# Considerations for Success: Forming Parts with 3rd Gen Steel

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GREAT DESIGNS IN STEEL™

# Outline

Introduction

What Makes 3rd Gen Steels Different

Material Card Should Reflect The Actual Material

Press Tonnage Predictability

Closing Remarks

# Engineering Quality Solutions


GDIS

## Engineering, consulting & training in sheet metal forming

Core competence:

***Product applications assistance to materials & manufacturing companies***

Focus – Hands-On: Materials selection/ optimization, tooling buyoff, field formability analyses, stamping failure troubleshooting, manufacturing process improvement, and cost savings / cost avoidance projects.

Focus – Education: Teaching the fundamentals and practical details of material properties, forming technologies, processes, and troubleshooting skills needed to reliably form high quality components

Market: Global, primarily North America, Europe, and Asia

# Billur Metal Form

Founded by Dr. Eren Billur in 2015. Located in Ankara and employs 3 engineers.

Consulting, engineering, training and simulation services around sheet metal forming processes and different sheet metal grades.

Core-competence: Hot stamping of steel and new generation AHSS.

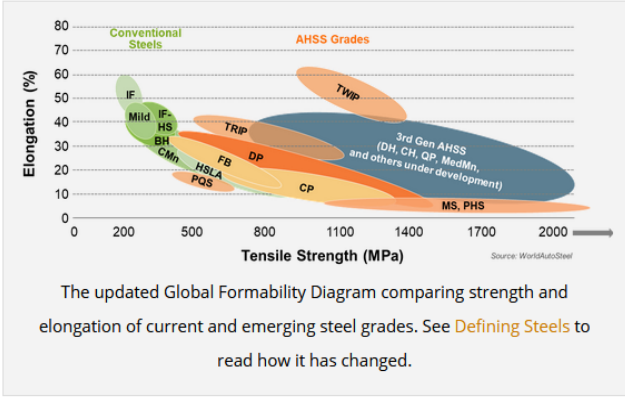
Customers from USA, Germany, Japan and China accounting over 60%.

«Cutting Edge» column in Metalforming Magazine since 2020

Contribution to worldautosteel's AHSS Guidelines.


MetalForming Magazine

**Welcome to the All New AHSS Application Guidelines!**




The updated Global Formability Diagram comparing strength and elongation of current and emerging steel grades. See Defining Steels to read how it has changed.

We are very excited to announce today the launch of a new version of the Advanced High-Strength Steels (AHSS) Application Guidelines, the leading source for technical best practices on AHSS metallurgy, forming and joining. The AHSS Application Guidelines Version 7.0 is now online at ahssinsights.org in this searchable database, allowing users to pinpoint information critical to successful use of these amazingly capable steels. WorldAutoSteel member companies make these Guidelines freely available for use to the world's automotive community.

Thanks are given to Eren Billur, Ph.D., Billur MetalForm, who contributed this article.

## Vision

Making lives better by being the best supplier we can be in the products we make and the services we provide.

## Mission

We make people's lives better by:

- Delivering outstanding quality products and services to our customers;
- Providing meaningful opportunity, job satisfaction, and job security for our people;
- Providing superior long-term investment returns to our stake holders; and,
- Being positive contributors to our communities.

19,000 Team Members

10 Countries

56 Locations

# OUR PRODUCTS AND CAPABILITIES

STEP ONE

### DESIGN AND DEVELOPMENT

- 3D Modeling: Extensive suite of CAD modeling software
- Finite Element Analysis: Static stress, modal, fatigue life prediction, dynamic performance, crash capabilities and multi-body dynamics
- Design for Manufacturing:
  - Forming: Stamping, hydro form simulation, nesting and tooling optimization
  - Assembly: Line simulation, joining and ergonomics
  - Coating: Optimization simulations
  - Shipping: Product density studies, packaging optimization, test simulations

STEP TWO

### PROTOTYPE AND TESTING

- Prototypes:
  - Fit and function prototypes
  - Production emulated soft tooled prototypes
  - Rapid prototyping
- Test Lab:
  - Real phase fatigue
  - Suspension module fatigue
  - Component fatigue
  - Road simulators
  - Stiffness analysis
  - Data acquisition
  - Material testing

STEP FOUR

### VALUE ENGINEERING

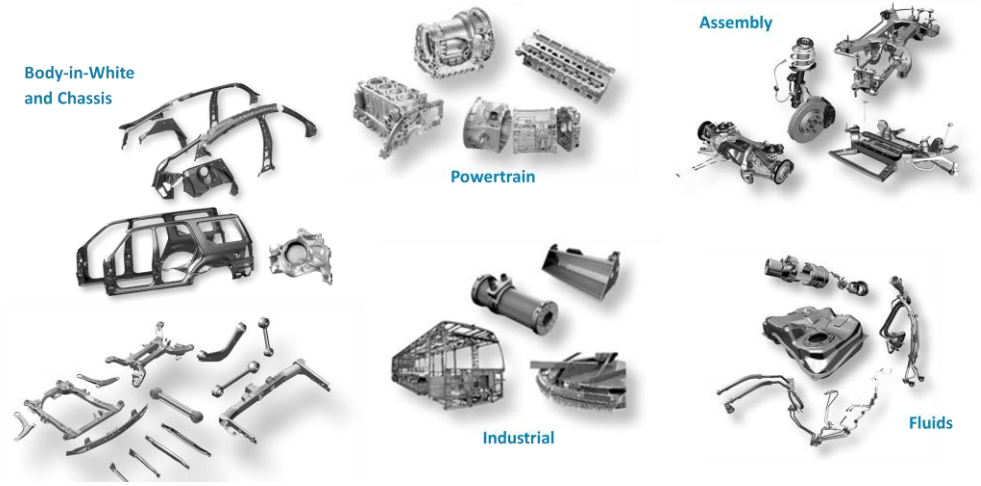
- Value Added – Value Engineering:
  - Product and process optimization
- Engineering change Management:
  - Complete product lifecycle management

STEP THREE

### PRODUCTION LAUNCH

- Martinrea Project Management System:
  - Production launch system shaped into six project phases and gate controls which include APQP, TS16949, SQAM and Martinrea and customer requirements
  - Phases: Planning, sourcing, execution, approval, ramp up, closure & reflection

# OUR PRODUCTS AND CAPABILITIES





*Leading Tier One automotive supplier in lightweight structures and propulsion systems*

# What Makes 3rd Gen Steels Different

Most steelmakers use similar strategies to produce mild steels: viewed as a commodity

Microstructure is typically 100% soft ferrite – *uniform hardness*

Wide window of allowable properties – or even no tensile requirements in some specifications

Most steelmakers use similar strategies to produce HSLA steels: might be viewed as a commodity

Microstructure is typically close to 100% fine grained, precipitate strengthened ferrite – *uniform hardness*

Restricted window of allowable properties; Limited number of alloying approaches to satisfy property windows

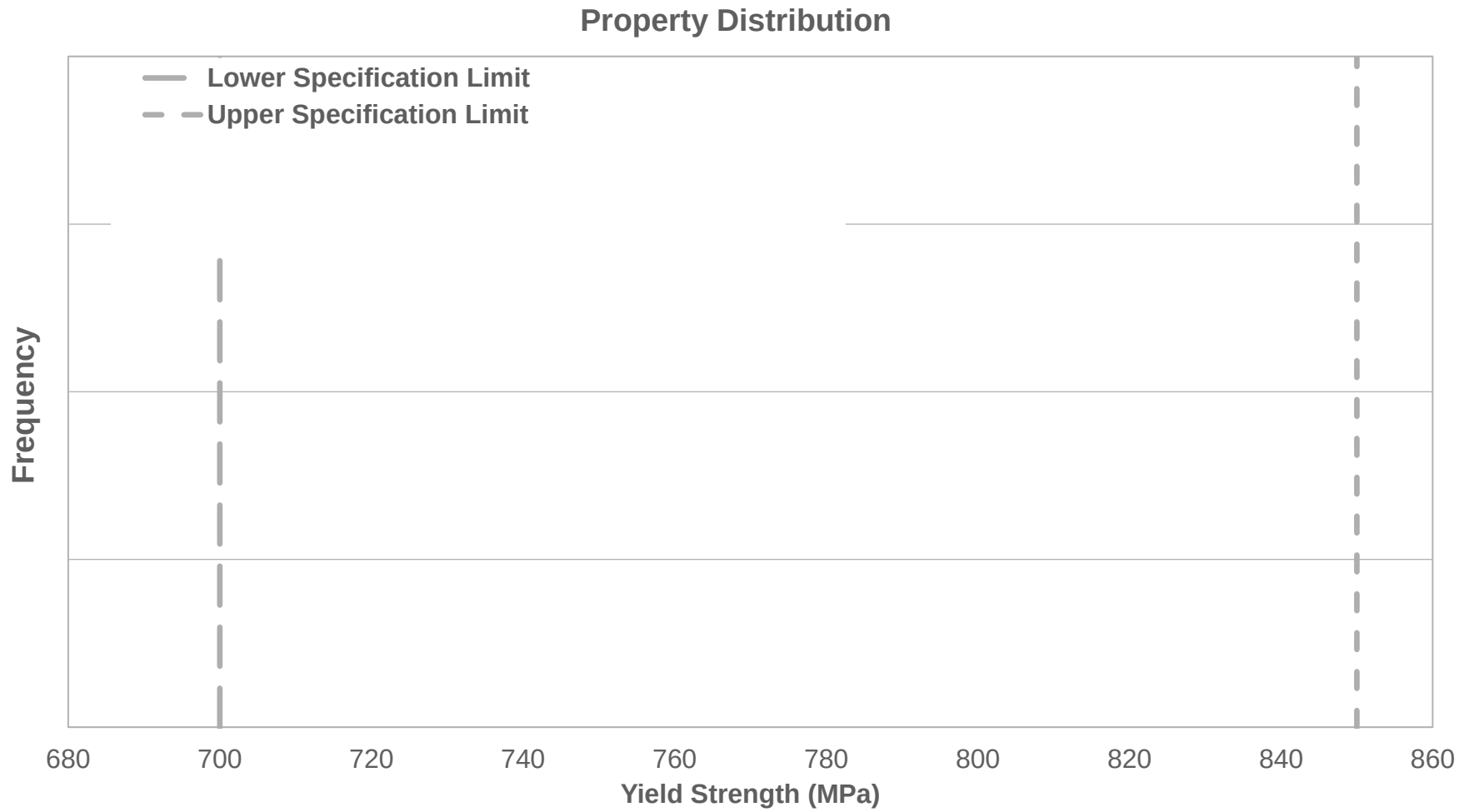
All steelmakers use different strategies to produce 3rd Gen steels: cannot be viewed as a commodity

Each family has different balance and distribution of ferrite, bainite, austenite, martensite – *non-uniform hardness*

Approach to producing specific phase type, balance, and distribution is constrained by physics and the specific recipe from each steel mill optimized for their available equipment and other internal constraints

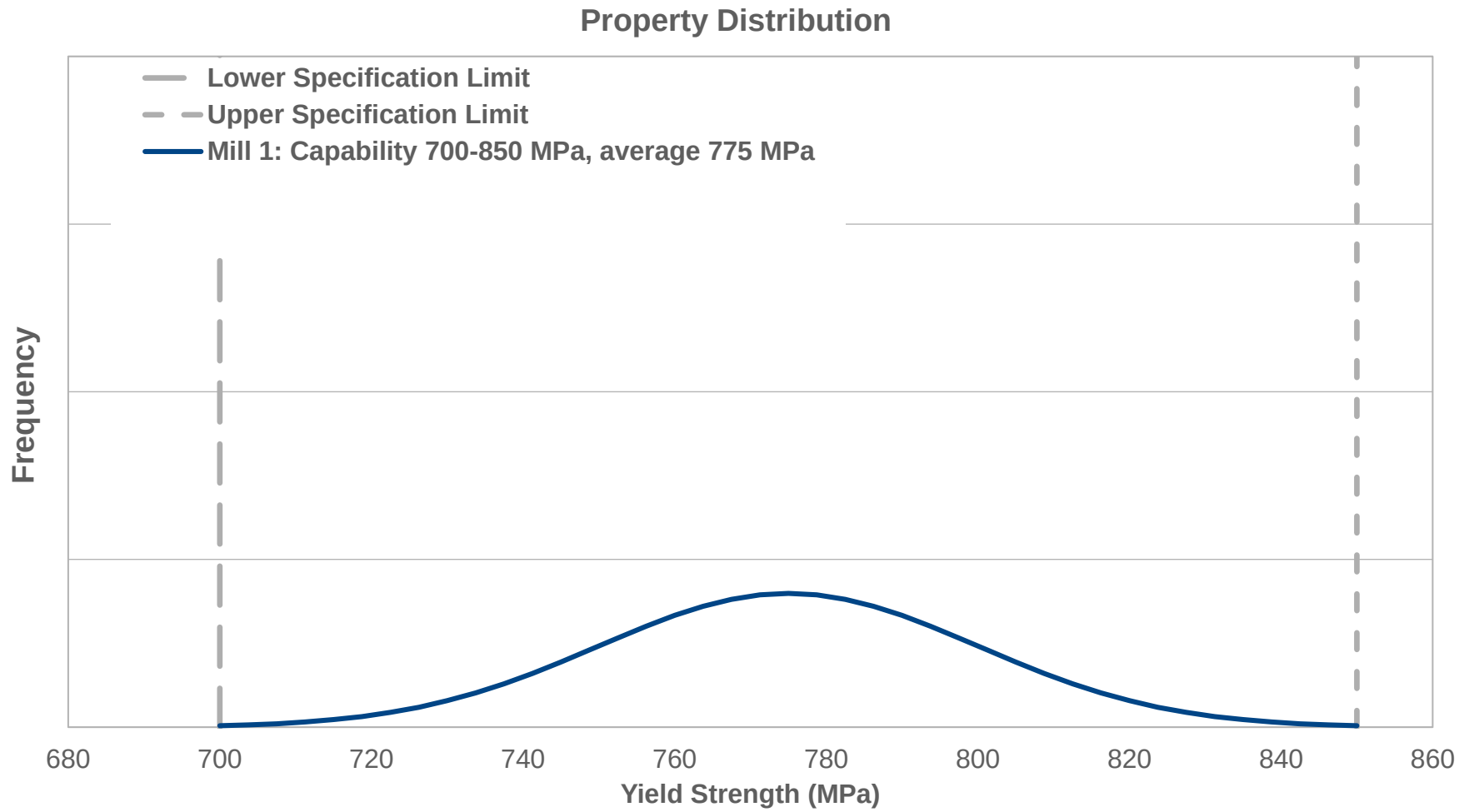
All approved mills meet the OEM window for chemistry and tensile requirements, but may occupy different portions since they get there in different ways

# As an example … CR-700Y980T-DH



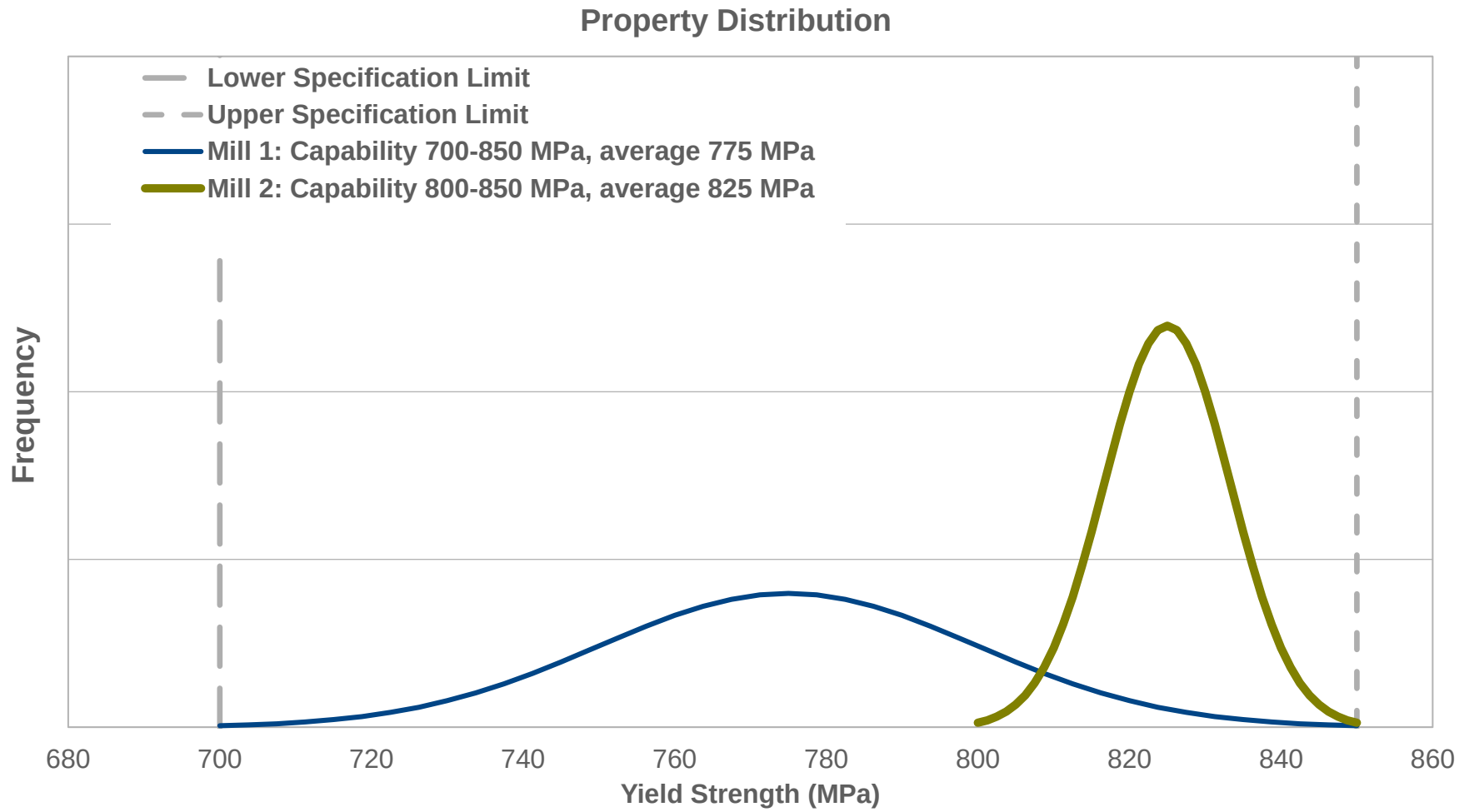

**Allowable yield strength: 700 MPa to 850 MPa**

# As an example … CR-700Y980T-DH



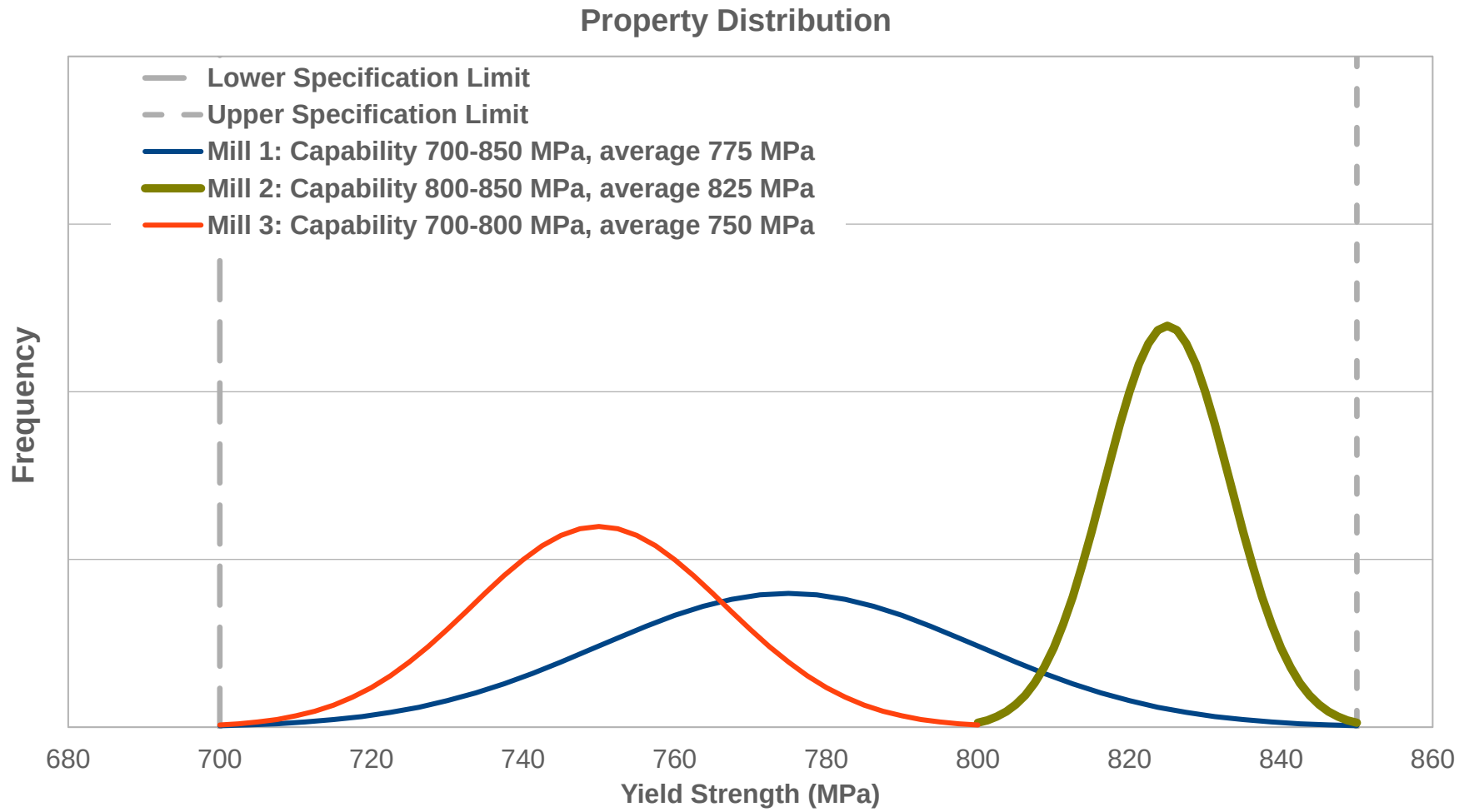

**One Qualified Mill: Production Capability = Entire Allowable Range**

# As an example … CR-700Y980T-DH




**Two Qualified Mills, But One Produces At The (likely) "Less Formable" End**

# As an example … CR-700Y980T-DH




**Three Qualified Mills: Stamping Plant Experience Will Differ Depending on Production Source**

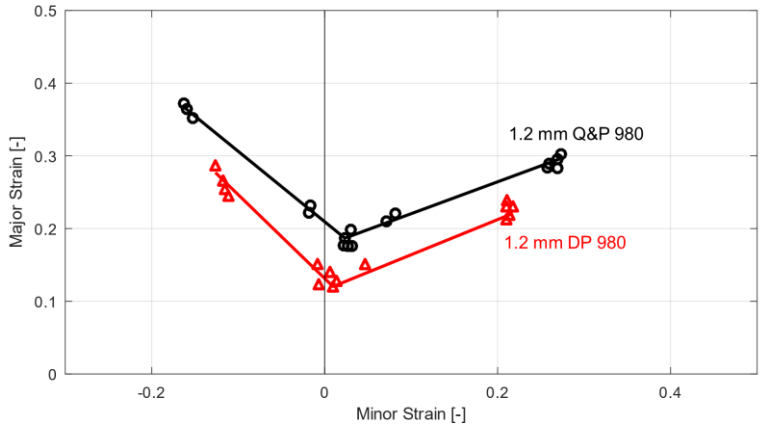
# Some Implications of Higher Strength

3rd Gen: high strength + high formability

Allows for transition from thicker, lower strength formable steels

**But now we have much higher strength steel!**

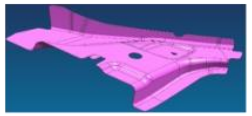
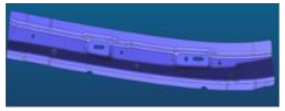
**Impact on flatness correction, blanking/punching/drawing loads, blanking/punching edge quality, etc.**




| Material | Thickness (mm) | Yield strength (MPa) | Tensile strength (MPa) | Total elongation (%) | Uniform elongation (%) | R-value (r0) | N-value |
|---|---|---|---|---|---|---|---|
| QP980 | 1.2 | 689 | 1054 | 23.41 | 17.26 | 0.758 | 0.179 |
| DP980 | 1.2 | 674 | 1005 | 16.66 | 8.58 | 0.752 | 0.102 |

X. Chen, C. Niu, C. Lian, and J Lin, "The Evaluation of Formability of the 3rd Generation Advanced High Strength Steels QP980 based on Digital Image Correlation Method," Procedia Engineering, Volume 207, 2017, Pages 556-561, doi.org/10.1016/j.proeng.2017.10.1020.

**590 → 980 is a 66% increase in strength!**

| Part | Material | Part model | Part prototype |
|---|---|---|---|
| Kick Down Lower | DP590 1.8→QP980 1.6 Weight saving:0.38kg |  |  |
| A Pillar Inner Lower | DP590 1.2→QP980 1.0 Weight saving:0.20kg |  |  |
| Hinge Pillar Inner | DP590 1.2→QP980 1.0 Weight saving:0.58kg |  |  |
| A Pillar Inner upper | DP590 1.2→QP980 1.0 Weight saving:0.30kg |  |  |

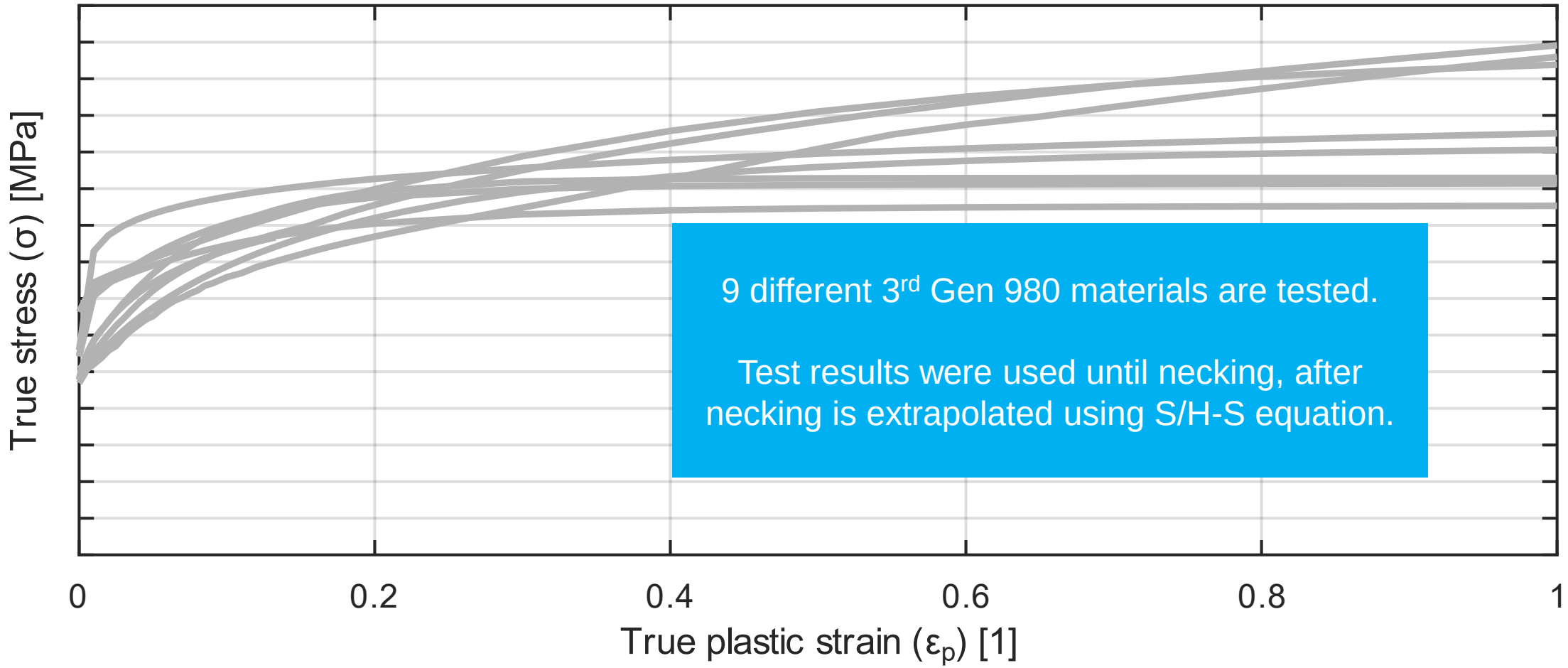
L. Wang, J. Bian, J. Wang, and Y. Ye, "Development and Application of New Generation AHSS Based on Q&P Process", Materials in Car Body Engineering 2019, Bad Nauheim, Germany.

# Simulation May Not Match Reality

| Factor | Shop Floor Reality | Simulation |
|---|---|---|
| **Sheet metal properties** | Complex | Simplified |
| **Uniformity of sheet metal properties** | Not constant through the coil; not constant coil-to-coil | Assumed constant through the coil and coil-to-coil |
| **Press speed** | Not constant | Assumed constant or neglected |
| **Friction** | Dependent on lube type, distribution, & quantity; roughness of sheet metal & tool; contact pressure; sliding velocity; local temp | Typically considered constant, although some programs offer tribology add-ons |
| **Temperature** | Increases due to heat generation | Typically considered constant |
| **Tool and Press Stiffness** | Elastic | Considered rigid |
| **Changes from pre-production sim to home line launch** | Tryout may change punch, die, blankholder, blank shape, and bead especially after using grinder | Simplified punch, die, binder, BHF, blank shape, and bead geometry, location & restraining forces. |

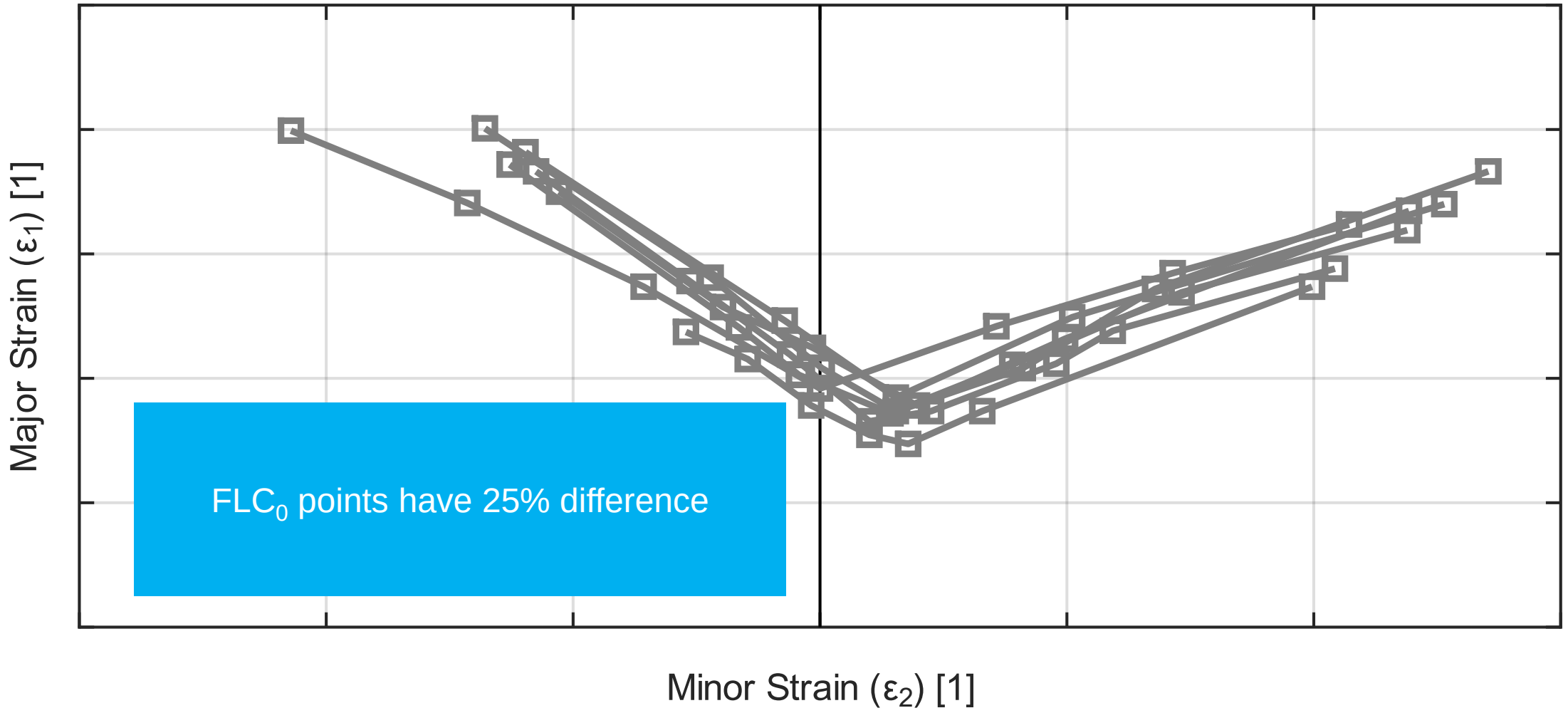
Based on K. Roll, “Simulation of Sheet Metal Forming – Necessary Developments in the Future”, 2008 German LS-DYNA Forum, DYNAmore GmbH.

# 3rd Gen 980 Hardening Curves




Y-axis information has been removed to preserve confidentiality.

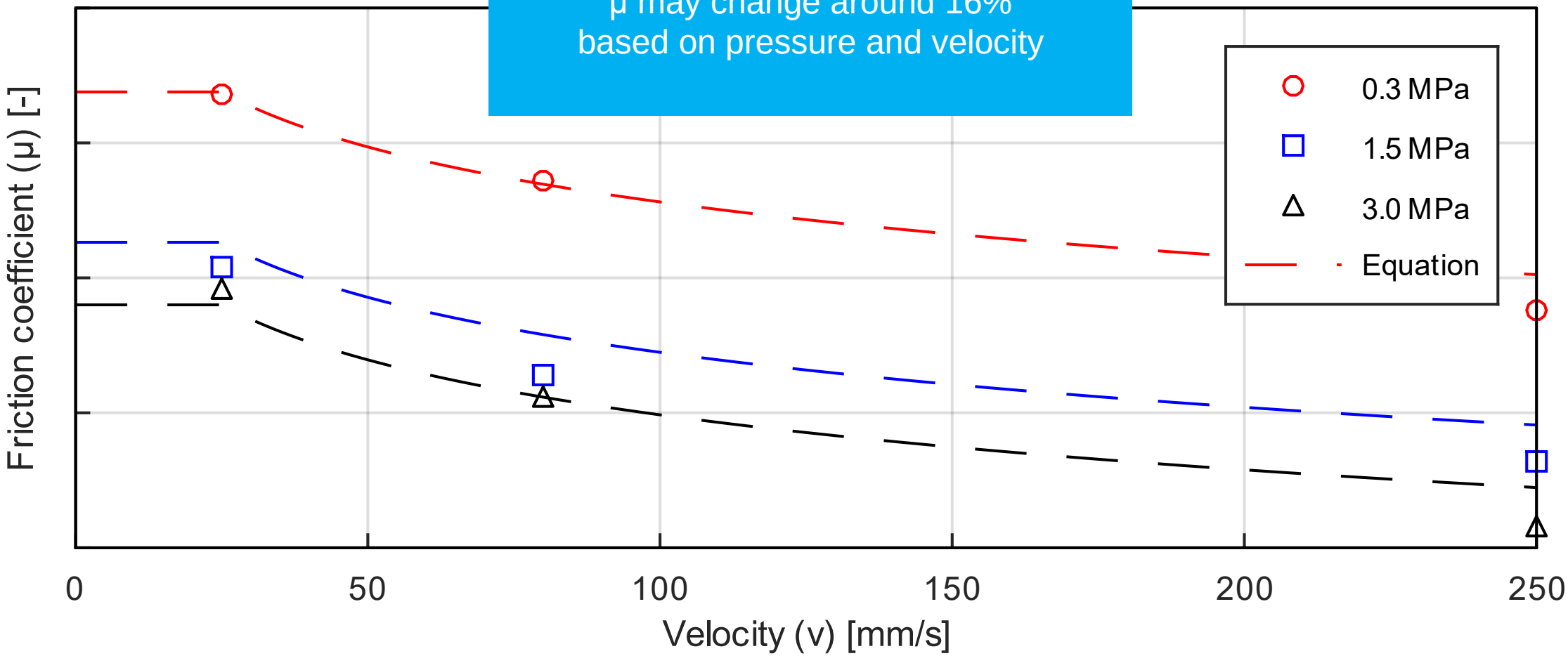
# 3rd Gen 980 Forming Limit Curves




X and Y-Axes information has been removed to preserve confidentiality.

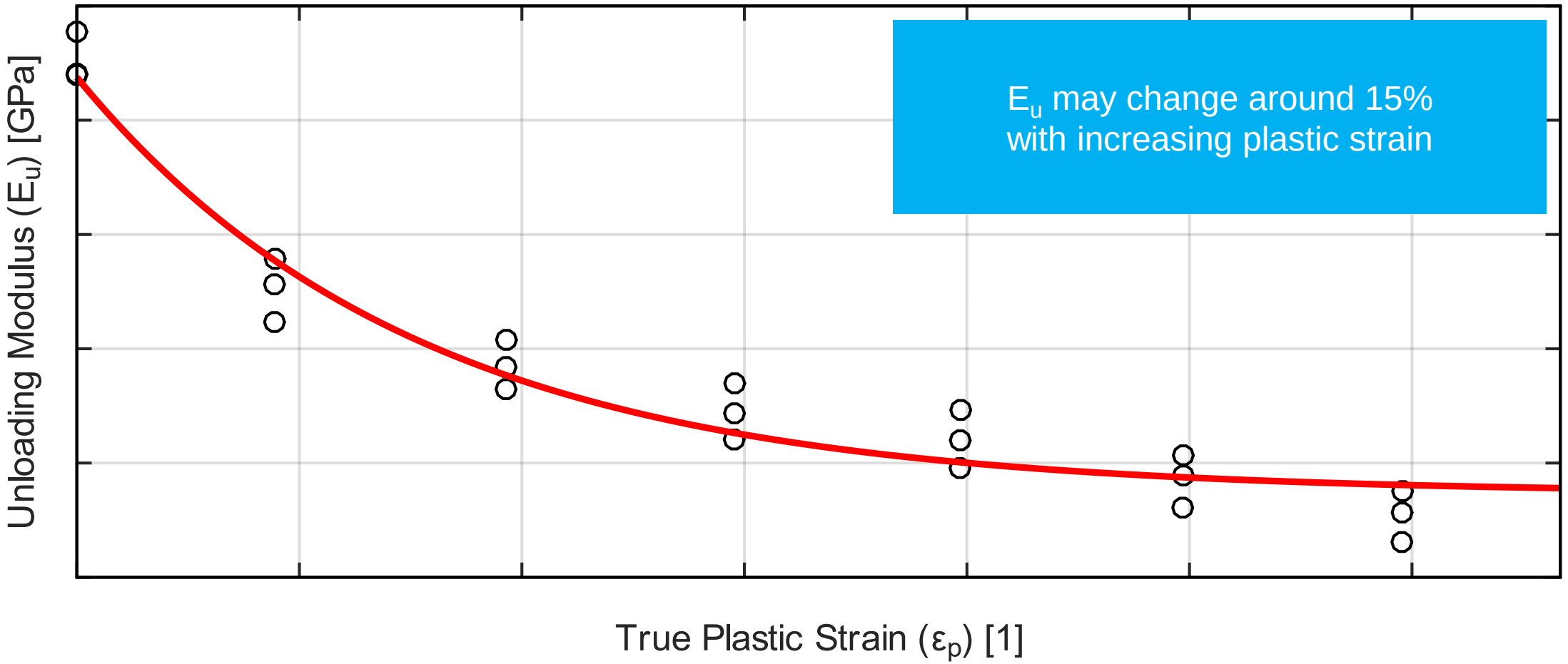
# 3rd Gen 980 Friction Model

μ may change around 16%
based on pressure and velocity



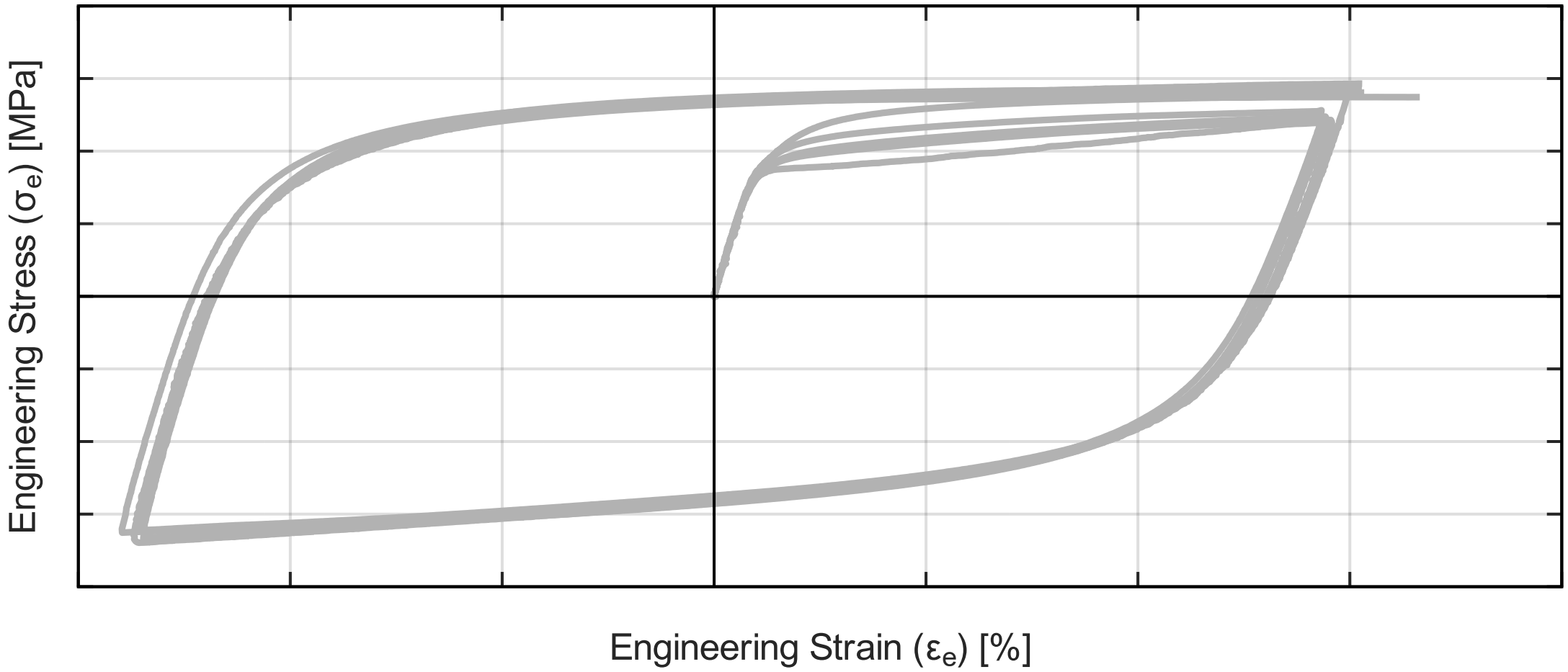

Y-axis information has been removed to preserve confidentiality.

# 3rd Gen 980 Unloading Modulus Variation




X and Y-Axes information has been removed to preserve confidentiality.

# 3rd Gen 980 Bauschinger Effect Variation

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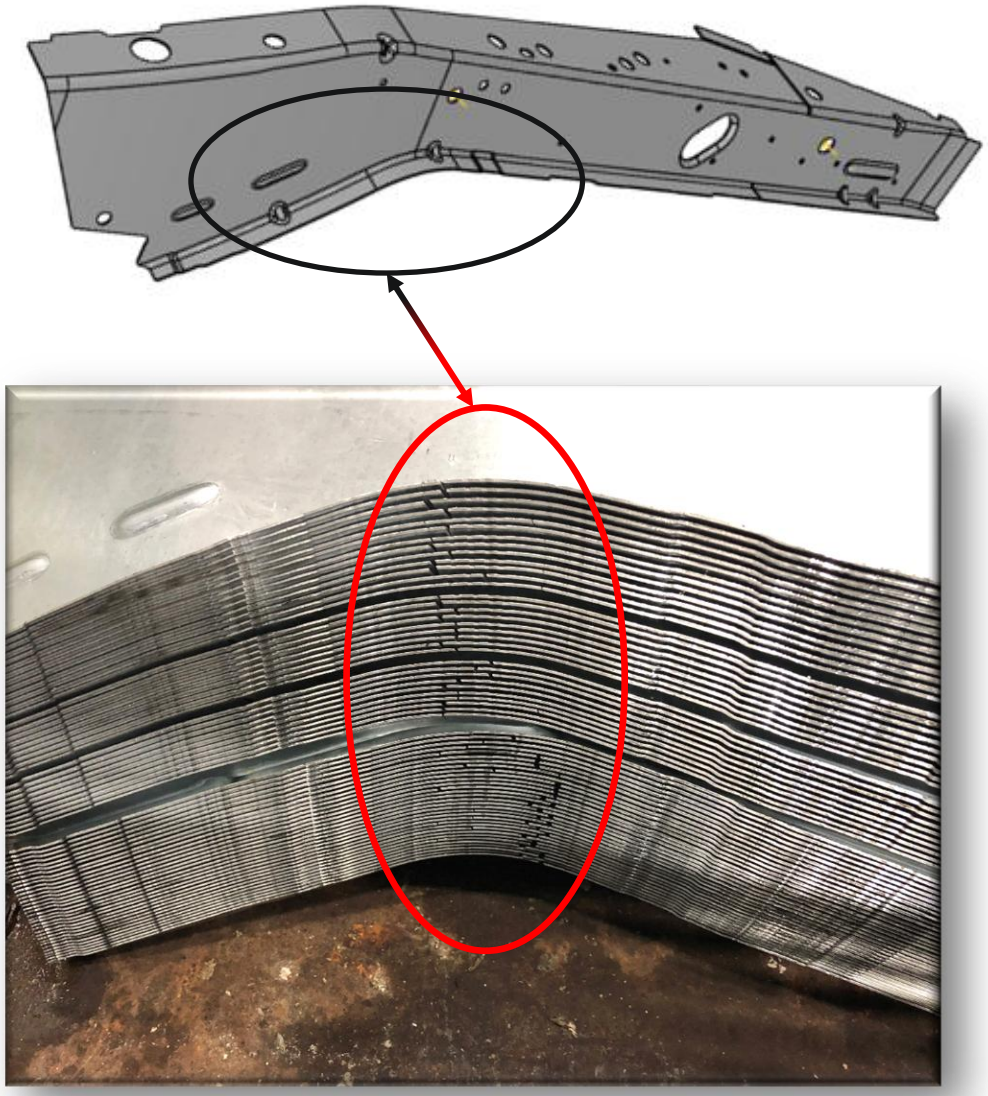
# Forming Parts with 3rd Gen Steel



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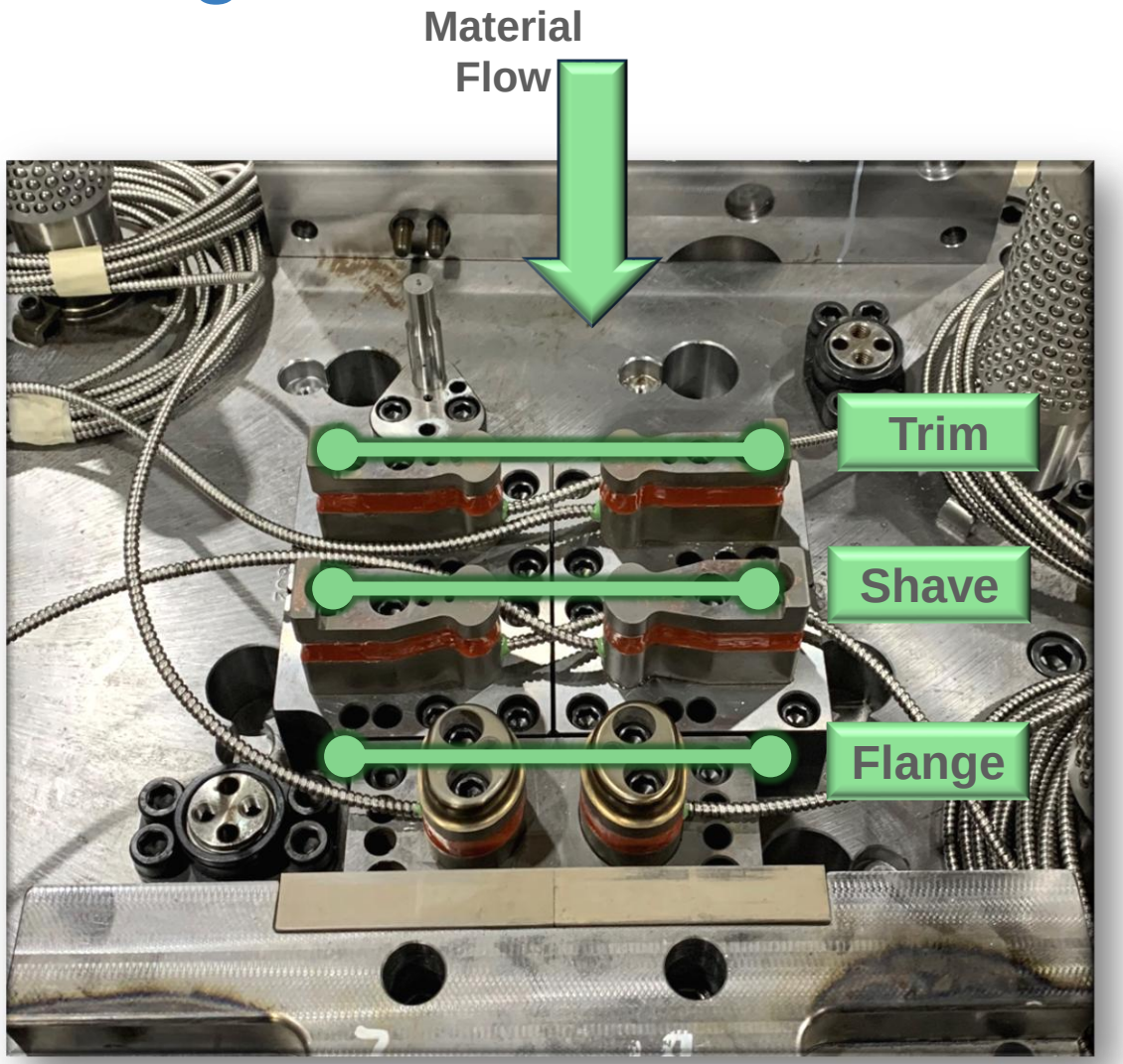
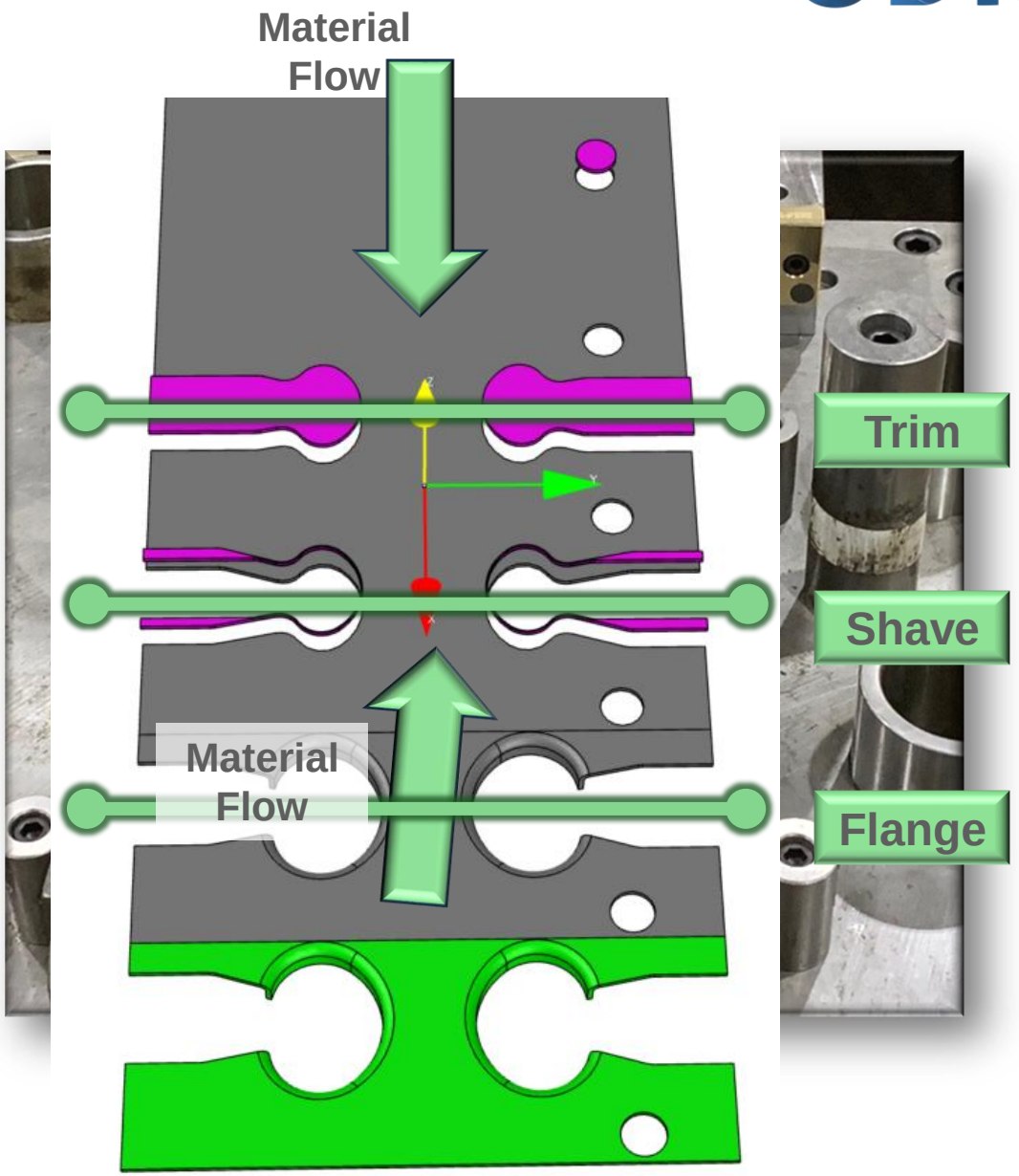
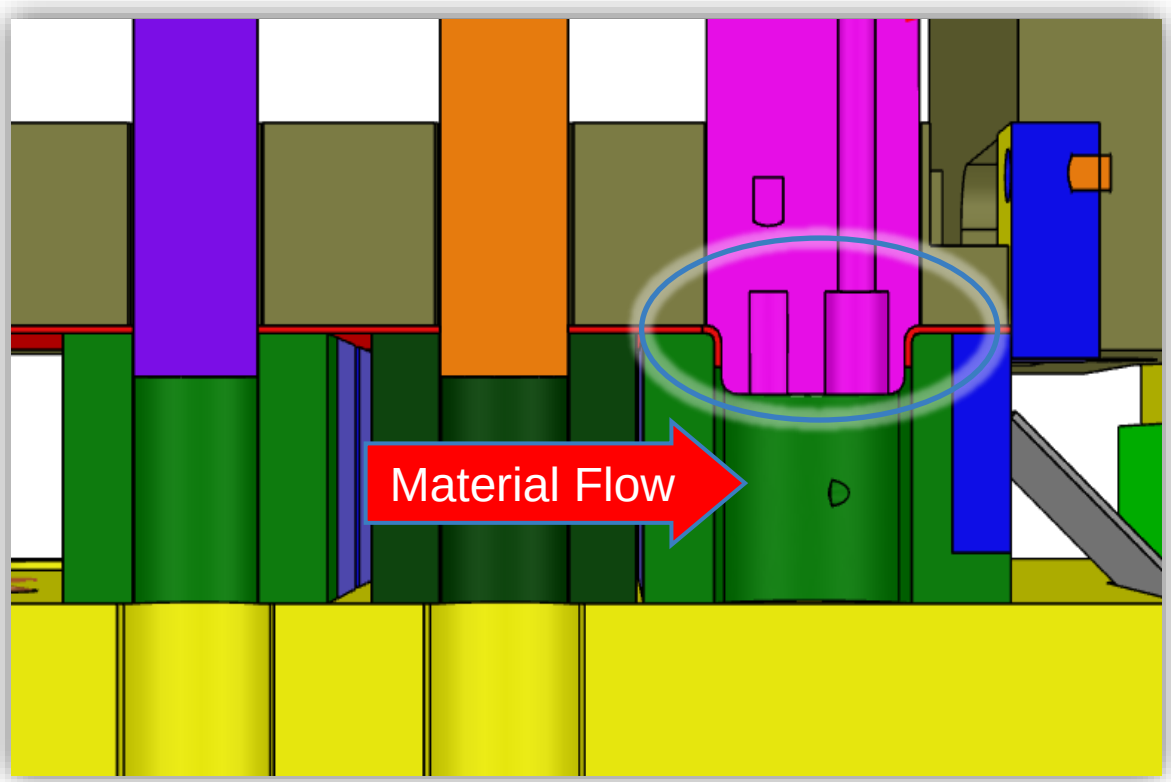


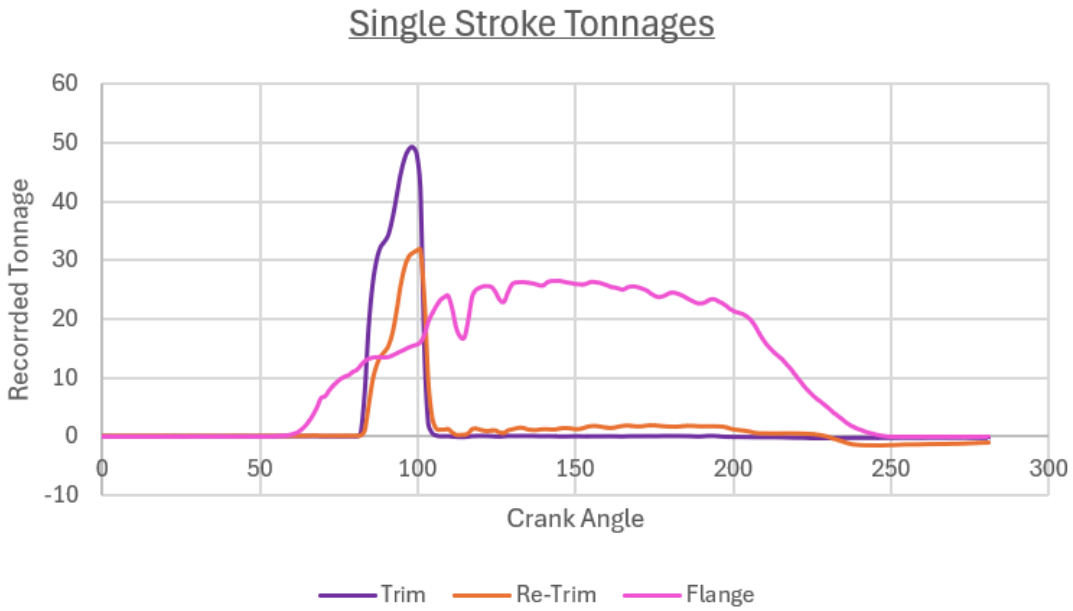



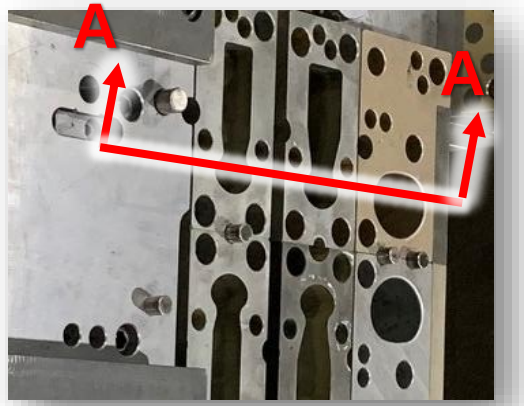

**Upper Die**

# Forming Parts with 3rd Gen Steel

Trim | Re-Trim Shave | Flange

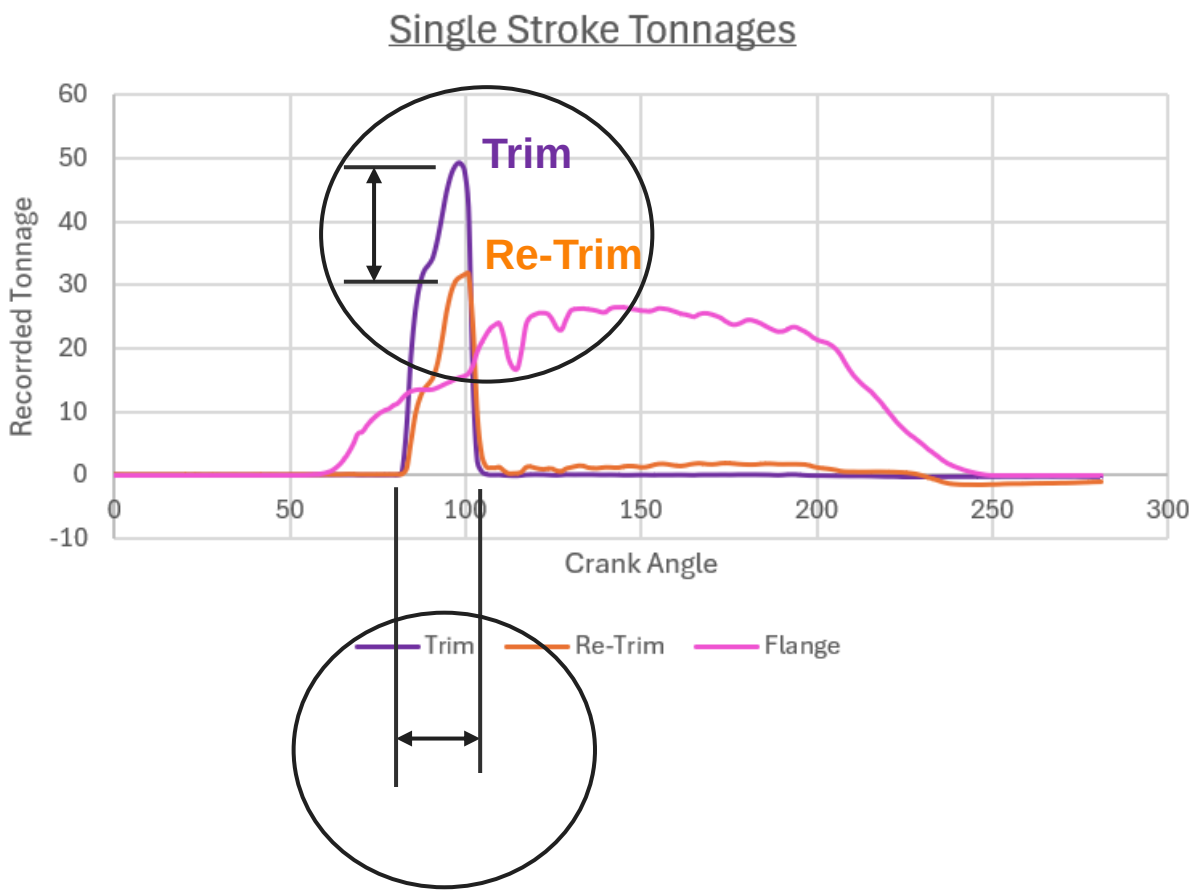


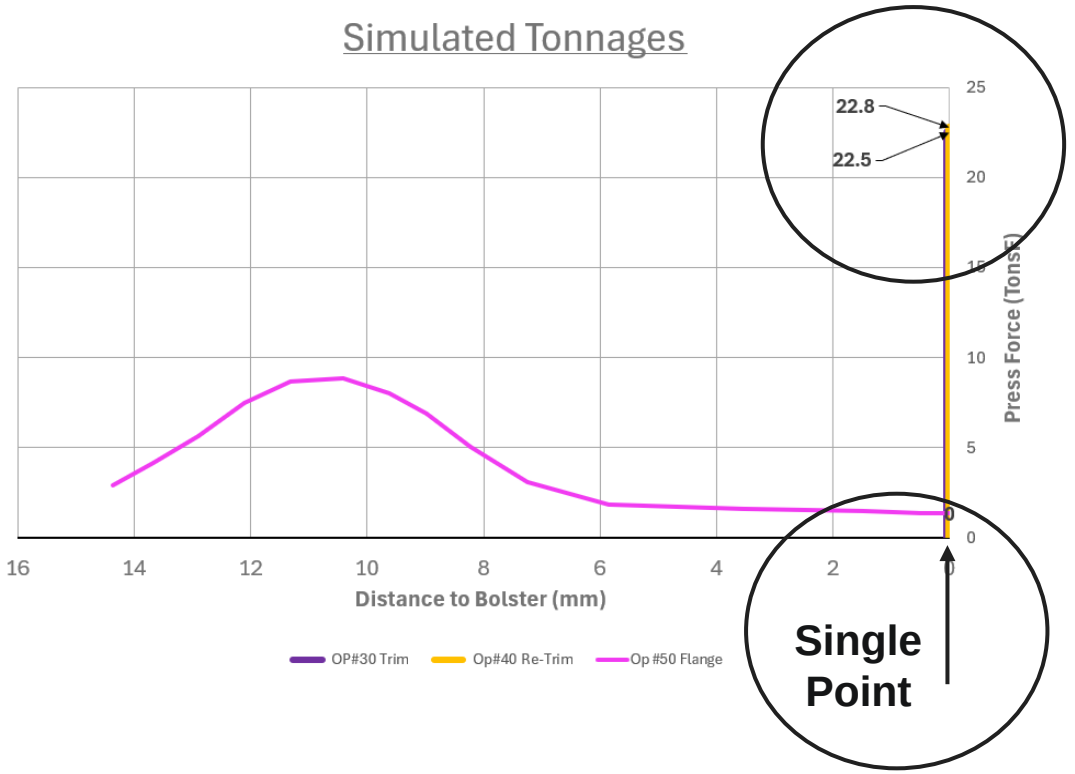




Section A-A

# Forming Parts with 3rd Gen Steel



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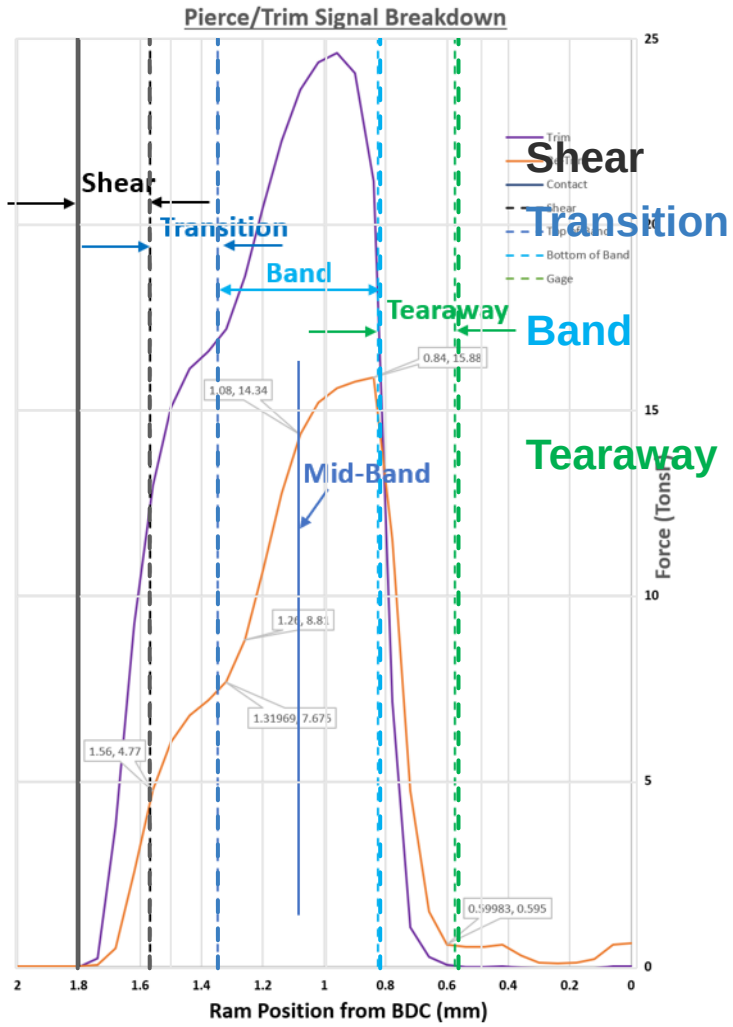


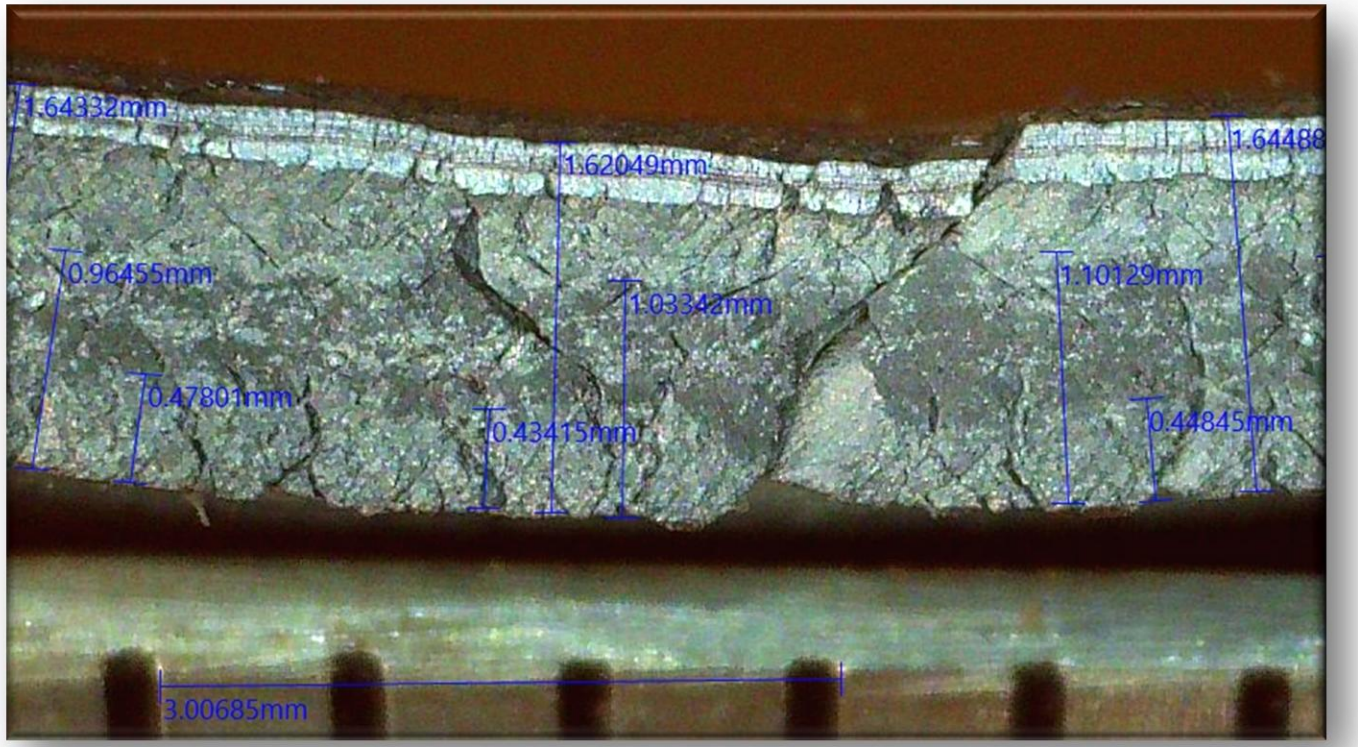

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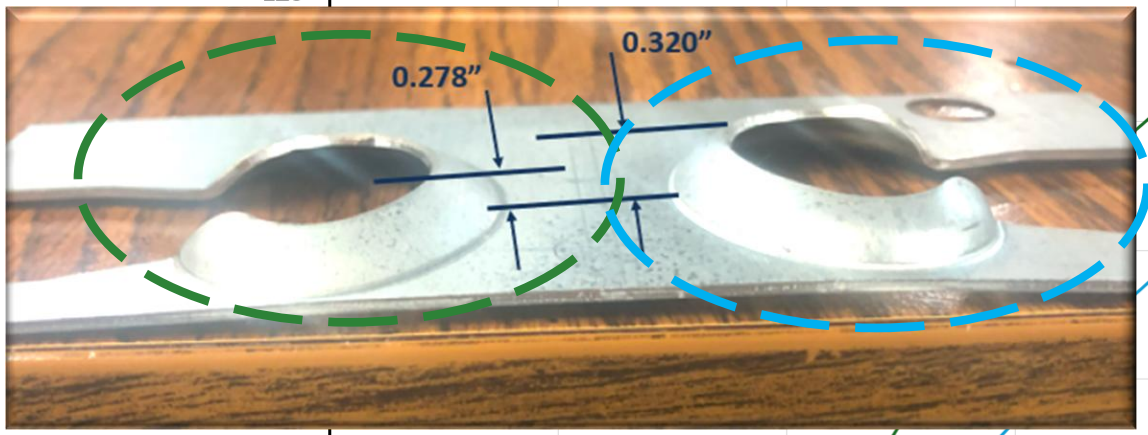
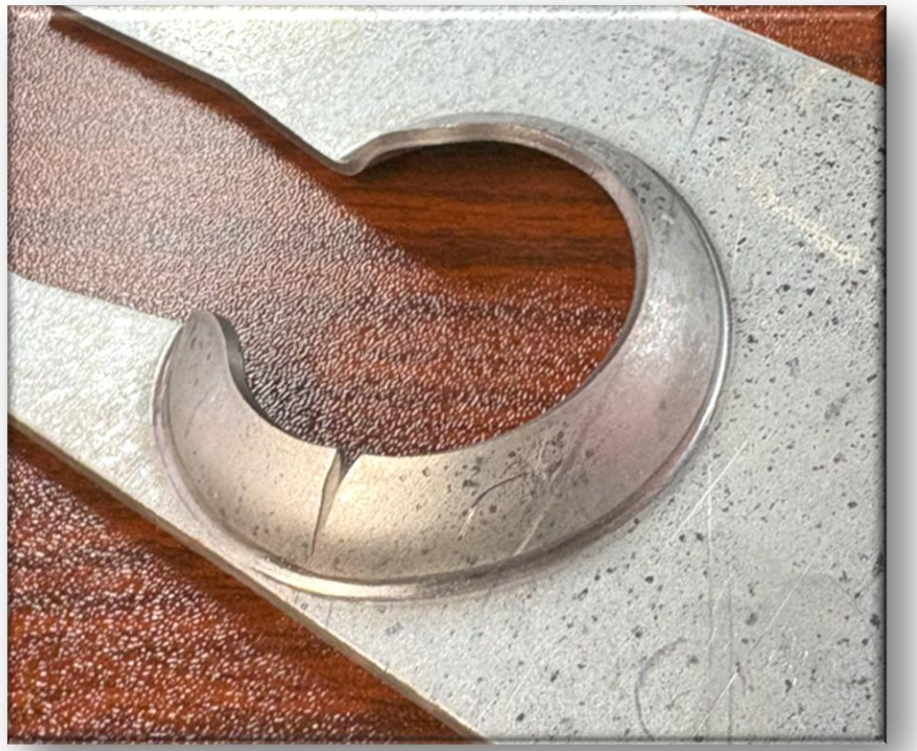


# Forming Parts with 3rd Gen Steel

GDIS

## Conventional Processing



Conventional Simulations
Conventional Material Cards

## State of the Art Processing

Conventional Simulations
????
Conventional Material Cards

# Tying Things Together

3rd Gen Steels are still steel, but users should remember:

- Cannot treat new grades as commodities: swapping suppliers requires due diligence throughout the process
- Much higher strength than before: flattening, blanking, forming, punching forces, springback all increase
- New and different failure modes not (yet) predictable in simulation: edge cracking
- 3rd Gen steels are produced through a variety of chemical compositions and thermomechanical processing techniques, ending up with significant variation in mechanical properties – all within allowable tolerances.
  - This study shows 15-25% difference in mechanical properties within different 3rd Gen grades.
- Tonnage signatures from the press can be utilized to visualize the four “Zones” of a trimmed edge
- Engineering the width of the “Tearaway” zone can produce more aggressive shapes
- Simulation package(s) capable of demonstrating a “Plant Floor” mindset, including modern material cards and processing technologies, will ultimately gain market share
- Age-old simulation speed/accuracy trade-off may need to be re-evaluated because of $$$ at risk

# For more information

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