



Niobium for advanced steel  
forgings

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# Contents

- Key properties of forging steels
- Benefits of Niobium

# Automotive forging steels

- Forging uses compressive force to shape metal
- Metal can be cold, warm or hot forged
- Forging process increases the strength and toughness of a part due to deformation and heating process
- Used to produce parts such as
  - Connecting rods
  - Wheel hubs
  - Suspension components and
  - Transmission parts

# OEMs have competing requirements

- Modern automotive forging steels need to balance a number of potentially conflicting properties



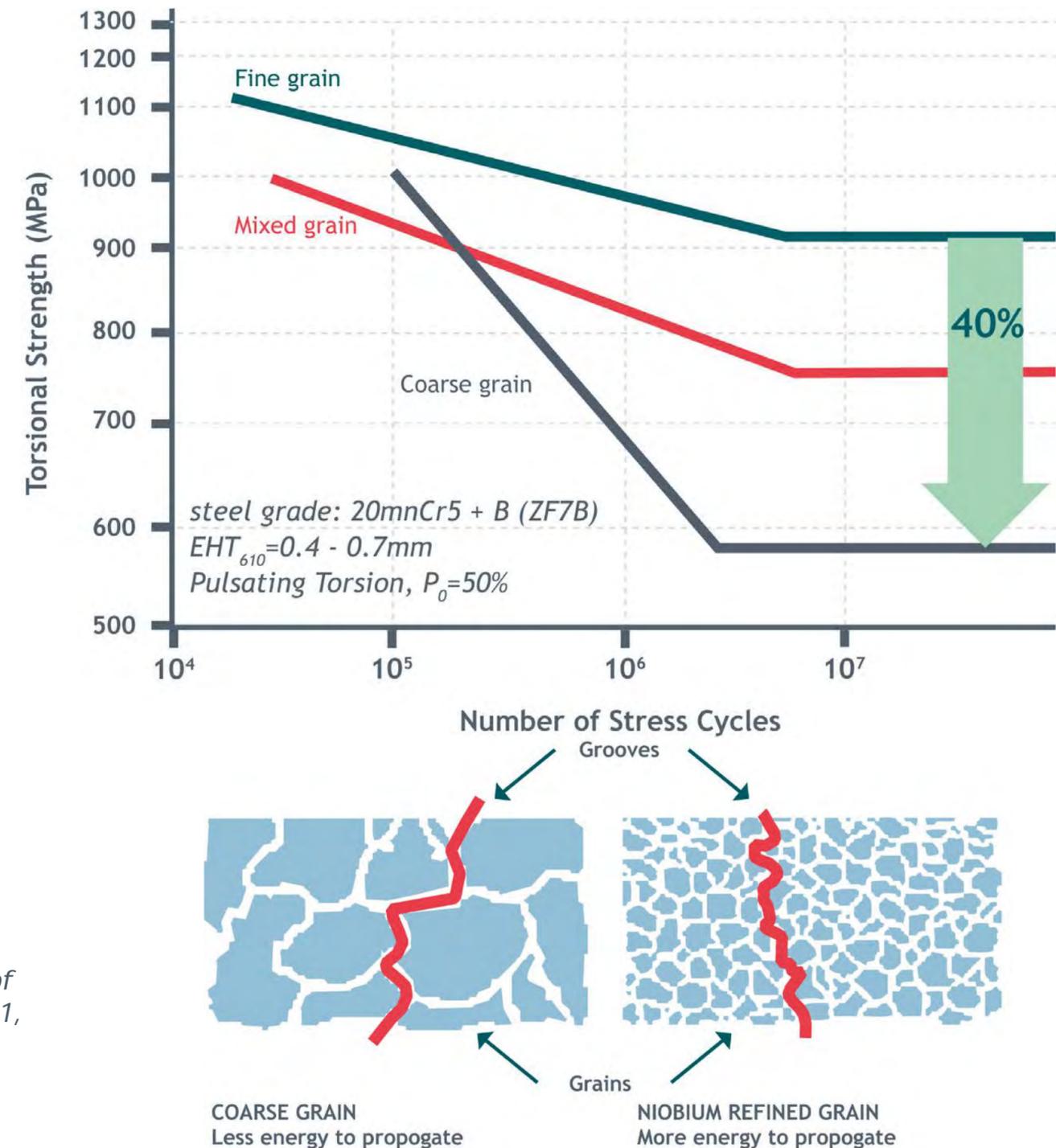
# Trends in development of forging steels

- Improved machinability to reduce production costs
- Warm and cold formability becoming more common
- Optimize heat treatments via thermomechanical processing to achieve:
  - Greater productivity
  - Better energy efficiency
  - Improved product performance
  - Reduced environmental impact

**Conventional forging steels require extensive and costly heat treatments to achieve desired mechanical properties**

# Better forging steels

- 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 process temperatures
  - Assures homogeneous microstructural phase distribution, achieving desired mechanical properties without costly heat treatment
  - Improves strength, toughness and fatigue resistance

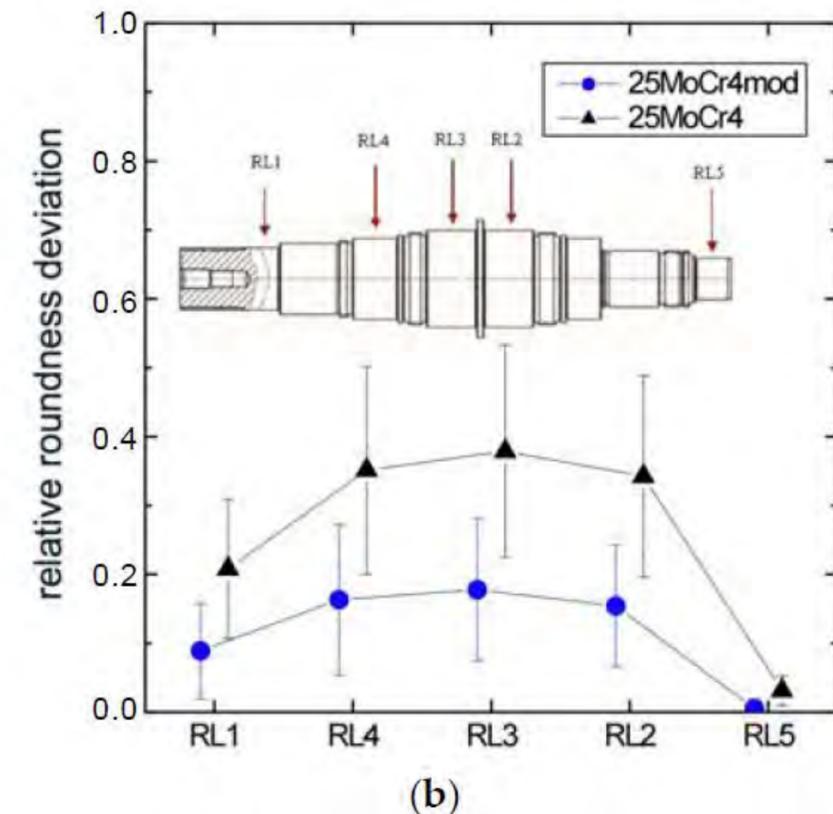
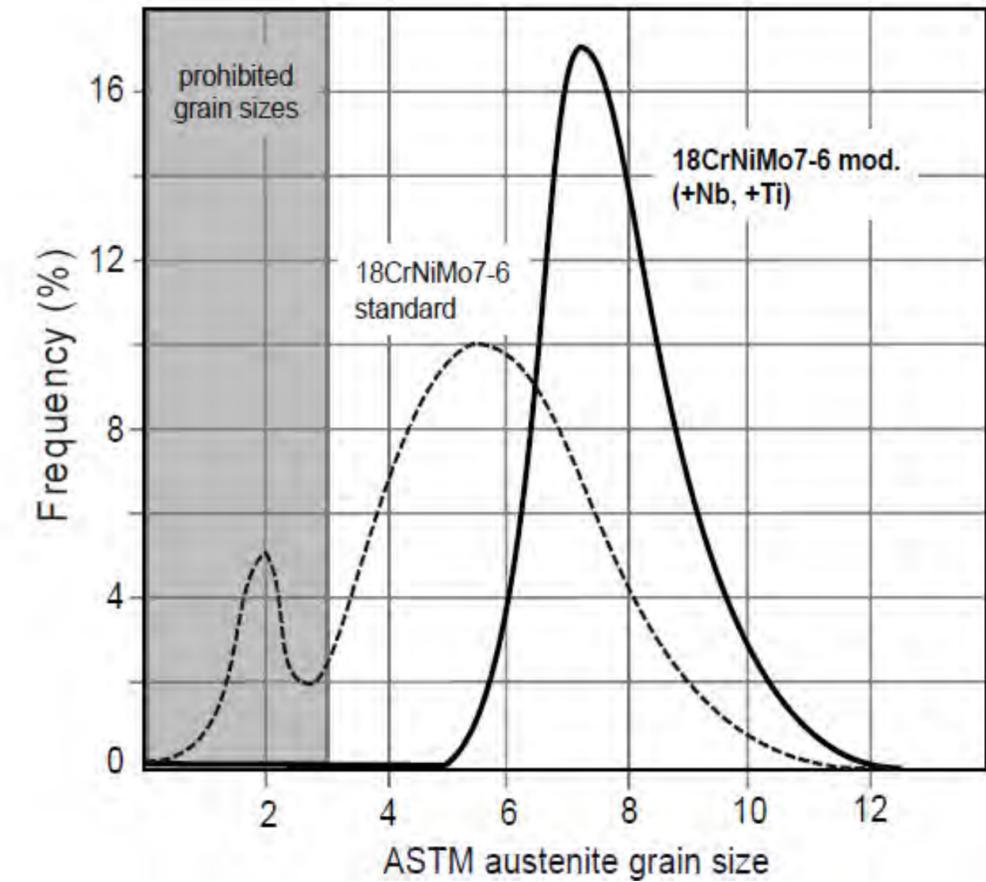


Hardy Mohrbacher, Reverse metallurgical engineering towards sustainable manufacturing of vehicles using Nb and Mo alloyed high performance steels, *Advances in Manufacturing*, Vol 1, N.1, p. 28-41, 2013.

# Niobium grain reduction

Niobium application gives two significant benefits

- Significant reduction in grain size
  - Improving toughness, fatigue resistance and hardenability
  - Once formed, cracks do not propagate easily
  
- Narrower distribution of grain sizes
  - Improving dimensional stability after heat treatment



Source: T. Tobie , F. Hippenstiel and H. Mohrbacher, Optimizing Gear Performance by Alloy Modification of Carburizing Steel Metals, October, 2017

# Powertrain forging steels – microalloyed steel design

- Microalloyed steel can help reduce energy costs in the forging process
  - Warm forging is an effective strategy for achieving mechanical final properties in as forged steel, without need for costly quenching and tempering
- Mechanical requirements can also be achieved via microalloying elements, mainly Vanadium and Niobium
  - Microalloying with Niobium and Vanadium can achieve desired forging steel mechanical properties
- Estimated 10% to 15% operational cost reduction can be achieved by using microalloyed steels

*Jansto Steven G.. "Niobium Bearing Steel Technological Developments for Long Products and Forgings" International Conference on Advances in Metallurgy of Long and Forged Products, USA, 2015*

# Niobium's benefits for forging steels

Niobium has two main benefits...

- Avoiding post forging heat treatments
  - Niobium suppresses grain growth in austenite
- Microalloying enables use of warm forging instead of hot forging
  - Controlled cooling to take advantage of the microalloying strategy

Which result in...

- Reduced production costs and
- More consistent material performance