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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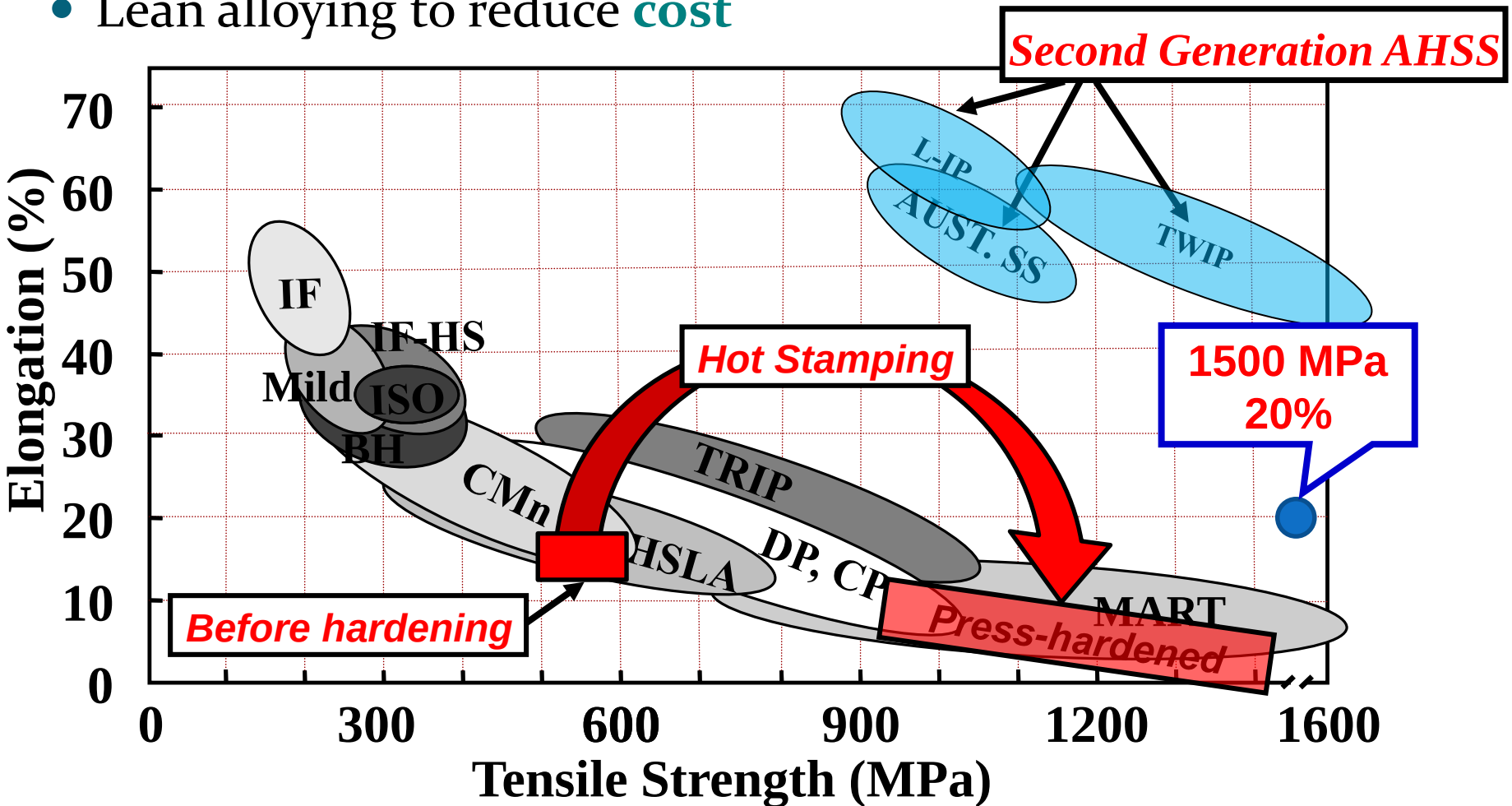
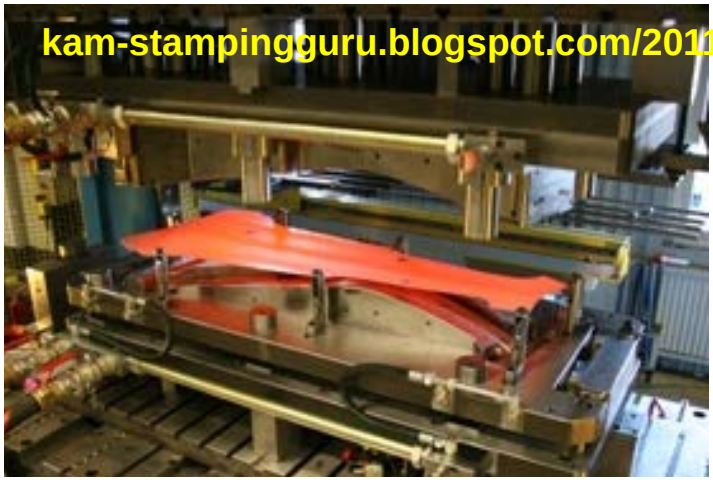
Project Objective

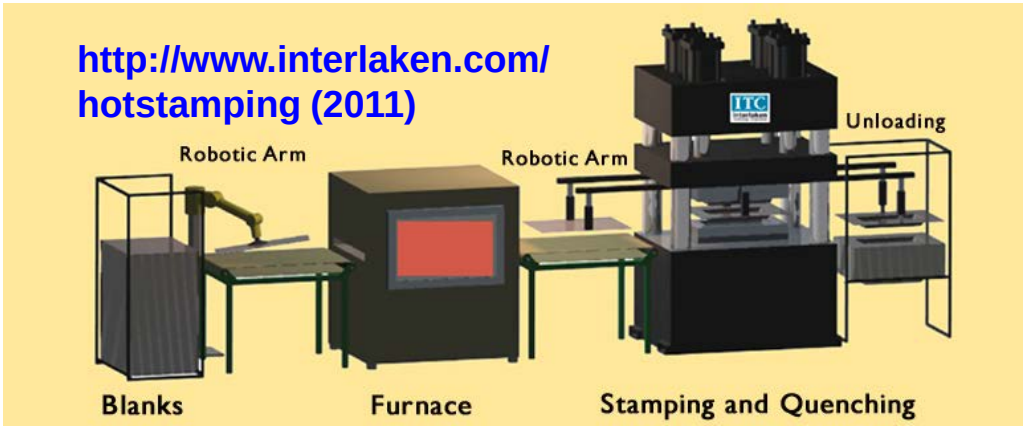
- Develop **advanced high strength sheet steels** (AHSS) for the automotive industry that can be **formed** at room temperature
- Lean alloying to reduce **cost**



Technical Approach

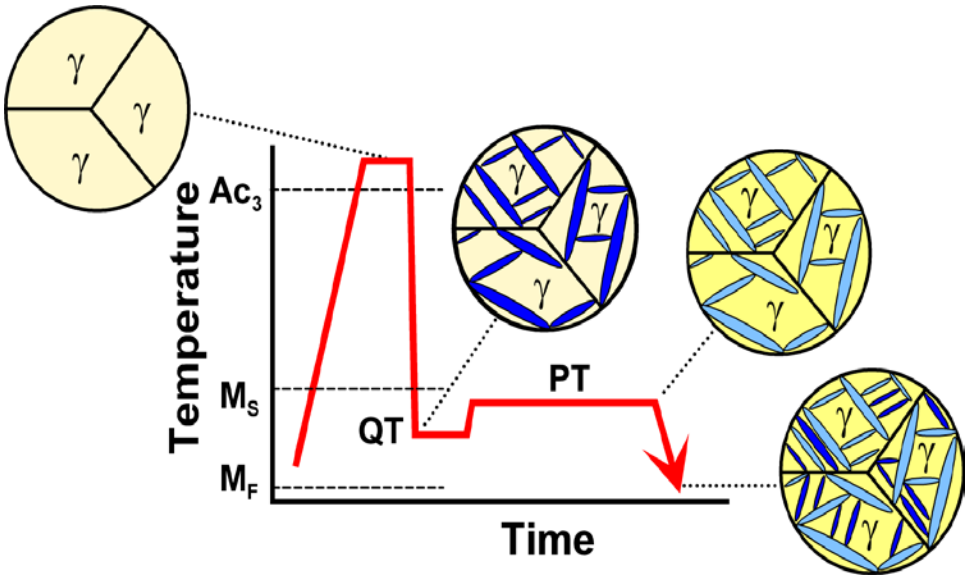
- Practice today: Hot Stamping Process
- Reheating to > 900 °C and forming, quenching in die
- Energy consumption associated with reheating
- Slow production speeds due to in die quenching step
- Microstructural change during quenching yields high strength (e.g., 1500 MPa)





Technical Approach

- Develop high strength materials **with good formability at room temperature** by innovative heat treating in continuous processing/annealing lines.
- **Quenching and Partitioning** heat treating process to produce martensite/austenite microstructures 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

- AK Steel Dearborn Works

Dearborn, MI

modification of current
hot dip galvanizing line
to produce next generation
AHSS

$29 million investment
completion Fall of 2016
www.aksteel.com
June 01, 2015 press release

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 => 09/'16
- Tasks:

BP1: Alloy Design and Test Matrix Development (completed)

Laboratory Material Production (completed)

BP2: Tensile Properties Assessment (completed)

Initial Microstructural Characterization (completed)

Property/Microstructure Analysis (completed)

BP3: Local Formability Study (40 pct)

Detailed Microstructural Characterization (completed)

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, 3)
- Tensile properties assessment (milestone 2, 6 => 8)
- Targeted 1200 MPa ultimate tensile strength and 15 pct total elongation exceeded in four alloys
- Austenite fractions assessment (milest. 9=>12)

up to 25 vol pct obtained

- Detailed microstructural

characterization (milestone 4)

- Future work:

Local formability study