Niobium

Dual Phase Steels

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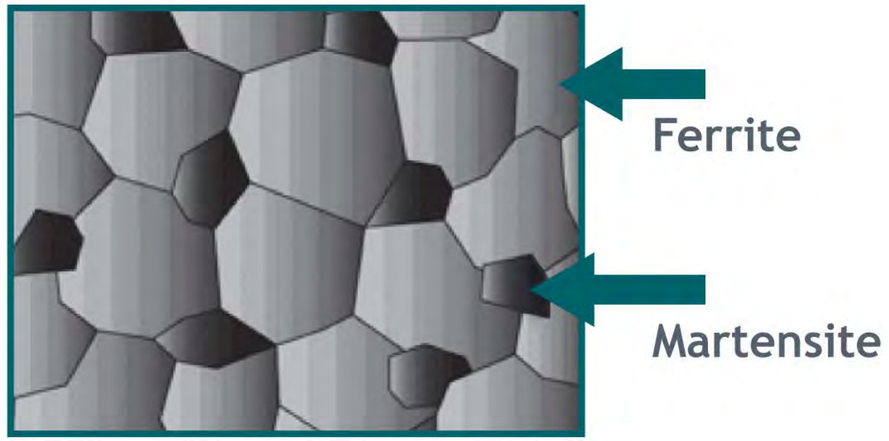
What are Dual Phase Steels

- Class of steels which can vary in strength from 550MPA to >1,000MPA
- Produced by hot or cold rolling followed by controlled thermal processing to achieve a dual phase microstructure
- Attractive because they combine strength and ductility
- Widely used in automotive industry, though uptake impacted by production issues

Dual Phase Microstructure



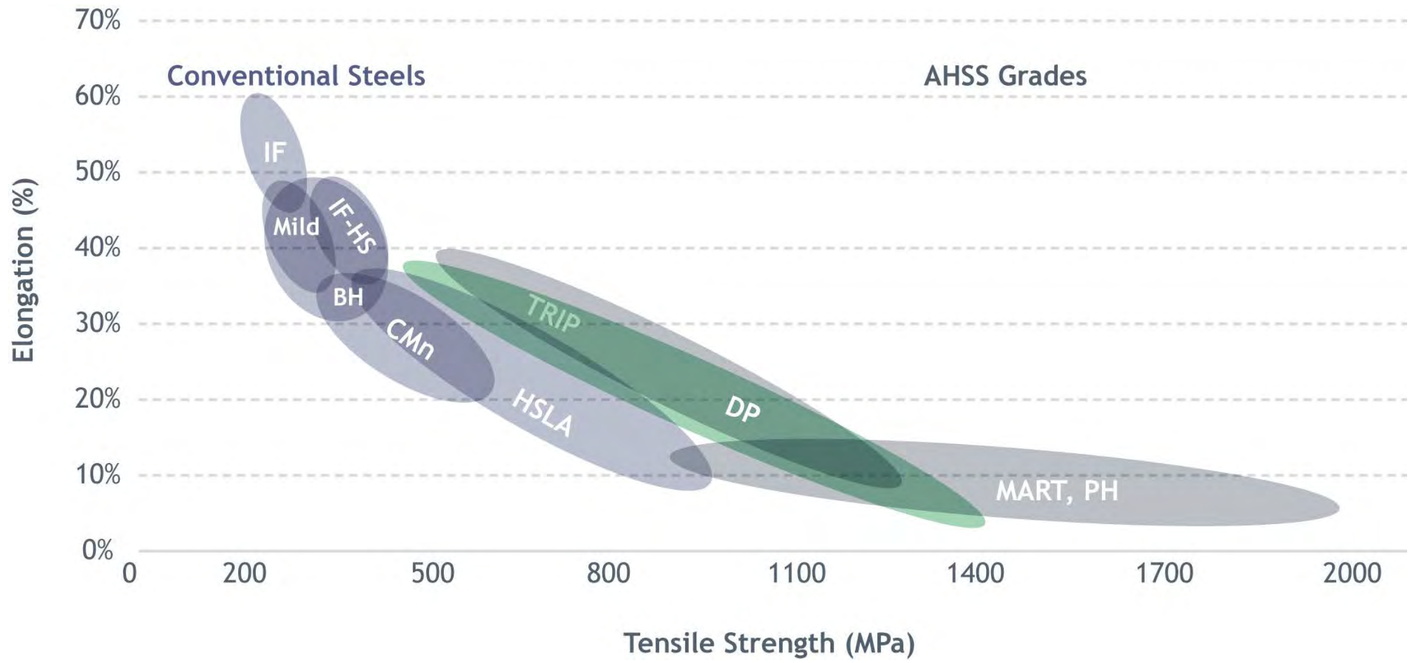
Example of a microstructure of a dual phase steel, showing the martensite (dark) and ferrite (light) phases

Source: Advanced High-Strength Steels Application Guidelines V5.0, May 2014, WorldAutoSteel, editors: S. Keeler and M. Kimchi

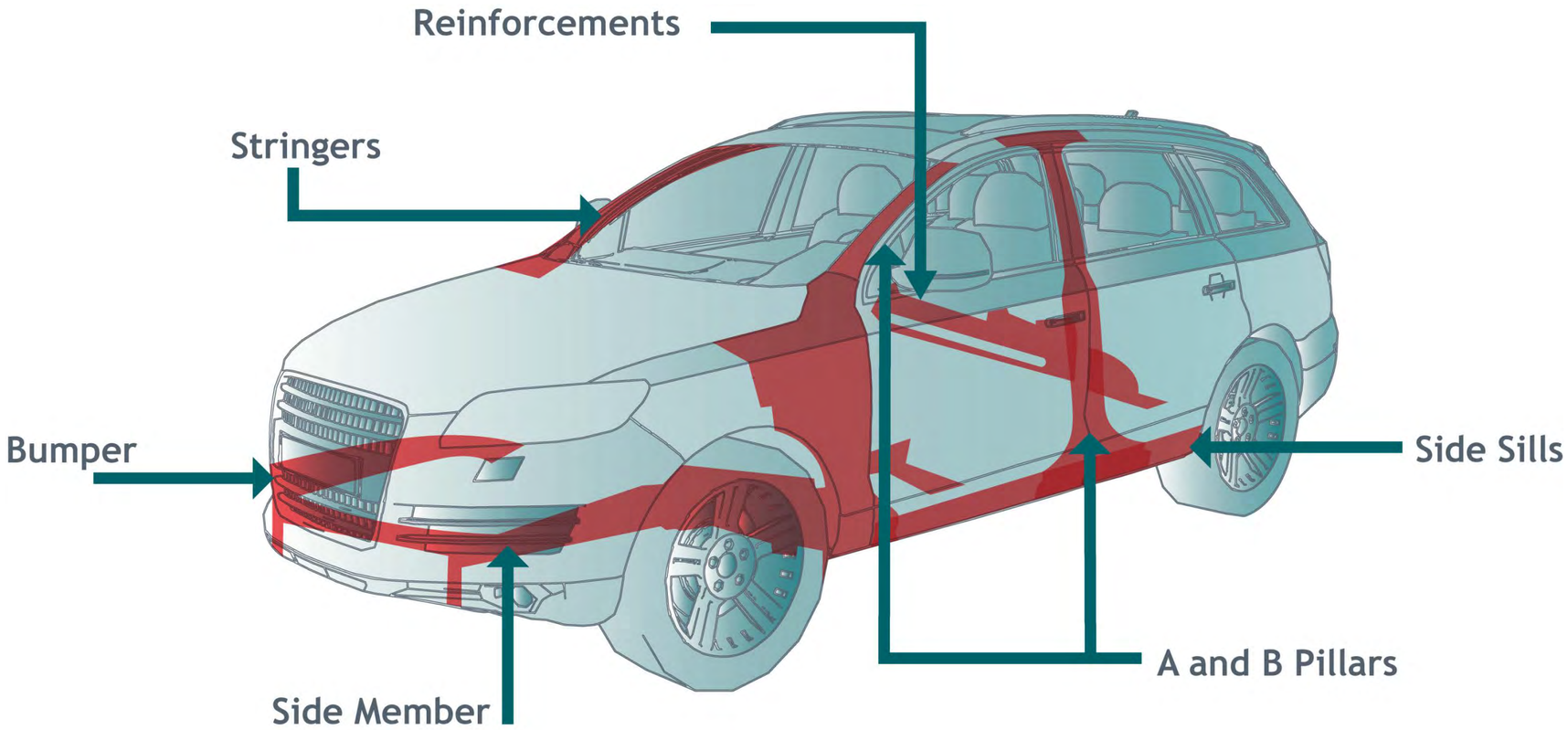
Benefits of Dual Phase Steels

- Combination of strength and ductility creates a number of potential benefits
  - Lightweighting
  - Energy (crash) absorption
  - Increased production efficiency (cold workability)
- Simpler processing and low level of alloying compared to CP, TRIP of TWIP steels

Greater elongation at higher strength

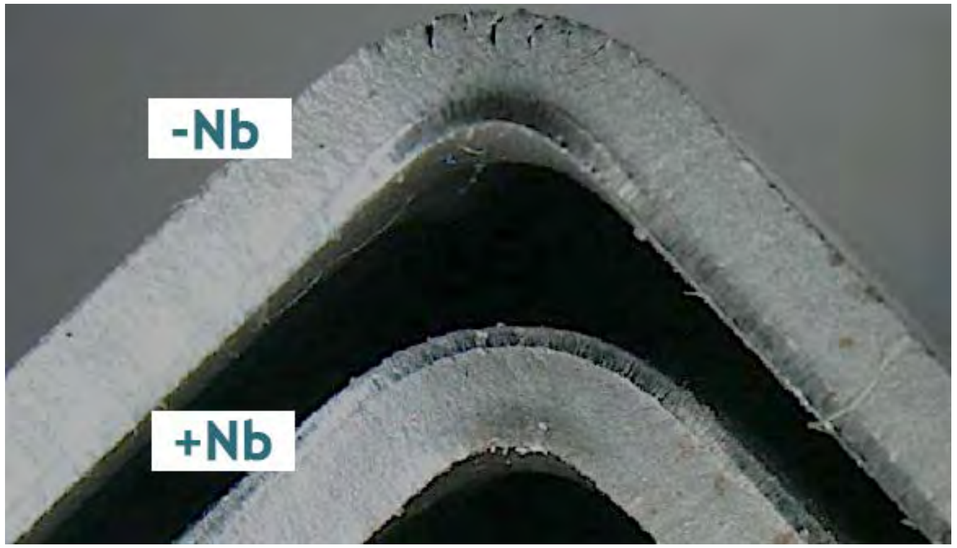


Applications



Challenges of Dual Phase Steels

- Dual Phase steels designed to produce press stamped parts with complex shapes
- However, in practice encountered problems during forming which caused parts to fail
  - Non-uniform shaping which caused cracking
  - Localised stretching issues causing parts to fail
- Niobium micro-alloying developed to solve these problems by improving local formability

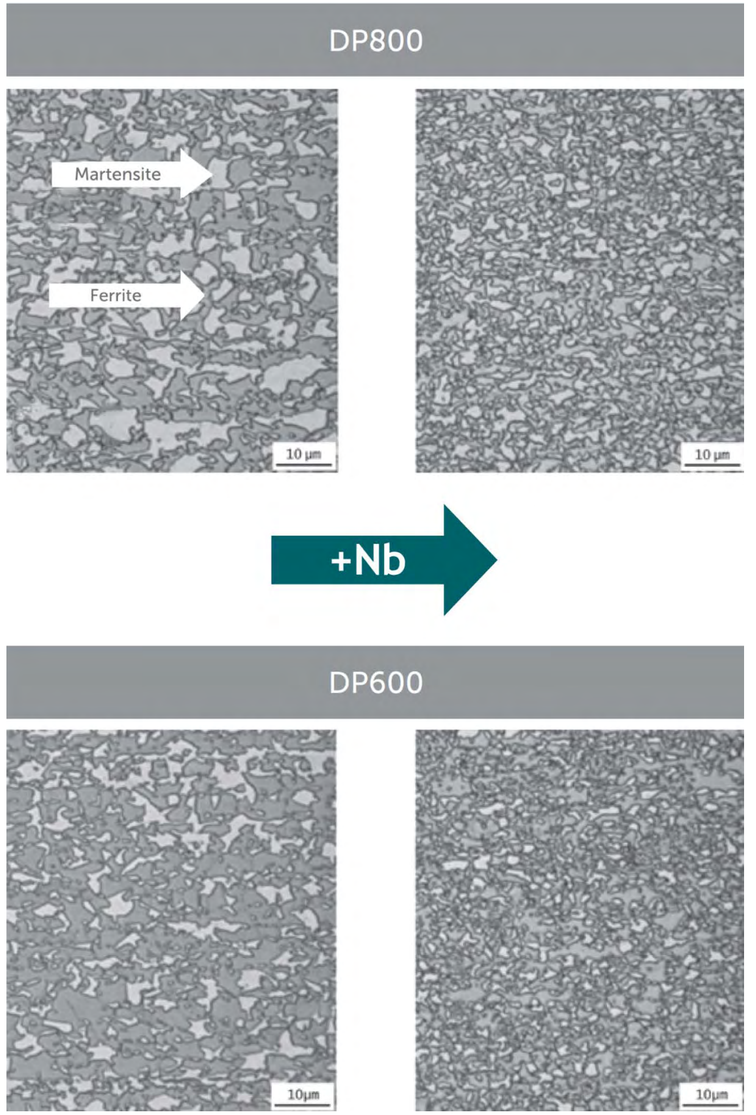


Source: H. Mohrbacher. Intl. Symp. on New Developments in Advanced High-Strength Sheet Steels, AIST, 2013, p. 319-329

The Niobium Solution

Niobium grain refinement addresses the problems of Dual Phase steels

- Results in significantly improved formability
  - Bendability
  - Hole-expansion ratio
- Can also improve
  - Strength
  - Weldability
  - Process robustness



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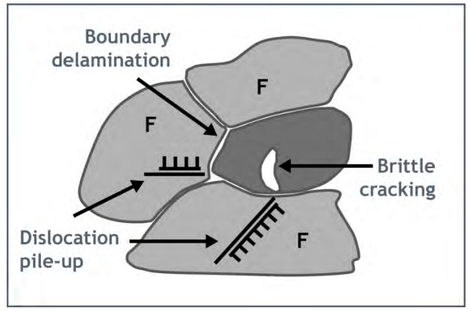
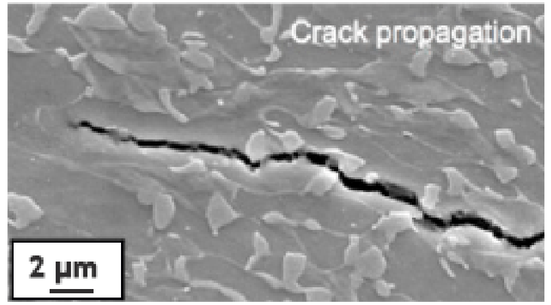
How Niobium Improves Formability

By refining the microstructure, Niobium:

- Prevents Martensite areas from becoming too large and brittle*
- Prevents crack propagation by refining martensite areas and stopping them from clustering
- Consequently Niobium Dual Phase steels
  - Are easier to bend
  - Can be stretched further (elongation)
  - Are easier to work when cold (n-value)





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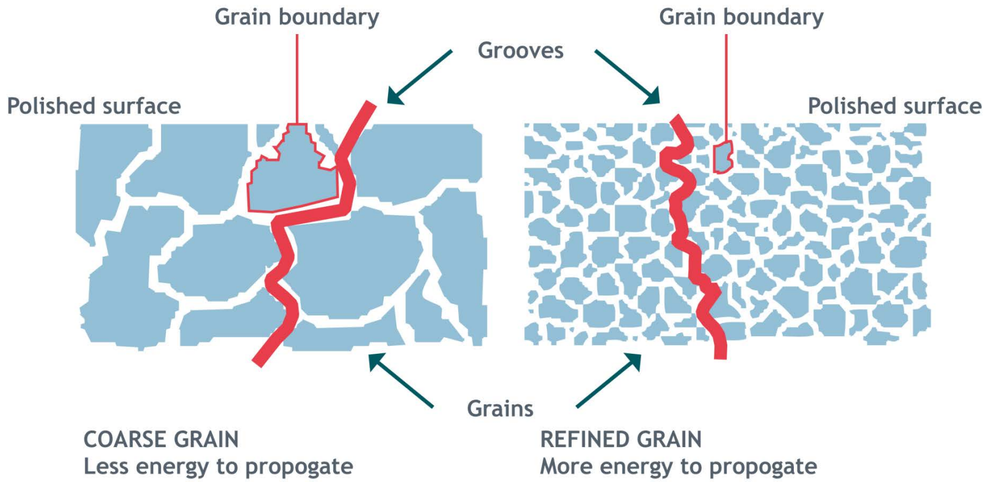


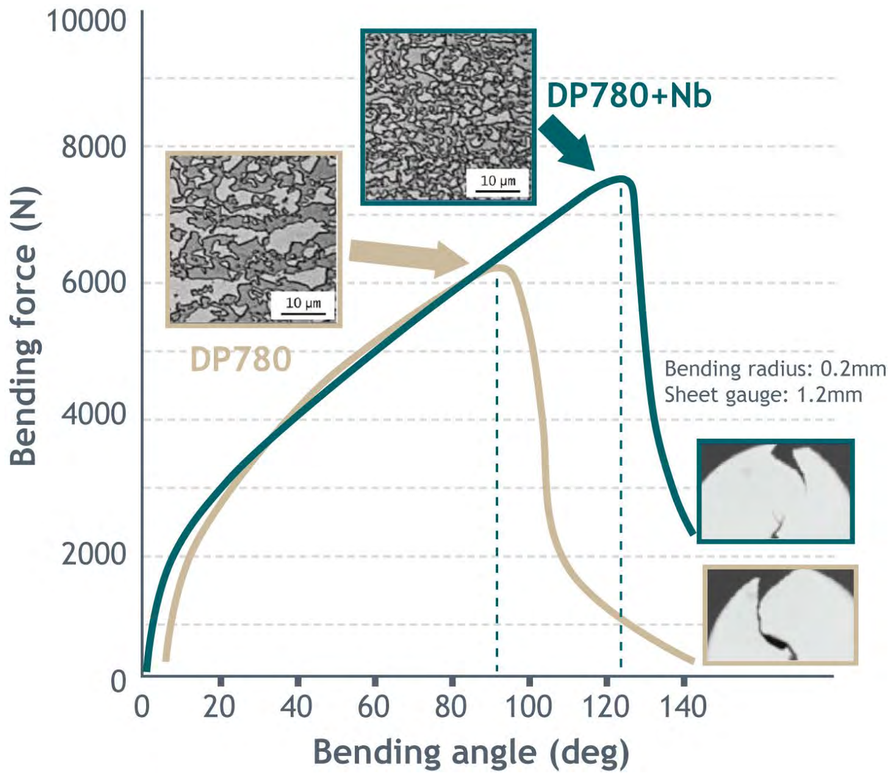
Source: CBMM

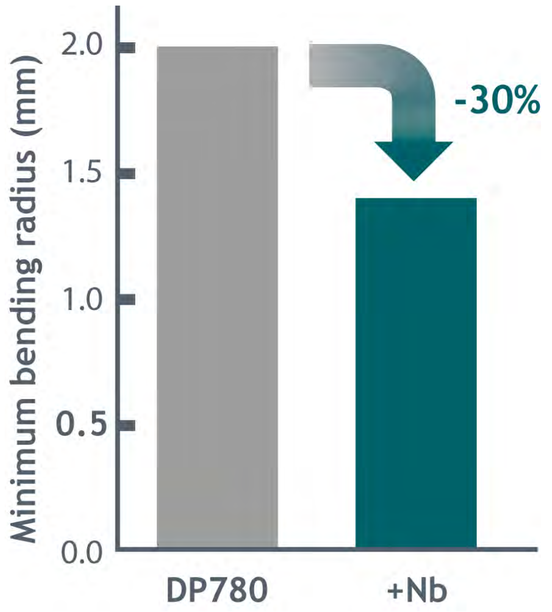
* Also partly avoiding martensite transforming into bainite

Significant Increase in Formability – Bending Angle

Microalloying of Niobium at 0.01/0.03% with standard Dual Phase steels significantly improves formability

- Increases angle material can be bent before it fails reducing cracking from 90° to 120°
- Reduces the minimum bending radius enabling design optimisation

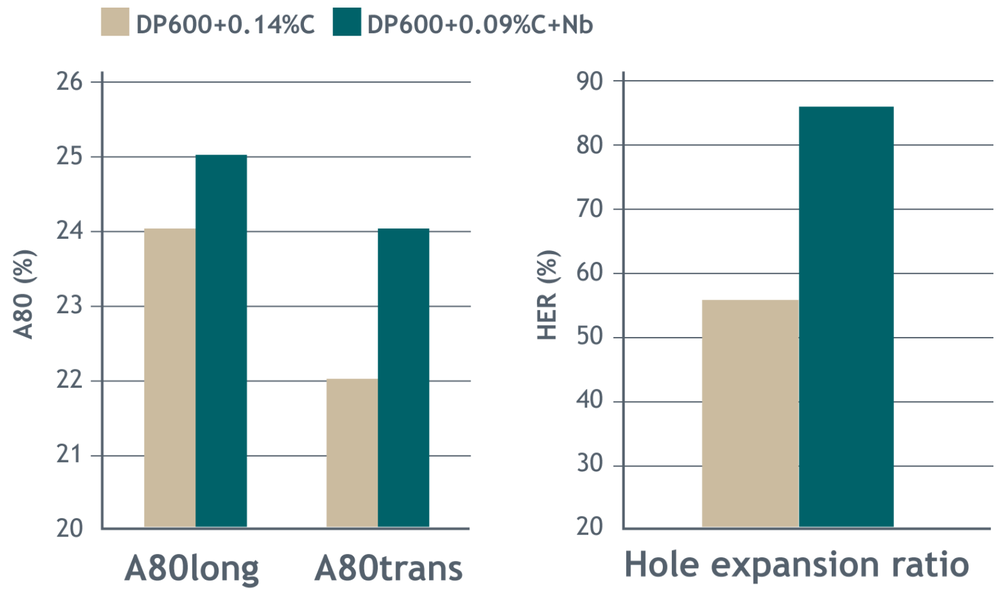




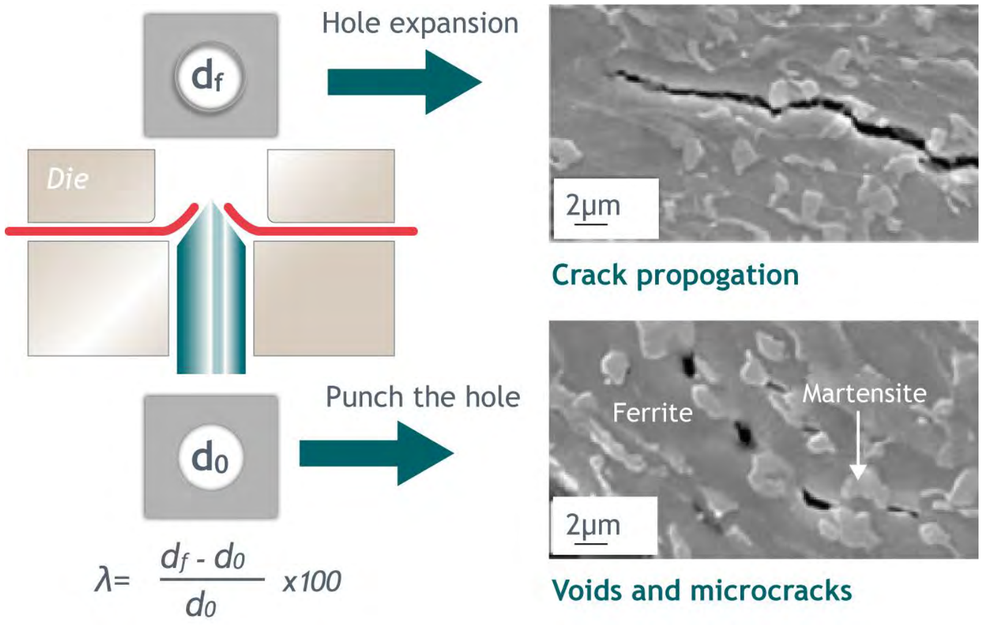
Source: H. Mohrbacher. Intl. Symp. on New Developments in Advanced High-Strength Sheet Steels, AIST, 2013, p. 319-329

Significant Increase in Formability – Hole Expansion

- By refining martensite areas Niobium improves hole expansion



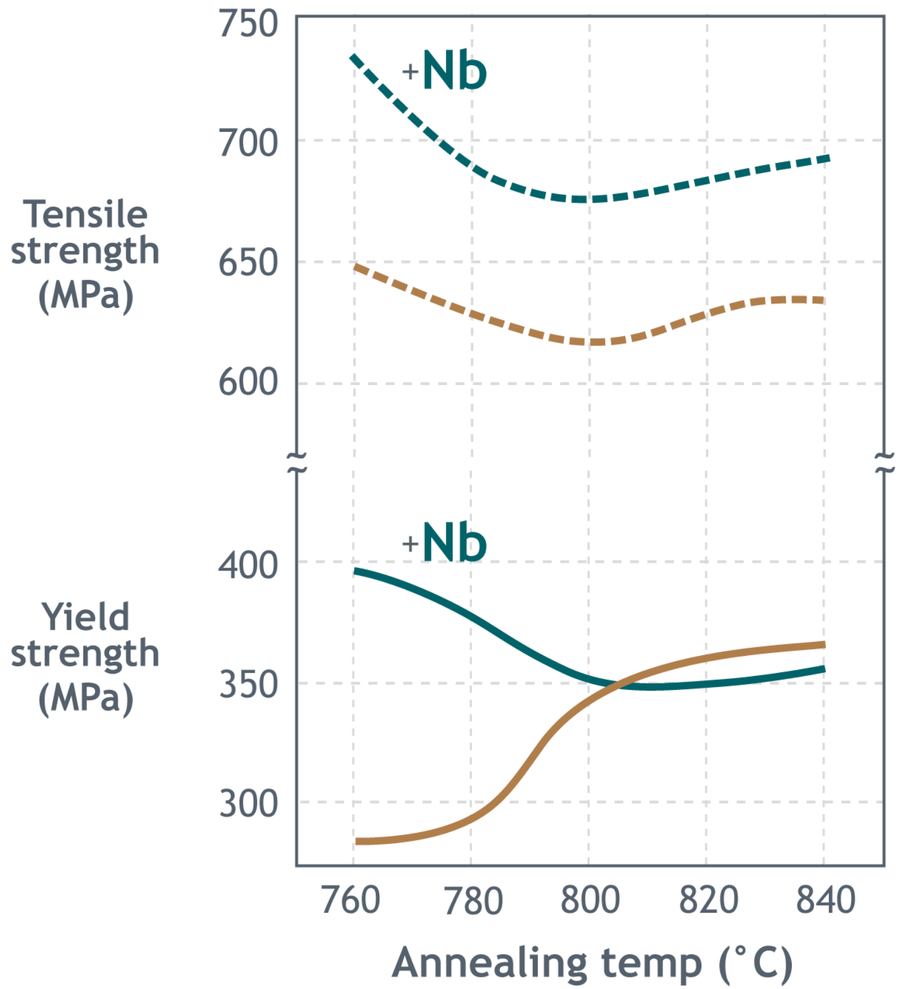
Source: Improvement of hole expansion ratio of low carbon DP600+Nb in comparison with conventional DP600+0.14%C



Source: J. Bian. Niobium microalloying in the automotive steels for light-weighting. South East Asia Iron and Steel Institute 2014

Additional Benefits

- **Strength:** Niobium grain refinement increases the tensile strength of steel
- **Elongation:** In addition to Niobium's grain refinement effect, increased tensile strength reduces need for martensite
- **Welding:** Carbon is major cause of welding problems and can be quite high in DP steels (up to 0.2%)
  Niobium grain refinement reduces welding embrittlement issues brought by higher carbon



Source: H. Mohrbacher. Intl. Symp. on New Developments in Advanced High-Strength Sheet Steels, AIST, 2013, p. 319-329

Niobium advantage

- Niobium usage creates a more **formable** Dual Phase steel, which is
  - Easy to bend, stamp and punch
  - Easy for existing production facilities to use
  - Simpler to process and with lower levels of alloying compared to CP, TRIP or TWIP steels
- Enables
  - Optimised parts
  - Production efficiencies
  - Reduced defects and increased production reliability
  - Improved crash performance