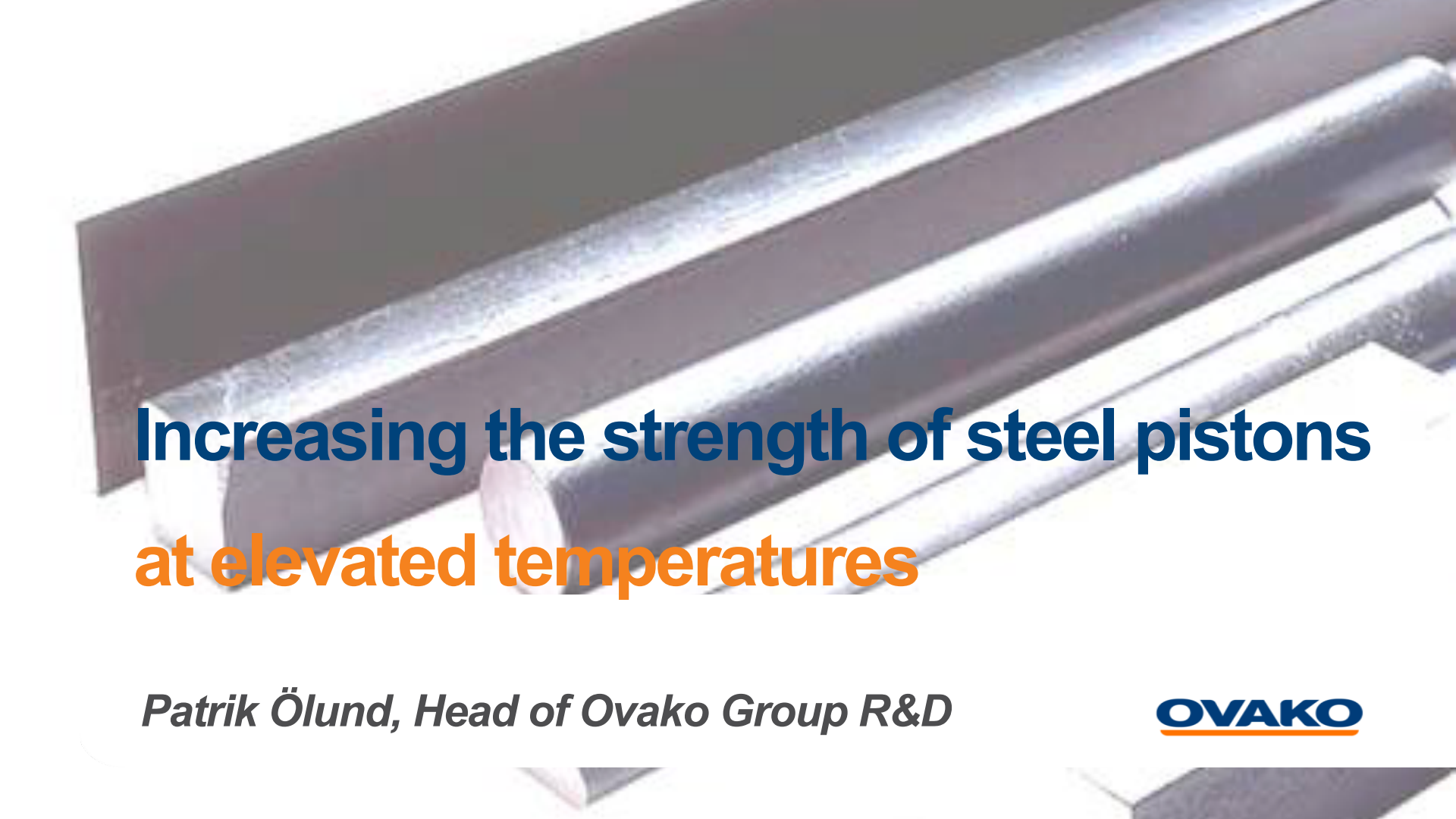

Increasing the strength of steel pistons

at elevated temperatures

Patrik Ölund, Head of Ovako Group R&D

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The starting point:
Meeting challenges from our customers

- Fatigue resistance at elevated temperature

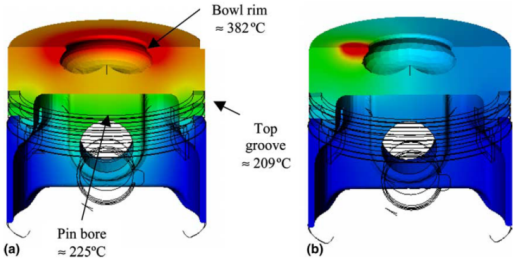


Fig. 13. Schematic thermal distribution at a piston: (a) homogeneous; (b) localized.

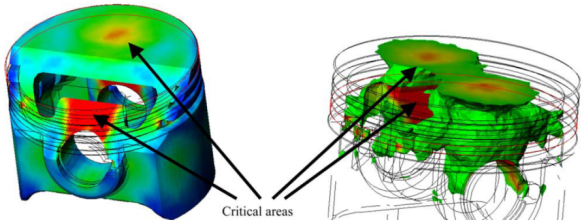
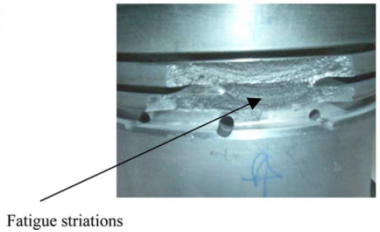


Fig. 2. Typical stress distribution on an engine piston.

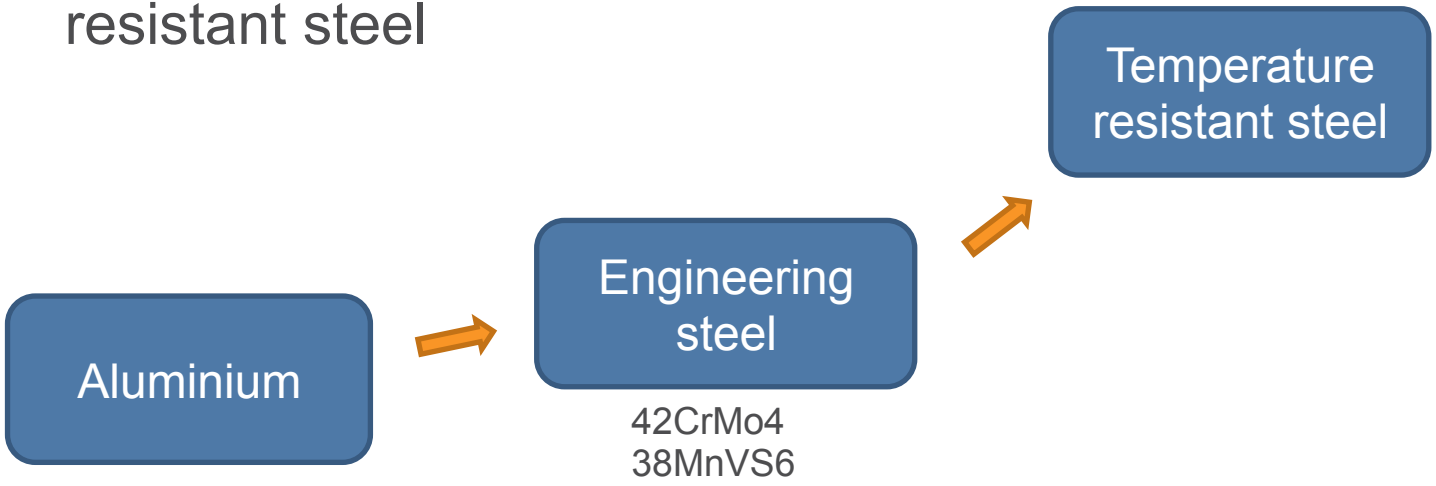
Fig. 5. Diesel engine piston with a crack from one side of the pin hole to the other pin hole going through the head of the piston.



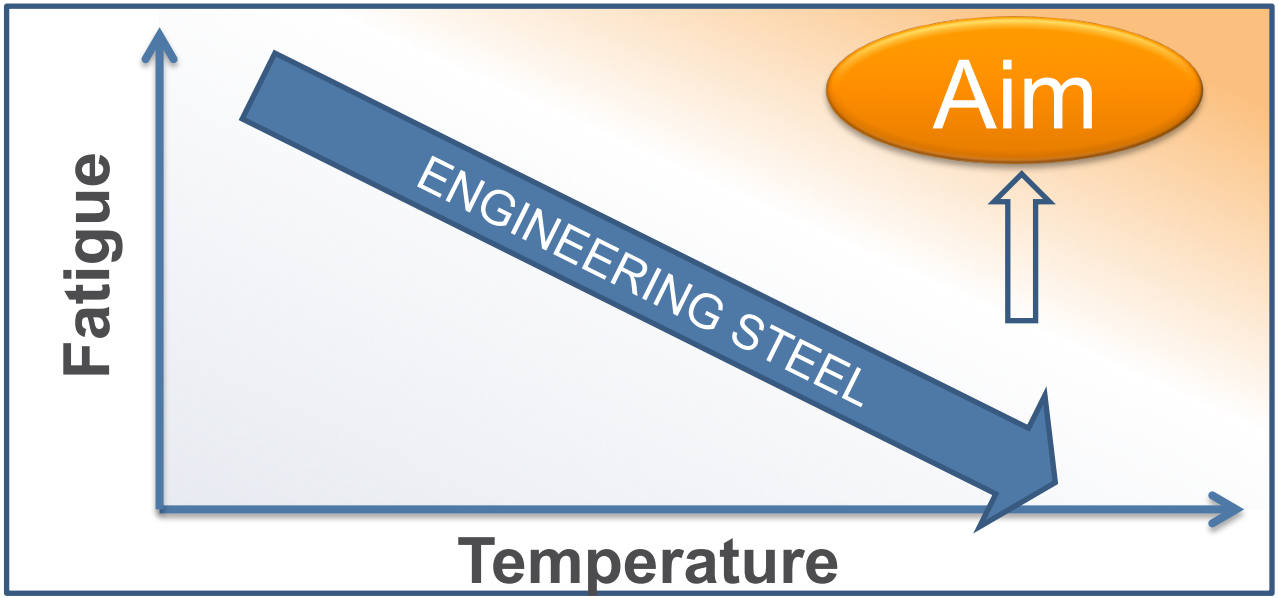
Ref: F.S. Silva, *"Fatigue on engine pistons – A compendium of case studies"*, Engineering Falure Analysis (2006), 480-492

Improvement opportunity

- Move from aluminium to steel
- Move from engineering steel to elevated temperature resistant steel



The aim:
Improved strength at elevated temperatures



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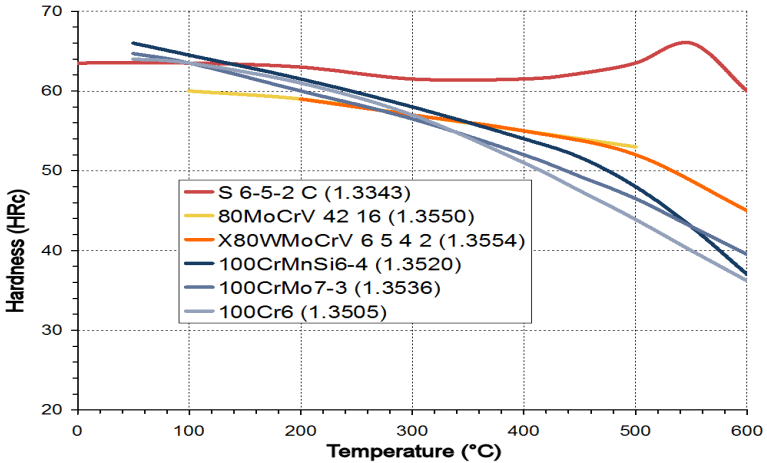
Steels for elevated temperatures
The situation today

- Highly alloyed, secondary hardening steel
  - Prone to segregation of certain chemical elements
  - Produced by expensive remelting practices



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Important boundary conditions

- Should be possible to produce in a high volume production process
  - Availability
  - Price

For Ovako to meet the demands we saw one of two options

1. Develop an air-melt process that reduces segregation

2. **Develop a steel with low segregation propensity but with sufficient strength suitable for mass production in electric arc furnace route.**
   - **i.e. material with different hardening mechanisms than only carbon and carbides**

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Using precipitates for hardening - Ovako 297A

OVAKO 297A, 65mm round

A hybrid steel with strength due to a combination of:

- Carbon in solid solution
- Secondary carbides
- Intermetallic precipitates

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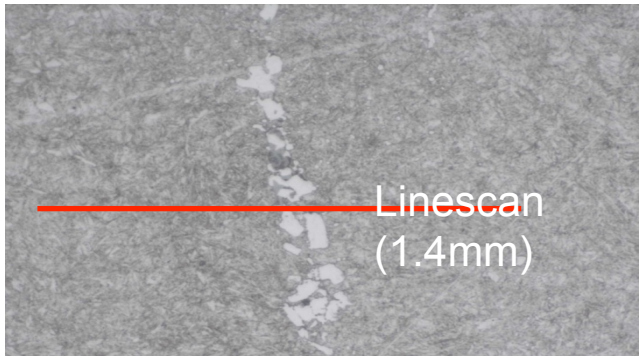
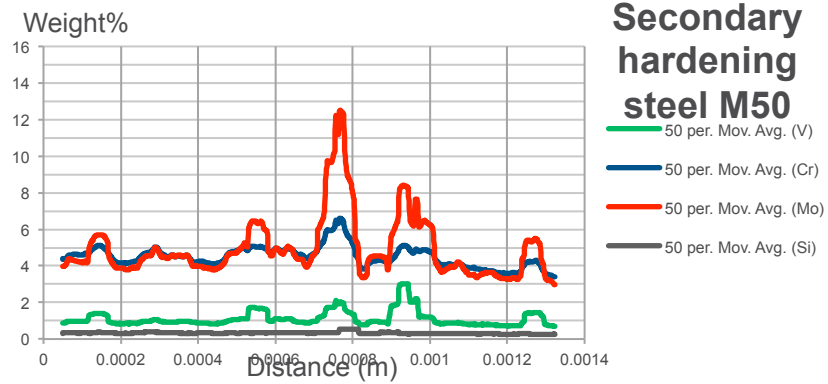
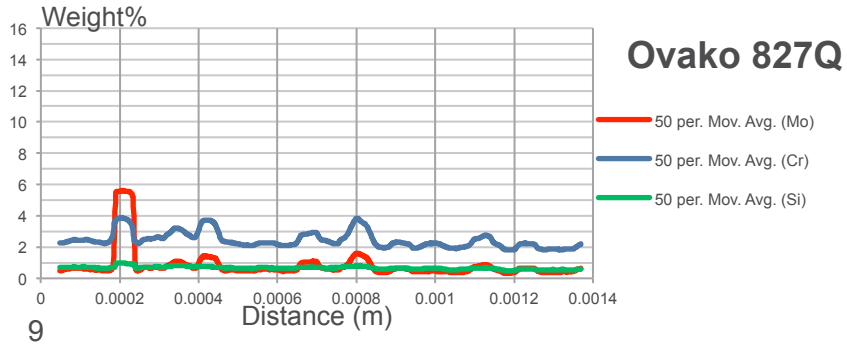
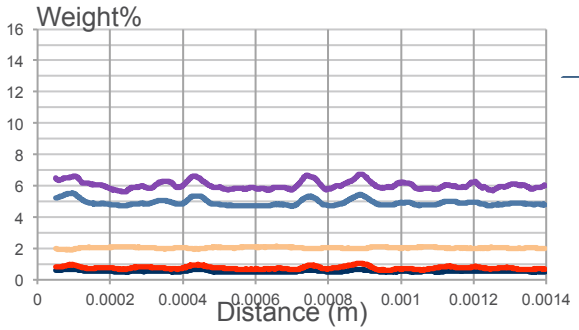
Ovako 297A offers a remarkably low segregation of key elements

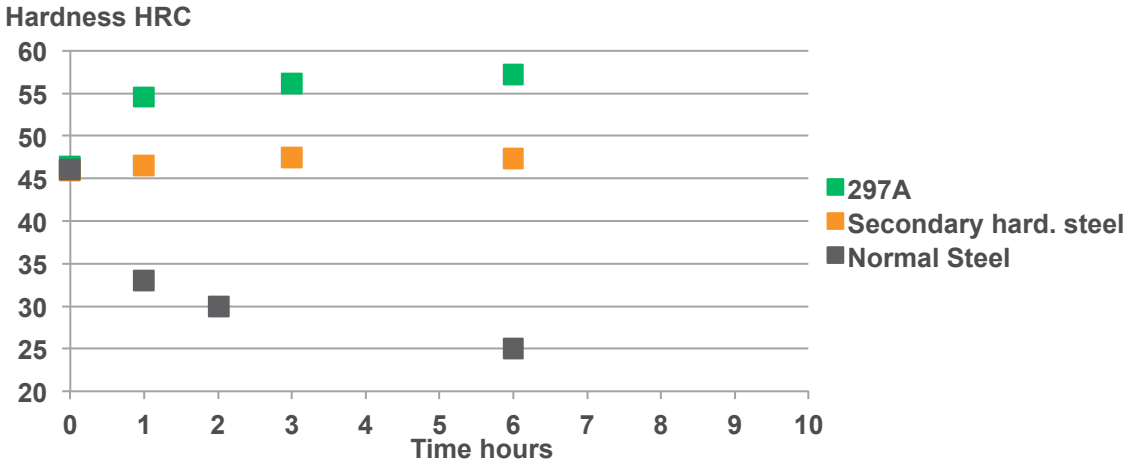


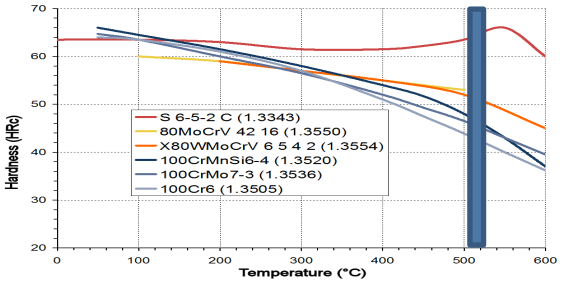






The hybrid effect
Tempering OVAKO 297A at 520°C





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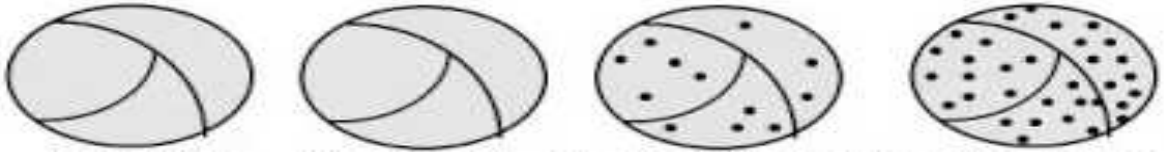
Added benefits
Smarter fabrication due to low distortion

- The benefits of an intermetallic precipition hardened steel
  - The hardness is increased by 10-15 HRC **during tempering**
  - Meaning that it can be first machined in softer condition

- Max hardness is reached after tempering at 520°C without any significant distortion (out-of-roundness)



Solutionized Quenched Growth Highest Strength

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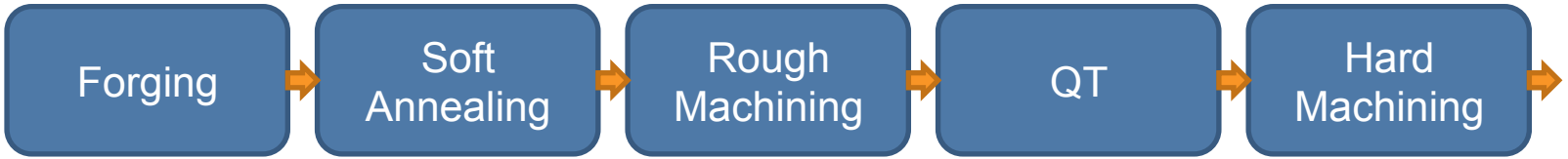
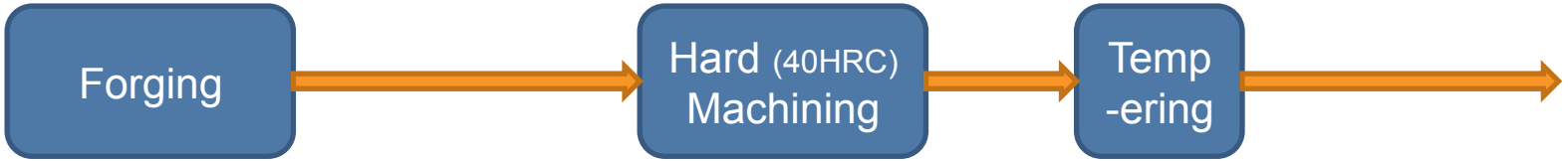
Possibility to remove manufacturing steps

Traditional route



Possible route with 297A



Final component

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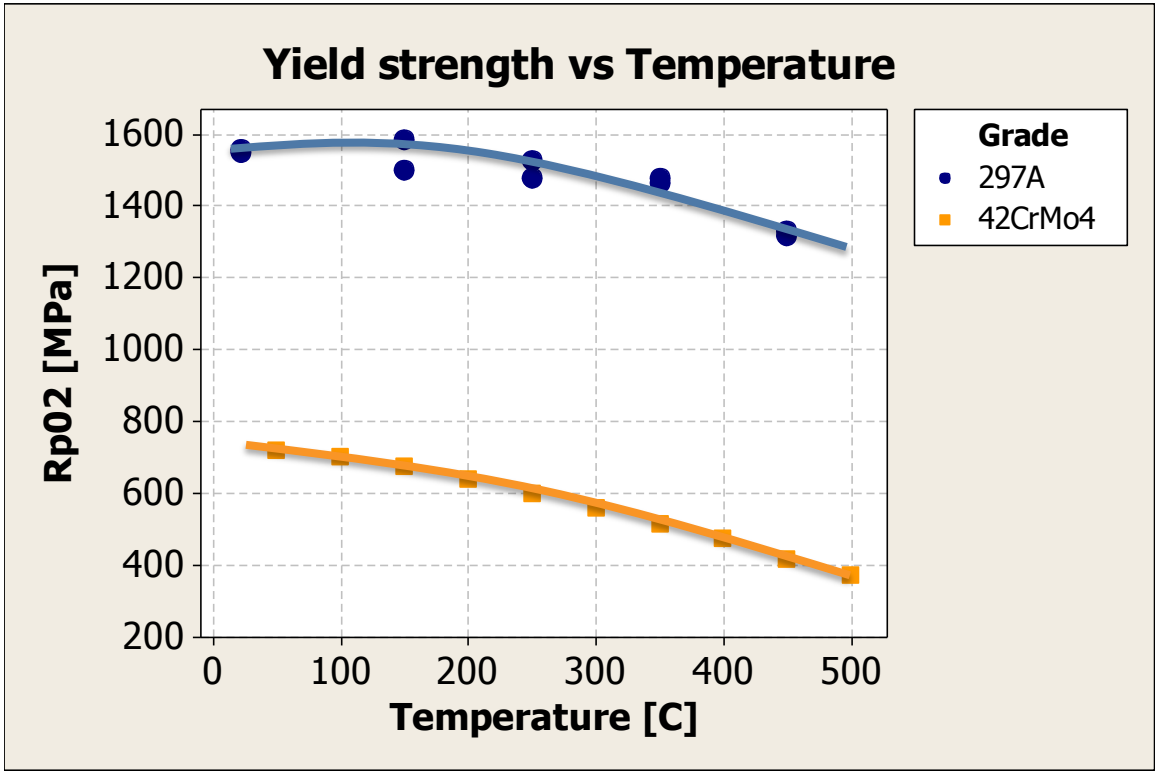
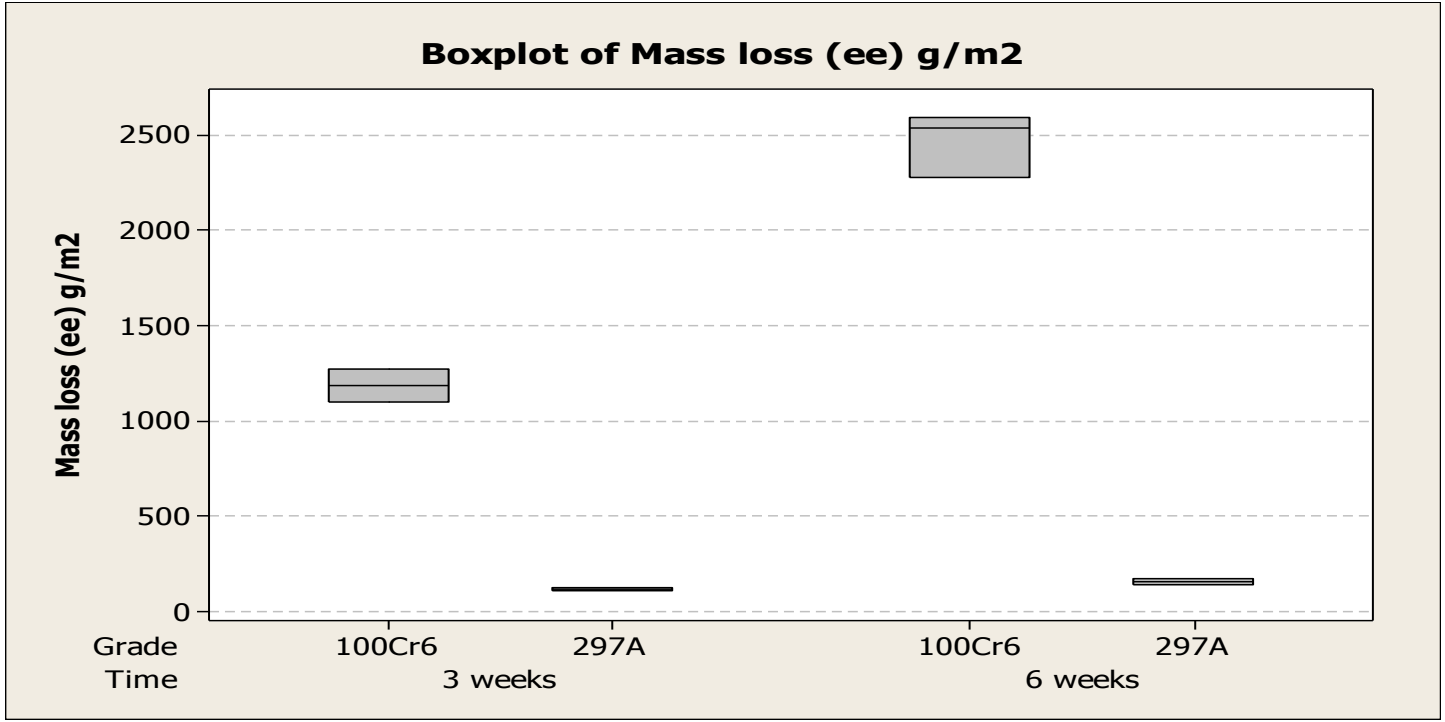
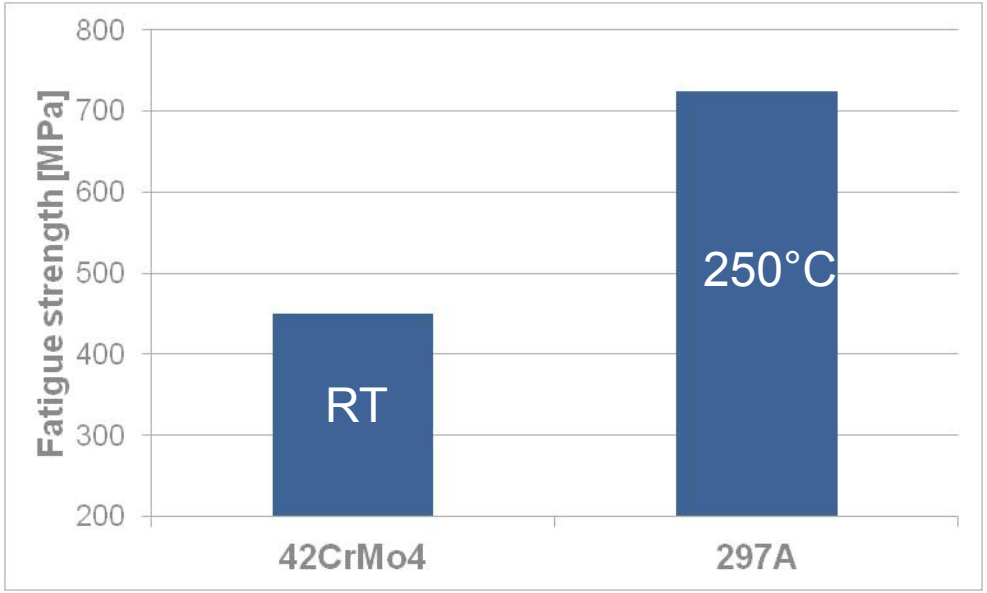
Three times the strength at elevated temperatures



Corrosion test (VDA 233-102)



Improved fatigue strength at elevated temperatures



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Other issues being addressed

- Machinability
- Corrosion in combustion gases
- Fatigue at 550°C
- Density
- Thermal conductivity
- Nitriding properties
- Coating
- Youngs modulus

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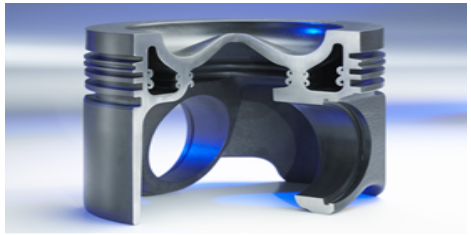
Potential engine applications Ovako 297A

- Pistons
- Turbo components
- Valves
- …



Conclusions

- A new steel has been developed for elevated temperature applications with the following charachteristics
  - Is a hybrid steel combining secondary hardening and precipitation hardening mechanisms without detrimental segregation issues
  - Significantly improved mechanical and fatigue properties
  - Gives possibility to reduce manufacturing steps
  - Produced in high volume production process

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Innovative steel for a better engineered future