



Application of Viscous Pressure Bulge (VPB) Test to Predict the Flow Stress of Sheet Materials under Biaxial Deformation Conditions

ERC
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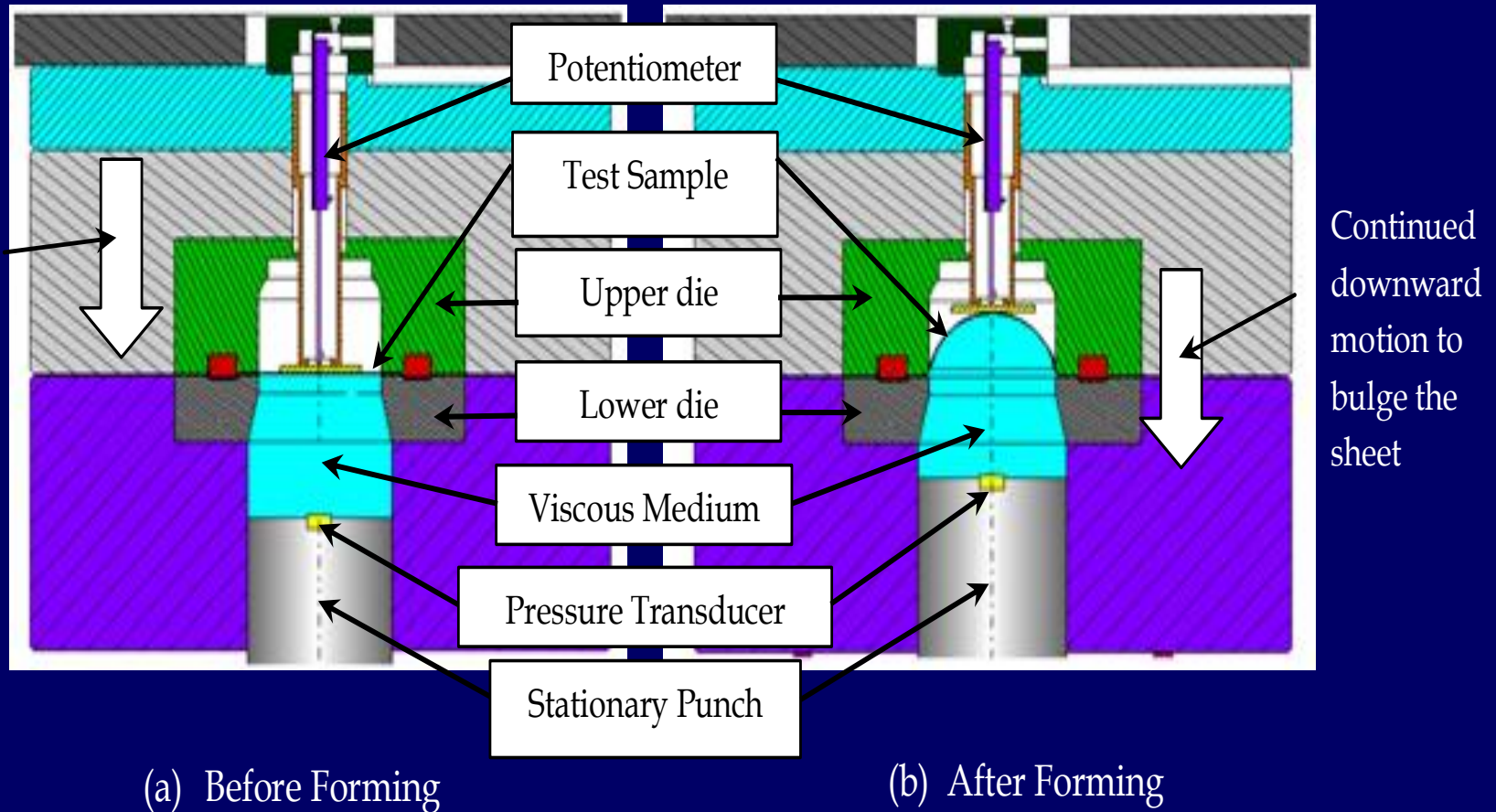
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www.ercnsm.org, www.cpforming.org

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Stamping Group

- Introduction
- Principles of Viscous Pressure Bulge (VPB) Test
- Methodology to Estimate Material Properties
- Objectives
- Procedure
- Results
- Evaluation of Formability using the VPB test
- Conclusions
- Acknowledgement
- Available Flow Stress data
- References

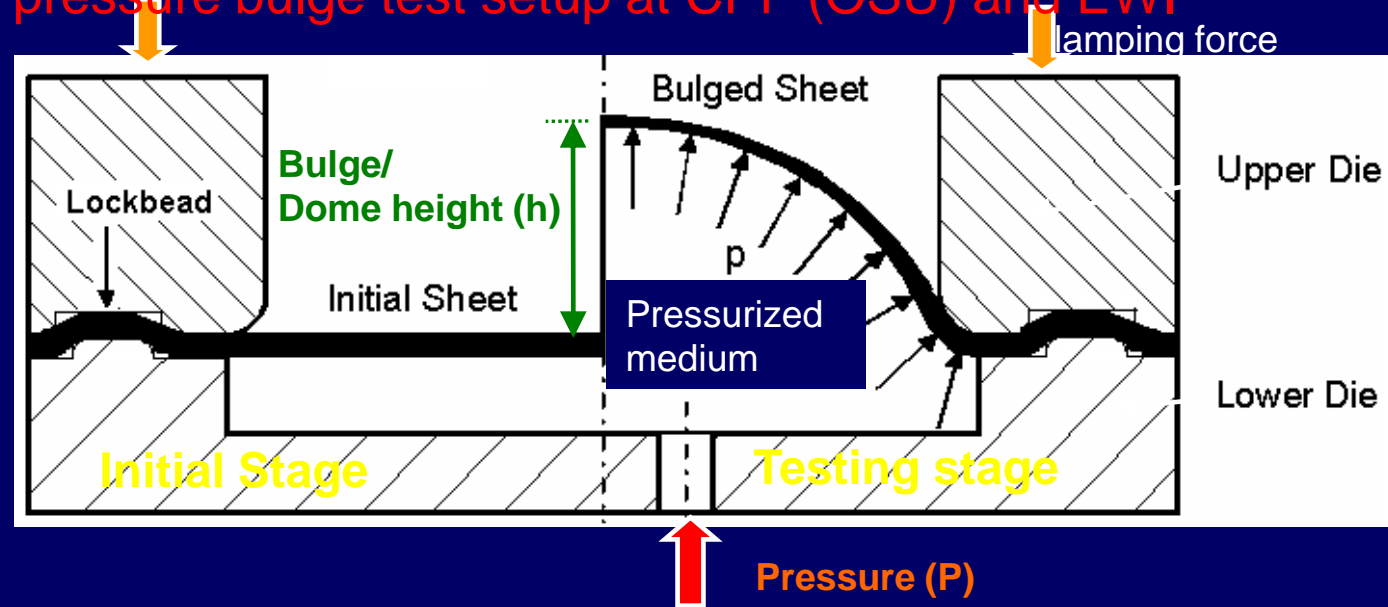
- AHSS and Al alloys are used increasingly in forming automotive structural parts because of safety and lightweight vehicle requirements.
- Some of these alloys have higher strength and low formability compare to conventional draw quality steels.
- One of the problems is the property variations in incoming materials which may not be determined by the tensile test.
- Tensile test is uniaxial and flow stress data is obtained to small strains, while the bulge test is biaxial and data is obtained to higher strains.



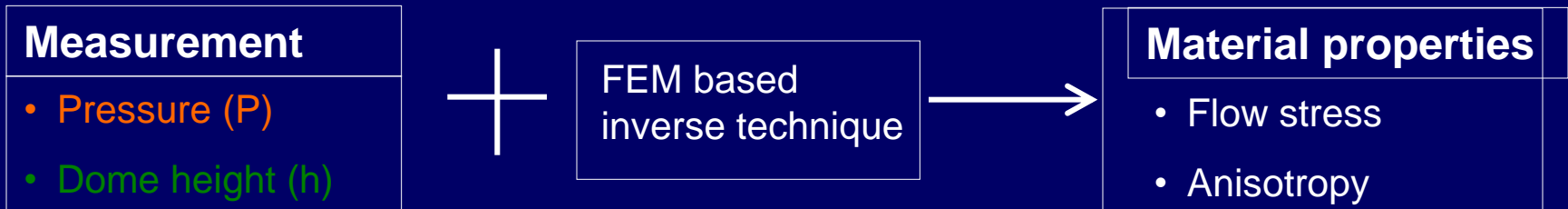
Viscous Pressure Bulge (VPB) test tooling

Schematic of viscous pressure bulge test setup at CPF (OSU) and EWI

- Die diameter = 4 inches (~ 100 mm)
- Die corner radius = 0.25 inch (~ 6 mm)

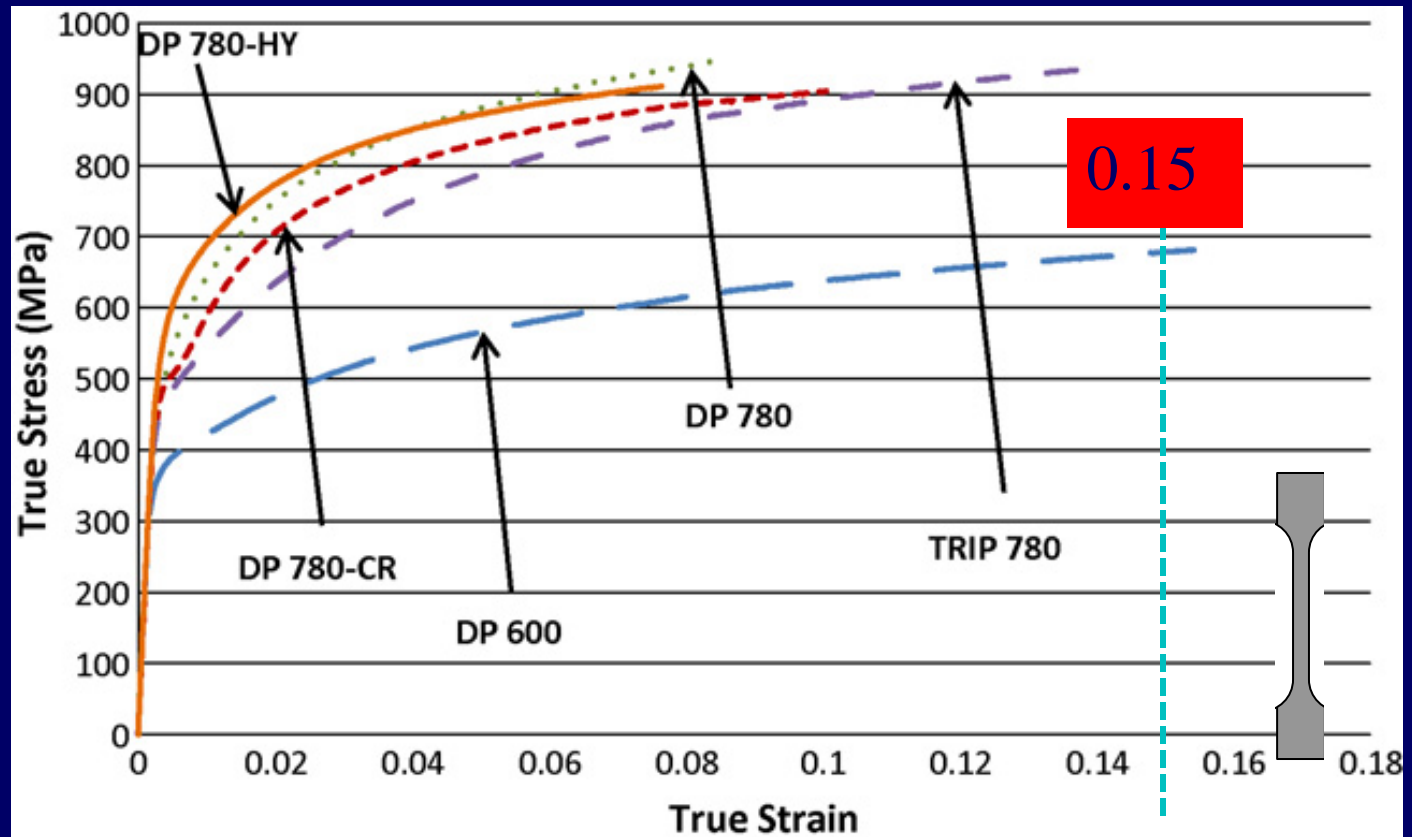


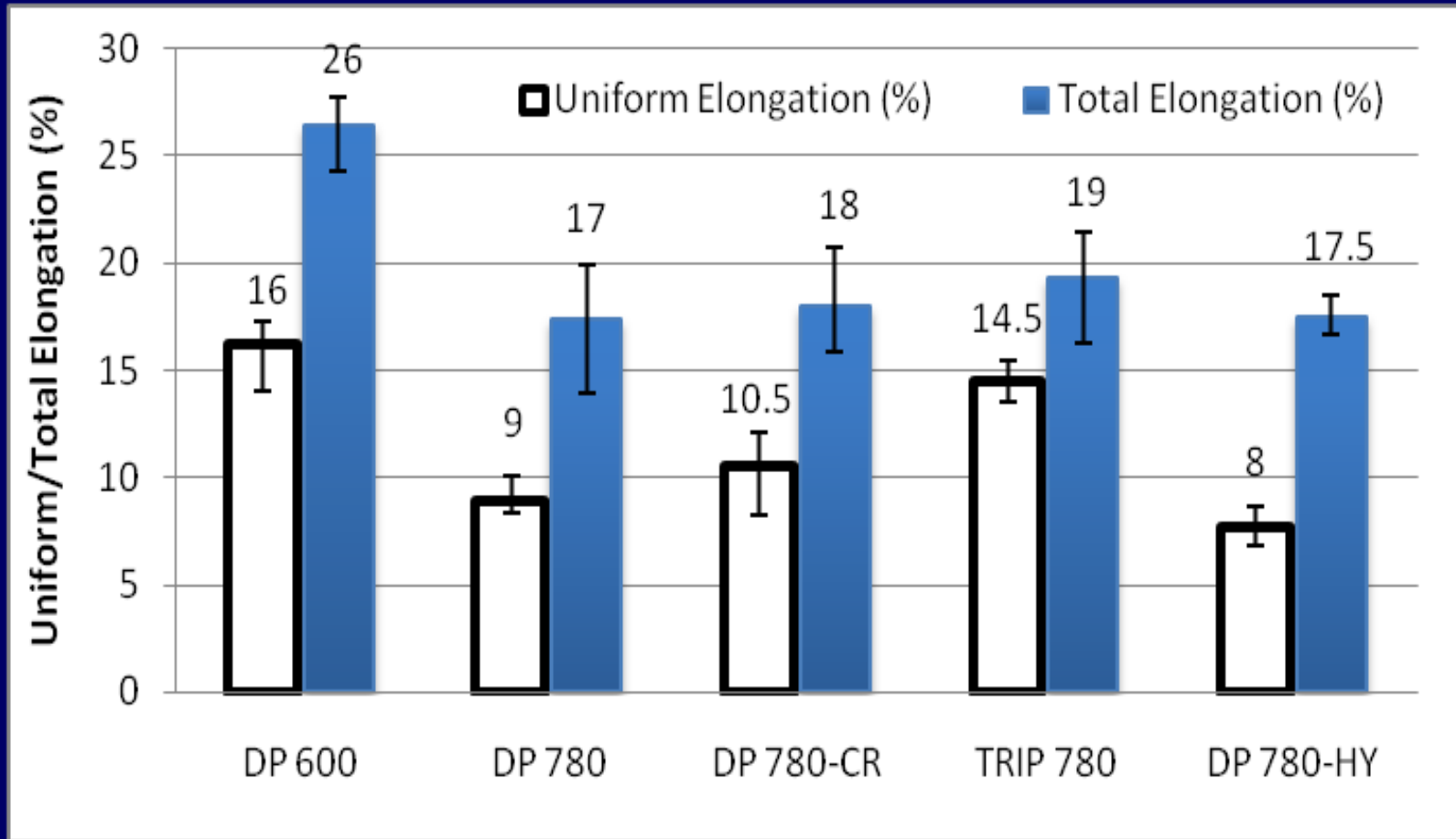
Methodology to estimate material properties from VPB test, developed at CPF (OSU)



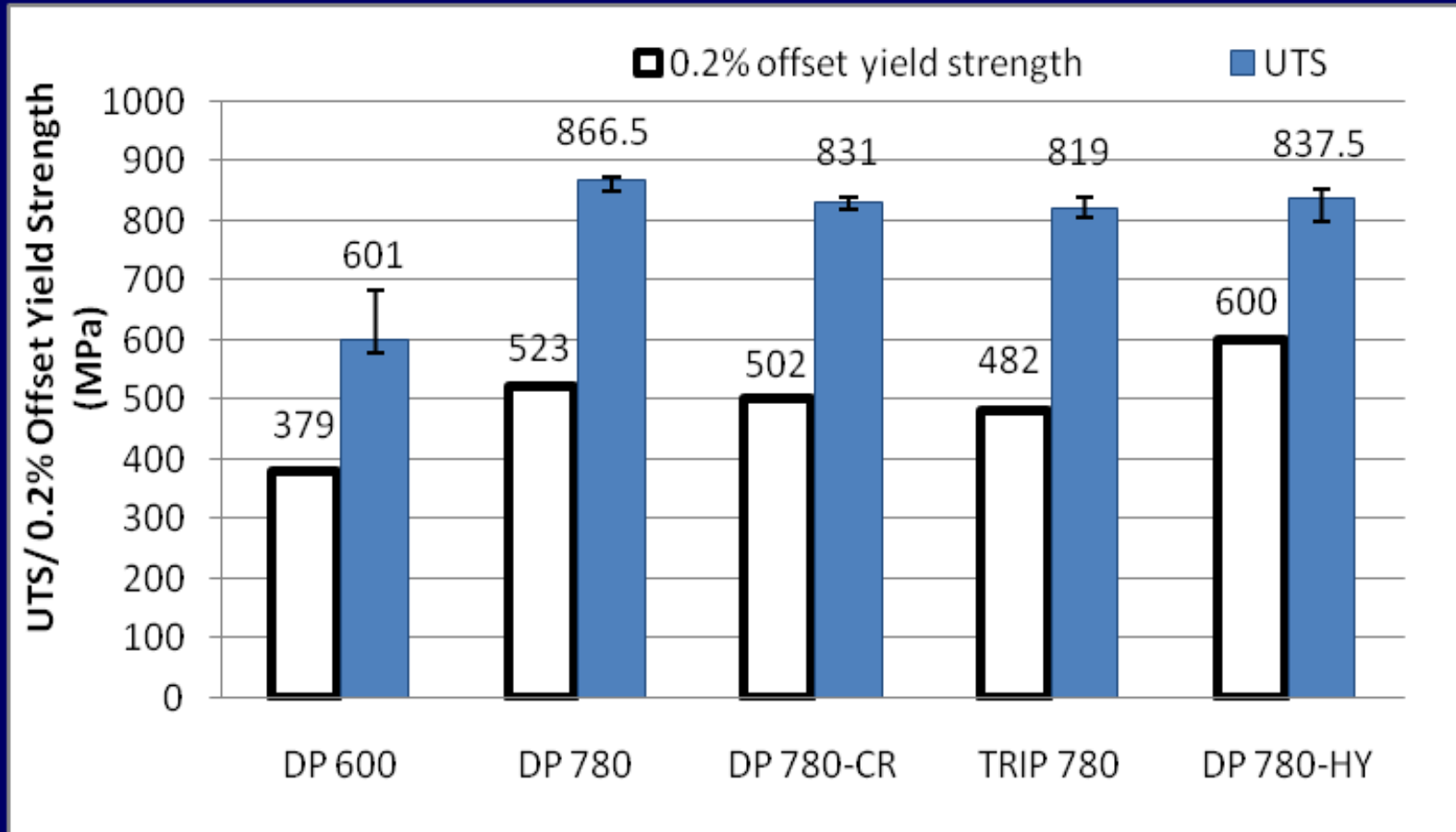
Determination of Flow Stress

Tensile Test





Uniform and Total Elongation of various AHSS grades (Gauge Length: 2 in)



UTS and 0.2% Offset Yield Strength of various AHSS grades

Bulge test samples

Before bursting

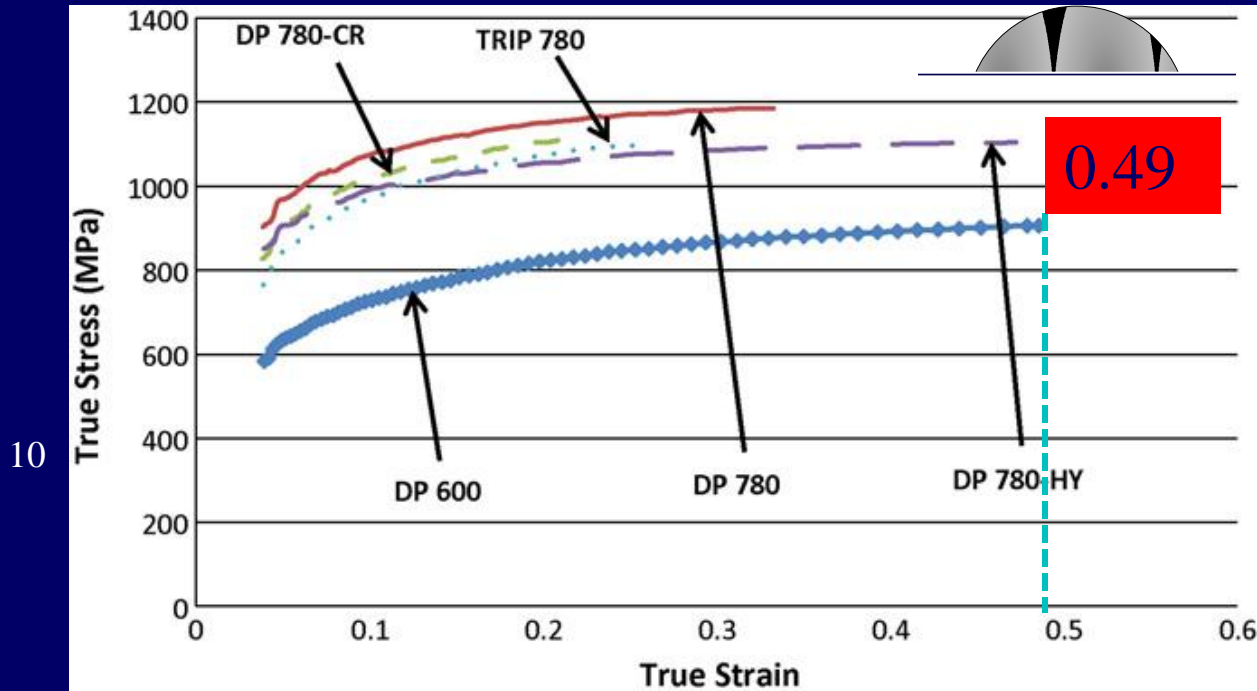


After bursting



Determination of Flow Stress

Bulge Test



Challenges:

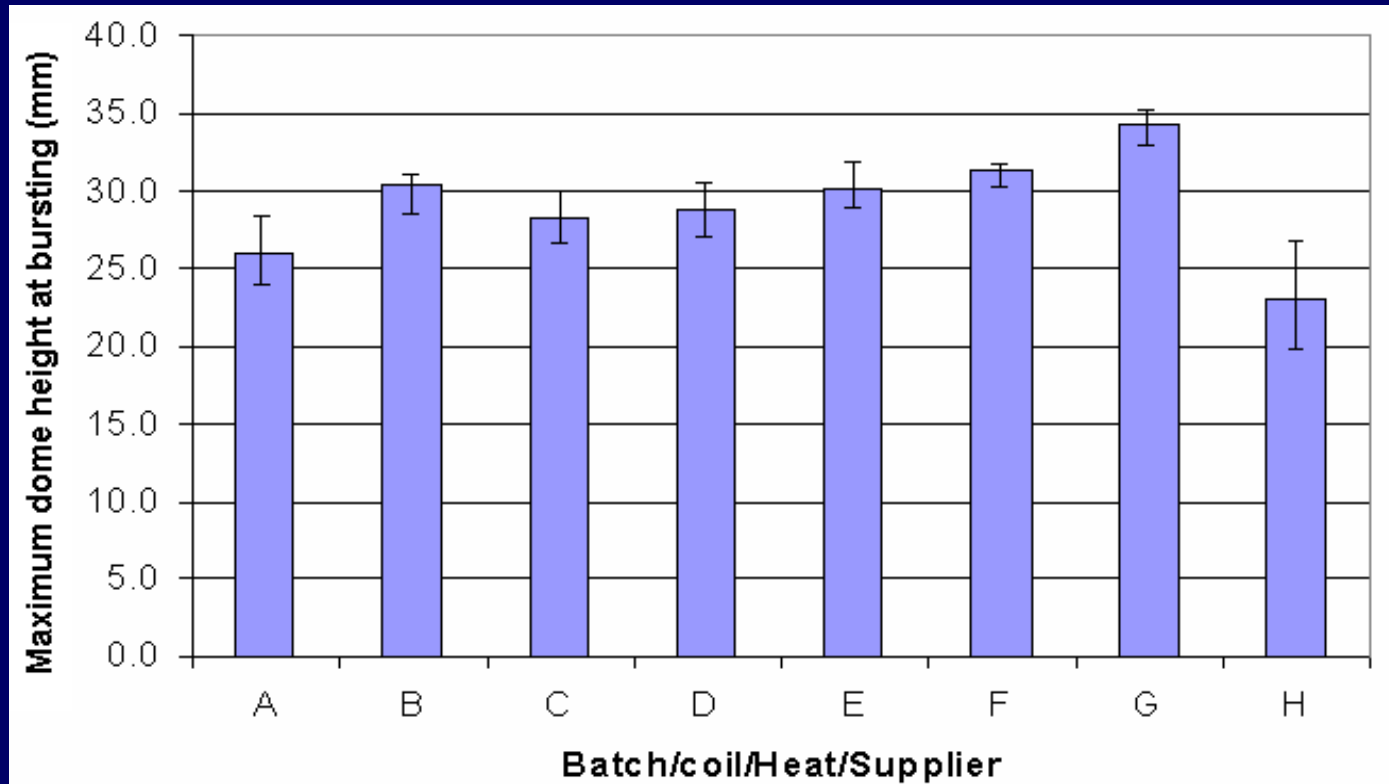
- 1) Tensile test gives a very limited information,
- 2) Bulge test gives more reliable strain-stress data.

Steels and Stainless Steels	
St 14	DP 780-CR
St 1403	DP 780-HY
AISI 1018	Bare DP 980 Y-type X
AKDQ 1050	Bare DP 780 T-Si type GA DP 780 T- AI Type
DR 120	GA DP 780 Y-type U
DDS	GA DP 780 Y-type V
BH 210	DQS-270F GA-Phosphate coated
HSS	DQS-270D GA-Phosphate coated
DP500	SS 201
DP 590	SS 301
DP 600	SS 304
DP 780	SS 409
TRIP 780	AMS 5504
DP 980	

Aluminum and Magnesium Alloys
AA 6111
AA 5754-O
AA 5182-O
X626 -T4P
AZ31B
AZ31B-O

Materials Tested at EWI-FC
AA-X620
270E
DP 980
TRIP 980
TWIP 980
TRIP 1180

Graph shows dome height comparison for **SS409** sheet material from eight different batches/coils [10 samples per batch]



Highest formability → G , Most consistent → F

Lowest formability and inconsistent → H

- **Strain values** obtained in the VPB test is **higher** than values obtained in the tensile test. Thus, **VPB test is more suitable** for providing **flow stress input to Finite Element Analysis (FEA)**.
- Some materials **may behave differently** under different states of state. VPB is closer to actual stamping operations than the uniaxial tensile test
- For some materials, **correcting** the flow stress obtained from the VPB test **for anisotropy** may be important.
- **Dome Height at bursting** in the VPB test is a **quick and reliable** test to check the **quality of incoming raw materials** (different batches, suppliers, ...) under biaxial state of stress.
- Large amount of **data may be lost (AHSS) when ending the VPB before bursting**. Thus, it is desirable to end the test as close, to the burst pressure, as possible.