



Niobium for  
advanced steel gears

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- Importance of improving fatigue resistance
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# Current gear technologies

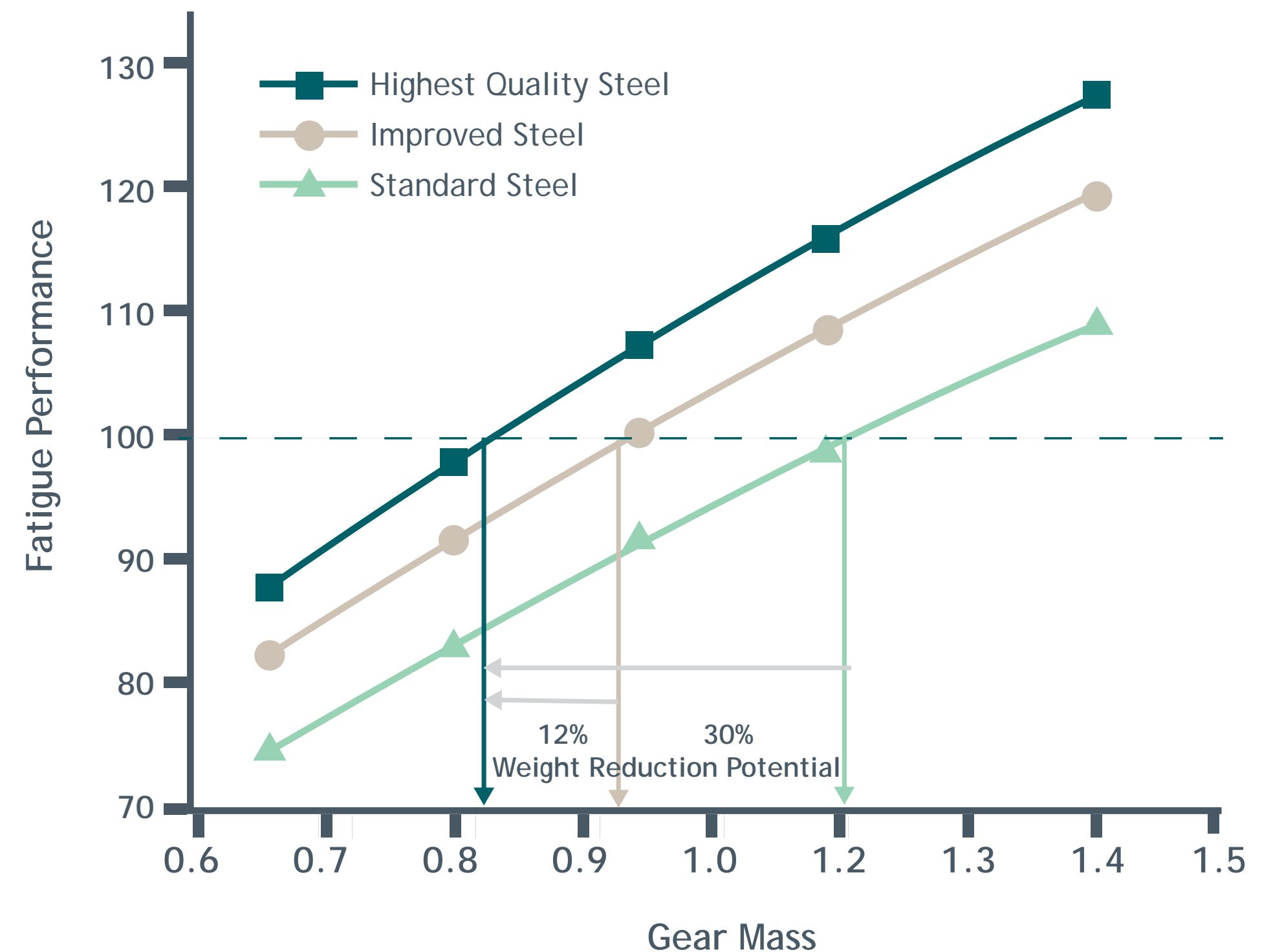
- Modern automotive gears rely upon technologies developed in 1960s
- Apply Aluminium microalloyed steels which create significant issues for modern car industry
  - Inherently limited fatigue resistance
  - Costly production processes
- Niobium can solve these problems
  - Concept already applied in large gears





# Importance of fatigue resistance

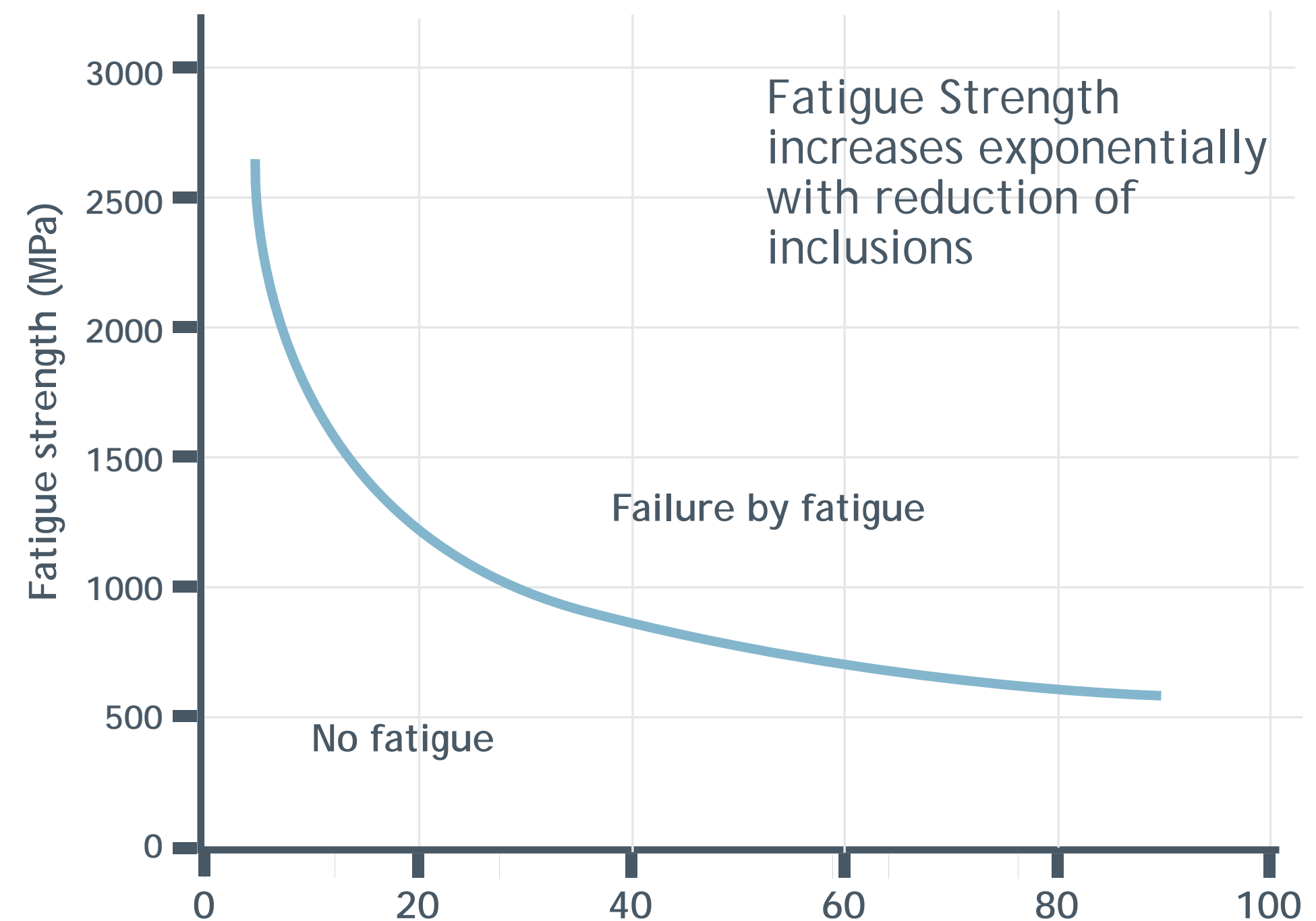
- Fatigue resistance is a key determinant of gear performance
- Studies show that better steels provide
  - Longer lasting gears
  - Up to 30% lighter gears



Source: E. B. Damm, P. C. Glaws, *Gear Design Relevant Cleanliness Metrics*, *Gear Solutions*, January, 2017

# Advanced Niobium steel gears

- Niobium micro alloyed steels can significantly improve fatigue resistance by
  - Stopping formation of non-metallic particles (inclusions) caused by oxidation (cleanliness)
  - Preventing cracks from forming and spreading through grain refinement
- They can also cut production costs by reducing energy consumption during manufacturing



# Cleaner gears

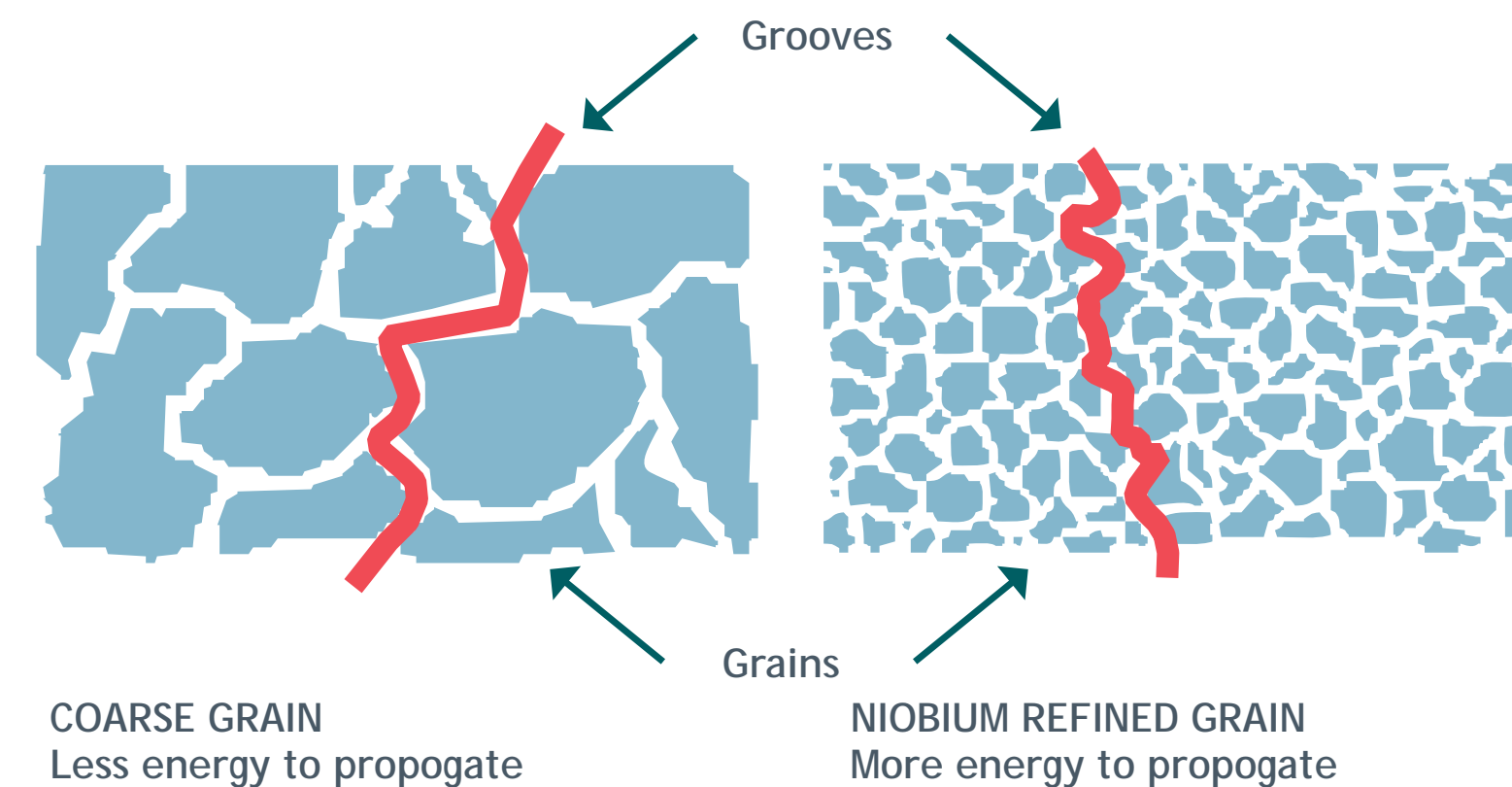
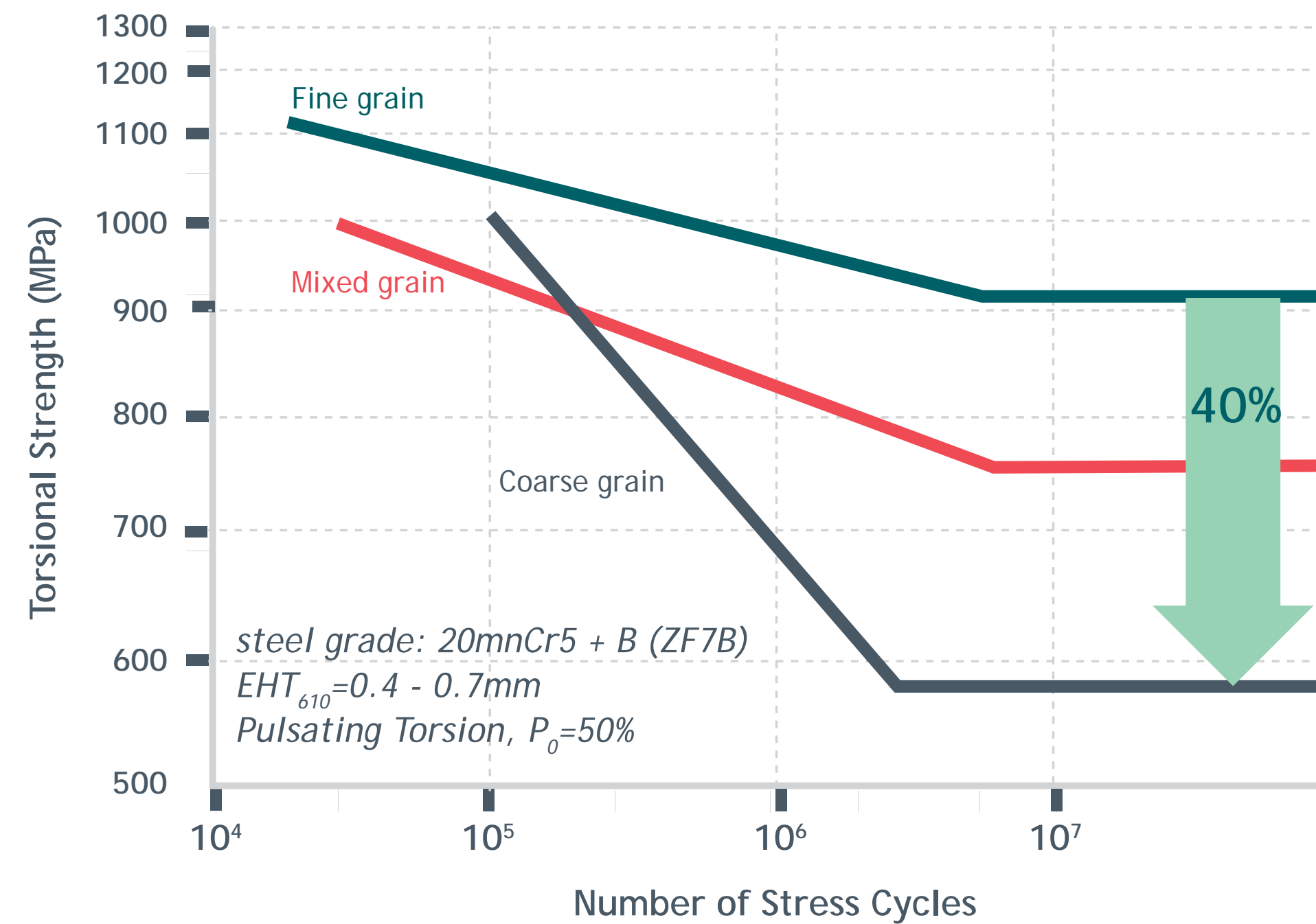
- Oxidisation creates non-metallic particles in steel which can create cracks that reduce fatigue strength
- Aluminium has very high affinity for Oxygen
  - Niobium has a low affinity for oxygen compared to Aluminium and other metals
  - In optimised vacuum production (no oxidisation) Niobium also contributes significant additional benefits
- Many other elements Oxidize before Niobium and in practice Niobium will never form oxide inclusions

Sequence of Oxidation in Liquid Steel (tendency to oxide formation)



# Stronger gears

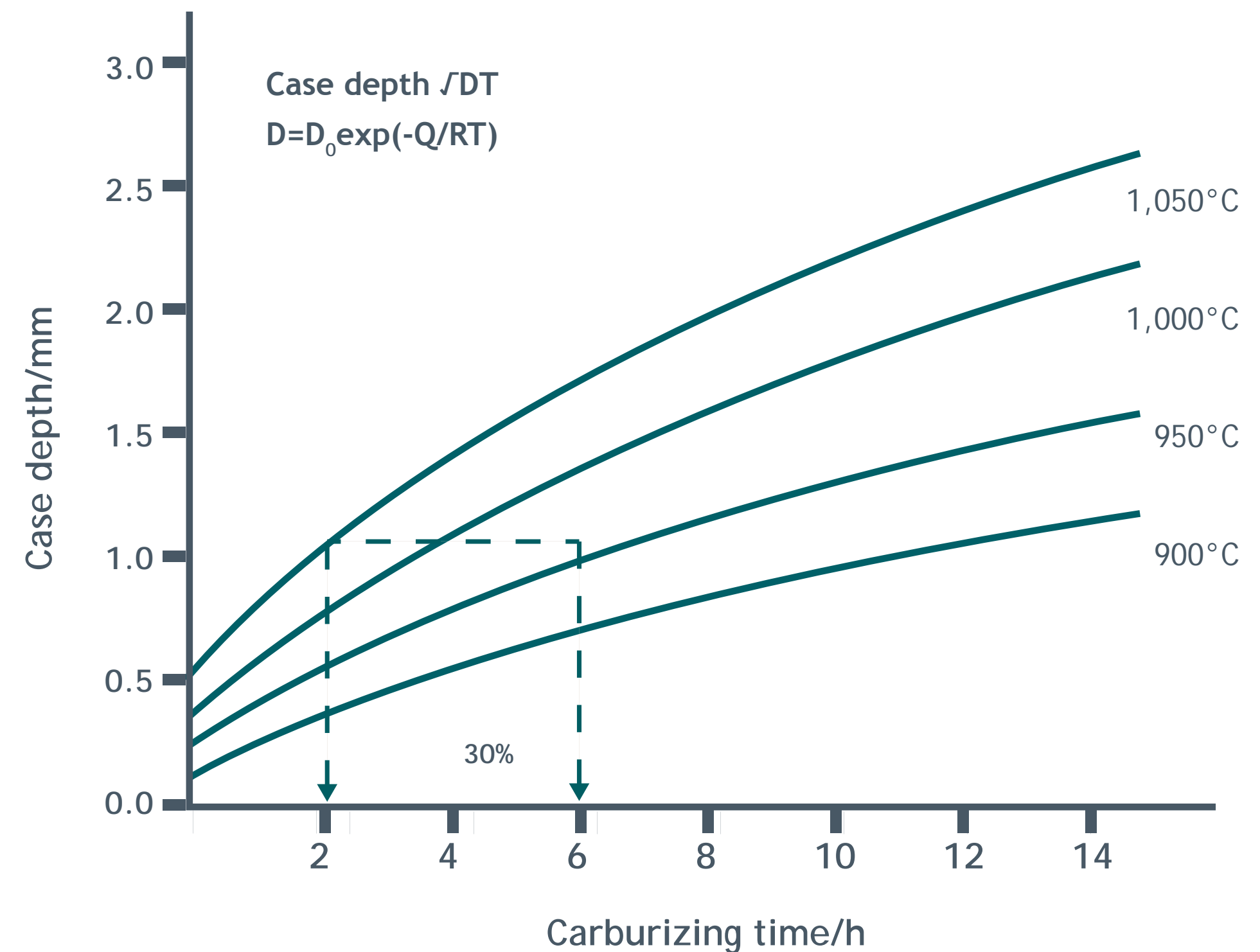
- Steels with large grains are more likely to fail under stress
  - Cracks more likely to form
  - Once formed, cracks propagate more easily
- Niobium is strongest grain refining alloy
  - Prevents formation of large grains even at very high temperatures





# Cheaper gears

- Gear steels require lengthy 6/10 hour heating process (carburizing) to increase toughness
  - With current steels, temperature has to be limited to prevent formation of large grains that reduce fatigue life
- Applying Niobium enables higher temperature heating as controls grain formation
  - Could reduce heating times from 6 to 2 hours, depending upon the part
- Therefore potential for significant reduction in energy costs and emissions from applying Niobium



# Conclusion

- Traditional gear steels (AISI 8620) based on old metallurgical concepts, using Aluminium to control grain growth
  - Aluminium not best element for controlling grain growth
  - Aluminium increases likelihood of inclusions, which are very detrimental for fatigue life
- Microalloying with Niobium creates much better fatigue resistance
  - Optimal combination of grain growth control and reduction of inclusions
- Potential to substantially reduce costs as Niobium's improved control over grain-growth allows higher carburizing temperatures and shorter treatment times