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, Severstal and Toyota

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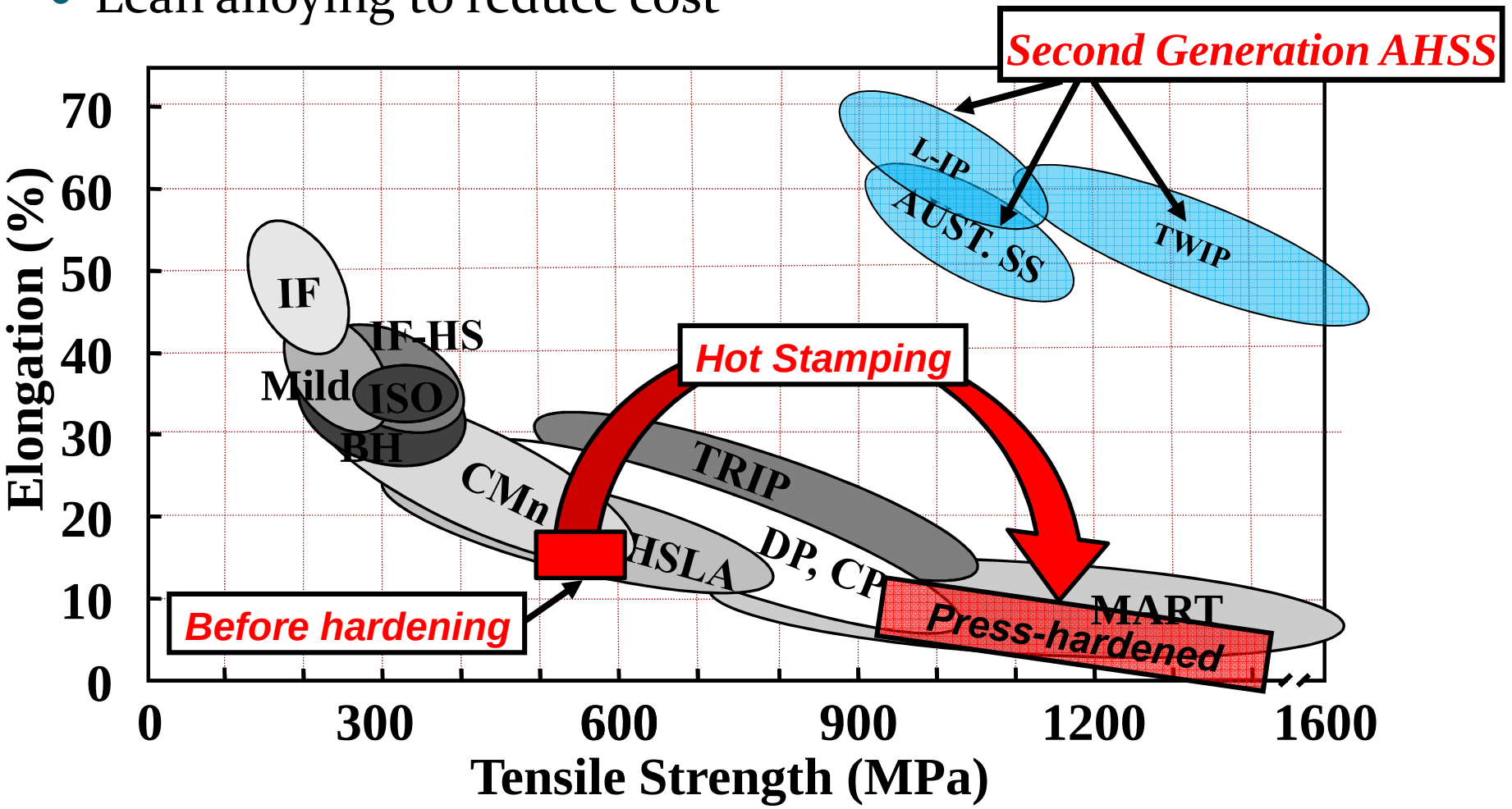
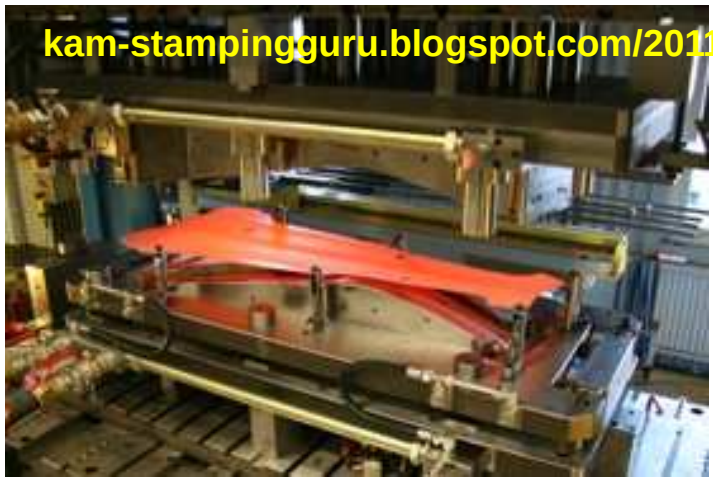
Develop High Strength Formable Steels

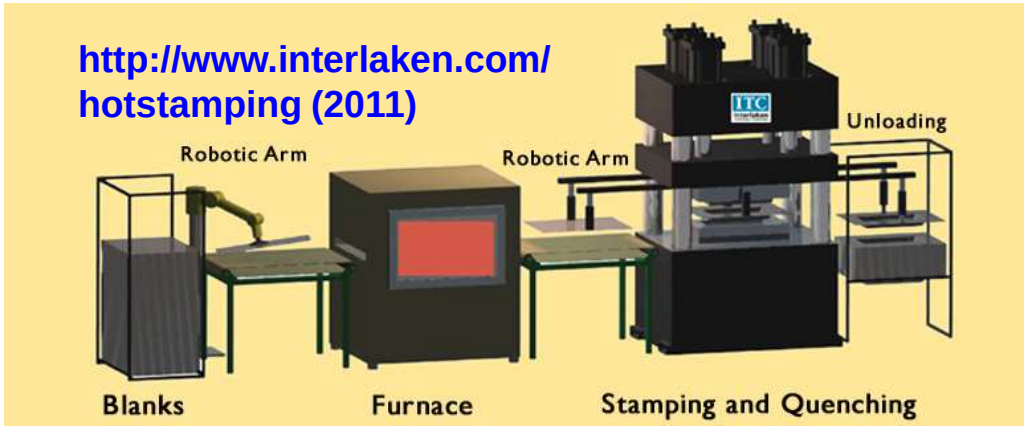
- Develop High Strength Sheet Steels for the automotive industry exhibiting good tensile ductility and formability
- Lean alloying to reduce cost



Technical Approach

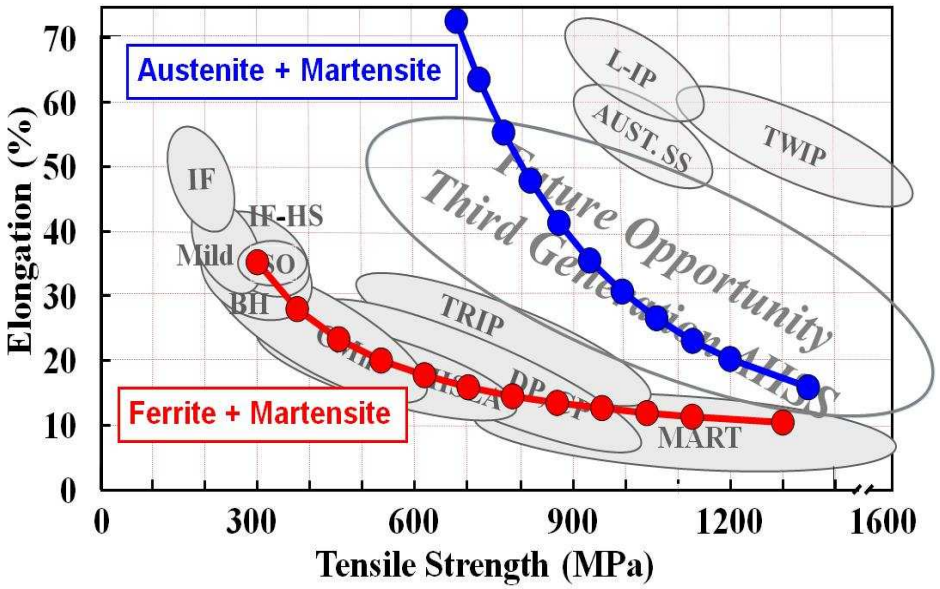
- Practice today: Hot Stamping Process
- Reheating to > 900 °C and forming, quenching in die
- Energy consumption associated with reheating
- Slow production speeds due to in die quenching step
- Microstructural change during quenching yields high strength (e.g. 1500 MPa)

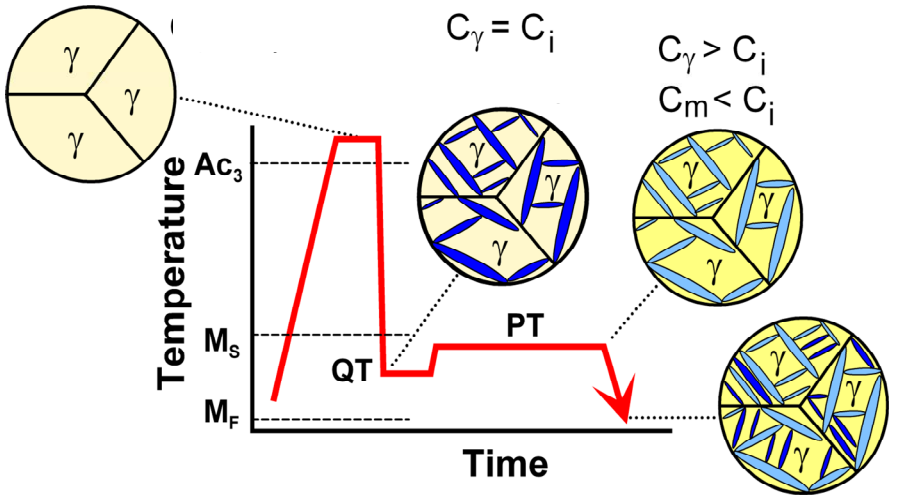




Technical Approach

- 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

- Examples of recent investments 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

Severstal Dearborn, MI
$740−million modernization program
“Dearborn – Reborn”
Pickle Line Tandem Cold Mill
Hot Dip Galvanizing Line
“continuous annealing line is being considered for 3rd gen AHSS for the future”
www.severstalna.com

Measure of Success

- Eliminating the need for hot stamping by development of cold formable Quenching and Partitioning 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

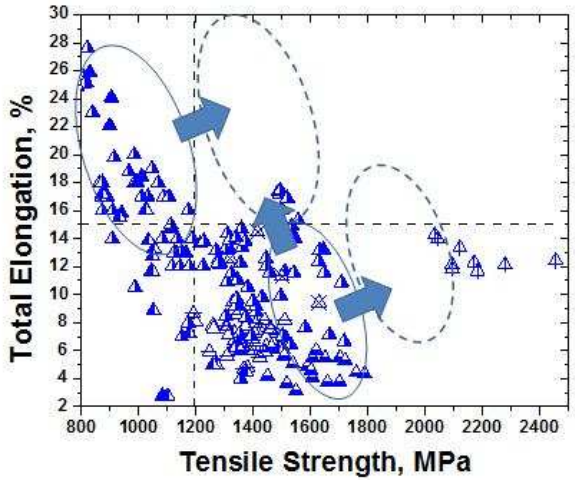
- Project duration: 3 years and 3 months, 07/'13 => 06/'16

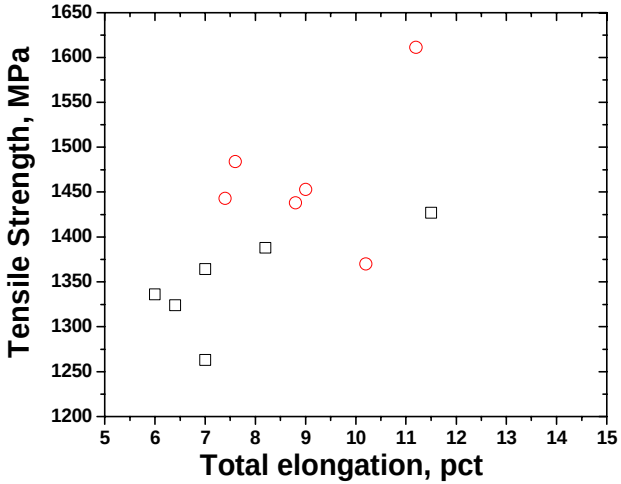
BUDGET PERIOD 1- MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Task 1: Alloy Design and Test Matrix Development																COMPLETE
Milestone 1: alloy design							x									COMPLETE
Milestone 3: heat treatment matrix definition											x					COMPLETE
Milestone 4: Restoration of Mössbauer spectrometer							x									COMPLETE
Milestone 5: Manufacture of die set for hole expansion testing												x				at 20 pct
Task 2: Laboratory Material Production																
Milestone 2: Lab Material Production													x			at 67 pct
Task 3: Tensile Properties Assessment																BP 2
Task 4: Initial Microstructural Characterization																BP 2
Task 5: Microstructure/Property Data analysis																BP 2
Task 6: Local Formability Study																BP 3
Task 7: Detailed Microstructural Characterization																BP 3
Task 8: Project Management and Reporting																All BP

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

Results and Accomplishments

- 12 alloys have been designed (milestone 1)
- Heat treating matrix defined (milestone 3)
- 8 alloys have been laboratory processed (task 2)
- Equipment refurbishment (milestone 4)
- Initial tensile properties have been generated for three alloys. Strength target obtained, ductility target not yet





- Future work: further assess alloys, microstructural characterization, local formability