Demands on Materials and Components for Existing and New Conventional Power Plants

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Content

motivation

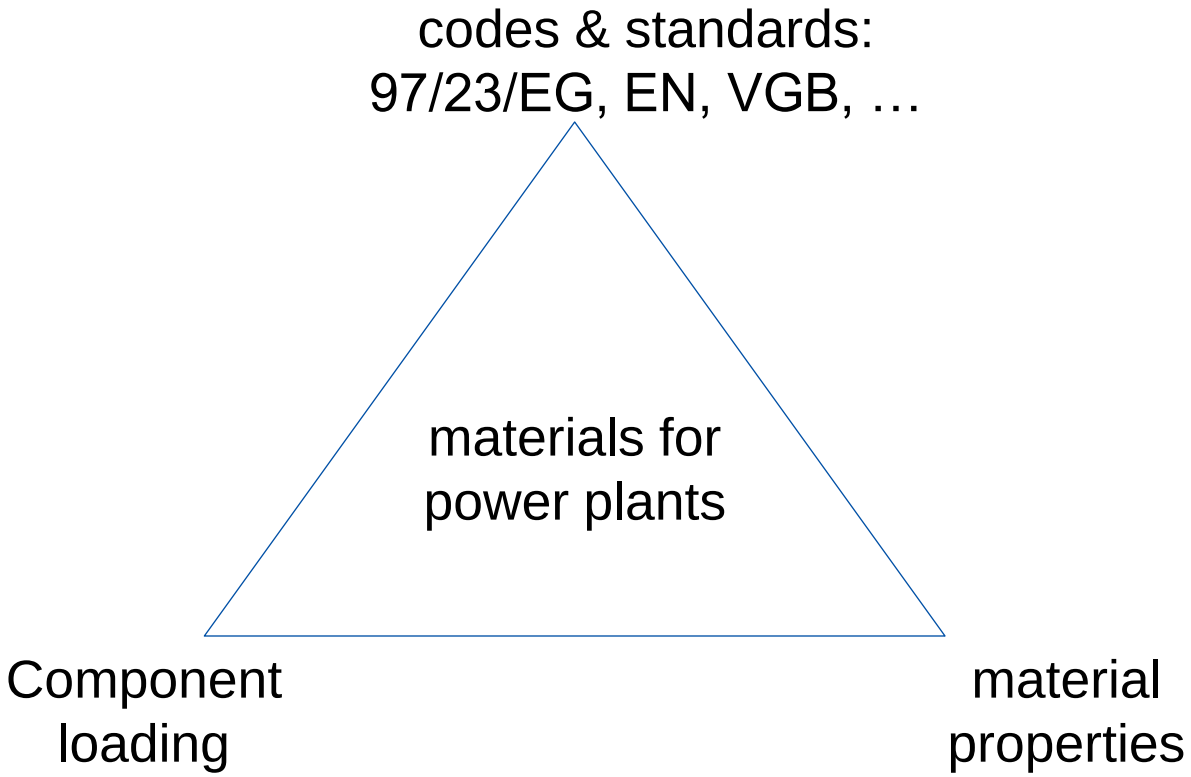
> how to use materials in power plants?
> how power plant service will change?

challenges

> thick-walled components
> weldments
> start-up and shut-down gradients
> interaction of static and cyclic loading

conclusion

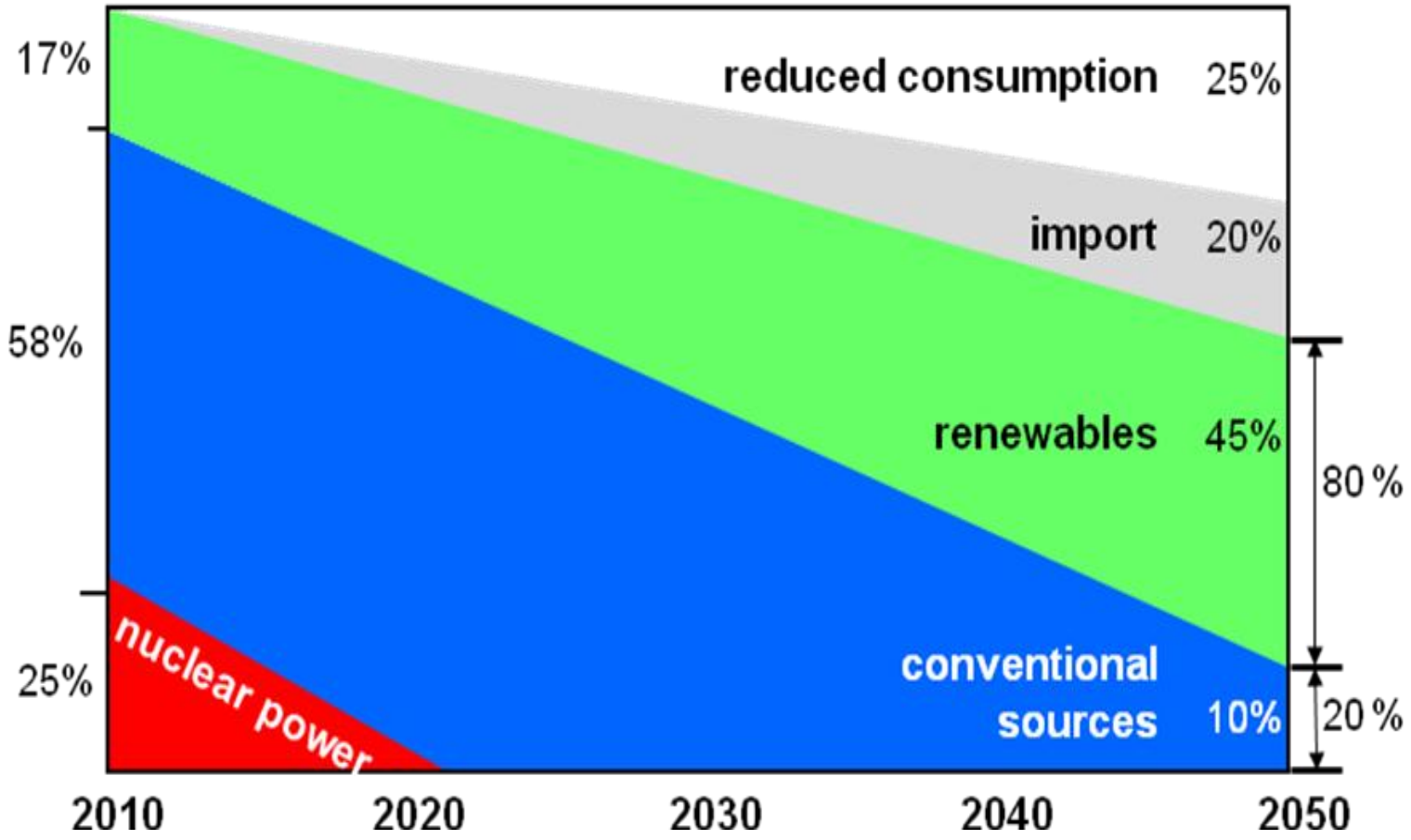
Motivation (1)



Motivation (2)

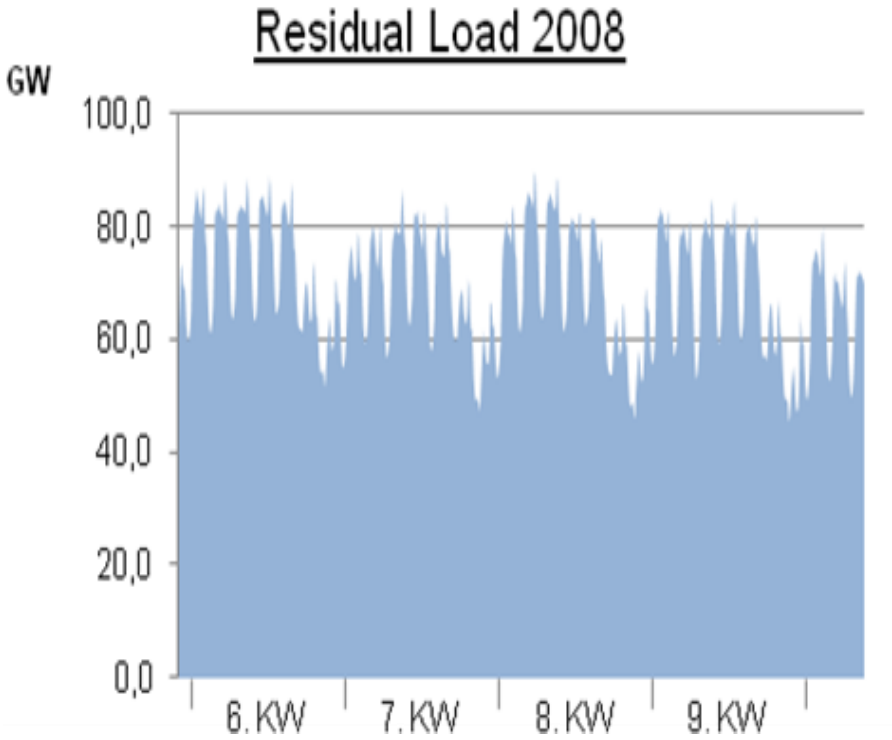
how power plant service will change?

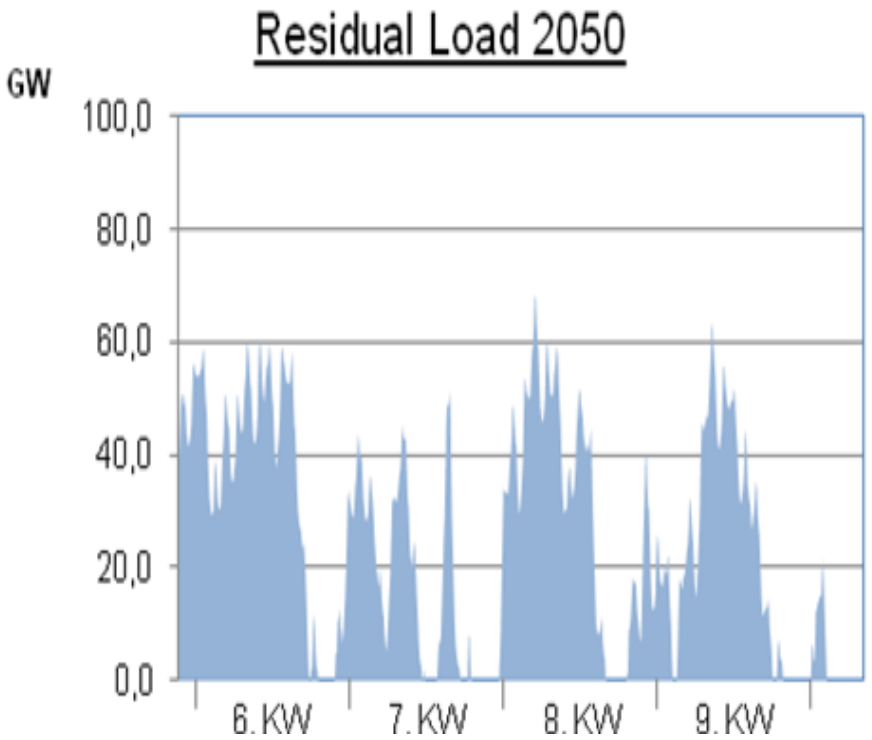
Gross Electric Energy Production in Germany



Source: EWI/Prognos/GWS Studies

Change of Residual Load Characteristic





→ Power plant fleet designed for many load changes, high load gradients and low minimum load is needed

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Thick-walled components

design of components

- linear-elastic stress calculation is often over-conservative, non-linear with creep equation are not practicable up to now

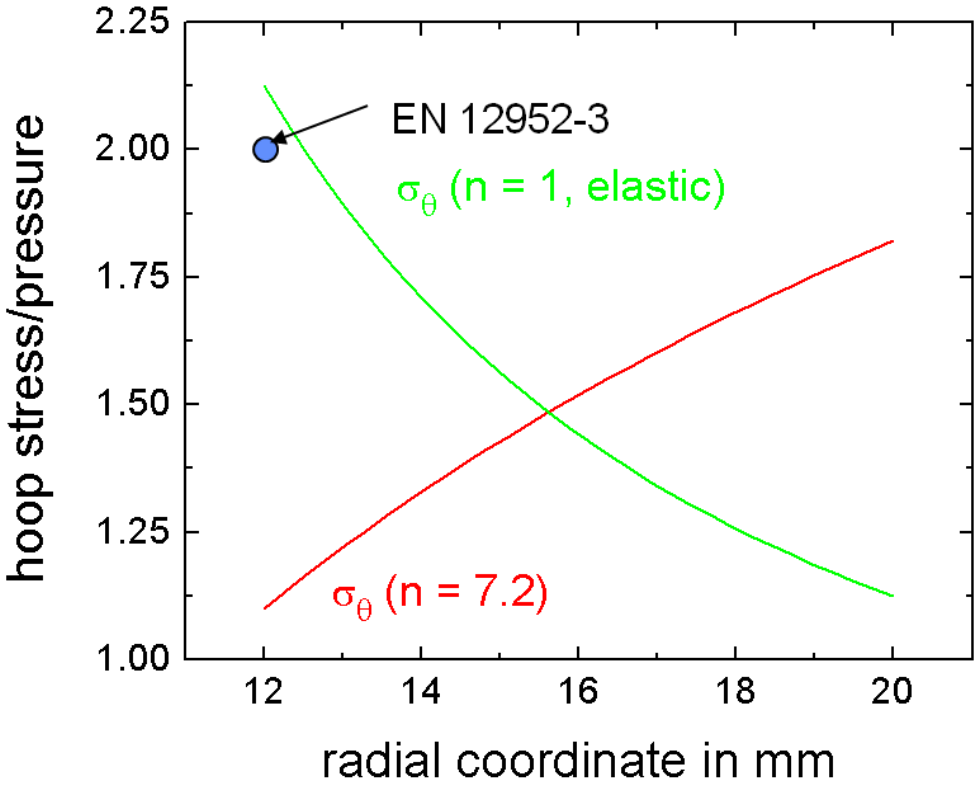
- over-conservative calculation results in higher wall thickness which leads to lower fatigue capabilities

Example: Design of thick-walled components

Umfangsspannung

$$\sigma_\theta = p\,\frac{1+(2/n-1)(R_a/r)^{2/n}}{(R_a/R_i)^{2/n}-1}$$

Innenradius	R_i = 12 mm
Außenradius	R_a = 20 mm
Norton-Exponent	n = 1 und 7.2
Radiale Koordinate	r
Druck	p



Weldments

assessment

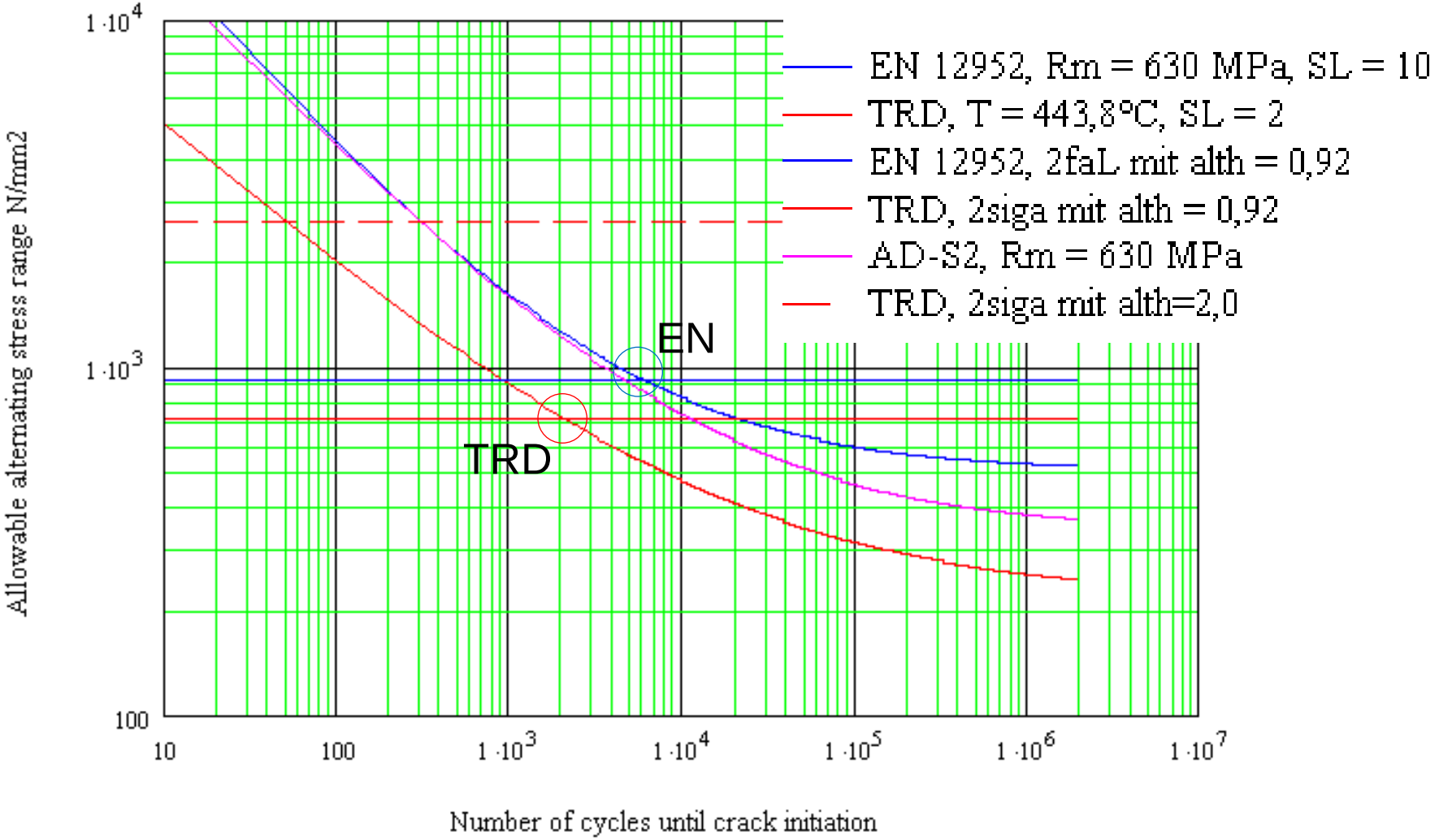
- pipe to pipe weldments have complex loading situations
- codes and standards are partly inconsistent applying strength hypotheses, assessment of primary and secondary stresses and weld reduction factors
- assessment of weldments are not compatible with modern none destructive test methods like image producing methods

Start-up and shut-down gradients

- during start-up and shut-down of thermal loaded components stresses occur due to constrained thermal strains
- assessment of stress ranges is defined by codes and standards
- different standards (i.e. old, TRD; new, EN) give different results up to a factor of 10 on allowable number of start-up and shut-down cycles

Start-up and shut-down gradients

comparison TRD – EN 12952



Interaction of static and cyclic loading

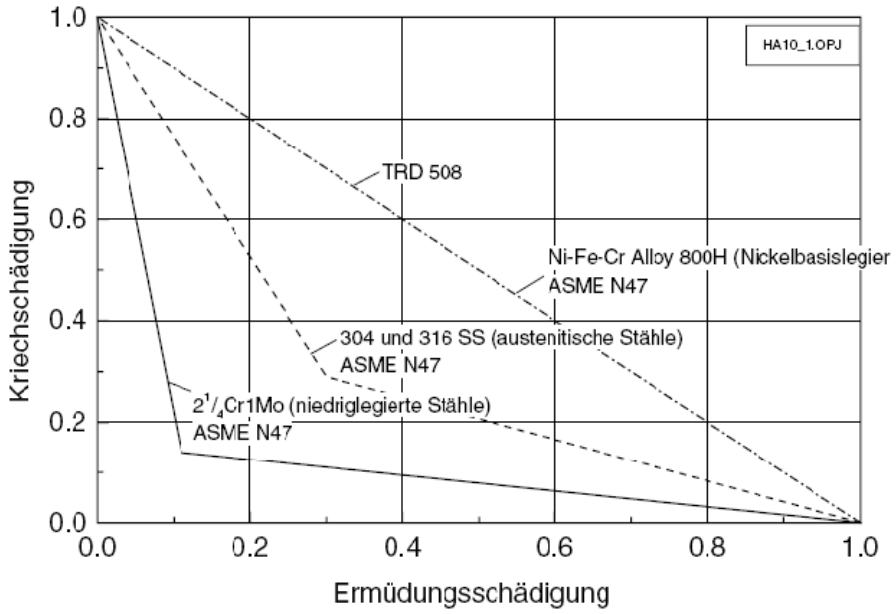
creep-fatigue interaction

> quantitative lifetime assessment of critical components is based on separation of static (creep) and cyclic portion of loading history

> in cases where static and cyclic portion are relevant, the interaction is considered

→ development of validated standards for the creep-fatigue interaction seems to be essential

Creep-fatigue interaction



Quelle:
Prof. Maile

- standards like TRD or DIN EN 12952-4 propose a linear summation
- ASME Section 8 Division 2 (API FFS1) proposes a non-linear dependence

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Conclusion

- The future service of conventional power plants is controlled by the growing demand on flexible production of electric power. The power plant fleet should allow more load changes, high load gradients and low minimum loads.

- Specific attention should be given to the calculation methods for thick walled components, weldments, start-up and shut-down procedures and the interaction of static and cyclic loading portions.

- Therefore a VGB working group was founded to analyze and to develop further these calculation methods.

Thank you very much for your attention and let's collectively be:

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