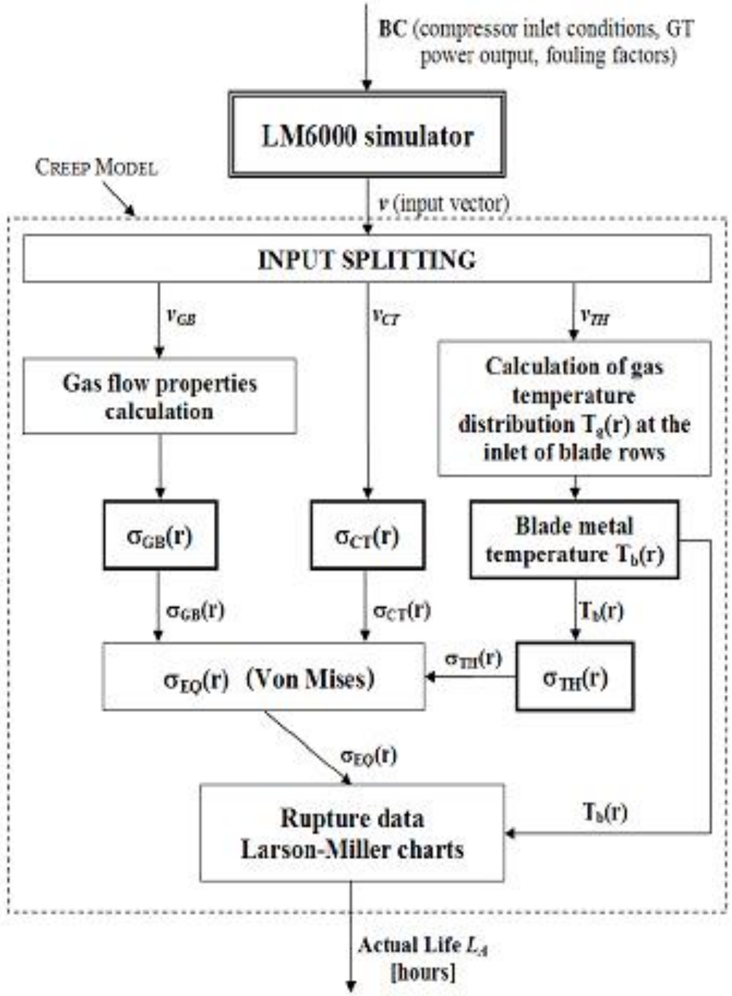
Actuality Functions

Data required for model implementation

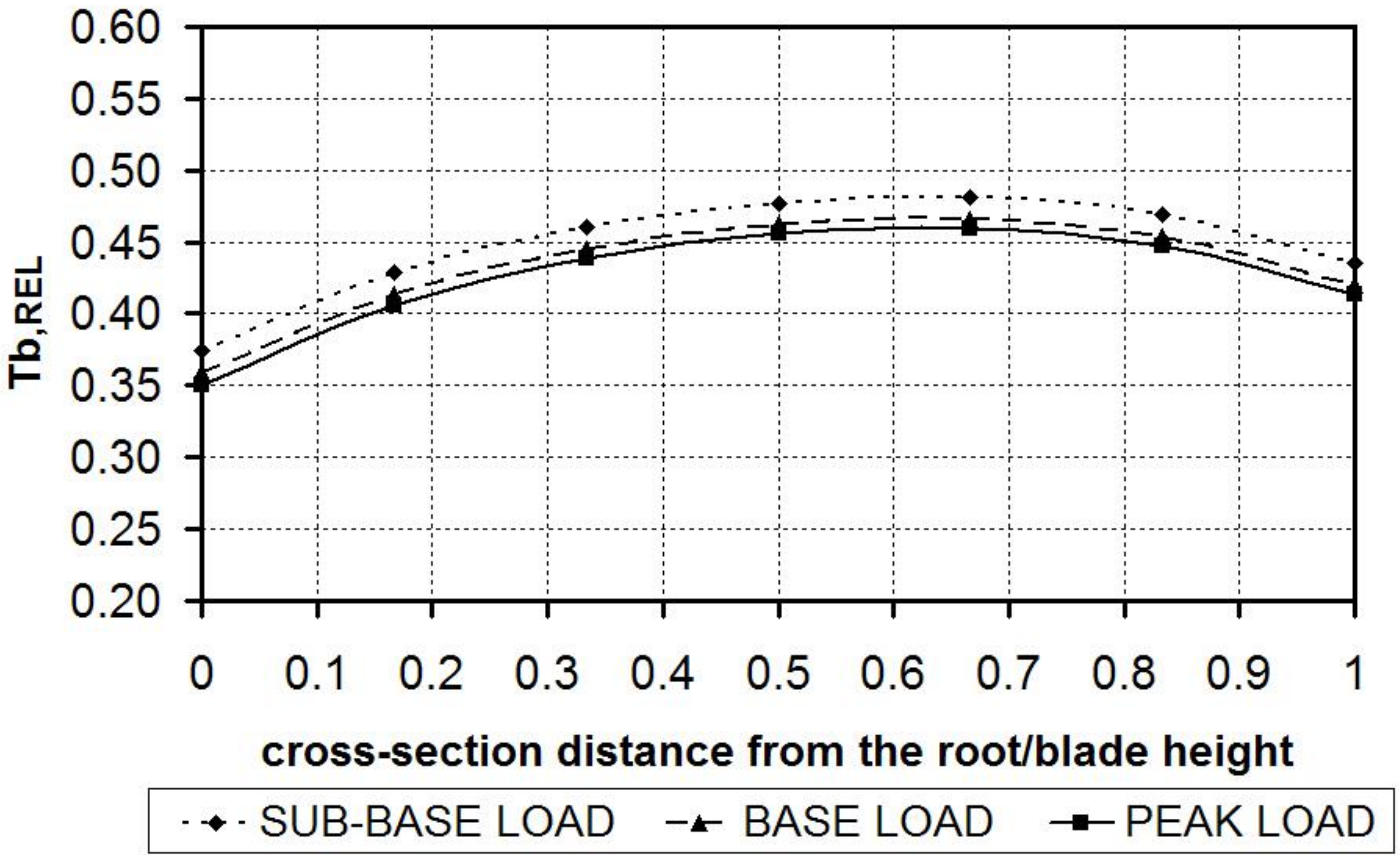
- Available design information
- Data from acceptance test or after major maintenance interventions
- Measured operating data

Creep Model

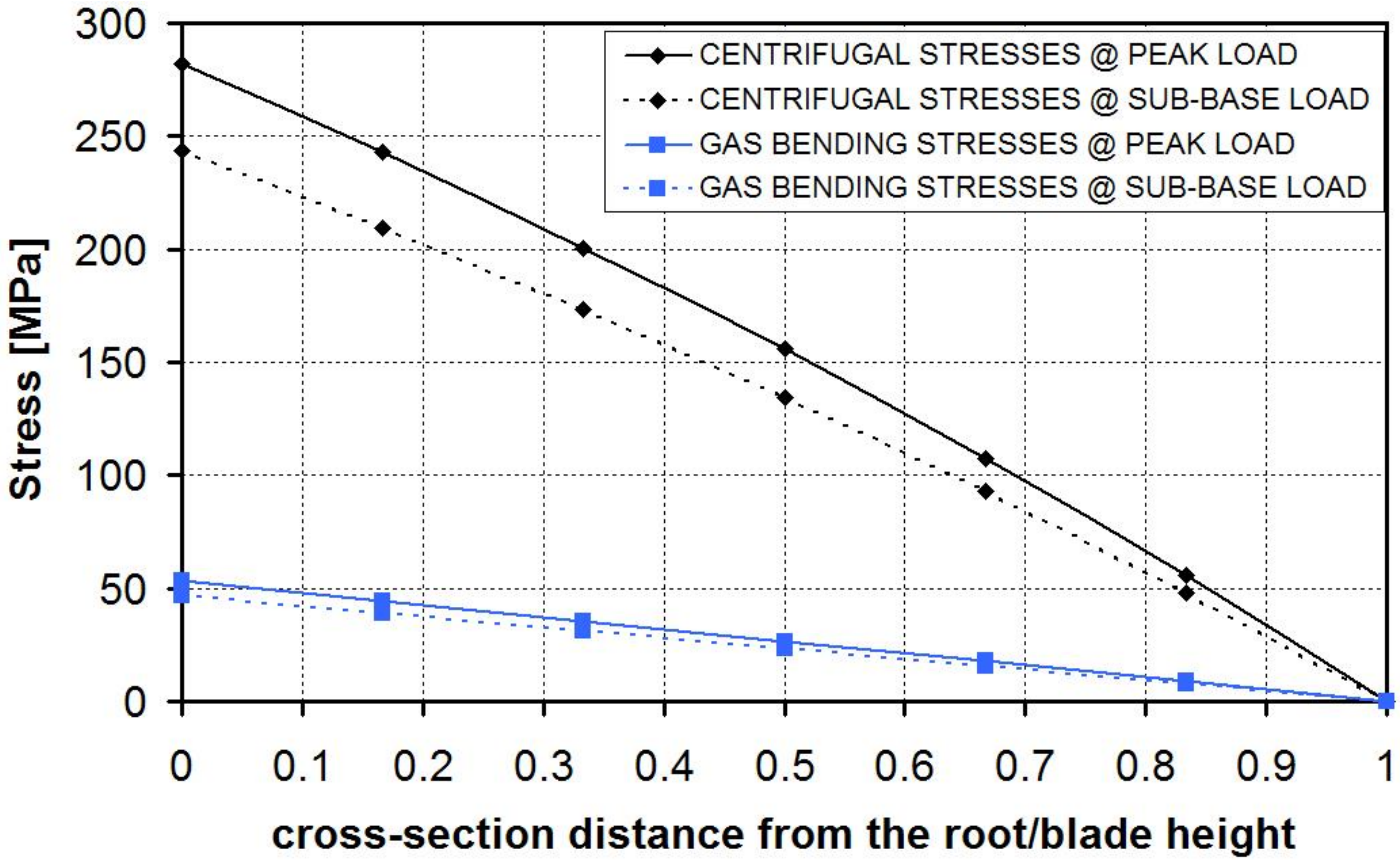
CREEP MODEL BLOCK DIAGRAM



Blade temperature distribution

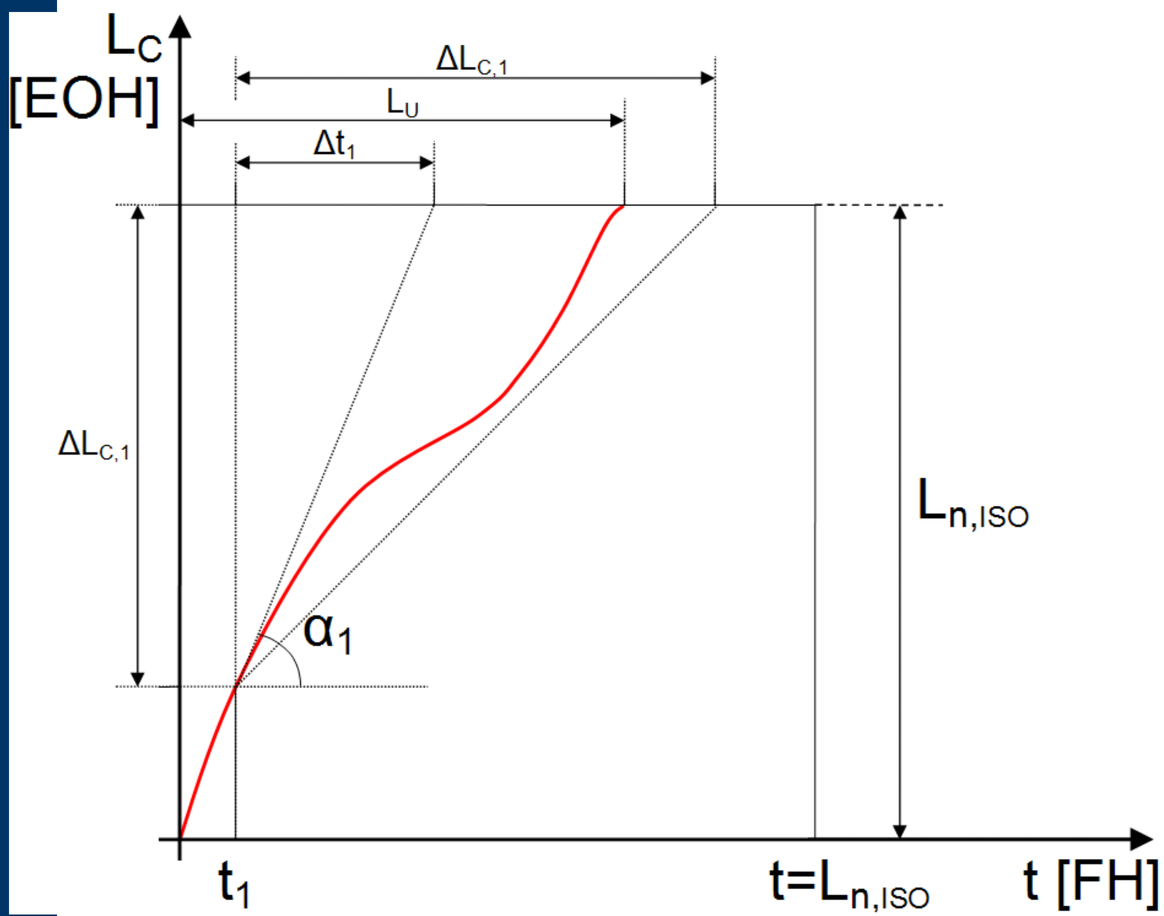


Centrifugal and gas bending stress curves



HPT 1st stage rotor; ISO conditions

Life consumption rate



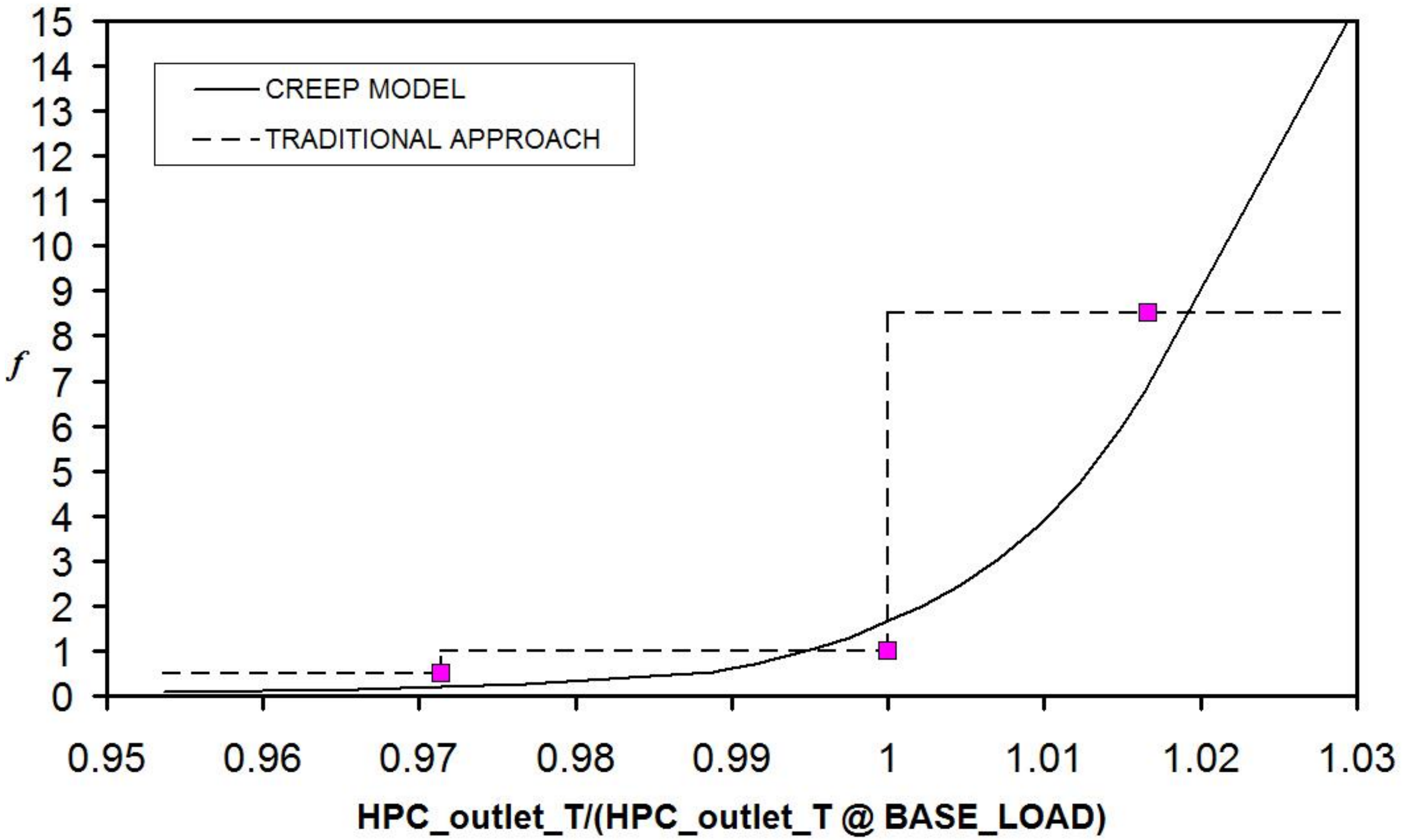
f = life consumption rate
$L_{n,ISO}$ = life @ BL & ISO [EOH]
L_C = consumed life [EOH]
t = actual fired hours [FH]
L_U = useful life [FH]

$$f = \frac{dL_C}{dt}$$

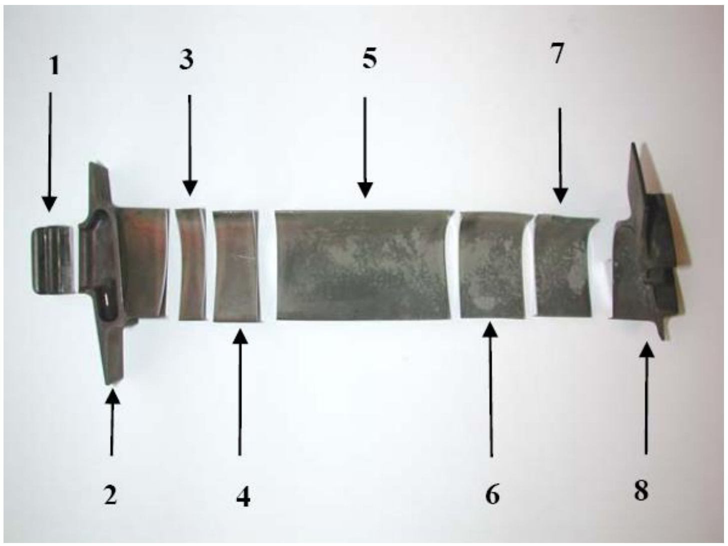
$$f(t_1) = tg(\alpha_1) = \frac{\Delta L_{C,1}}{\Delta t_1}$$

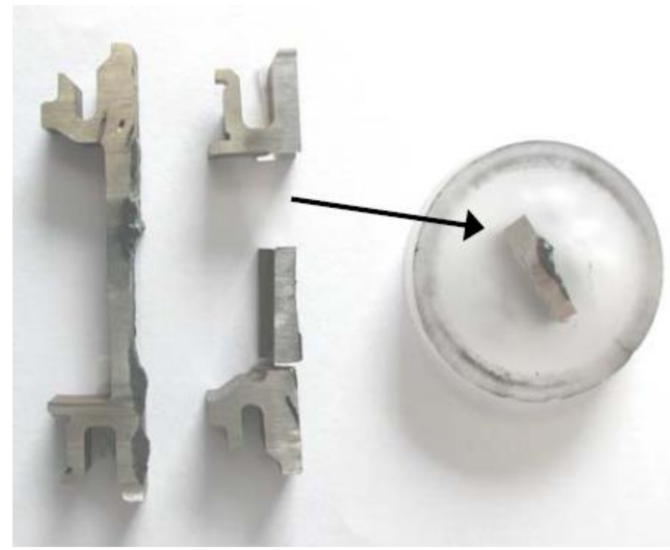
$$L_{n,ISO} = \int_0^{L_U} f \; dt$$

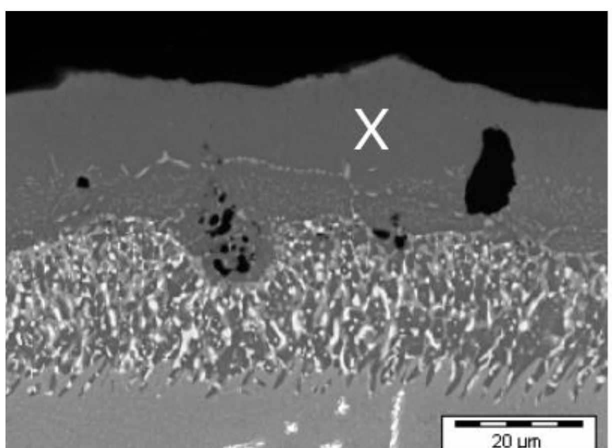
Damage Rate Assessment

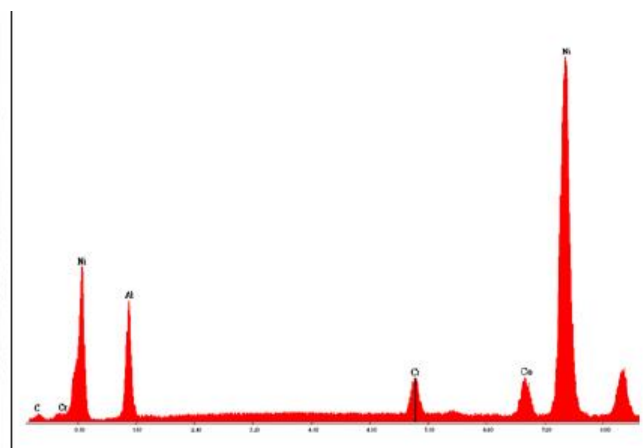


Hot-corrosion characterization (LM6000)









- A flexible tool able to simulate a GT in N&C and actual conditions has been developed.
- Such a tool includes a damage model to assess life consumption of GT hot section
- Damage model + plant simulator → life consumption related directly to GT operating conditions

  - profit maximisation, minimisation of downtime costs

  - evaluation of economic impact of extended-life operations

  - assessment of costs connected with peaking operation, start-up and shut-down…

Thank you for your attention!

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