Quenching and Partitioning Process Development to Replace Hot Stamping of High Strength Automotive Steel

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Colorado School of Mines, Los Alamos National Laboratory, AK Steel, General Motors, Nucor Steel, US Steel and Toyota

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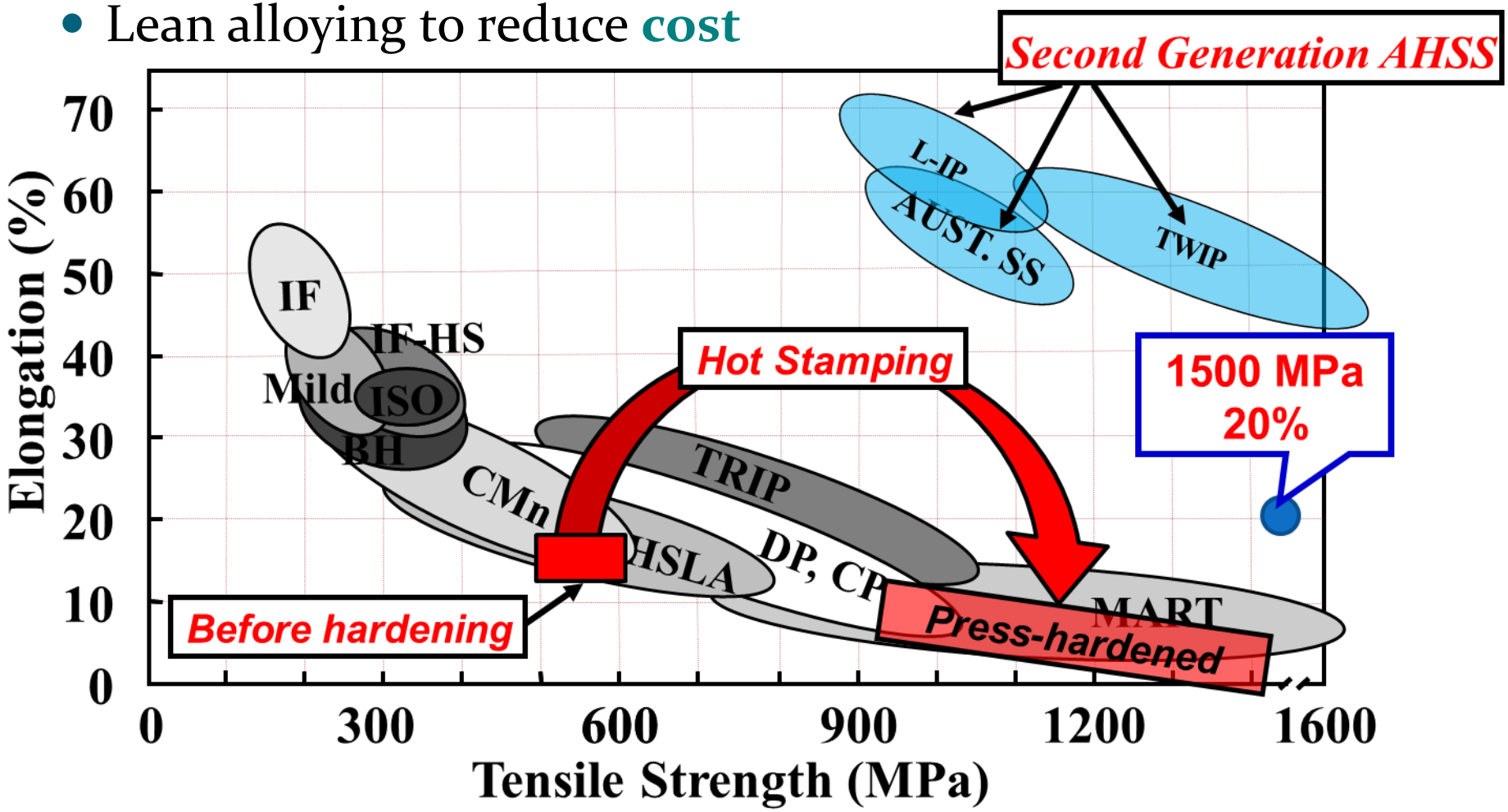
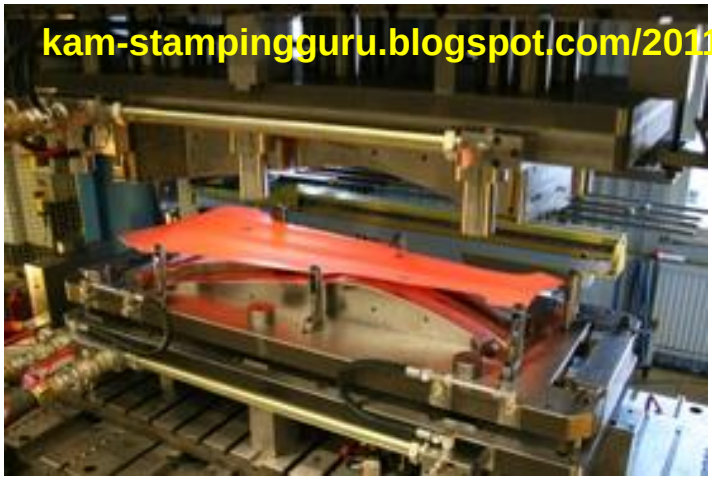
Project Objective

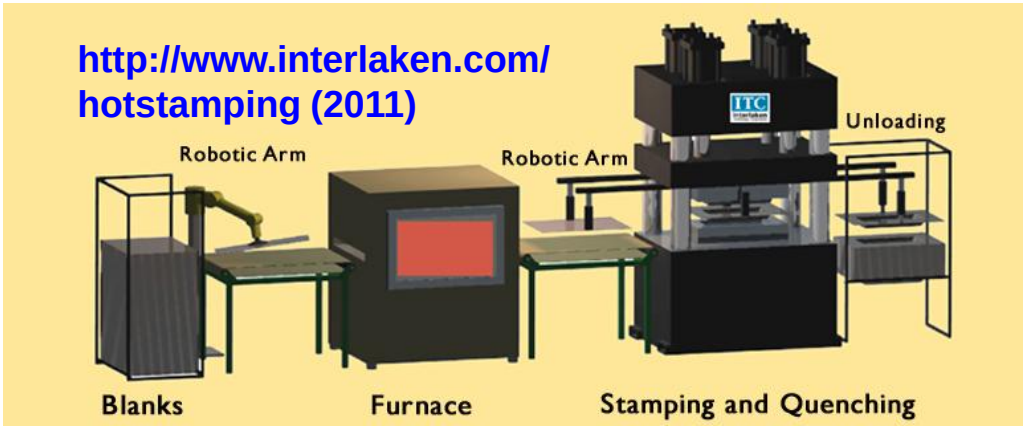
- Develop **high strength** sheet steels for the automotive industry that can be **formed** at room temperature
- Lean alloying to reduce **cost**



Technical Approach

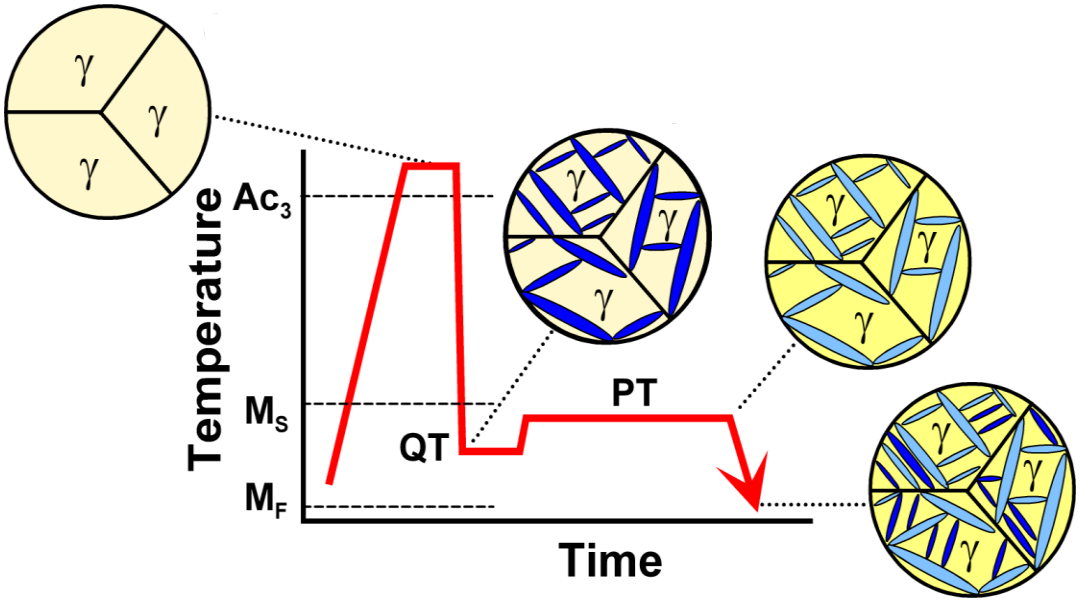
- Practice today: Hot Stamping Process
- Reheating to > 900 °C and forming, quenching in die
- Energy consumption associated with reheating
- Slow production speeds due to in die quenching step
- Microstructural change during quenching yields high strength (e.g. 1500 MPa)





Technical Approach

- Quenching and Partitioning process to produce martensite/austenite microstructures with high strength and good ductility to allow room temperature forming operations using lean alloy compositions



- Alloying, processing, microstructural evolution and mechanical properties inter-relationships are being studied.

Transition and Deployment

- Project serves needs of the **automotive industry** and can reduce manufacturing cost and contribute to reducing vehicle weight and increasing fuel efficiency.
- High strength cold formable steels to be processed on existing stamping lines.
- **Steel industry** faces competition from lightweight materials. High strength steels enable application of thinner sections and thereby weight savings.
- Quenching and Partitioning requires flexible continuous annealing with controlled cooling and reheating capabilities in the steel mill.

Transition and Deployment

Example investment towards production of advanced high strength sheet steels:

PROTEC Leipsic, OH
joint venture US steel & Kobe steel of Japan
continuous annealing line

$400 million investment

commissioned May 2013

www.proteccoating.com

Measure of Success

- Ultimate goal to reduce or eliminate the need for hot stamping by development of cold formable high strength steels
- Project target: tensile strength > **1200 MPa** and

  total elongation > **15 pct**
- Projected energy savings: up to 28.8 trillion Btu and 1.5 million tons of CO_2
- Energy savings result in $928 million manufacturing cost savings

Project Management & Budget

- Project duration: 3 years and 3 months, 07/'13 => 06/'16
- Tasks:

  BP1: Alloy Design and Test Matrix Development (completed)

  Laboratory Material Production (completed)

  BP2: Tensile Properties Assessment (30 pct)

  Initial Microstructural Characterization (30 pct)

  Property/Microstructure Analysis (25 pct)

  BP3: Local Formability Study (0 pct)

  Detailed Microstructural Characterization (30 pct)

Total Project Budget	
DOE Investment	$1,167,878
Cost Share	$469,800
Project Total	$1,637,678

Results and Accomplishments

- 12 alloys were designed and laboratory processed as cold rolled sheets (milestone 1 and 3)
- Tensile properties assessed in three alloys (milestone 6)
- Targeted 1200 MPa ultimate tensile strength and 15 pct total elongation exceeded in two alloys
- Austenite fractions up to 25 vol pct obtained (milest. 9)

- Future work:
  - Assess remaining alloys
  - Microstructural characterization
  - Local formability