GREAT DESIGNS IN STEEL

A COMPREHENSIVE CHARACTERIZATION OF NEXMET® 1000 FORMABILITY

Wei Wu, Ph.D

Research & Innovation, AK Steel Corporation

NEXMET® 1000

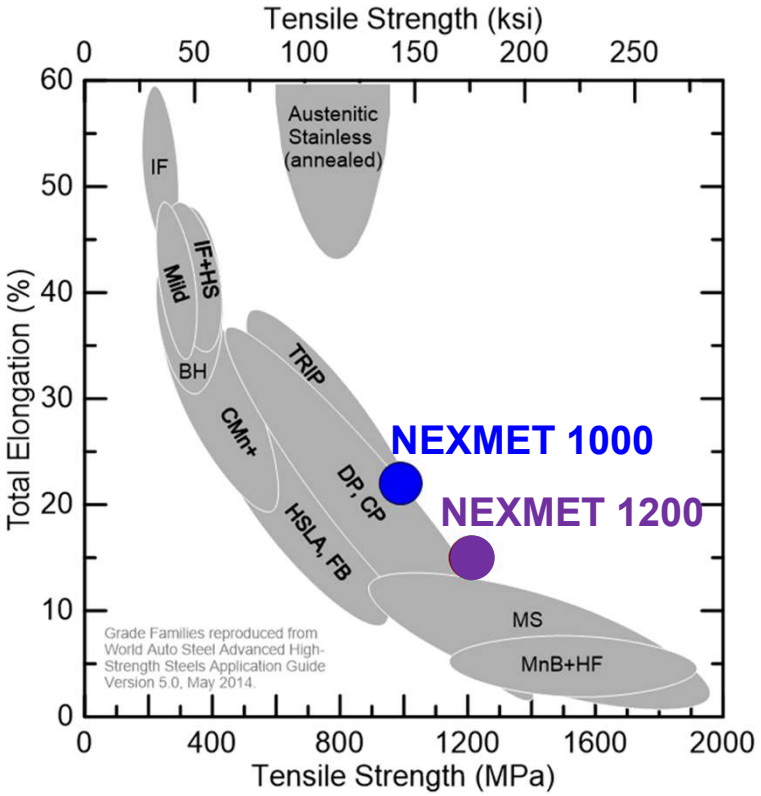
What is NEXMET® 1000?

NEXMET 1000 is next generation (3rd generation) advance high strength steel (AHSS) of AK Steel Corporation. It can be categorized as carbon steel or TRIP-assisted Quenched and Partitioned (Q&P) steel.

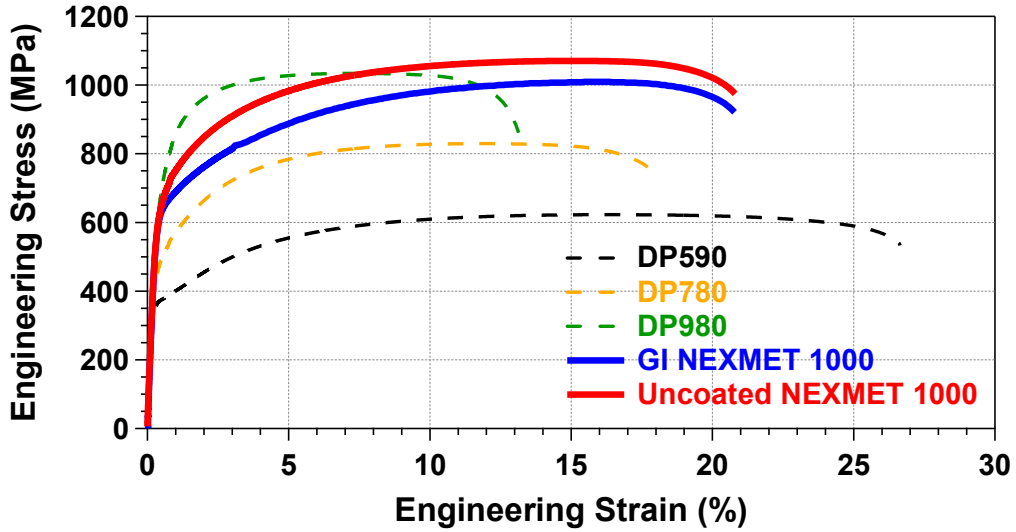
Where is NEXMET® 1000 produced?

NEXMET 1000 is manufactured locally in Dearborn, MI.

MECHANICAL PROPERTIES



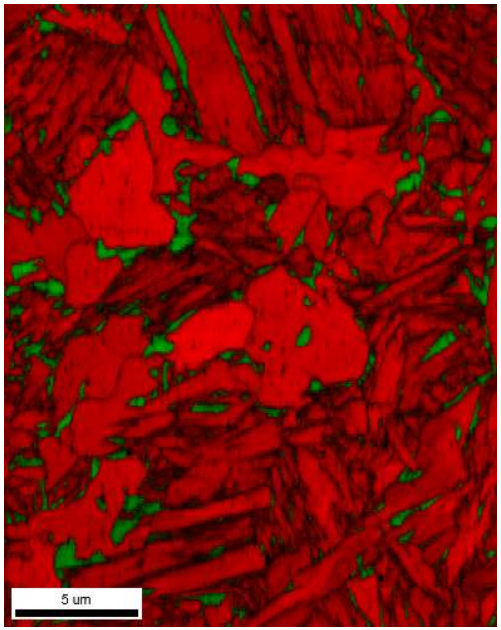
GI NEXMET 1000, 1.2 mm
"Typical" HER = 22 pct%

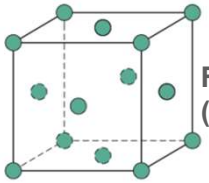


	YS (MPa)	UTS (MPa)	UE(%)	TE(%)
DP590	370	620	16	26
DP780	470	830	12	17
DP980	690	1030	7	13
GI NEXMET 1000	700	1010	15	21
Uncoated NEXMET 1000	650	1050	15	20

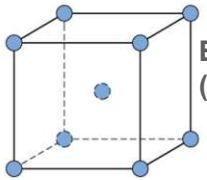
MICROSTRUCTURE

Electron Backscatter Diffraction

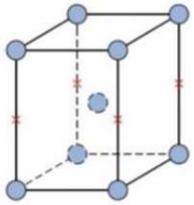




Face-Centered Cubic (FCC)



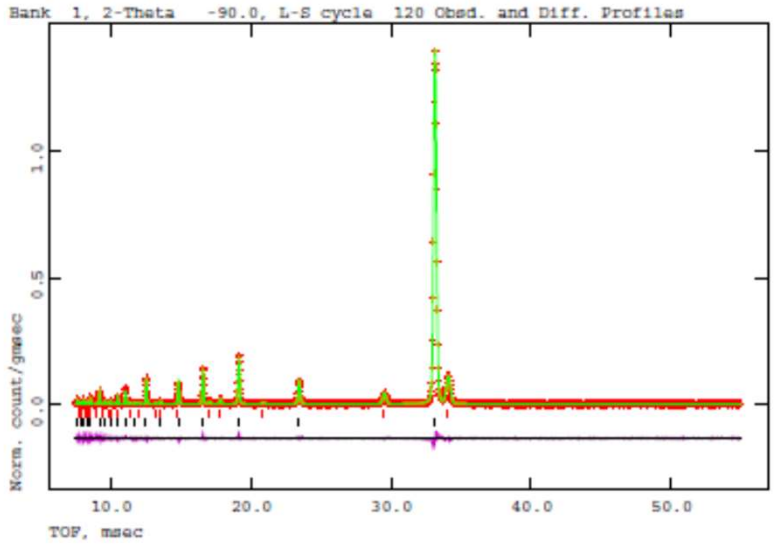
Body-Centered Cubic (BCC)



Body-Centered Tetragonal (BCT)

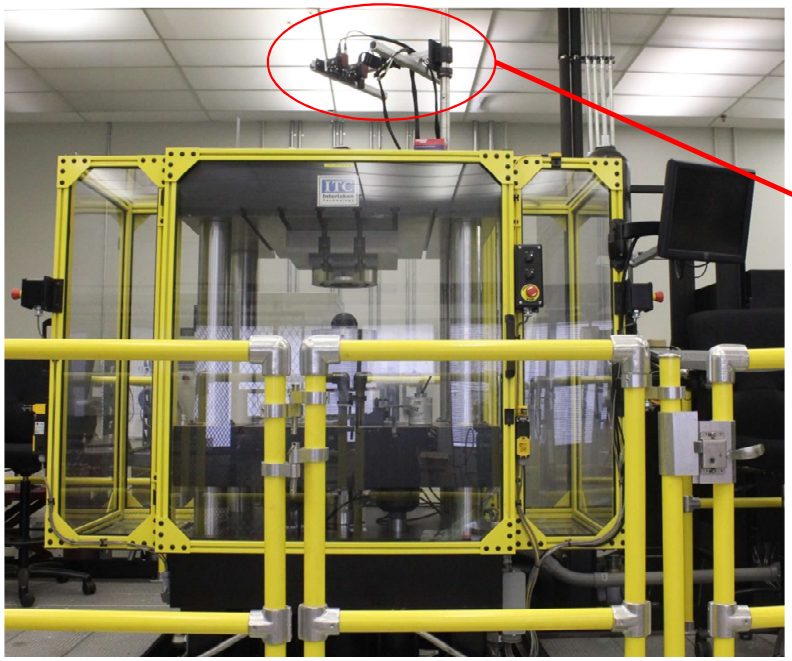
- Austenite (FCC)
- Ferrite (BCC) & Martensite (BCT)

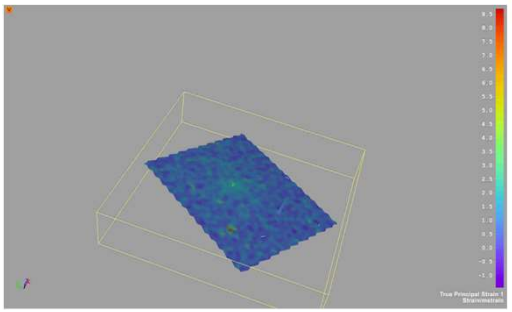
Neutron Diffraction Pattern

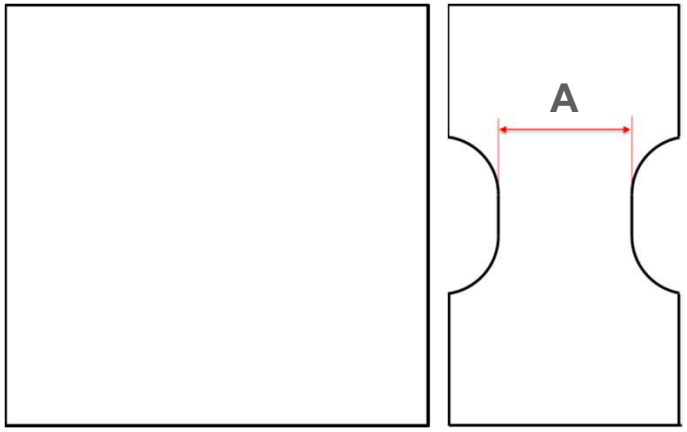


GI NEXMET 1000, 1.2 mm Retained Austenite Volume Fraction (RAVF): 12%

CHARACTERIZATION OF FORMING LIMIT CURVE USING DIGITAL IMAGE CORRELATION (DIC)



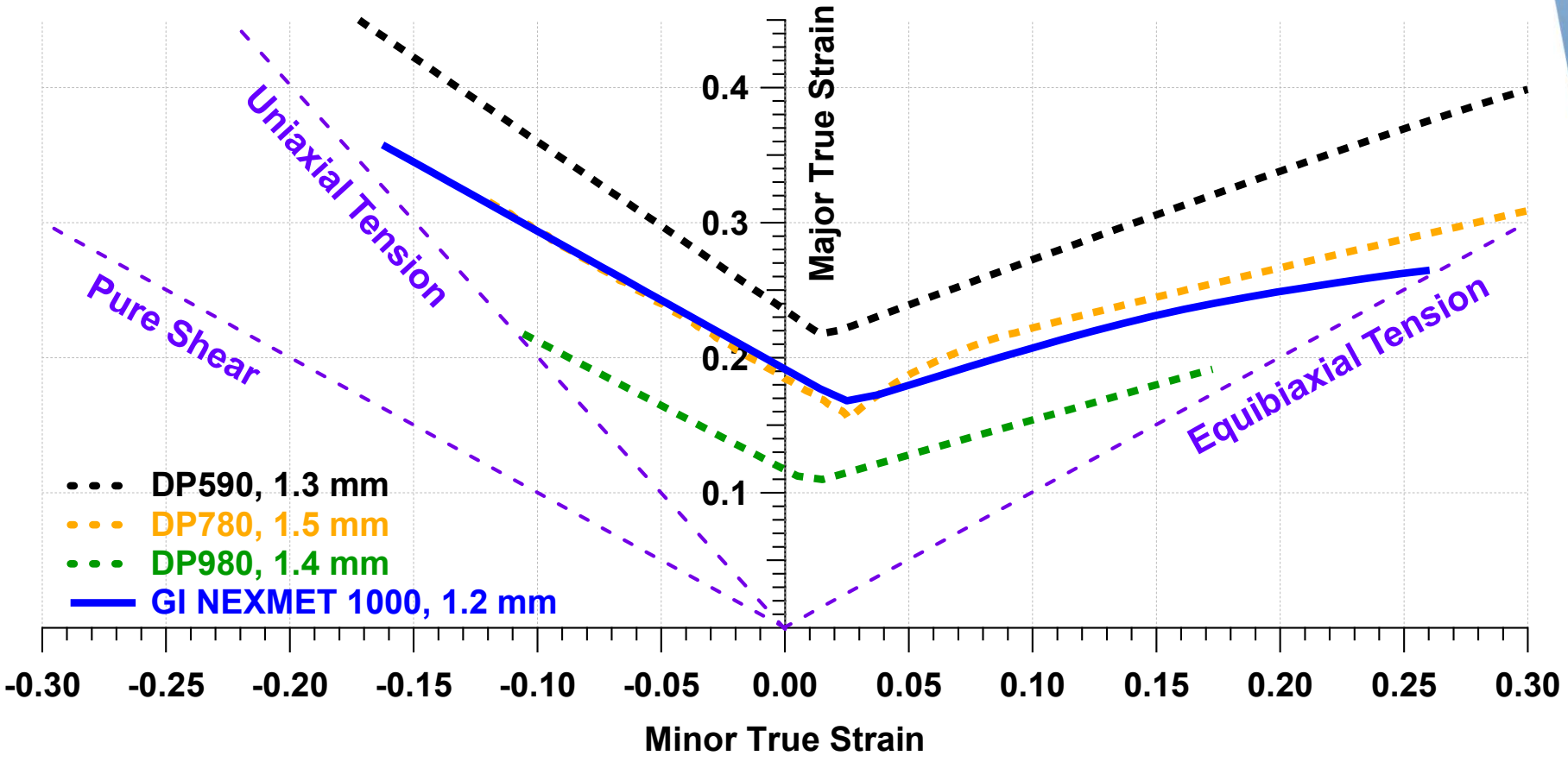




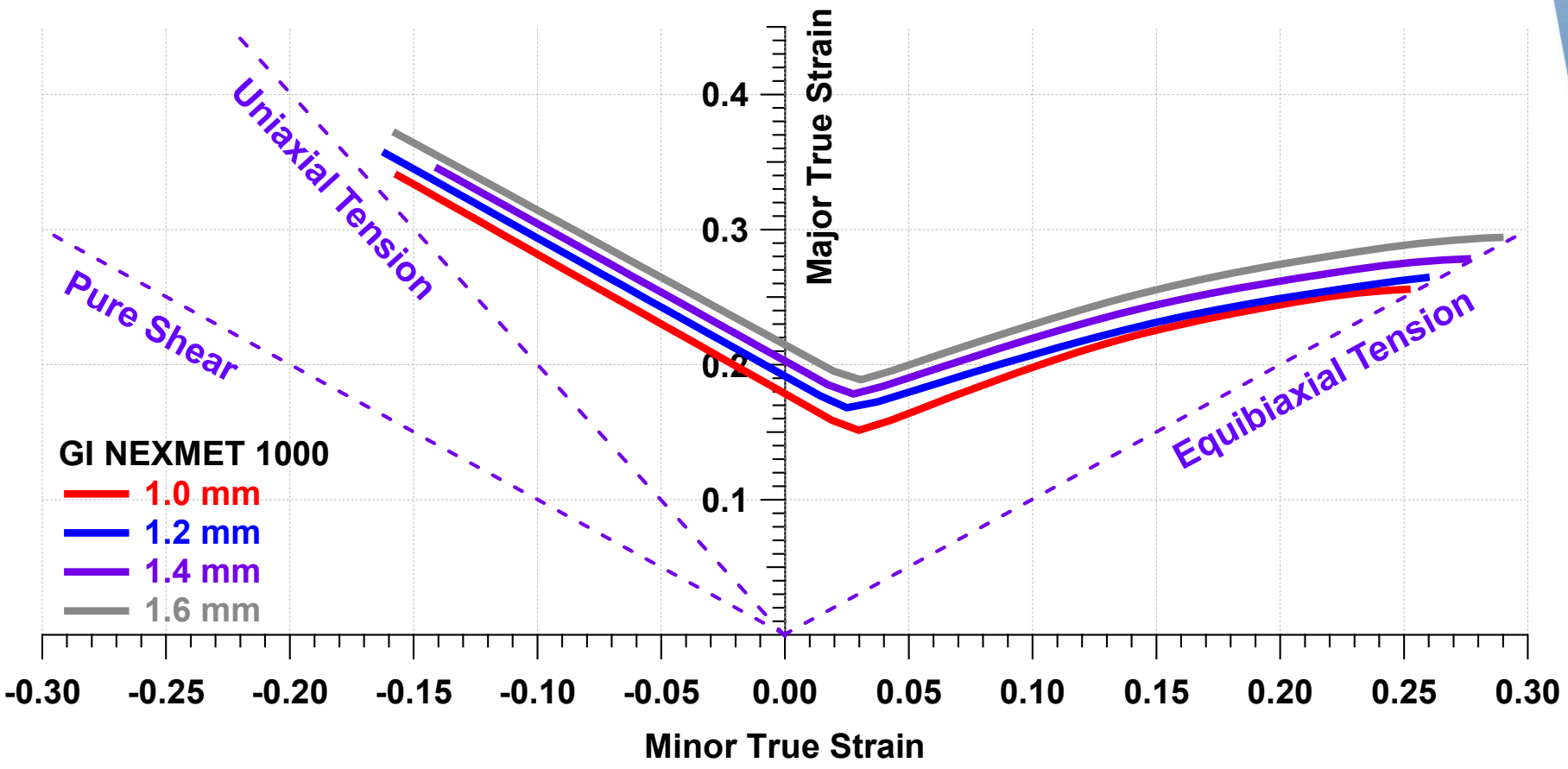
- Determination of FLC: ISO12004-2;
- 102 mm (4”) diameter steel ball;
- Lubricant: Teflon & grease.

A in mm:
20, 50, 80, 100, 120, 130, 140, 160

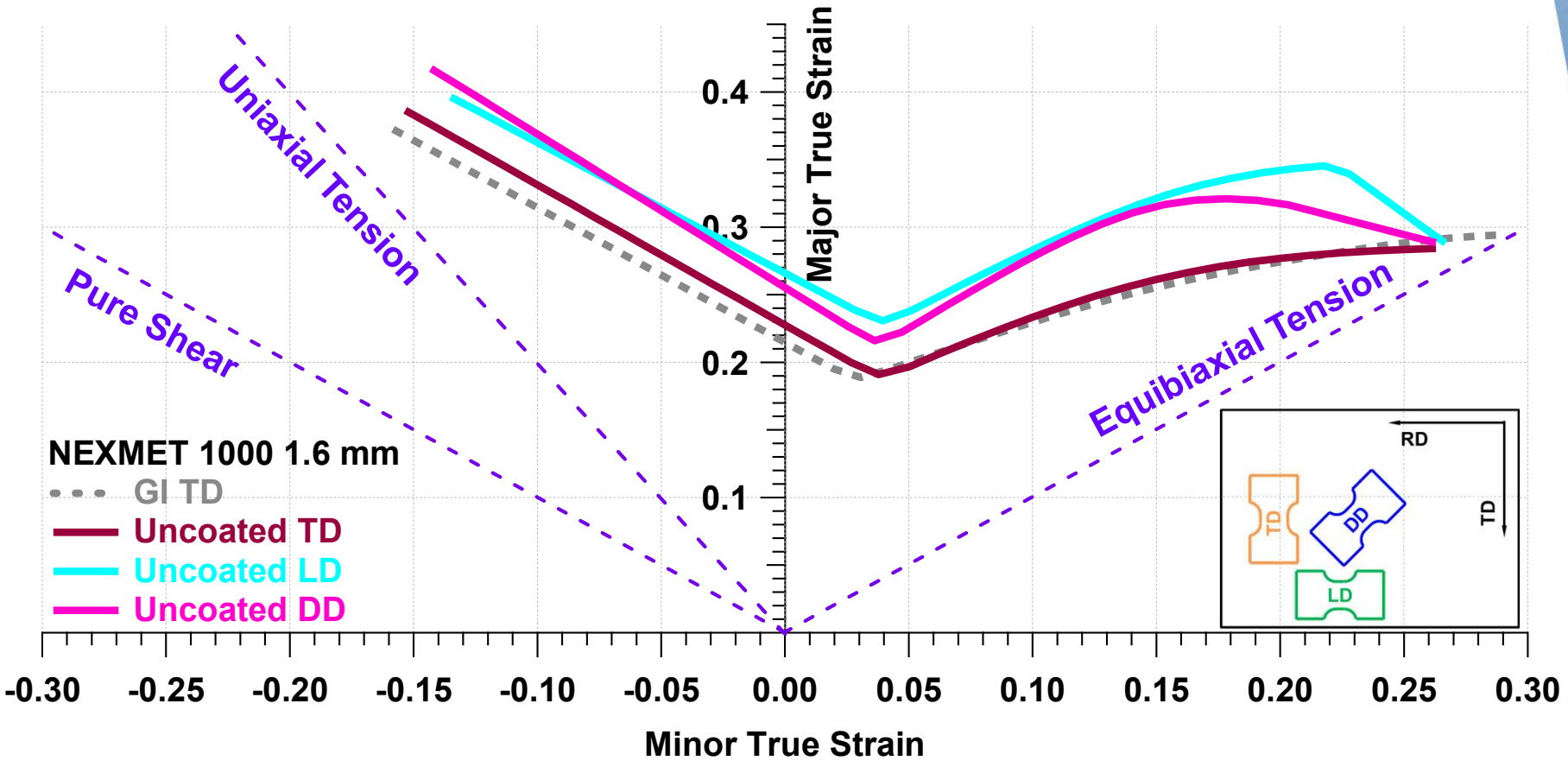
FORMING LIMIT CURVES: NEXMET 1000 VS. OTHER GRADES



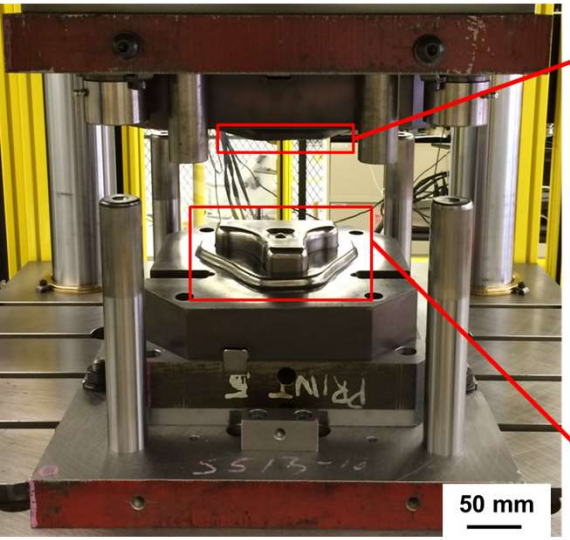
FORMING LIMIT CURVES OF NEXMET 1000: VARIOUS THICKNESS



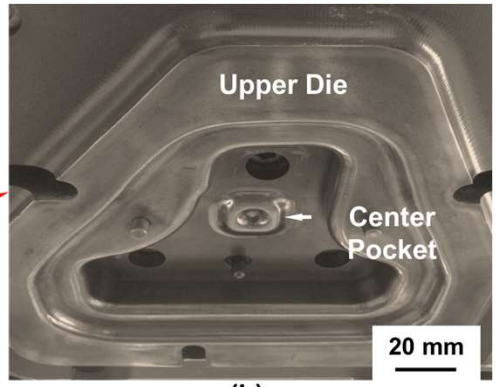
FORMING LIMIT CURVES OF NEXMET 1000: DIFFERENT SAMPLE ORIENTATIONS



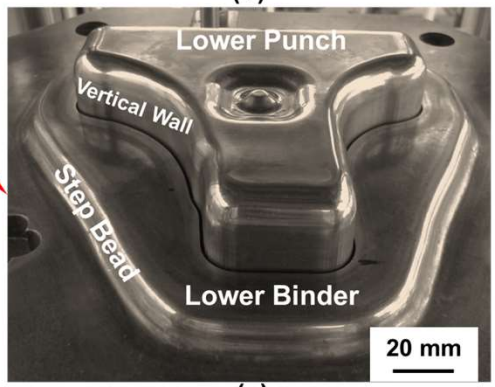
T-SHAPE FORMING



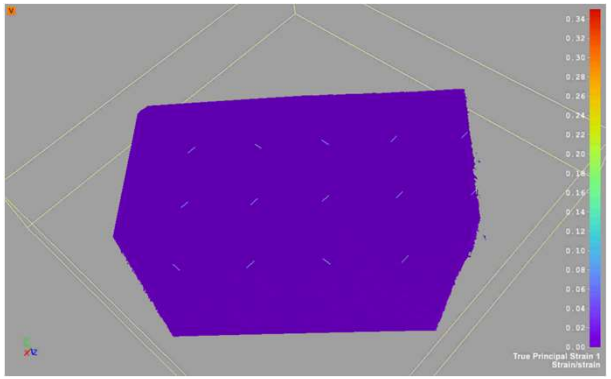
(a)

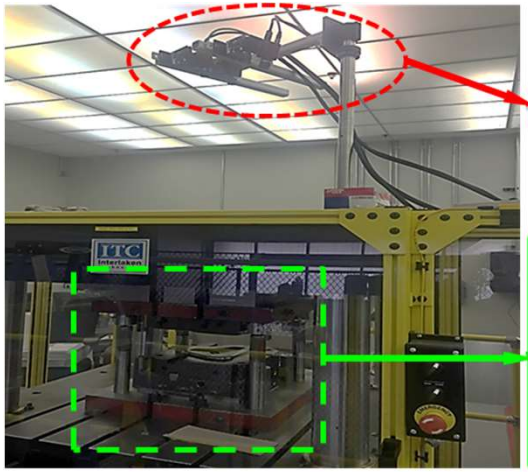


(b)

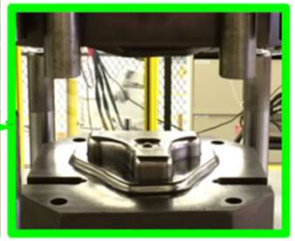


(c)



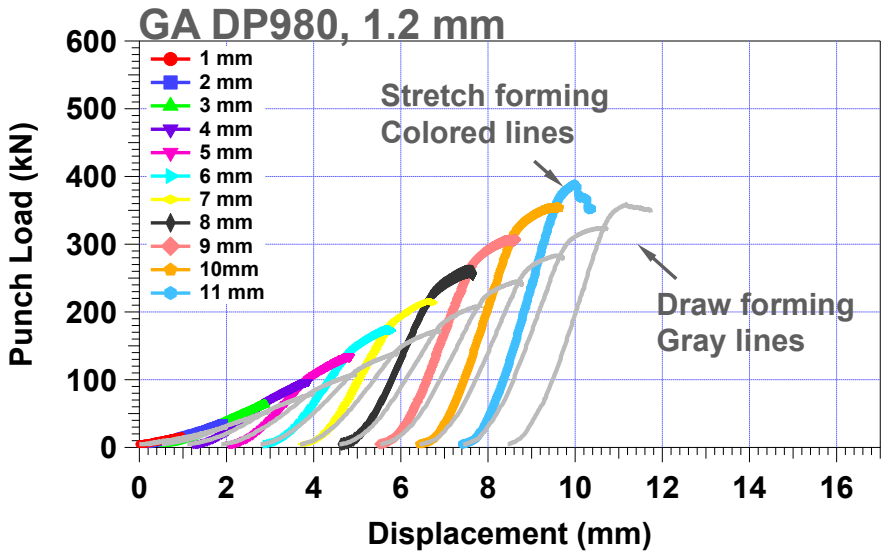


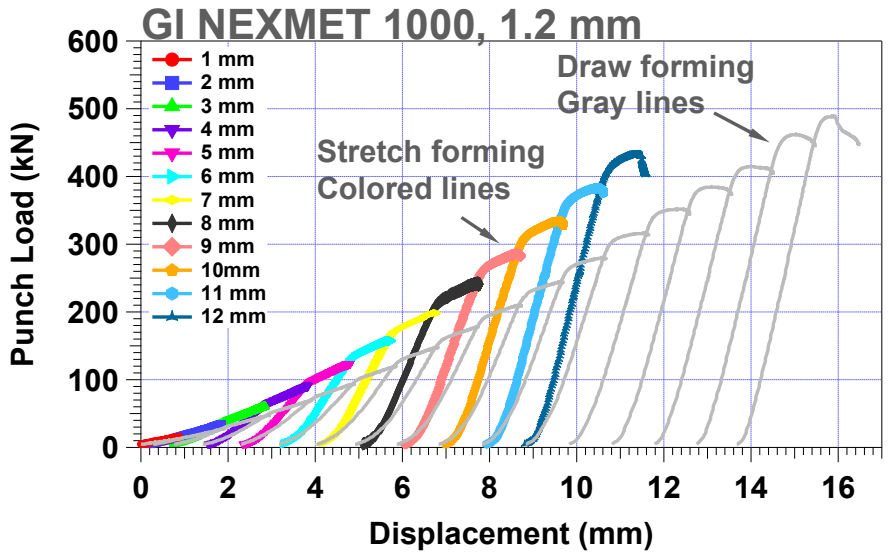
3 Camera DIC system



T-Shape Die

T-SHAPE FORMING: NEXMET 1000 VS. DP980



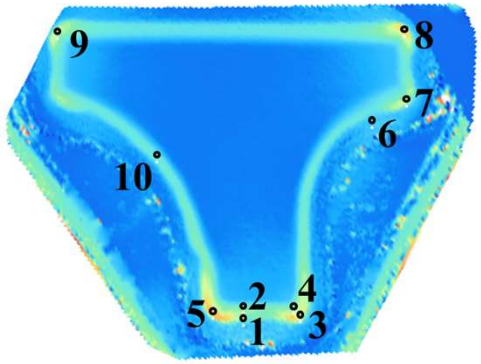


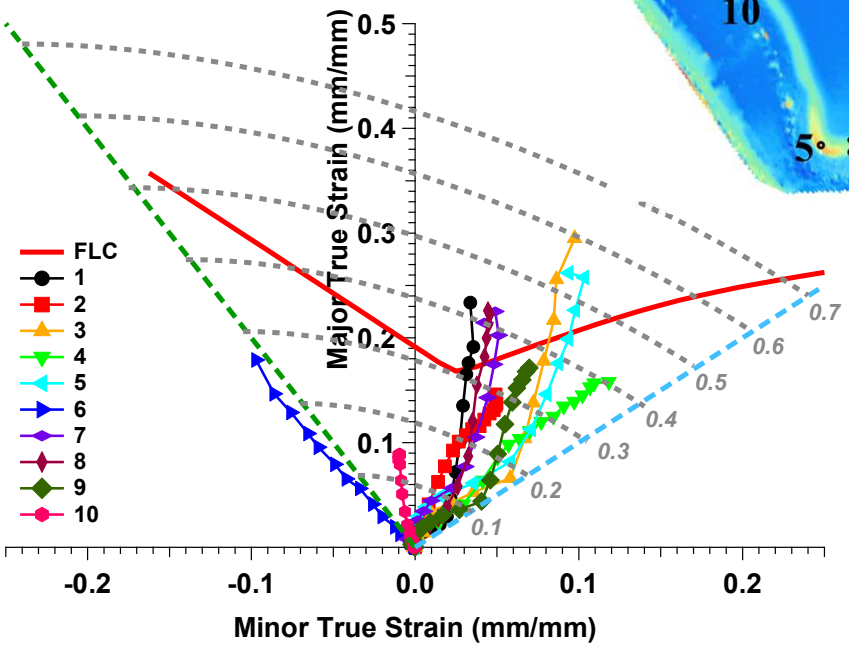
	Draw forming maximum depth (mm)	Stretch forming maximum depth (mm)
GA DP980, 1.2 mm	11.7	10.1
GI NEXMET 1000, 1.2 mm	16.1	11.5

DEFORMATION MODES AND STRAIN PATHS DURING T-SHAPE FORMING

GDIS

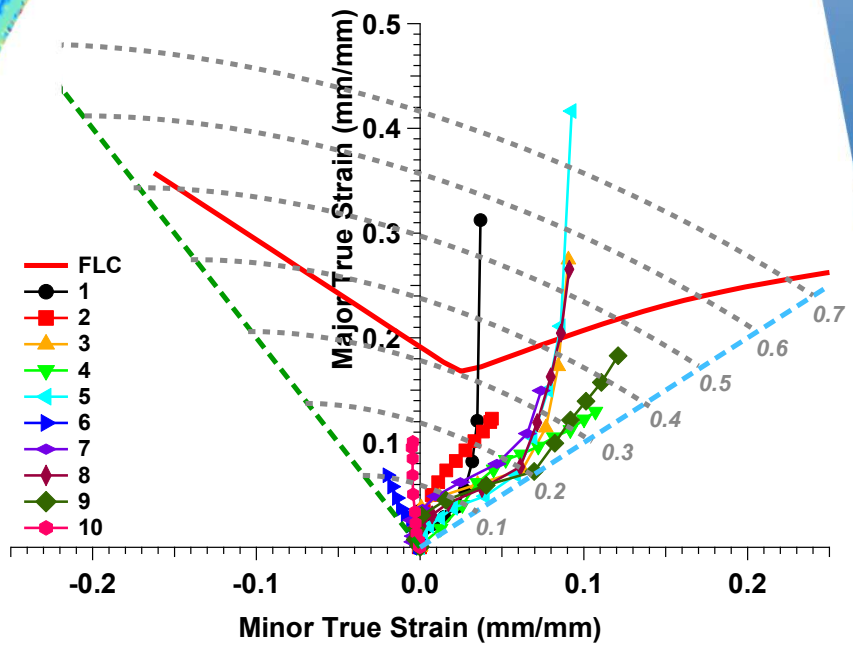
GI NEXMET 1000, 1.2 mm





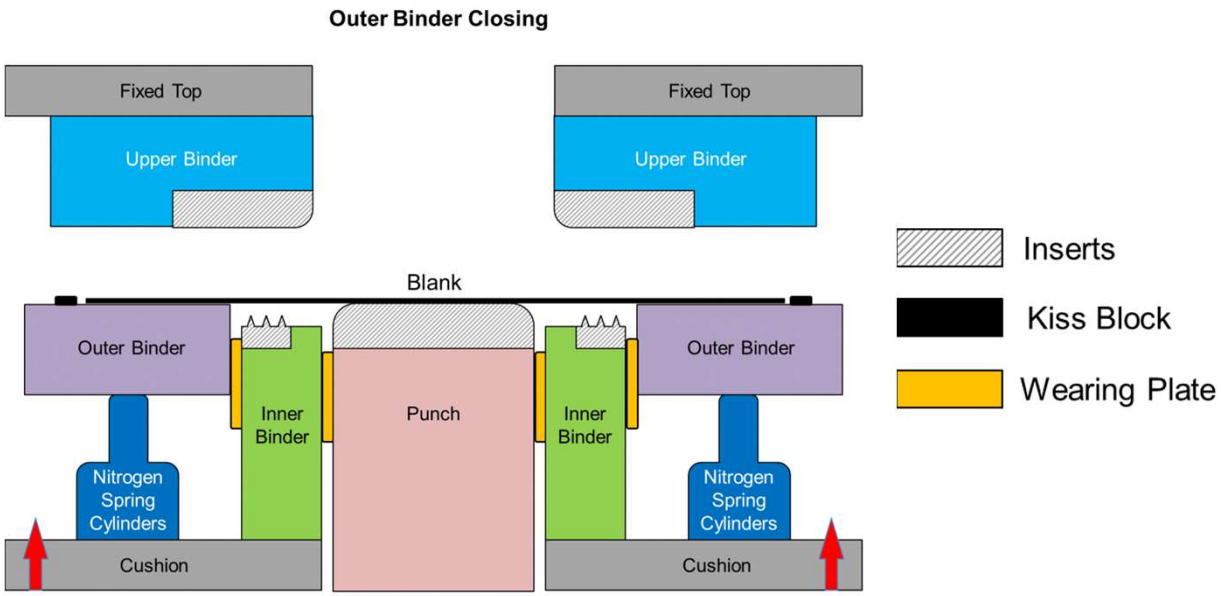
Draw Forming
Fractured at 16.1 mm

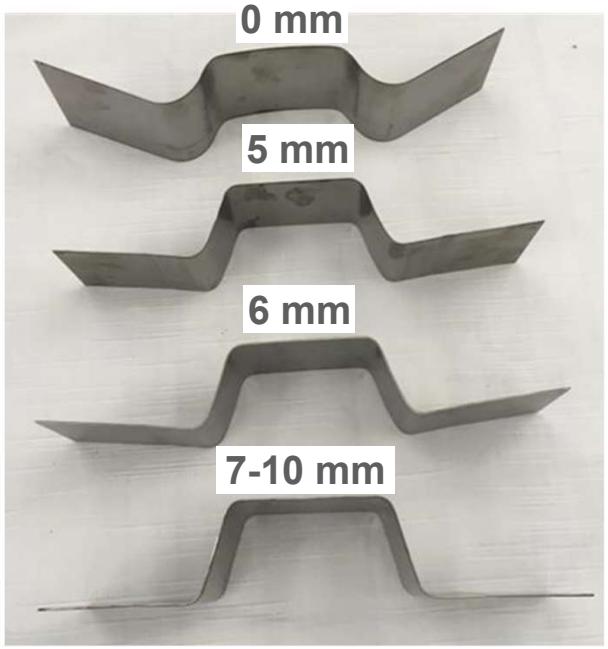
GI NEXMET 1000, 1.2 mm



Stretch Forming
Fractured at 11.5 mm

SPRINGBACK AND SPRINGBACK CONTROL



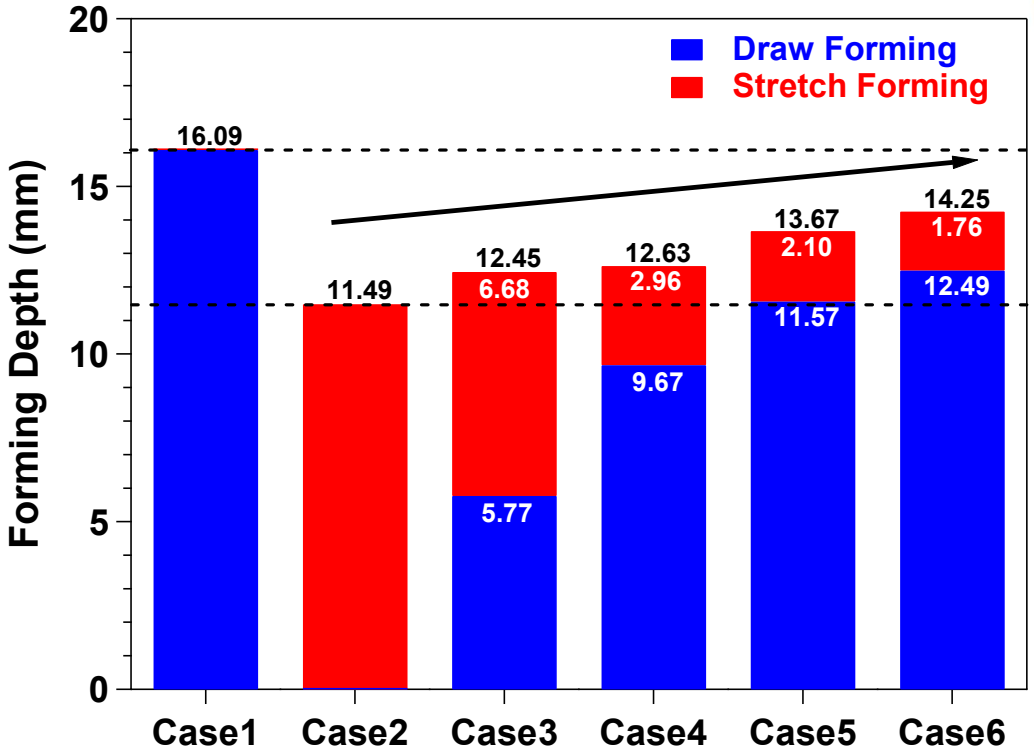


Effect of Post-stretching Amount

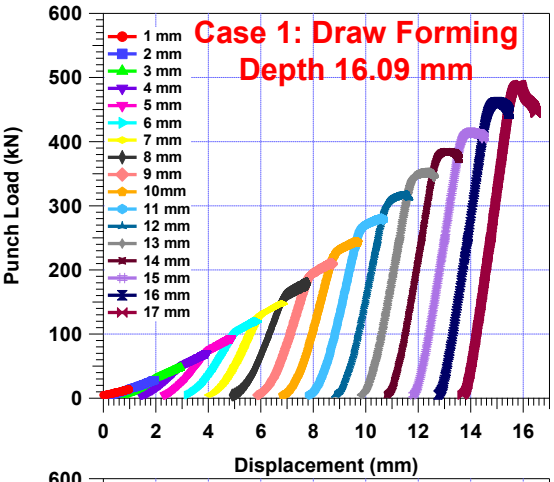
What is the effect of post-stretching on the formability???

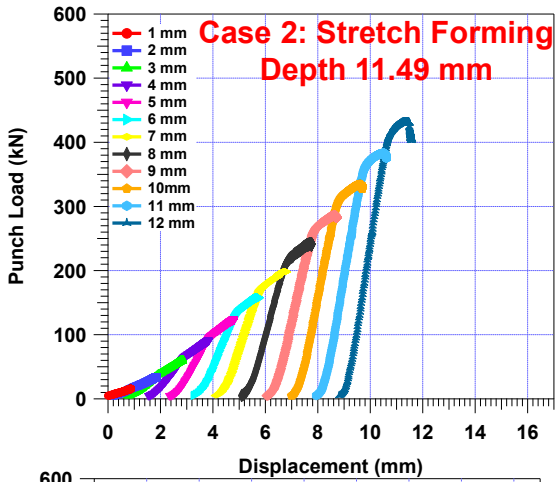
EFFECT OF DRAW / STRETCH FORMING ON T-SHAPE FORMING

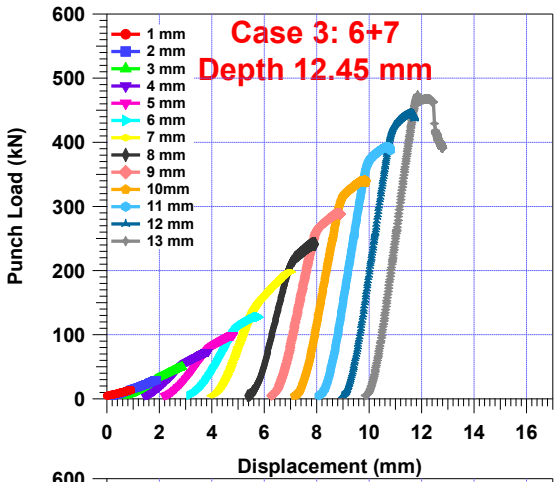
- Case 1: Draw Forming (10% Blank Thickness)
- Case 2: Stretch Forming (115 Ton Binder Tonnage)
- Case 3: Draw Forming 6 mm + Stretch Forming
- Case 4: Draw Forming 10 mm + Stretch Forming
- Case 5: Draw Forming 12 mm + Stretch Forming
- Case 6: Draw Forming 13 mm + Stretch Forming

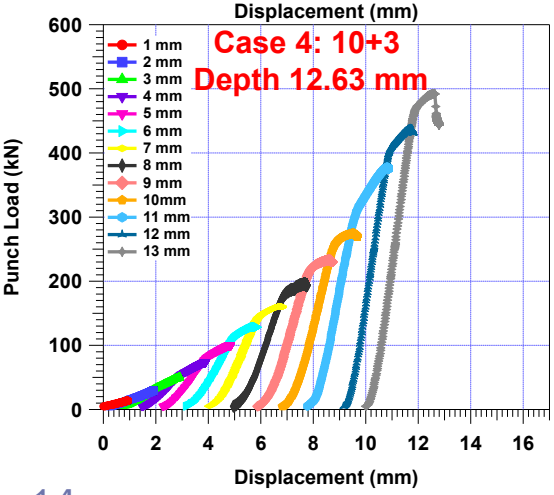


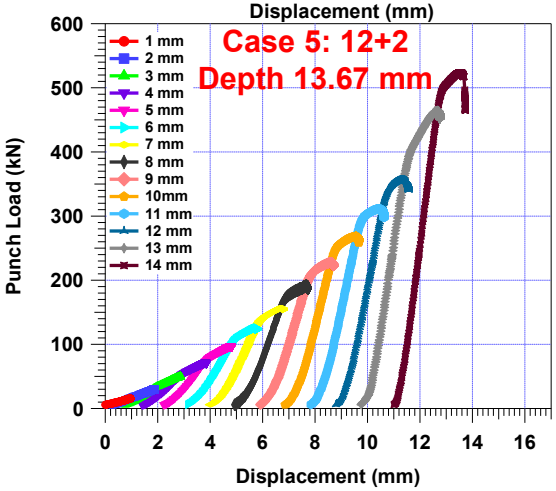
PUNCH LOAD VS. DISPLACEMENT

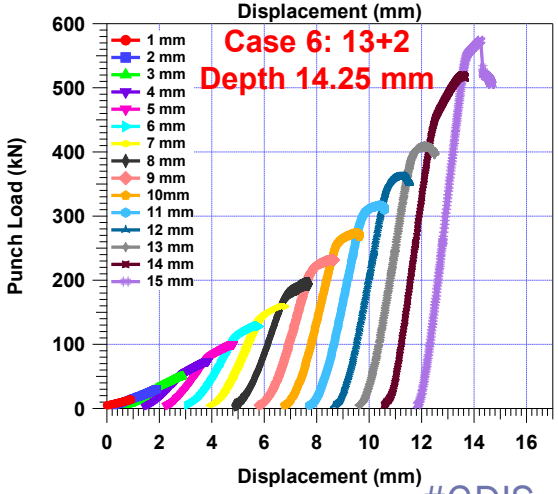




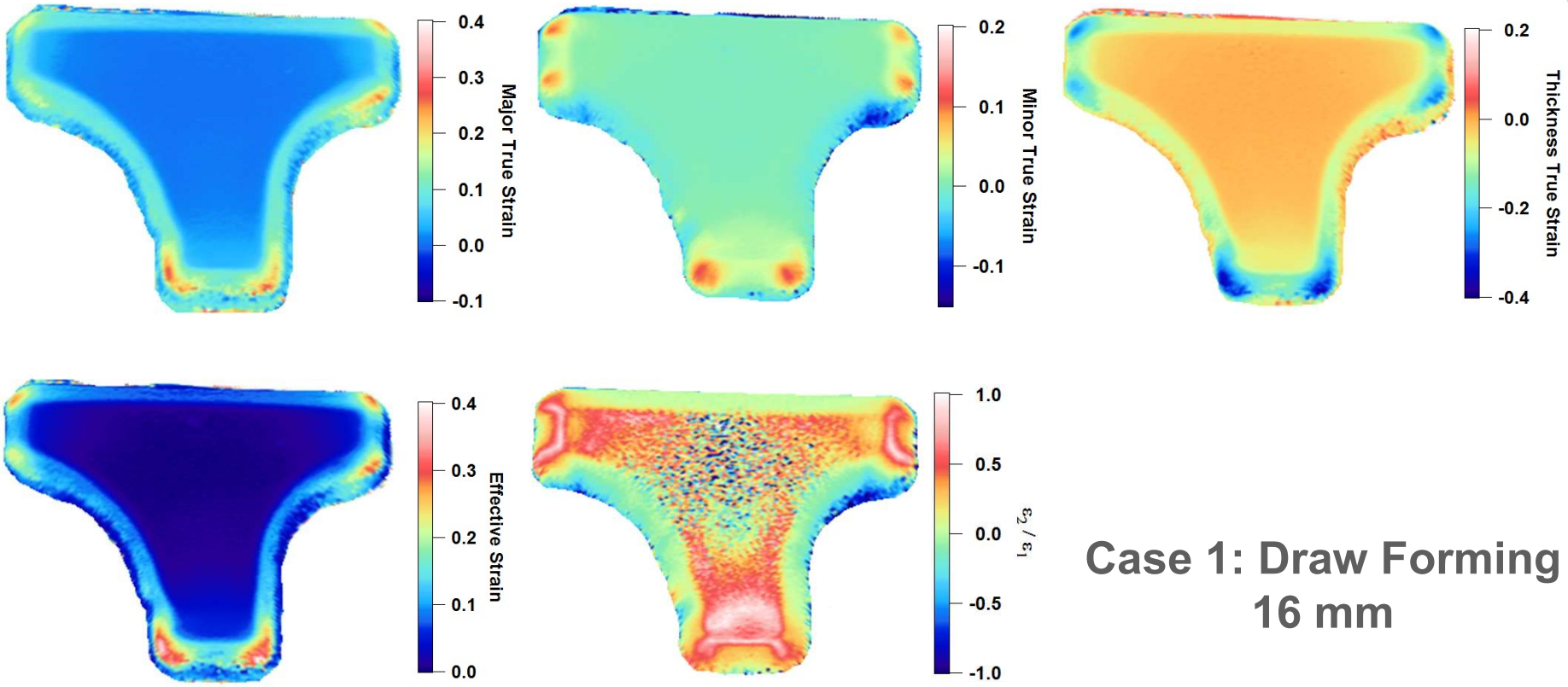






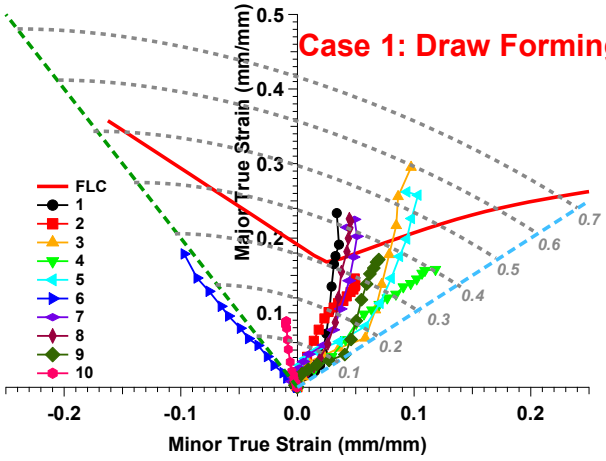


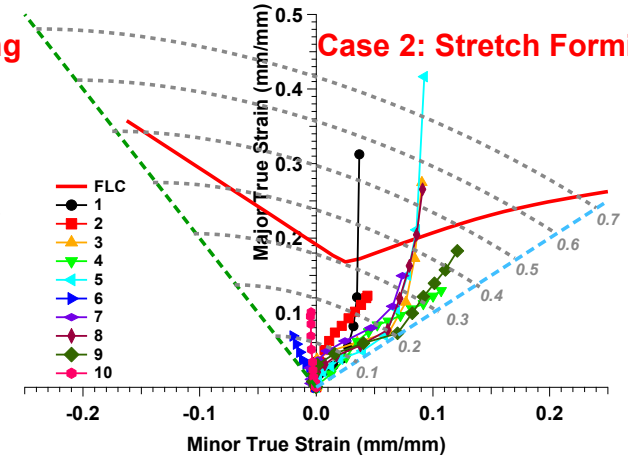
STRAIN DISTRIBUTION ON T-SHAPE PANEL

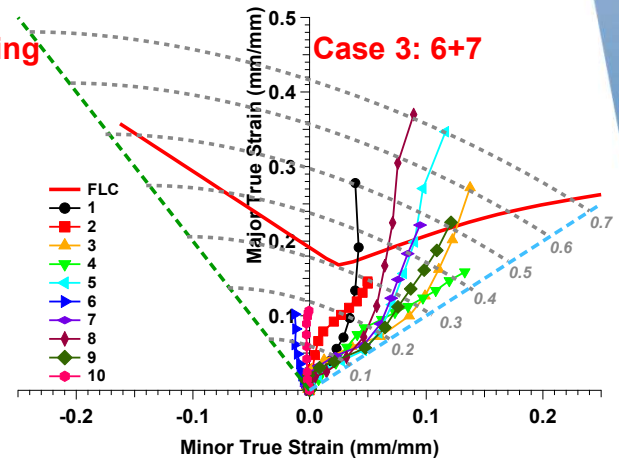


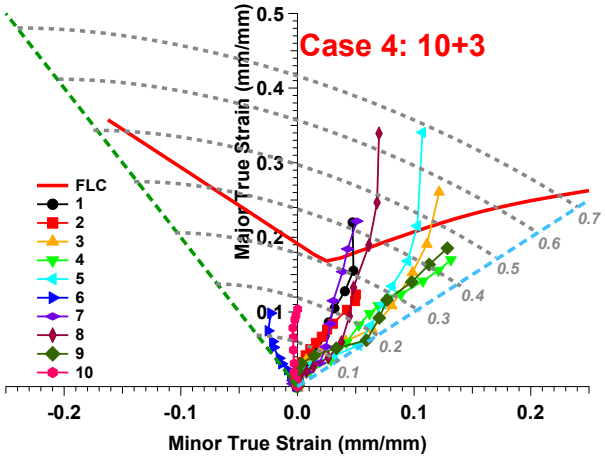
Case 1: Draw Forming
16 mm

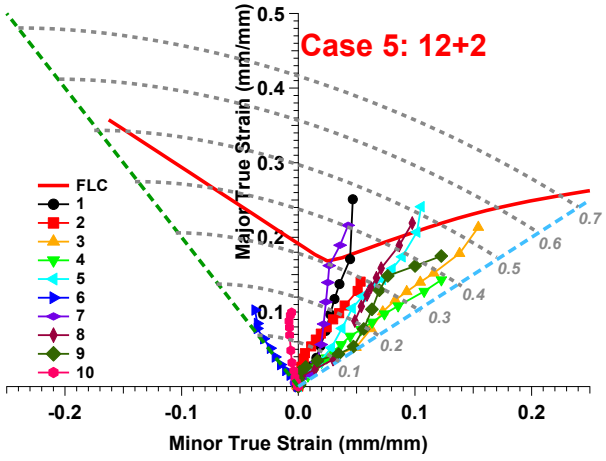
DEFORMATION MODES AND STRAIN PATHS

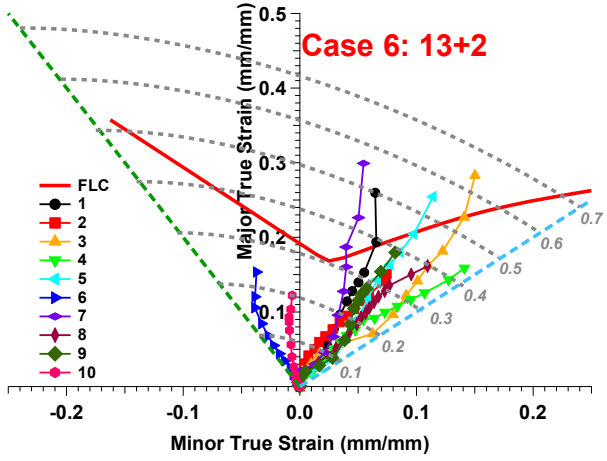




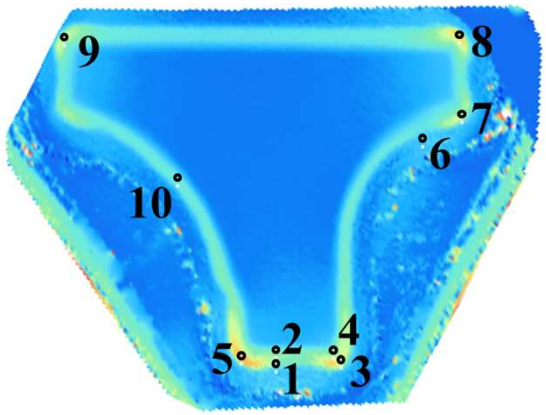


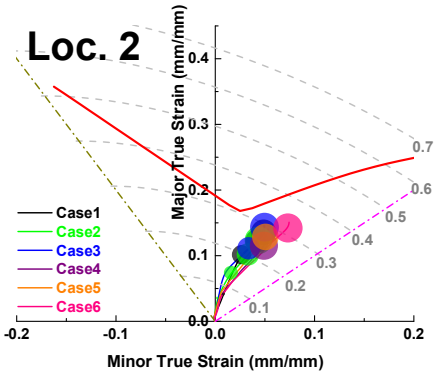


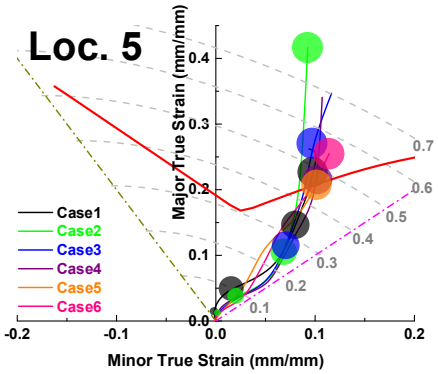


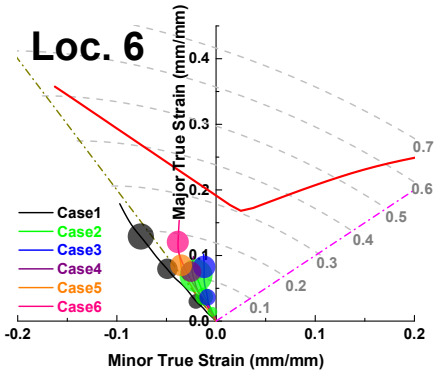


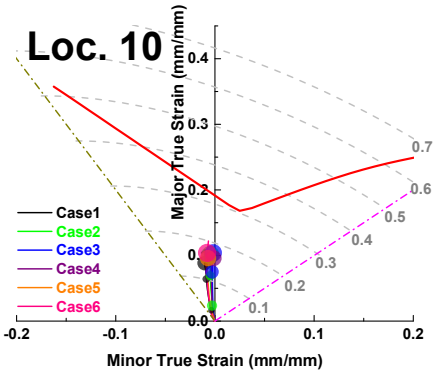
DEFORMATION MODES AND STRAIN PATHS DEPENDENCY OF MARTENSITE PHASE TRANSFORMATION

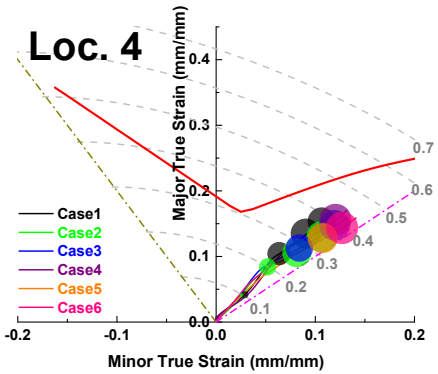












CONCLUSIONS

The forming limit of NEXMET 1000 is comparable to DP780, and much higher than DP980.

NEXMET 1000 exhibits excellent formability in T-shape forming.

The T-shape forming depth of NEXMET 1000 is further improved in post-stretching.

The deformation mode and strain path dependence of martensite phase transformation for NEXMET 1000 agrees with previous studies.

ACKNOWLEDGEMENT

Advanced Engineering:

Yu-Wei Wang

Panagiotis (John) Makrygiannis

Feng Zhu

Haoling Jia

Product Development:

Grant Thomas

Jeremy Hansman

Amrinder Gill

FOR MORE INFORMATION

Wei Wu
AK Steel Corporation
313-317-1298
wei.wu@aksteel.com

Yu-Wei Wang
AK Steel Corporation
313-623-4942
yu-wei.wang@aksteel.com

GREAT DESIGNS IN STEEL

Presentations will be available for download on SMDI's website on Wednesday, May 22