

5<sup>th</sup>

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on Steels in Cars and Trucks

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# Expanding borders of diesel engine pistons:

advanced steel grade for high operation temperatures



## Summary of experimental development

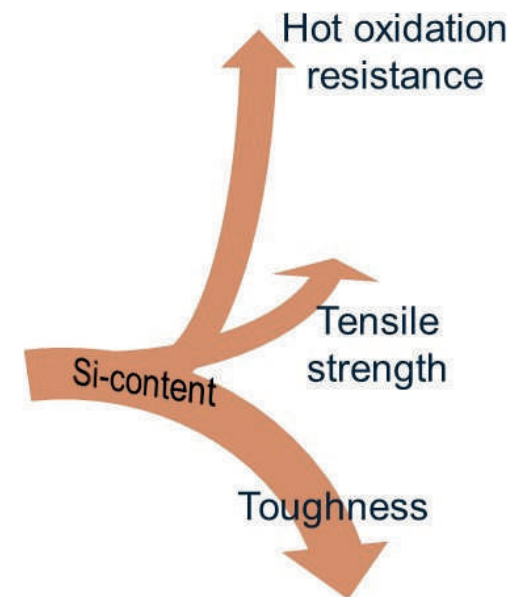
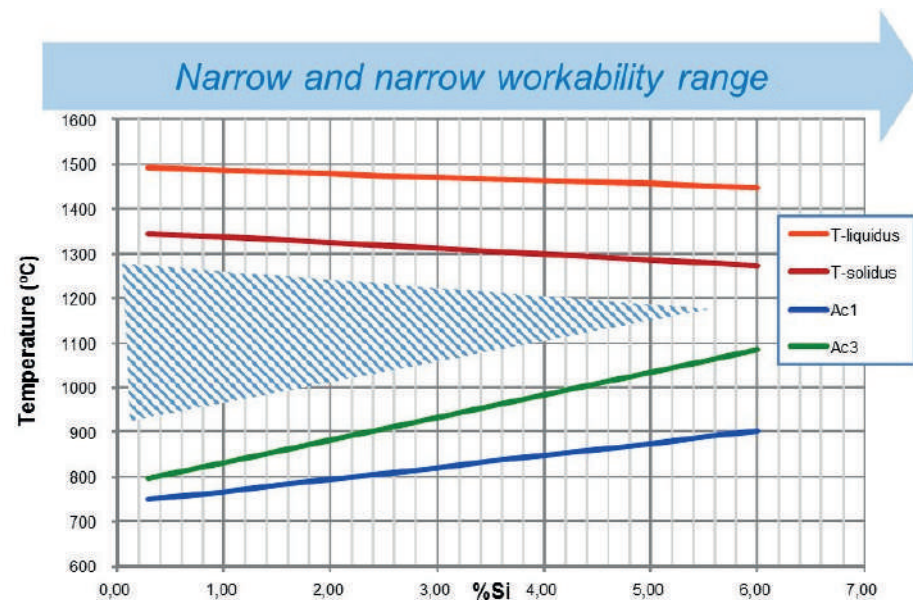
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- A new steel was recently developed to upgrade piston grades and fulfill the demands of engine designers respect to oxidation resistance and fatigue performance
- Silicon additions up to 3% had shown its good properties in valve steels to prevent oxidation at the combustion chamber
- Influence of different levels of Silicon on oxidation resistance and mechanical properties was analyzed in experimental casts
- The best balance of properties lead to the design of SCM40 steel, showing an outstanding performance



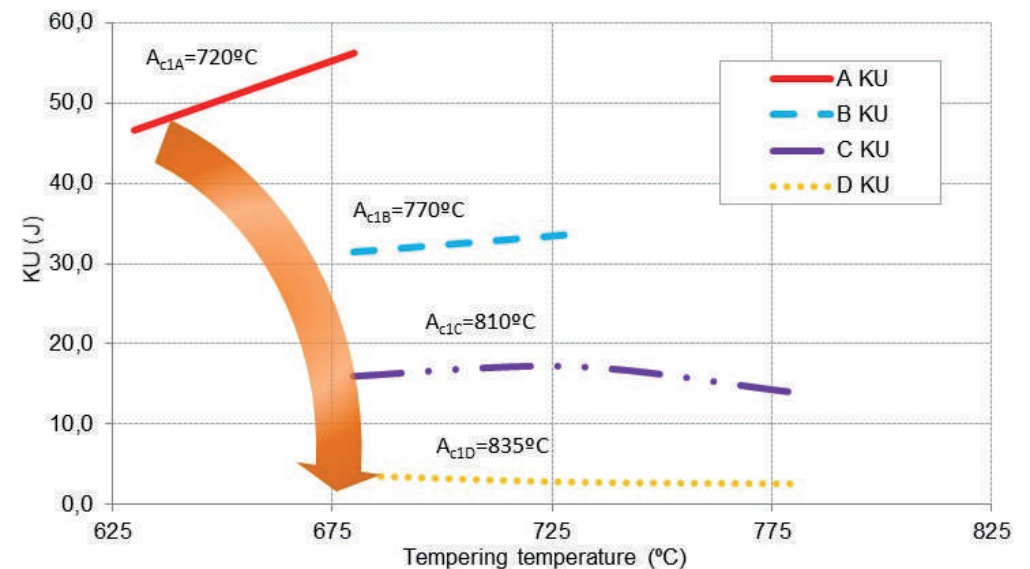
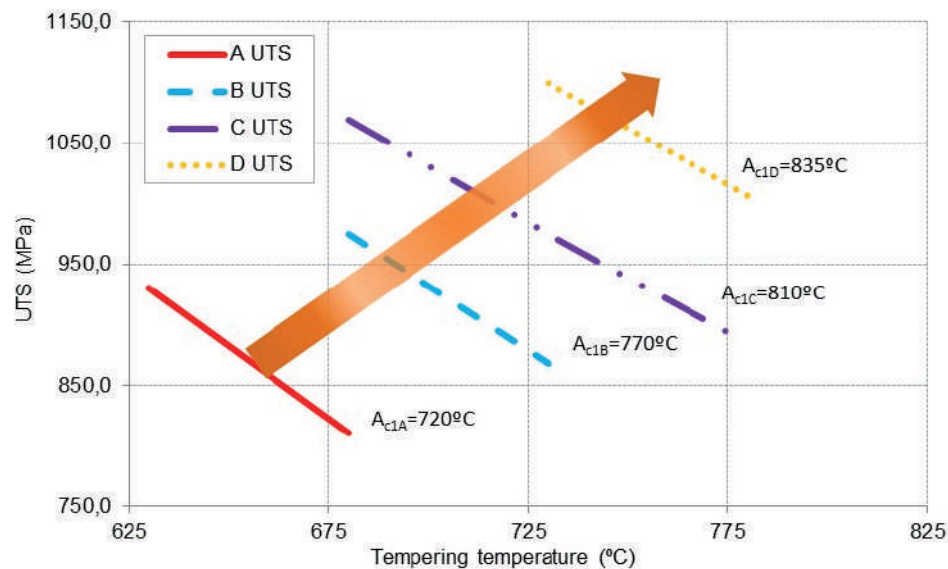
## Silicon influence on properties

Si increase improves oxidation resistance at high temperature, but reduces drastically toughness and limits hot workability to a narrow range. An optimum equilibrium must be achieved



## Tempering curves

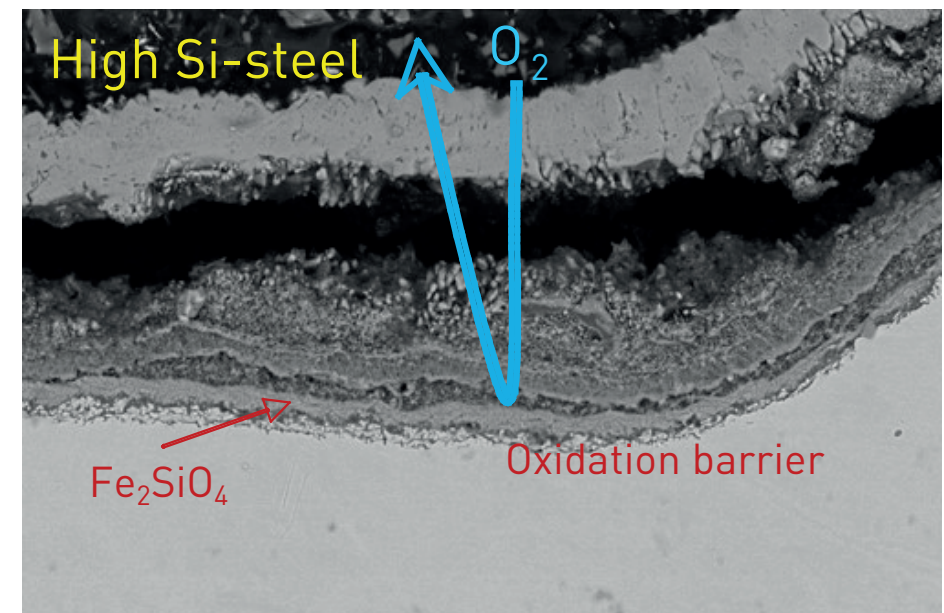
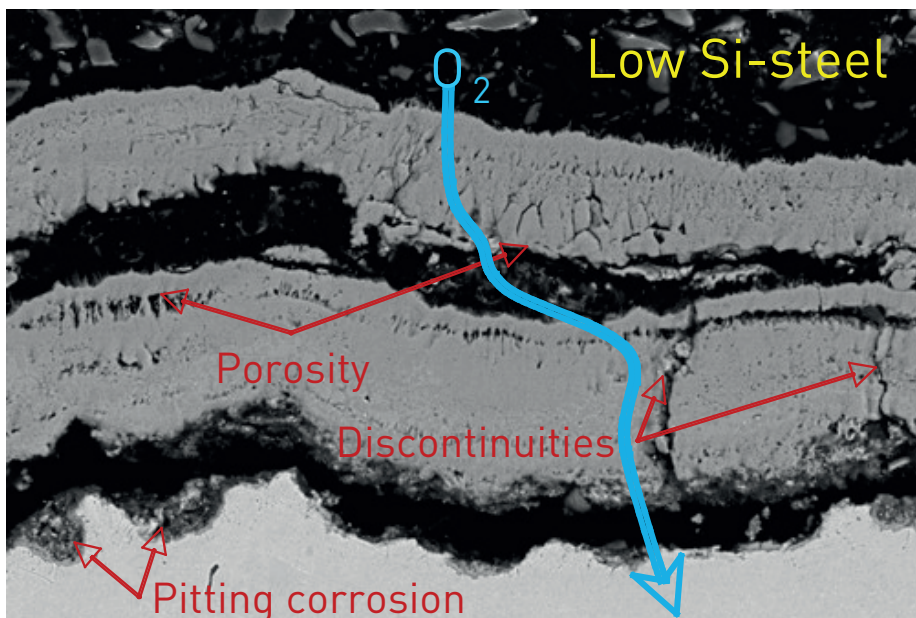
Silicon contributes to increase tensile strength, but the toughness drop is much sharper and limits the maximum amount of Si-addition





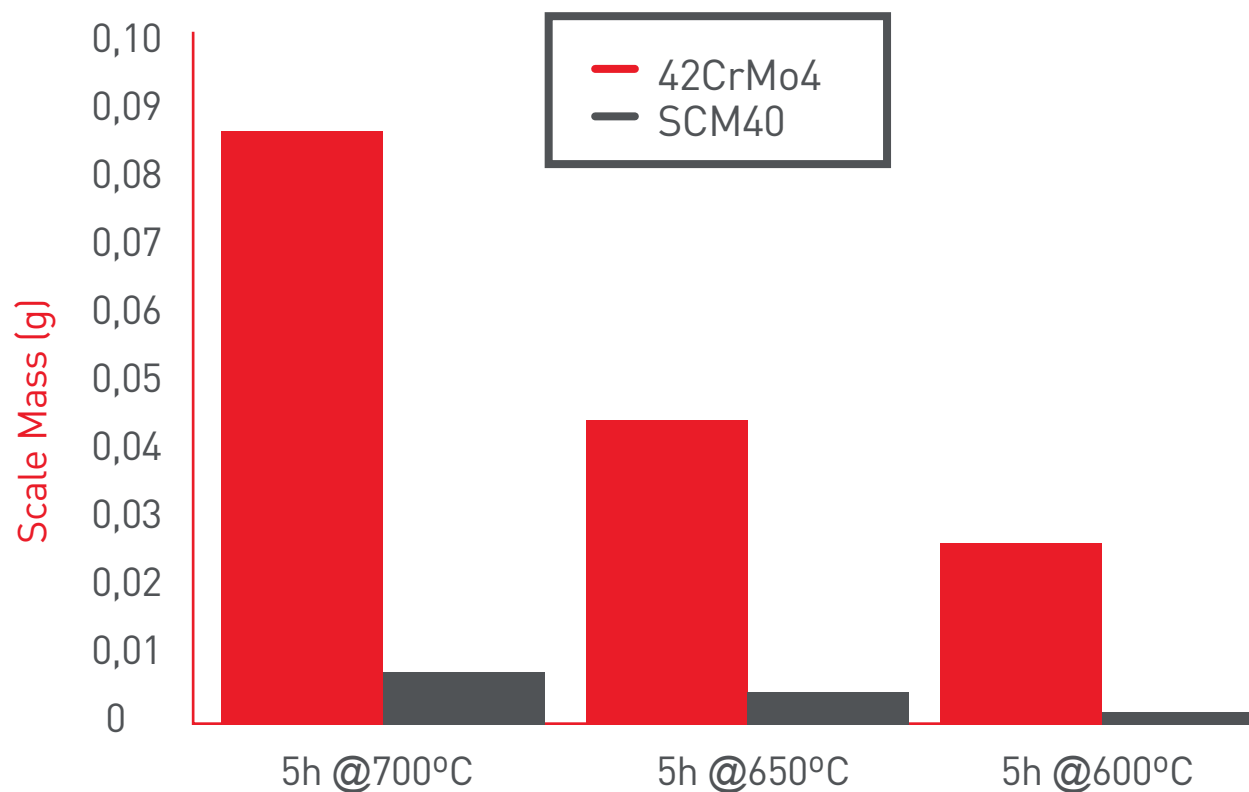
## Oxidation resistance mechanism

A thin and continuous layer of fayalite slows down the oxidation process and isolates steel from oxidizing atmosphere



## Scale formation at high temperature

The new steel has a remarkable resistance to oxidation at the operation temperatures of diesel engines, 10-20 times higher than steel grades currently used at the same conditions



	42CrMo4	New steel
Operation T	5h @600°C	5h @700°C
Scale mass	370	100



## Steel piston requirements

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**Lower weight > Higher strength**

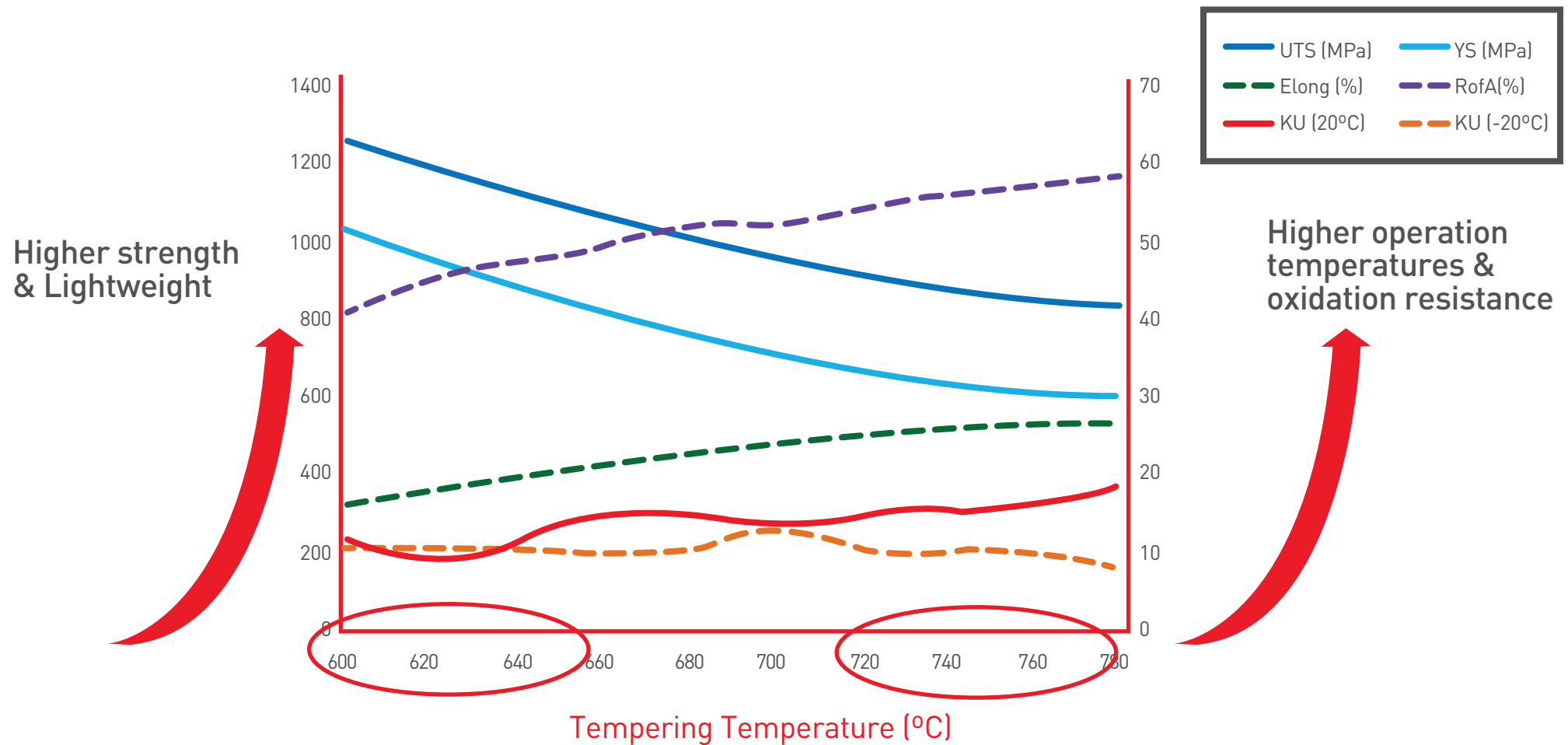


**Oxidation  
resistance at high T**

**Low thermal  
expansion**

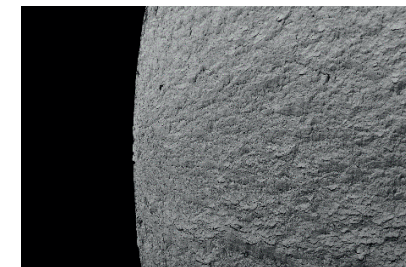
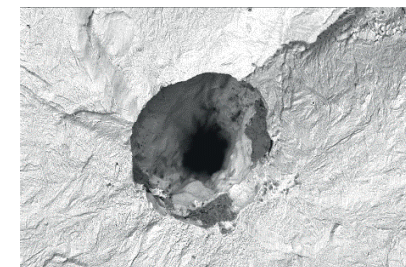
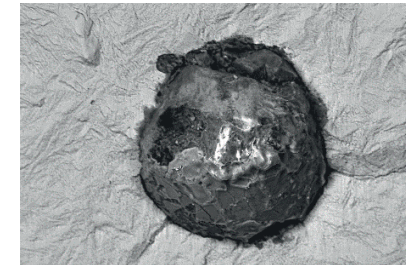
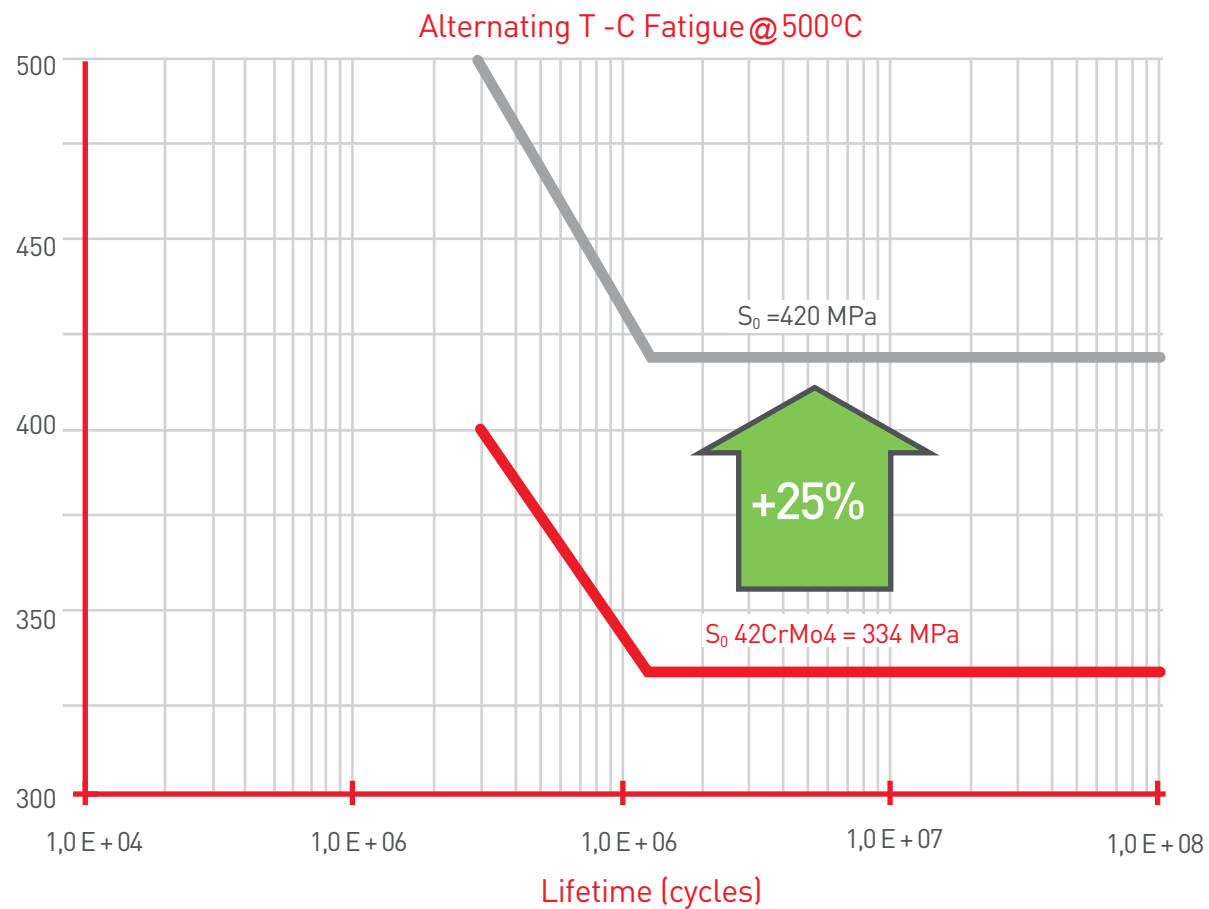
**Good high-T fatigue  
performance**

## Tuning of Properties



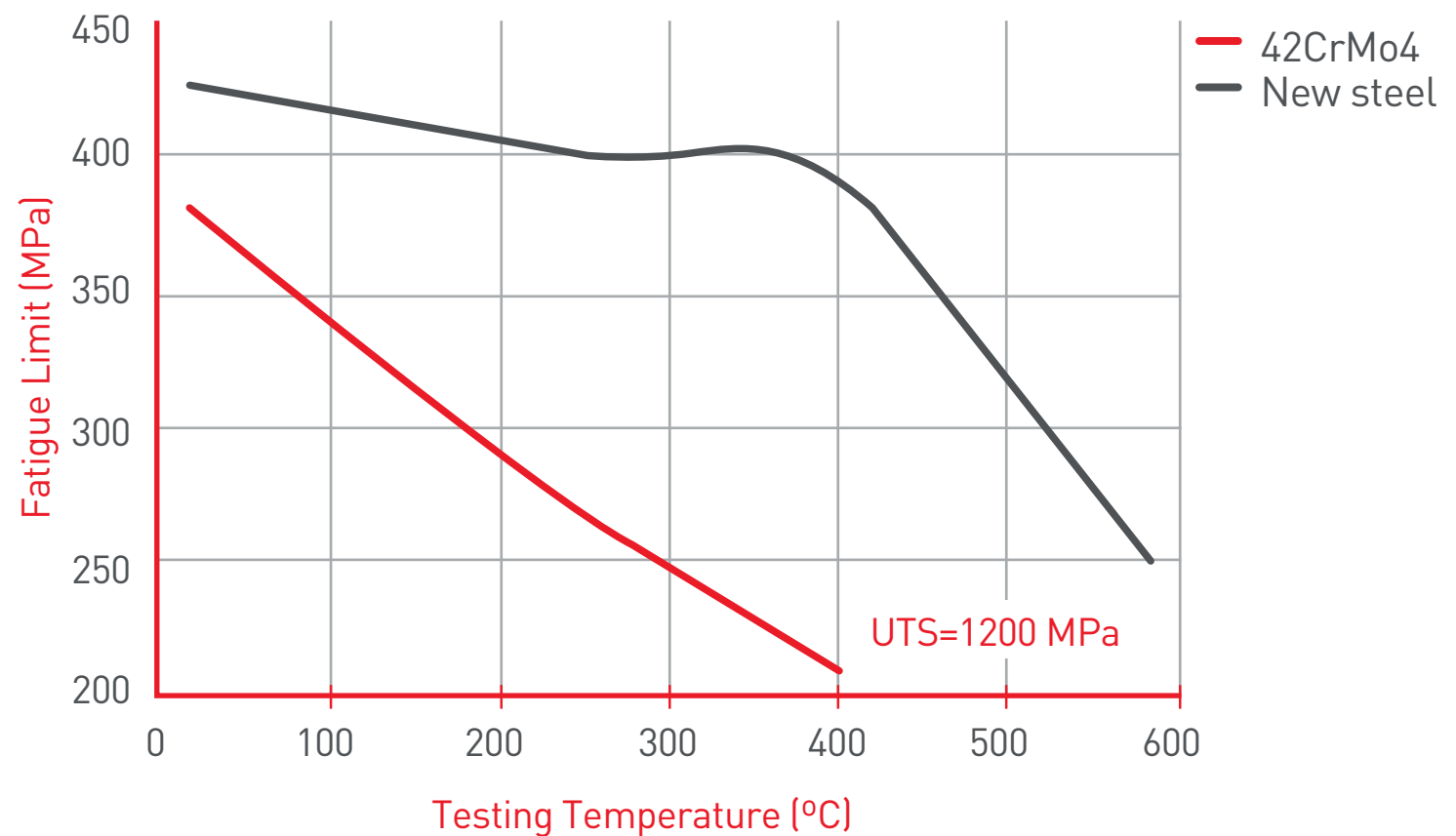


## Tensile-compression fatigue at 500°C



## Fatigue limit at high temperature

Independently of the equivalence (either same tensile strength, or same tempering temperature...) at high temperature the fatigue performance of the new steel is much better than standards 42CrMo4...





## Industrial trials

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Processing of the new steel can be carried out with some cautions:

- Shear cutting is not suitable. Saw cutting is highly recommendable
- Hot formability is good with very little scale
- Cold formability is poor
- Hardenability is high, therefore soft cooling is recommendable
- Austenizing temperature is around 975°C
- Tempering or annealing temperatures can rise up to 775°C
- Welding is feasible, but stress relieving should be carried out just afterwards to avoid subsequent cracks
- Machinability is a bit worse due to its higher hardness, but acceptable



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