Niobium

Niobium Press Hardening Steels

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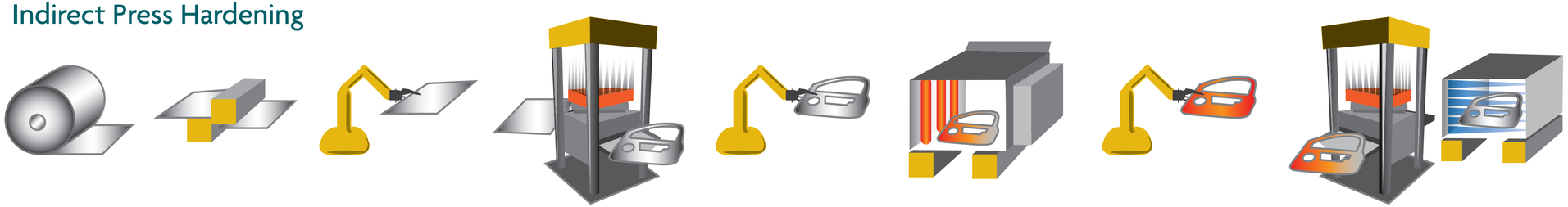
Contents

What is Press Hardening?

- Press Hardening (or Hot Stamping) process creates steels which are both very strong and can be formed into complex shapes
- Steel blanks are heated, then formed in a stamp before rapid cooling in dies
- Creates transformed and hardened material

Direct Press Hardening

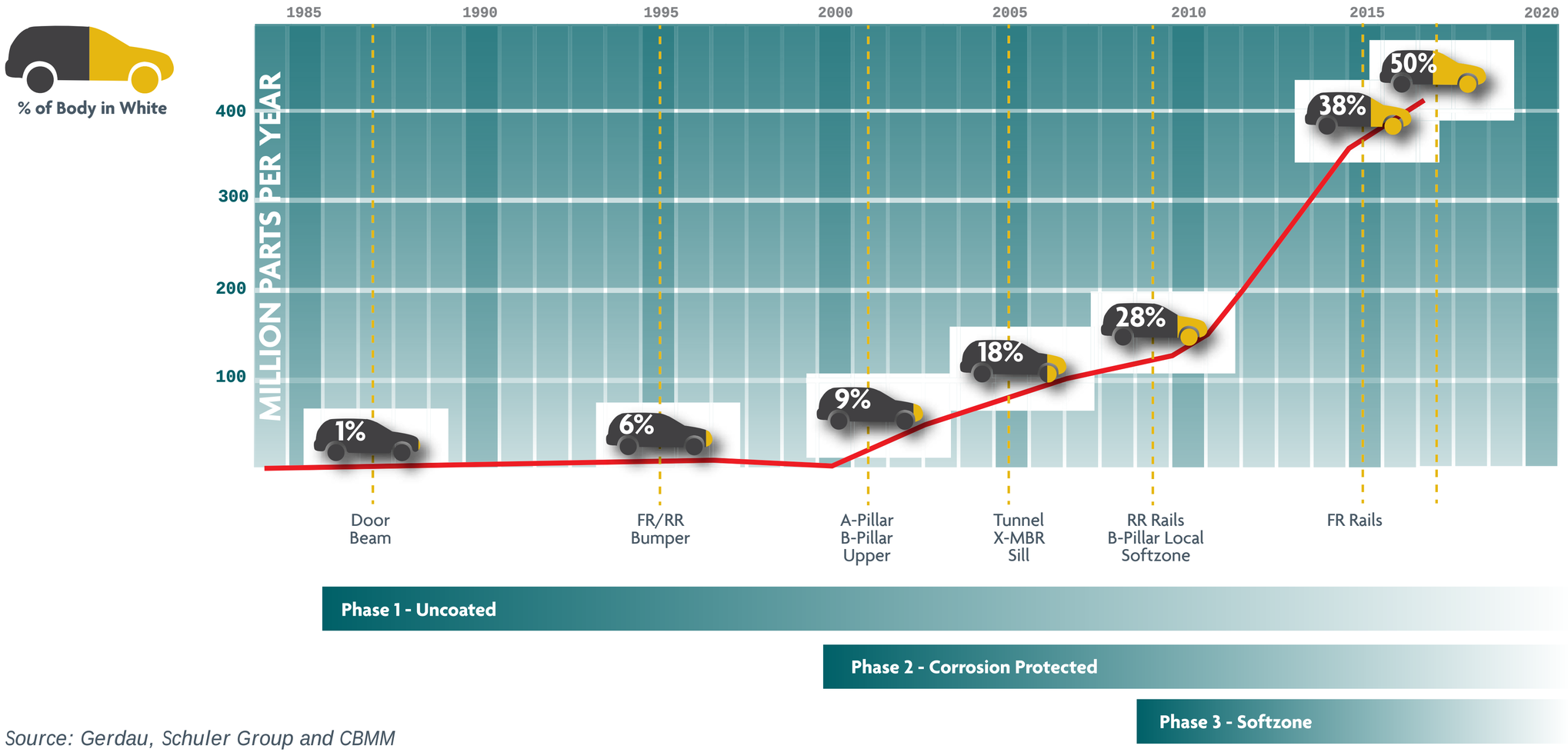
Indirect Press Hardening



History of Press Hardened Steels

- Developed in Sweden by SSAB, amongst others
- Initially used to make light and strong farm implements
- First used in automotive sector by SAAB and Jaguar in 1980s
- Early 1990s adopted by brands including VW, Porsche, SEAT, GM, Daimler, Mazda, Bentley, Land Rover and BMW
- 2013 SSAB patent expires leading to significant growth in production

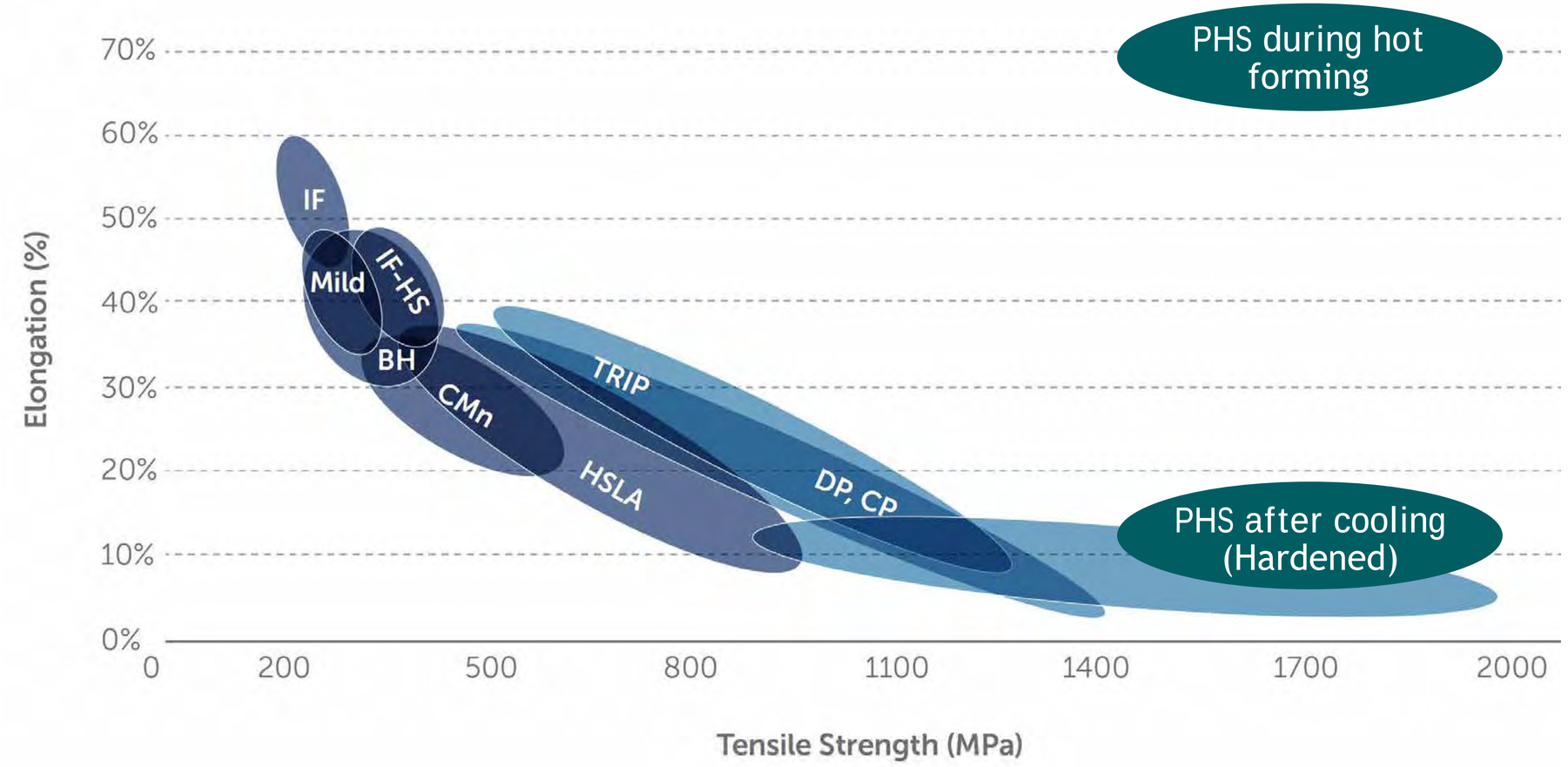
Trends in Usage of Press Hardened Steels



Source: Gerdau, Schuler Group and CBMM

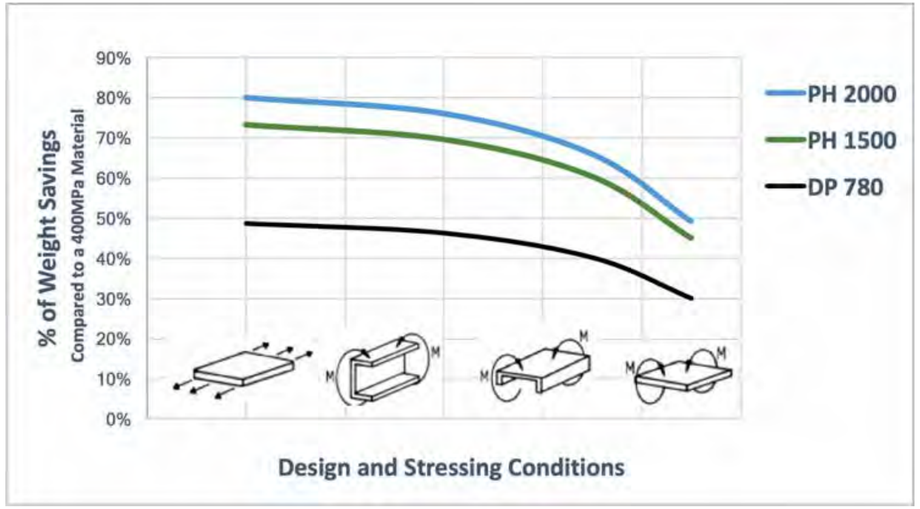
Key Benefits of Niobium Press Hardened Steels

- Historically, high strength steels suffered from low bendability
- Niobium Press Hardened steels combine high strength and bendability



Key Benefits of Niobium Press Hardened Steels

- Combination of high strength and bendability enables OEMs to meet previously conflicting objectives
- Weight reduction to meet fuel efficiency targets
- Improved crash resistance to meet tougher standards
- Higher stiffness than non-ferrous options (3x stiffer than Alu)



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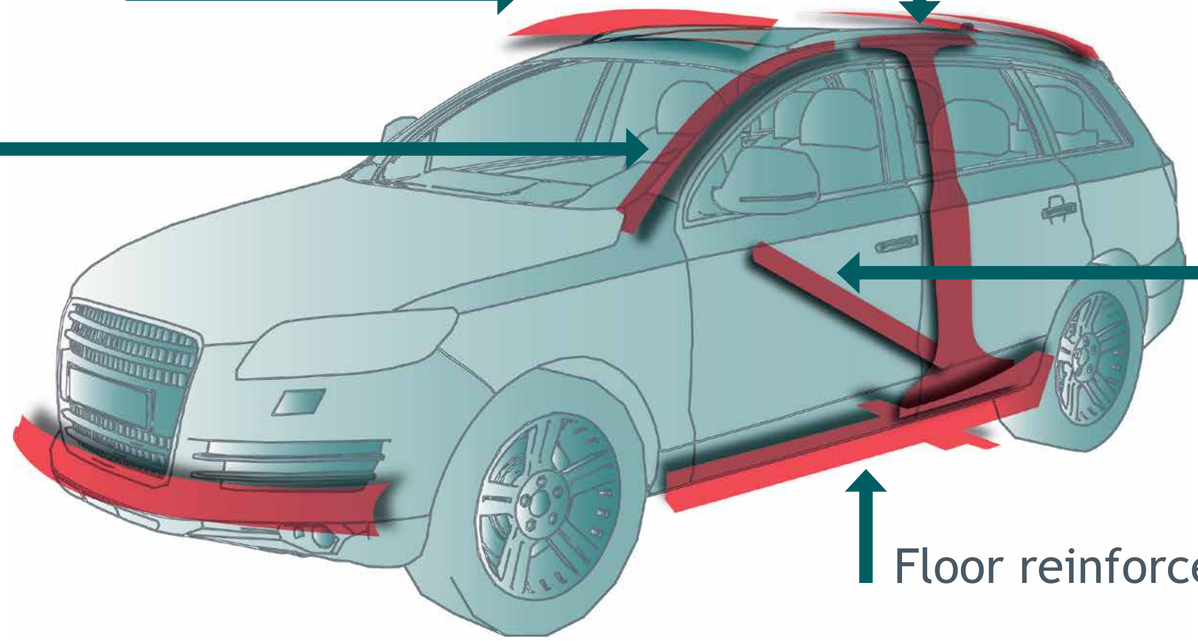
www.euroncap.com

Source: Modified from YOUNGER D.G, Metal Progress, 1975, No 5, p. 43-47.

Niobium delivers improved performance cost effectively

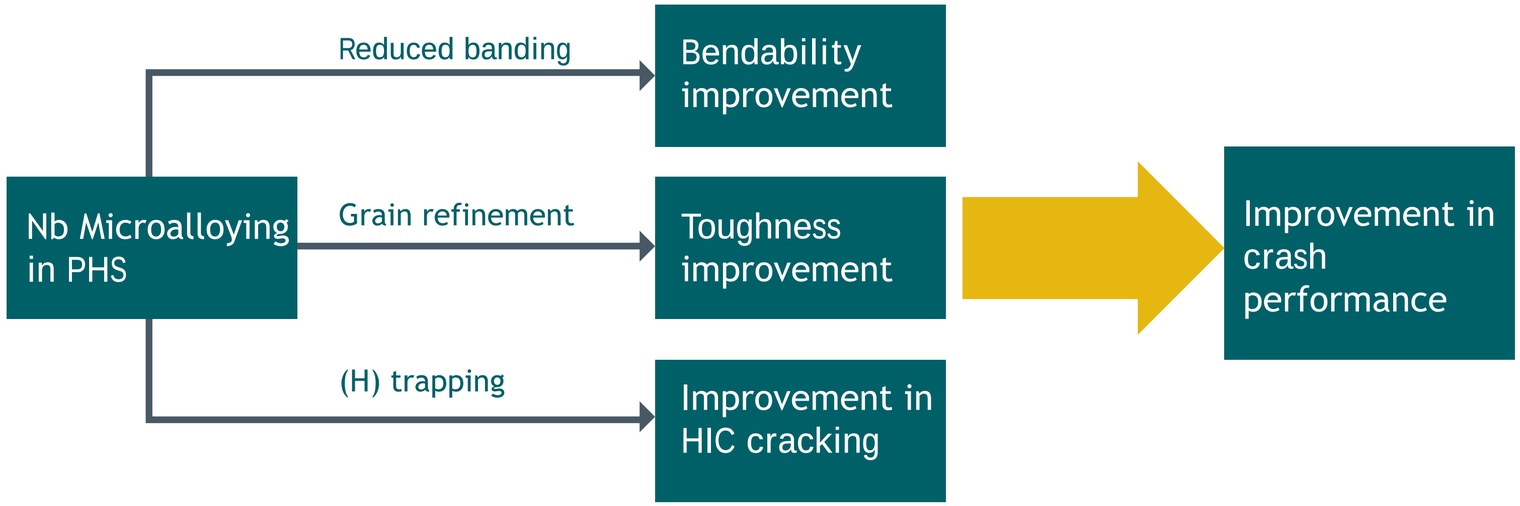
- Reduced alloying costs vs other steels
  - Low alloy content of 0.02-0.04% Niobium
- Lower investment and production costs than using non-ferrous materials
- Reduced material usage vs other steels
  - Less material required to achieve same results
  - 100% recyclable

Applications



What is the role of Niobium?

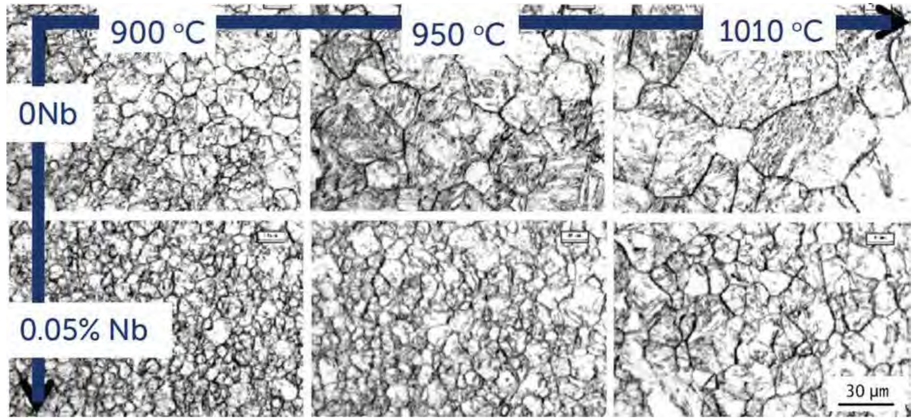
- Press Hardened steels originally developed using nonautomotive steels
- Newer advanced high strength steels with enhanced properties developed. However suffered from issues
  - Low bendability, limiting practical applications
  - Hydrogen embrittlement, reducing ultimate tensile strength
- Niobium microalloying addresses these issues



Toughness and bendability

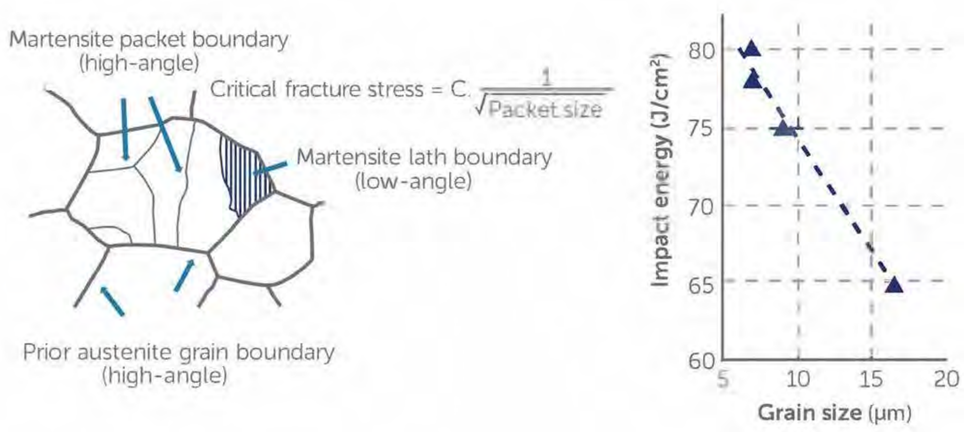
- Niobium refines structure during heating process
  - Increasing toughness
  - Improving bending

Niobium avoids grain coarsening



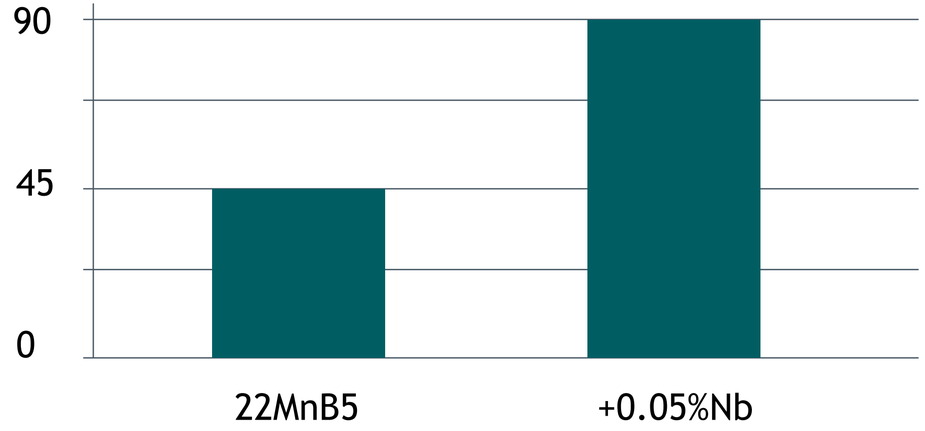
Examples of microstructure of a PH steel, showing grain refinement after the addition of Niobium

Source: J. Bian, W. Li, H. Mohrbacher, L. Hongzhou; W. Wenjun, Advanced Materials Research, 2014, Vol. 1063, p. 7



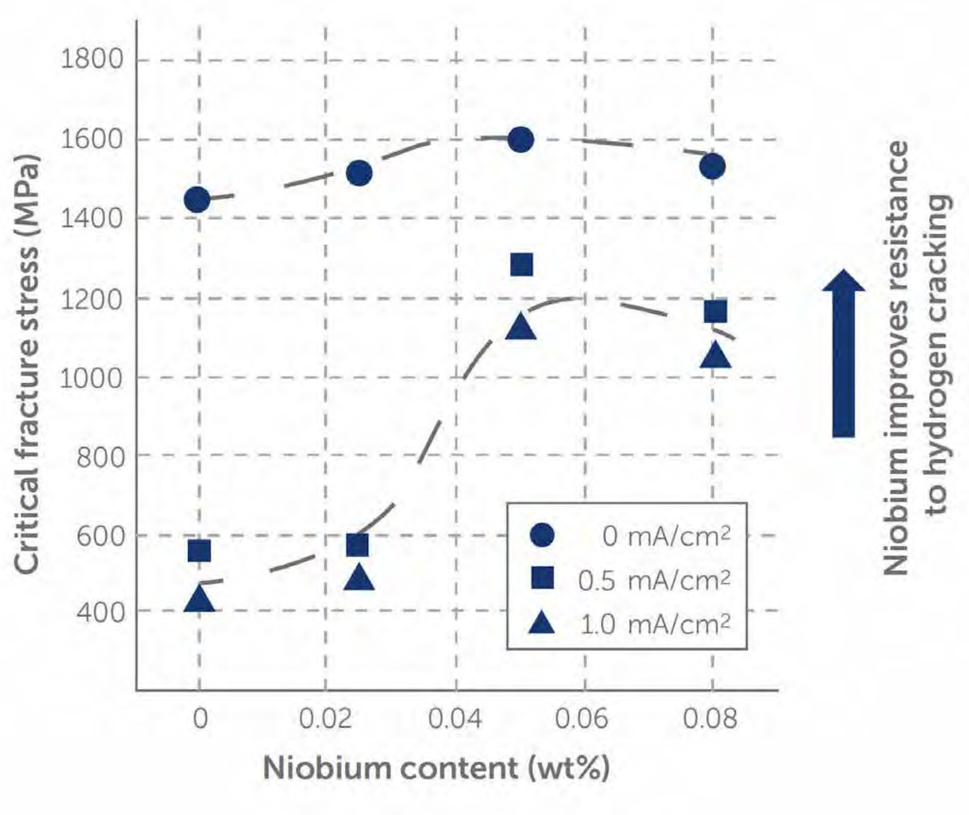
Schematic representation of how microstructure refinement increases toughness and the actual observed increase in impact energy with finer prior austenite grain size (PAGS)

Bending angle (deg)



Hydrogen embrittlement

- Niobium reduces hydrogen mobility giving better resistance to hydrogen embrittlement



Critical fracture stress (σHIC) of PH steel for various niobium contents under different hydrogen charging conditions given by the mA/cm2
Niobium increases the critical fracture stress for different hydrogen levels.

Source: J. Bian, W. Li, H. Mohrbacher, L. Hongzhou; W. Wenjun, Advanced Materials Research, 2014, Vol. 1063, p. 7