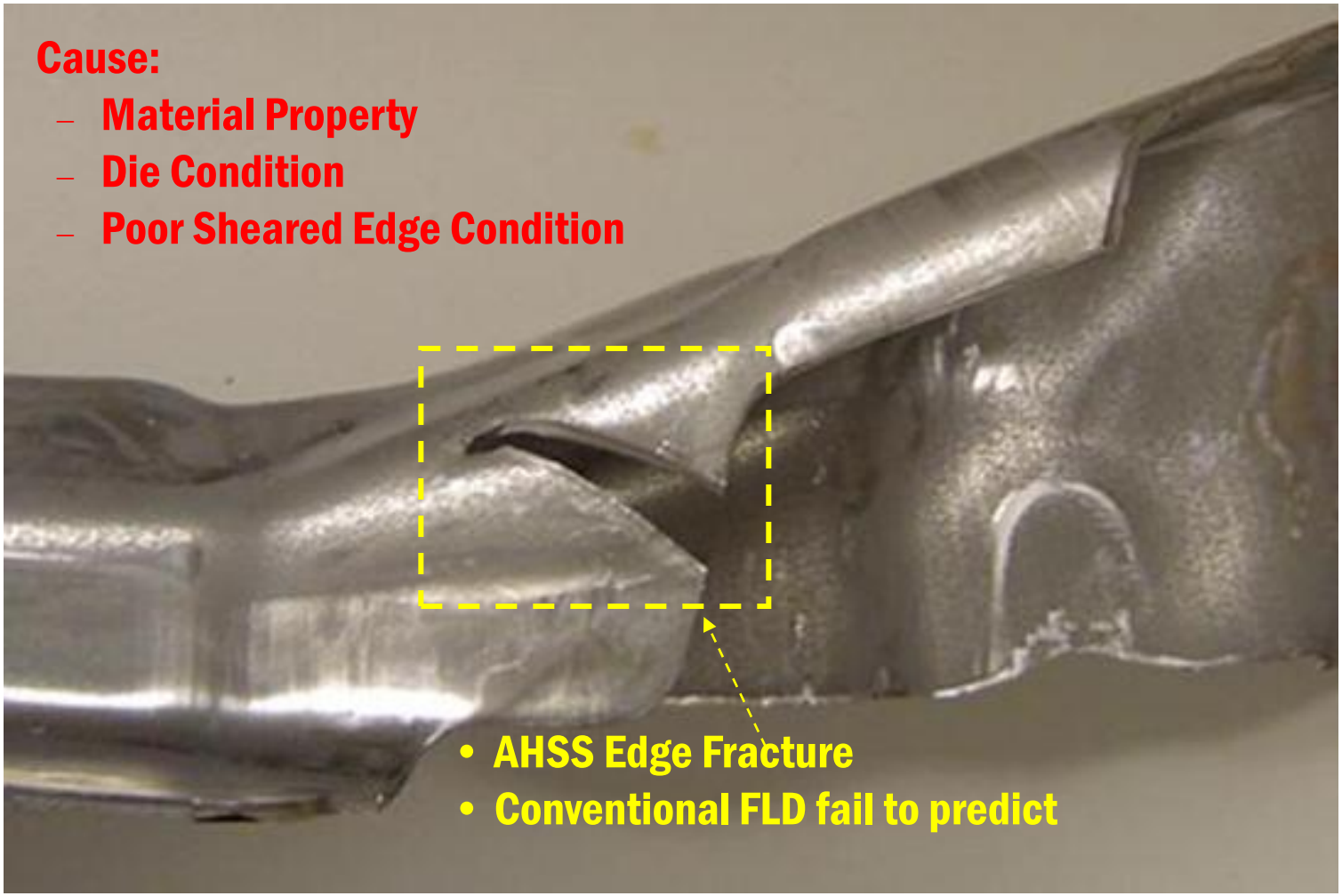
AN INNOVATIVE SHEARING PROCESS FOR AHSS EDGE STRETCHABILITY IMPROVEMENTS

Mike Shih
United States Steel Corporation

AHSS Edge Fracture

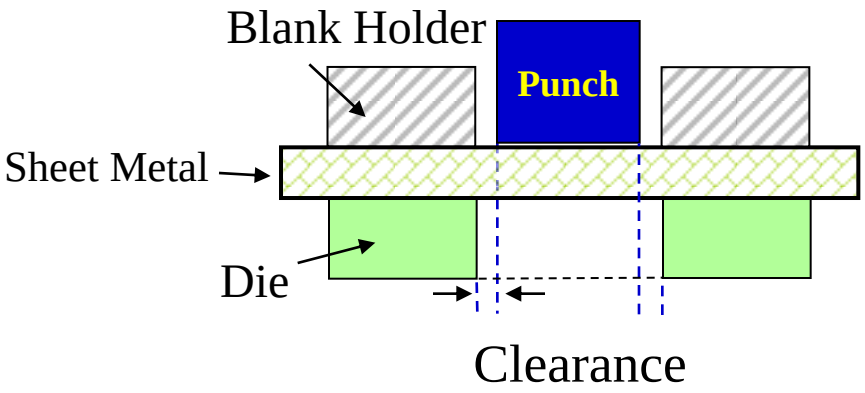


Outline

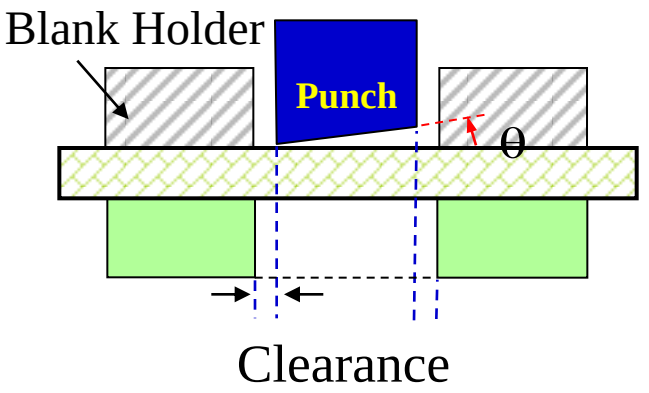
- Introduction
- Optimized Bevel Shear Hole Piercing
  - Hole Expansion Test
  - Evaluation of the Sheared Edge
- Developmental Straight Edge Shearing
  - Adjustable Shearing Device
  - Sheared Edge Tension Test
  - Sheared Edge Dome Test
  - Sheared Edge Limit Strain
- Conclusions

Shearing Processes

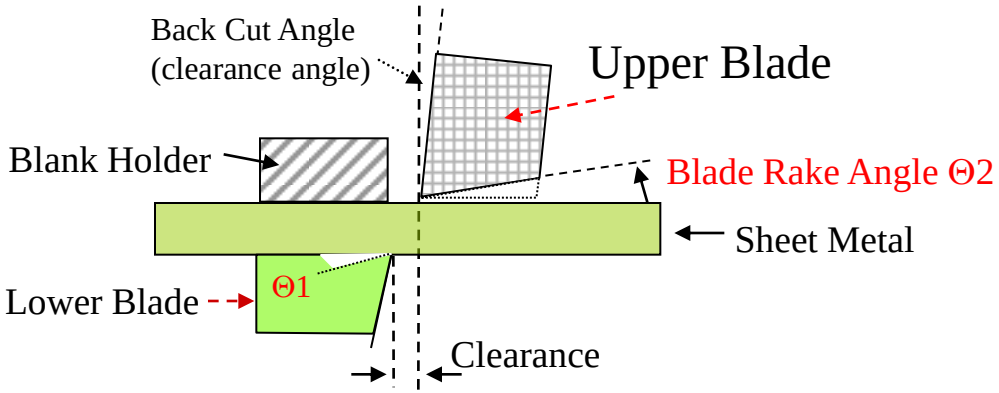
Hole Punching (Hole piercing die)

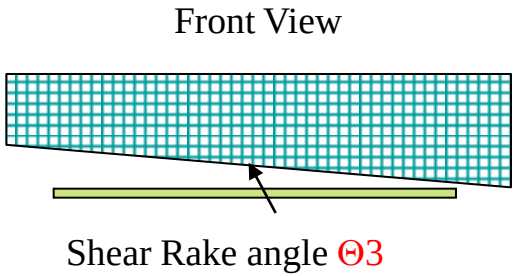


Bevel Shear

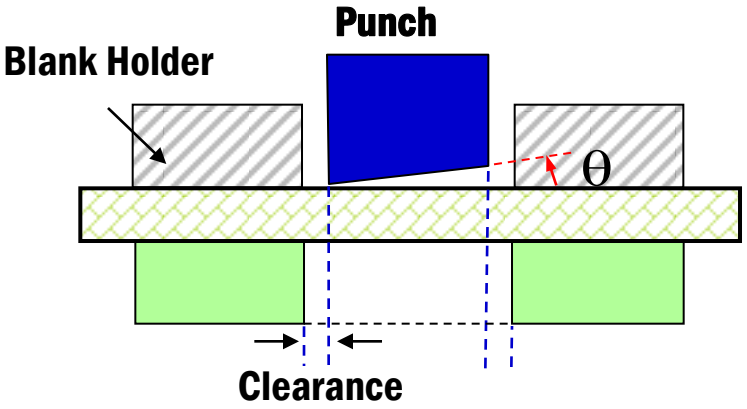


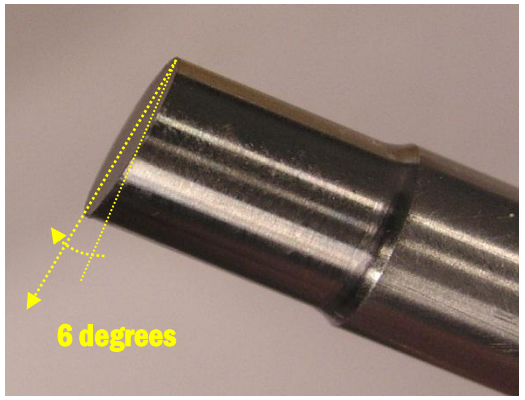
Straight Edge Shearing (Blanking die , Trimming die)

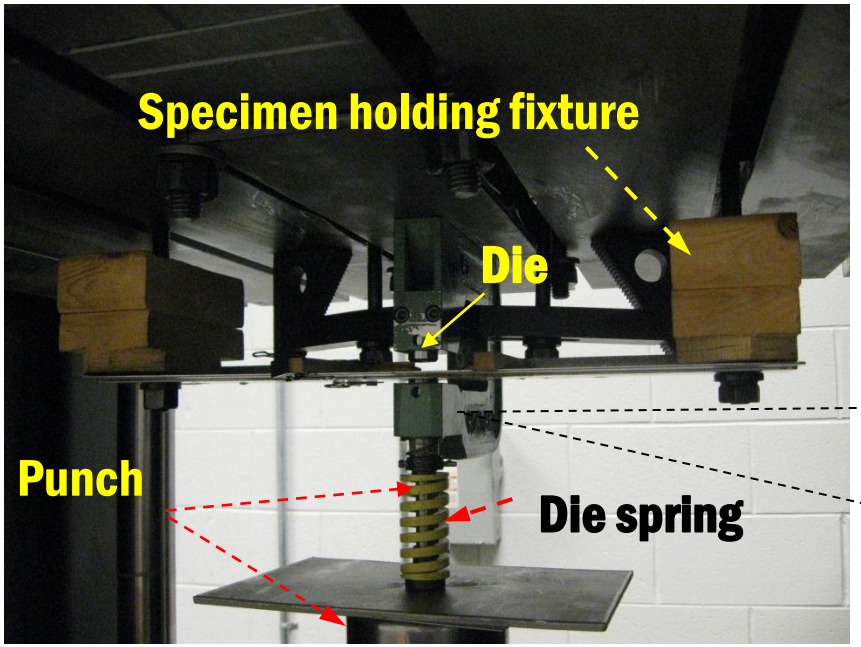


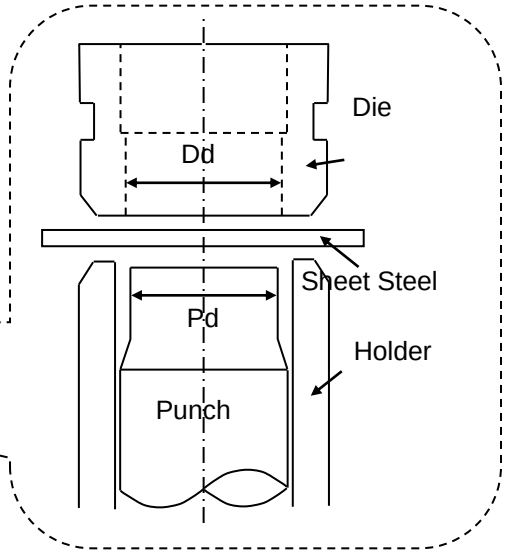


Optimized Bevel Shear Hole Piercing

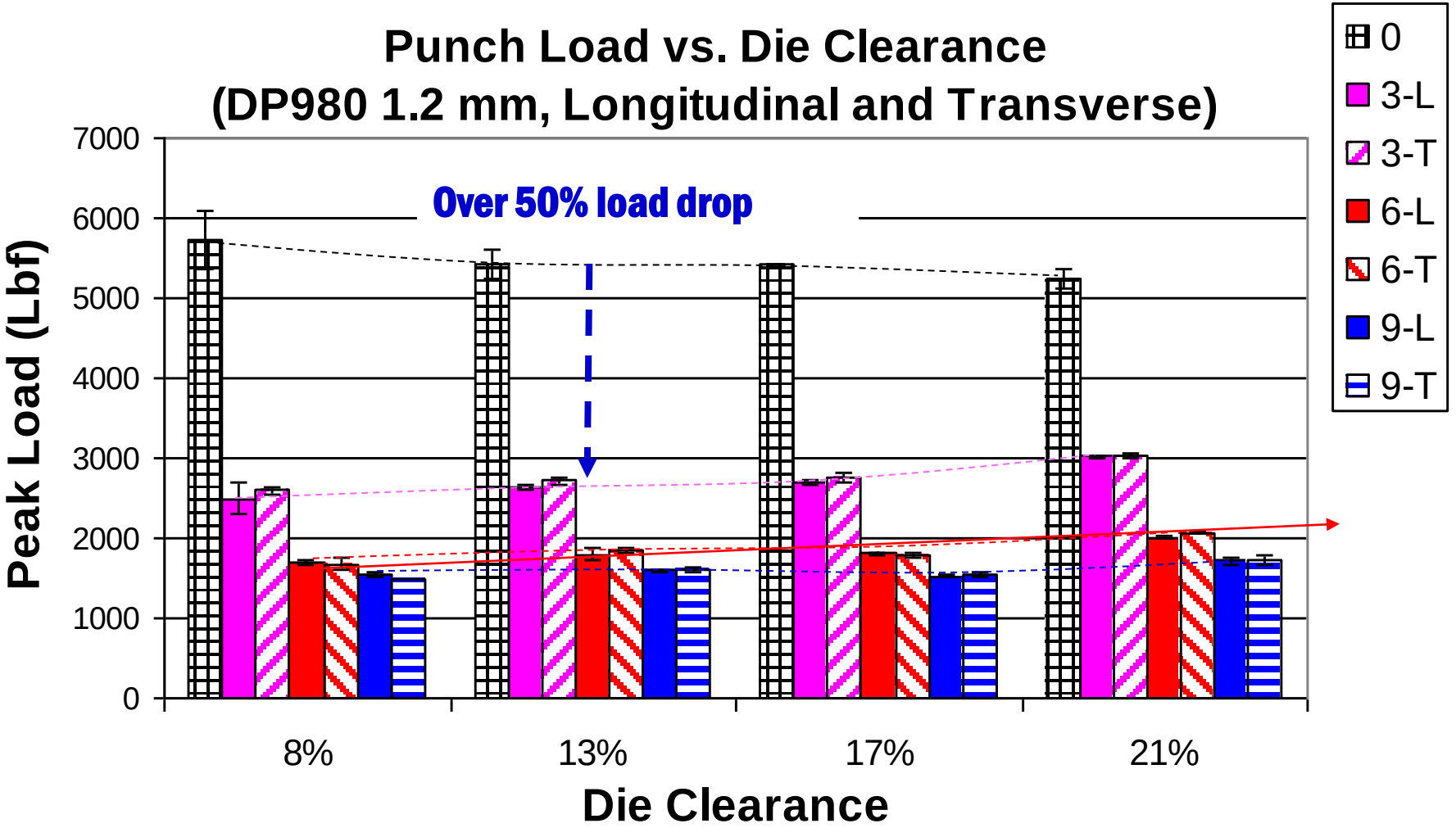




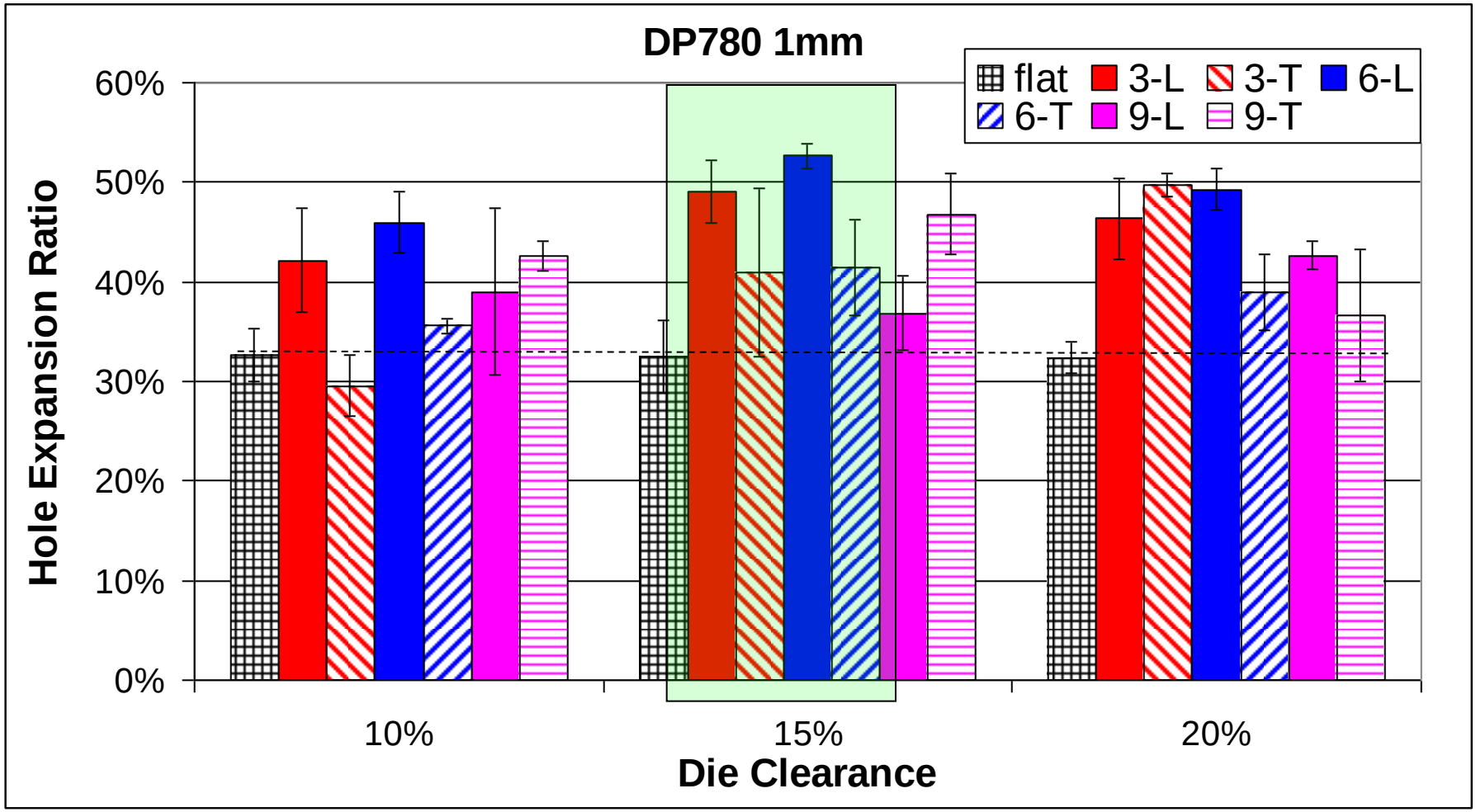




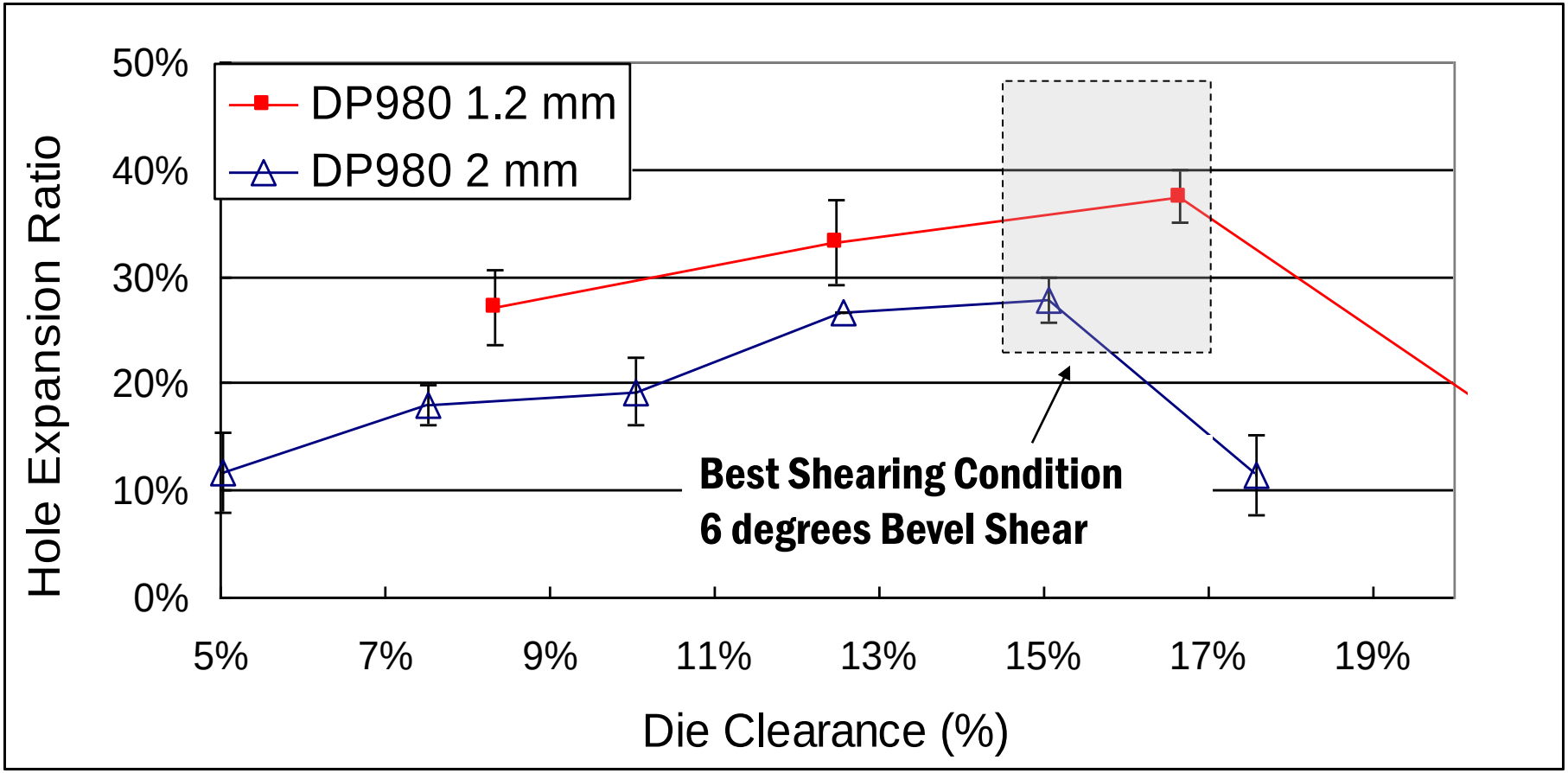
Shear Load


Punch Load vs. Die Clearance
(DP980 1.2 mm, Longitudinal and Transverse)
Over 50% load drop
Peak Load (Lbf)
7000
6000
5000
4000
3000
2000
1000
0
8%
13%
17%
21%
Die Clearance
0
3-L
3-T
6-L
6-T
9-L
9-T

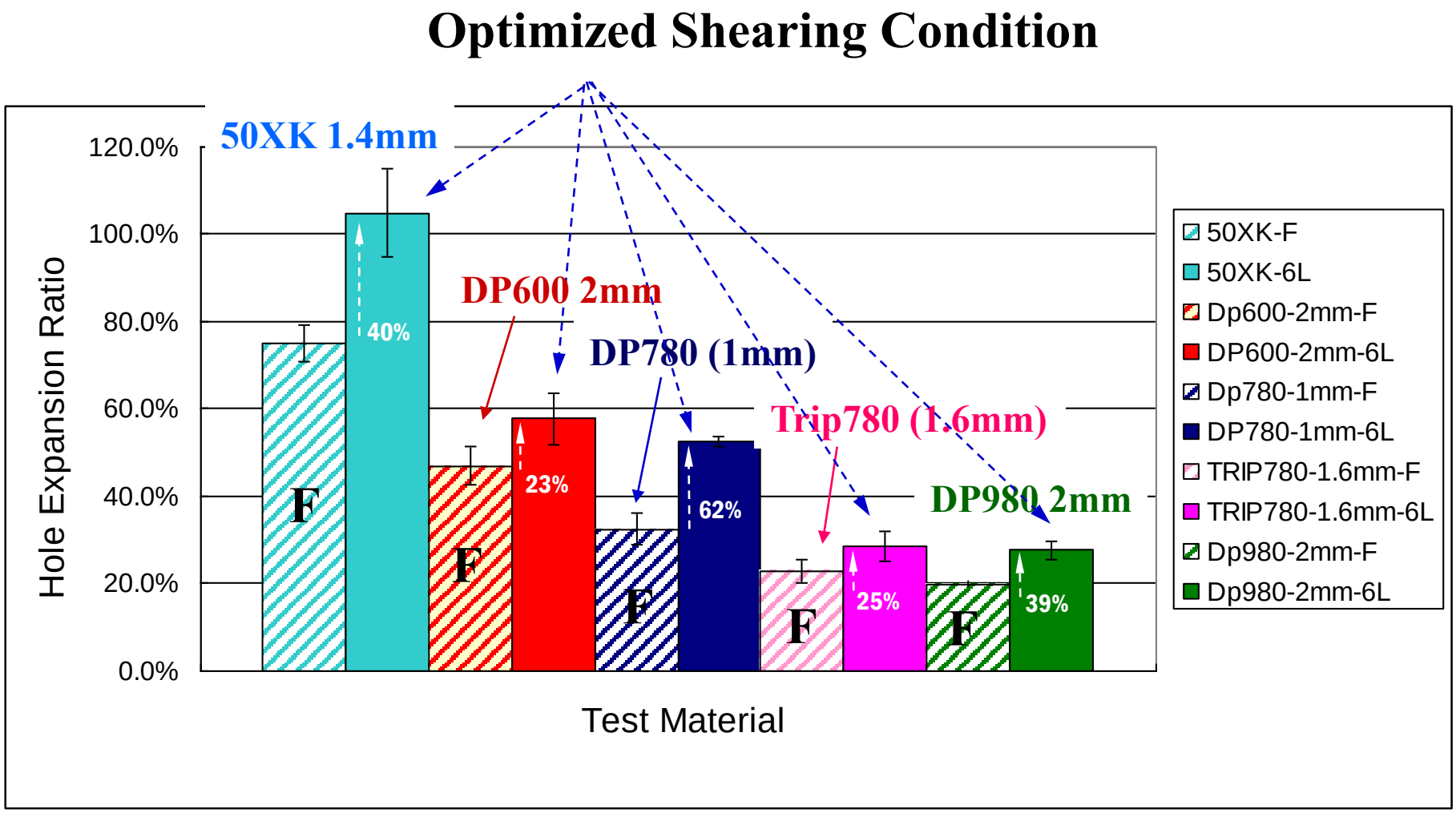
Hole Expansion Test



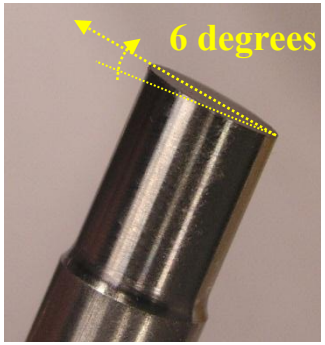
Hole Expansion Test - DP980



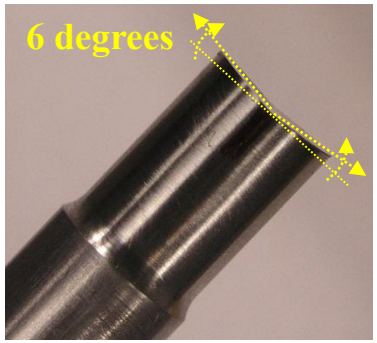
Optimized Shearing Condition
- 6 Degrees, 15% DC, Longitudinal Shearing



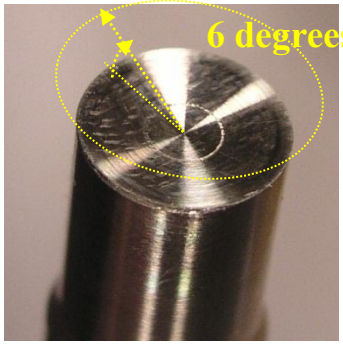
Concept Punch



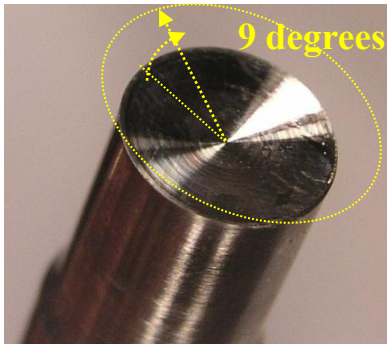
Optimized : 6L



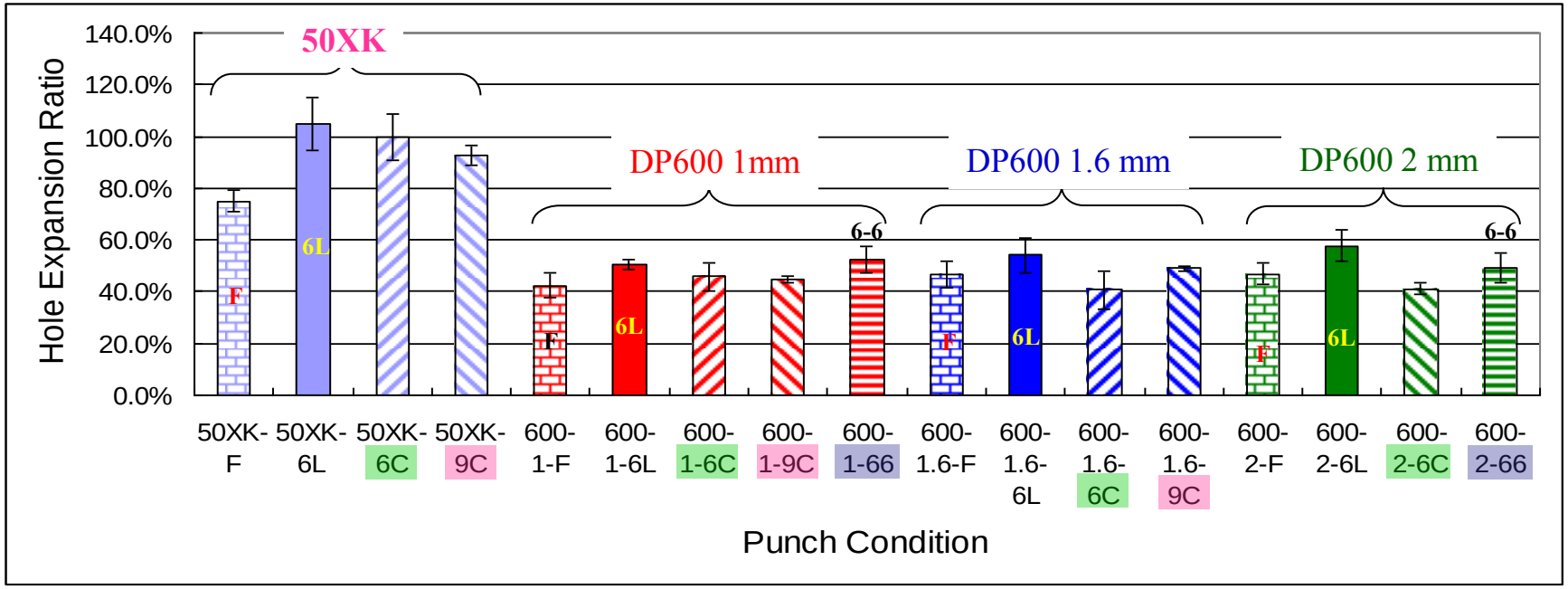
Concept 1 : 6-6



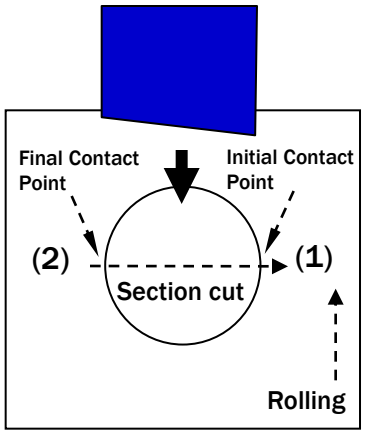
Concept 2 : 6C

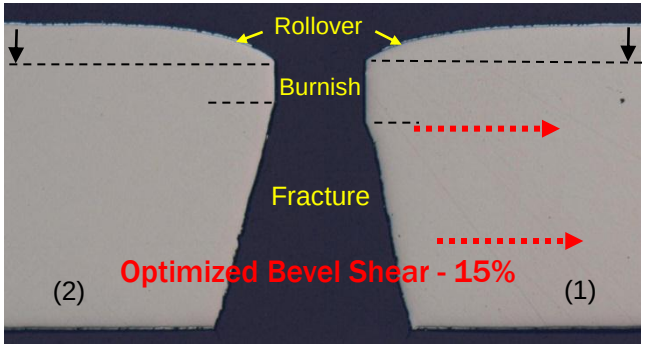


Concept 2 : 9C

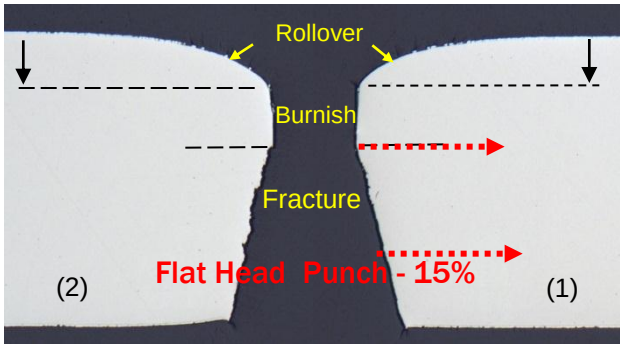


Evaluation of the Sheared Edge

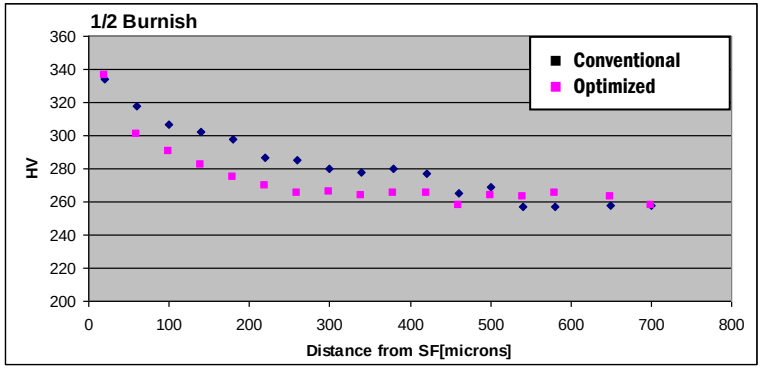


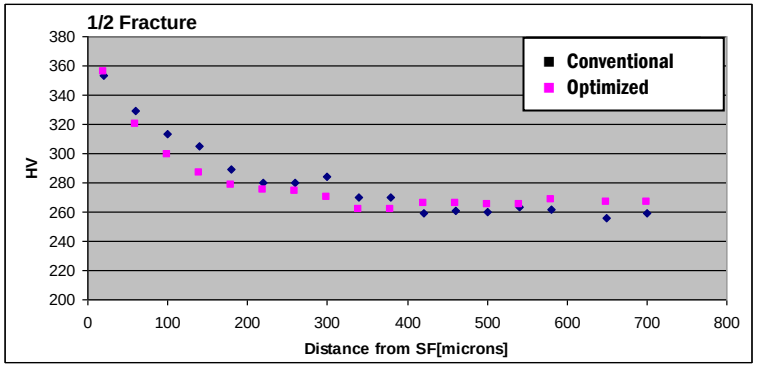


Bevel Shear	Rollover (%)	Burnish (%)	Fracture (%)	HER (%)
Side 1	12	21	68	53
Side 2	13	13	74	



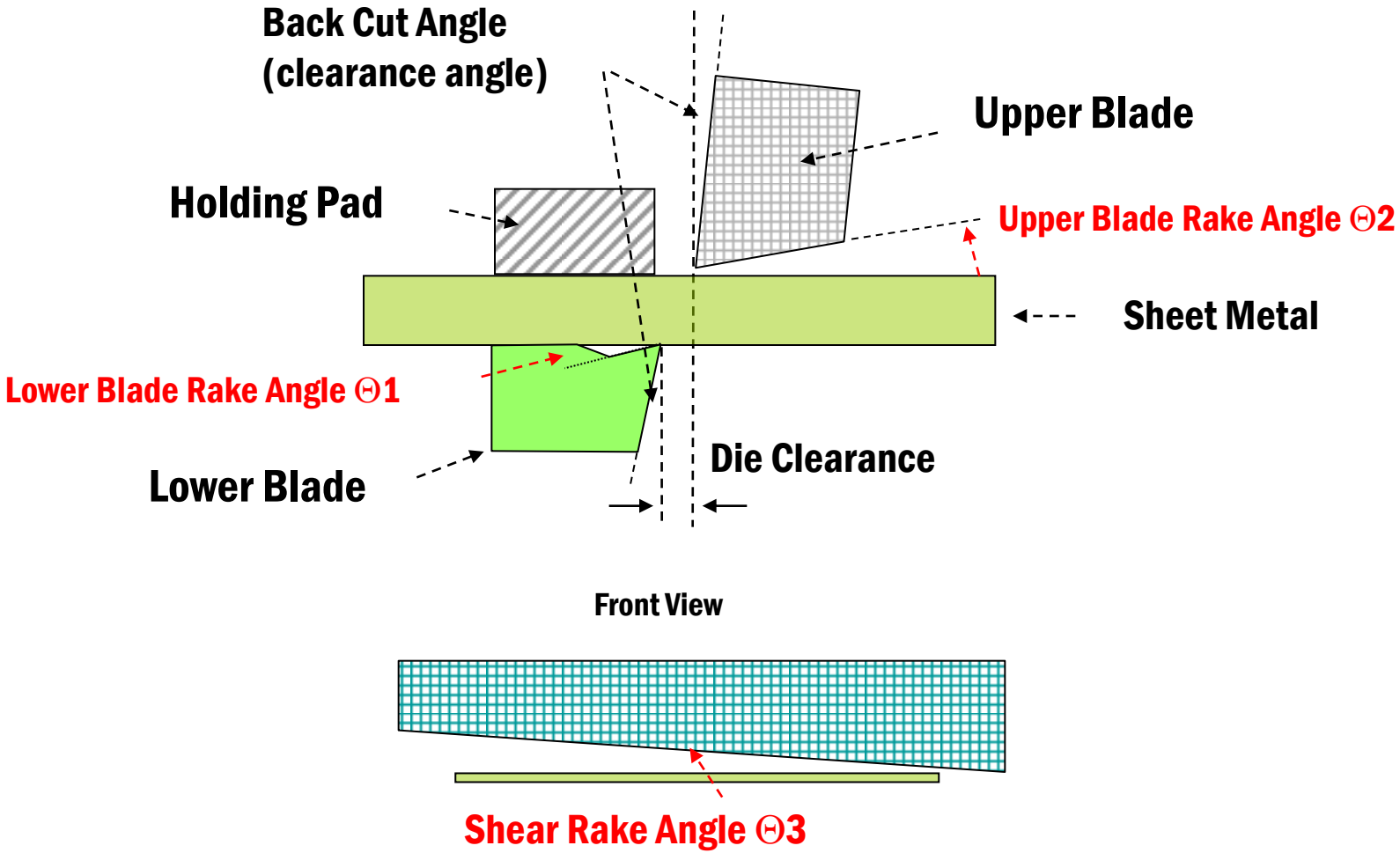
Flat Head	Rollover (%)	Burnish (%)	Fracture (%)	HER (%)
Side 1	16	21	63	32
Side 2	16	21	63	



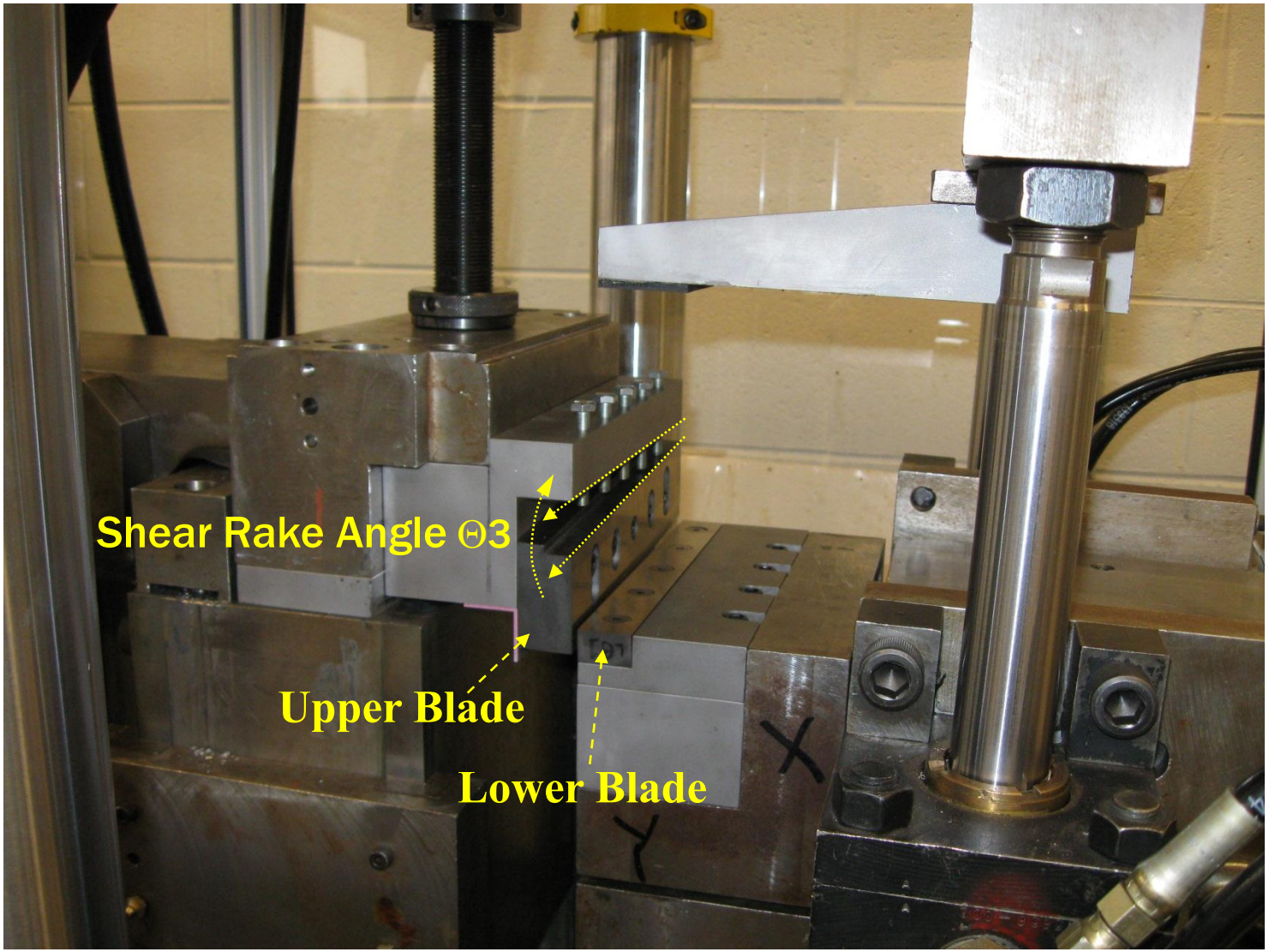


Microhardness profile of test DP780 , Chirlac, C. et al. 2011, MS&T 2011

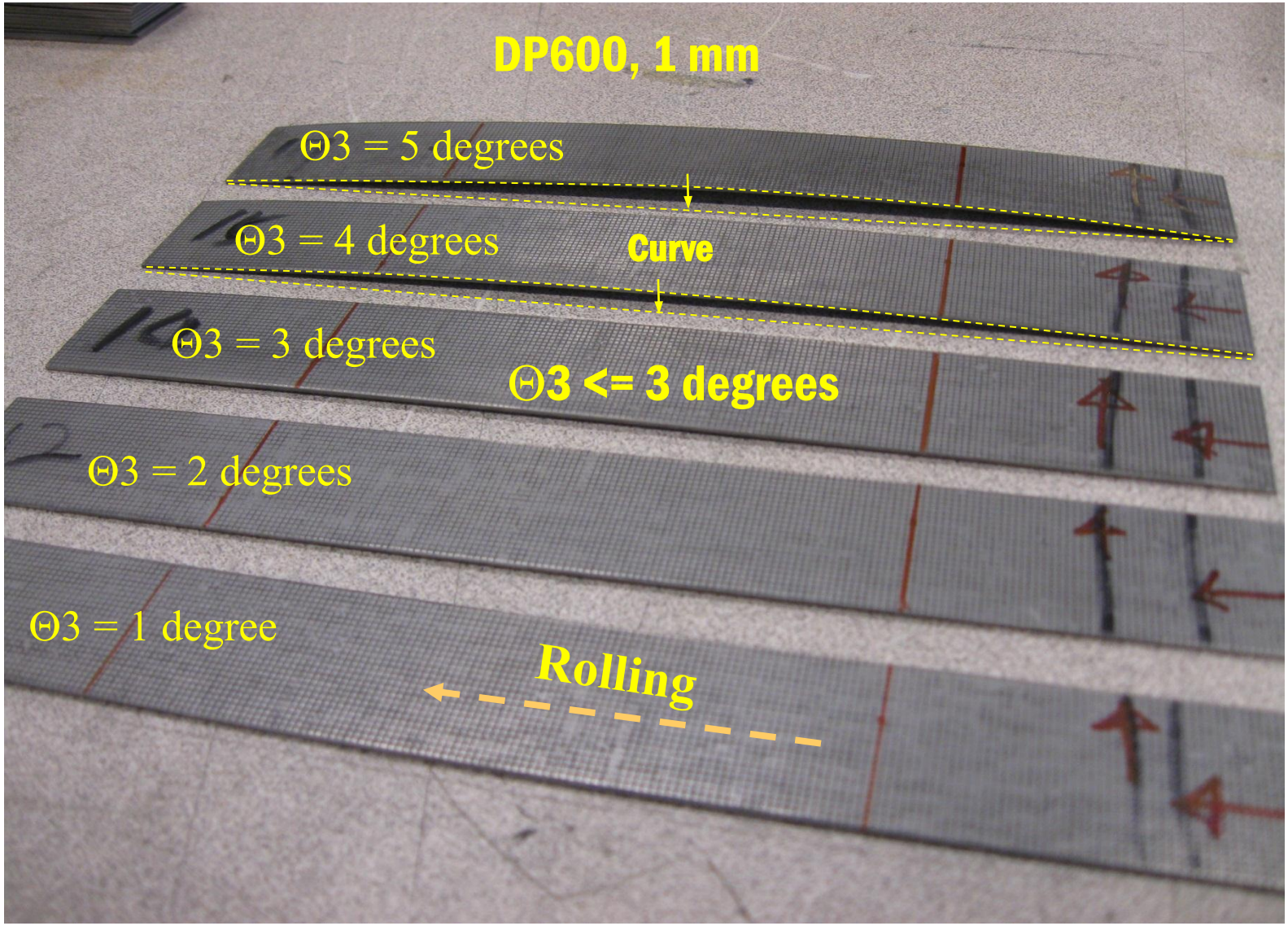
Developmental Straight Edge Shearing



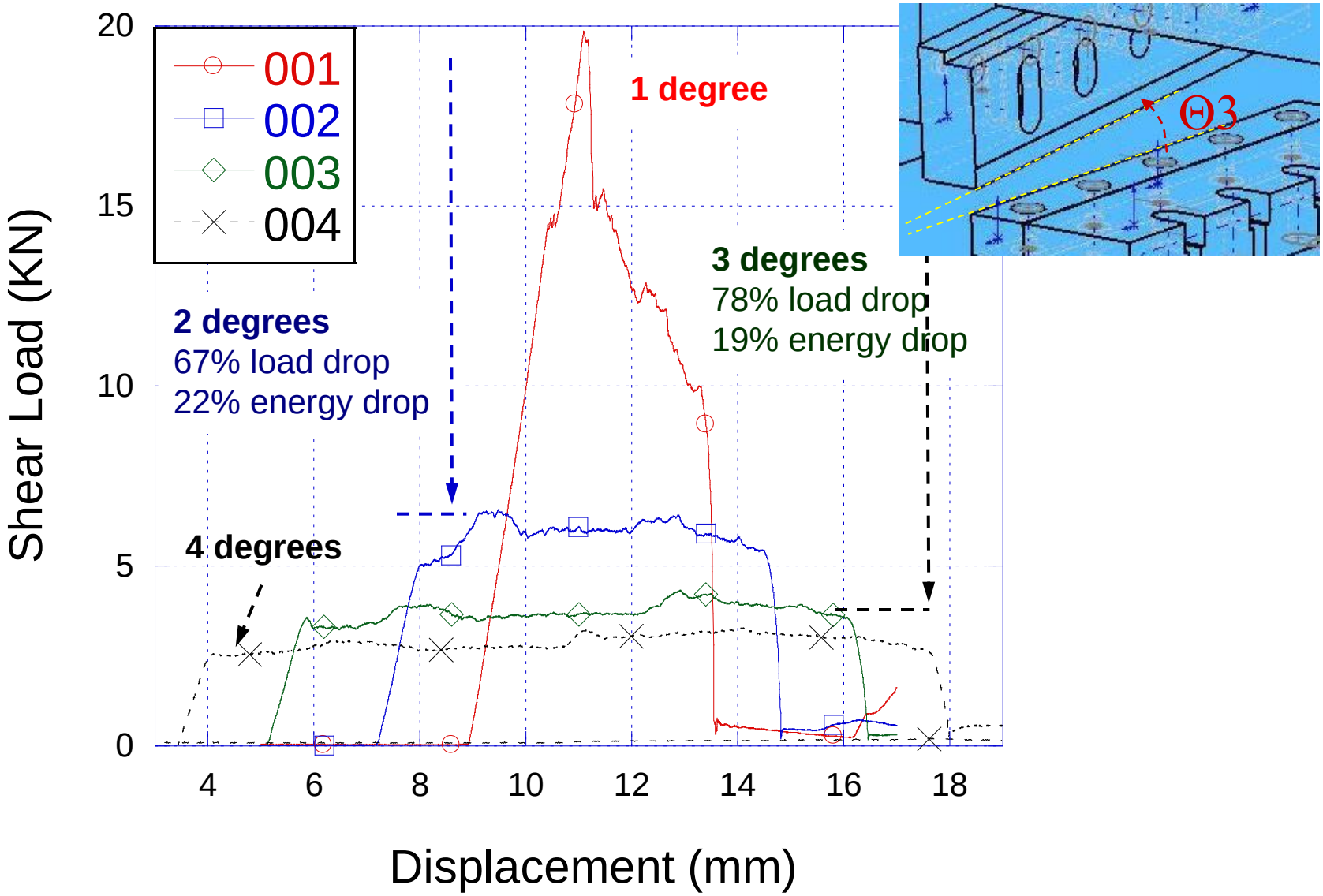
Adjustable Straight Edge Shearing Device



Effect of the Shear Rake Angle

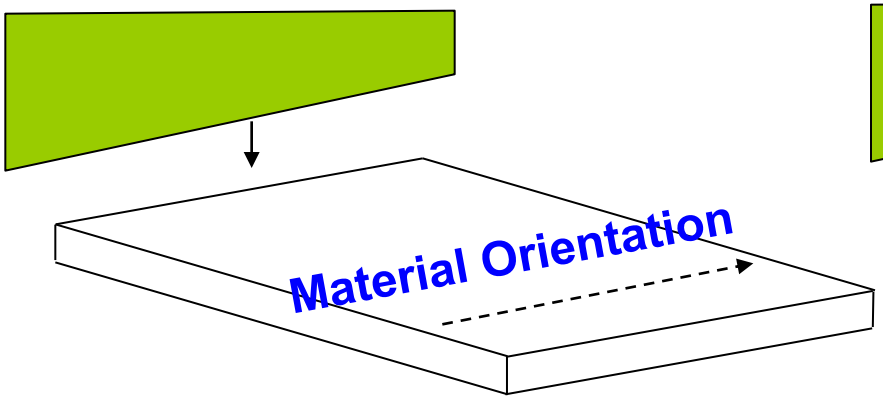


Shear Load Between Different Shear Rake Angles Θ3



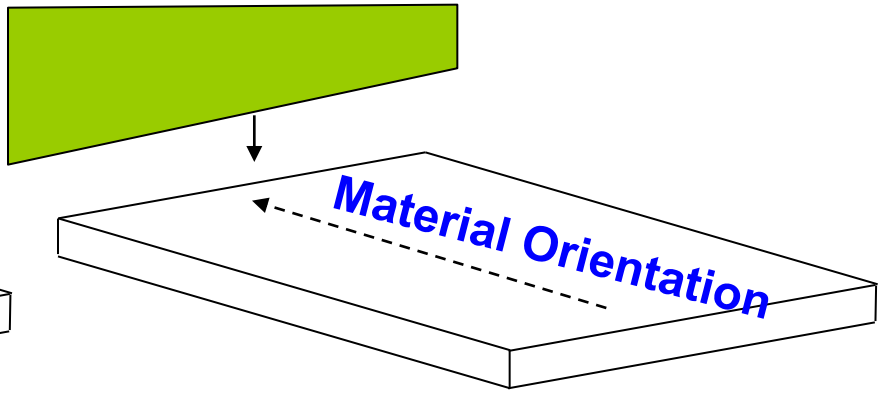
Specimen Shearing Direction

Longitudinal Shearing



Sheet Metal

Transverse Shearing

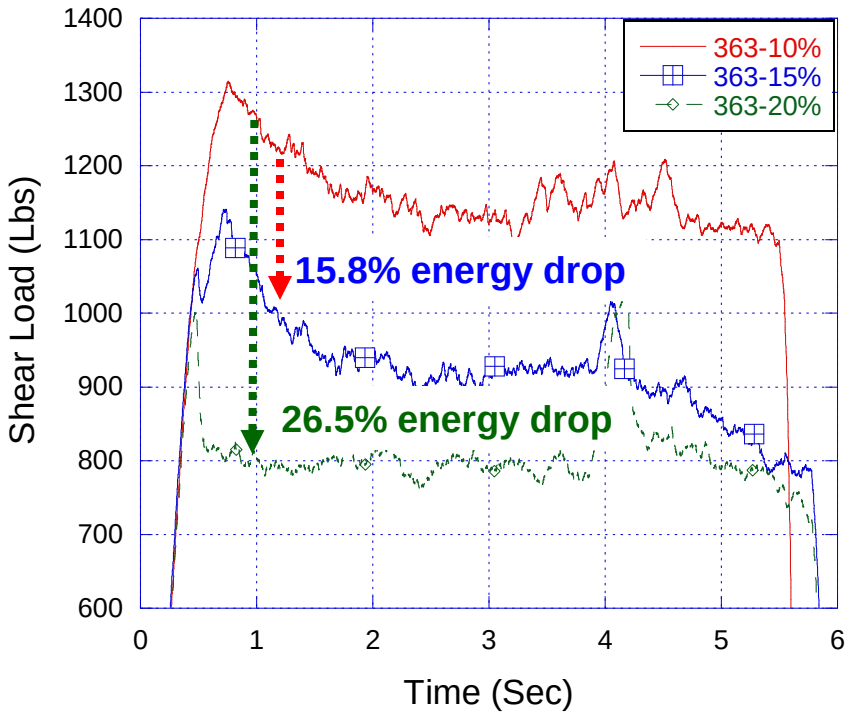


Sheet Metal

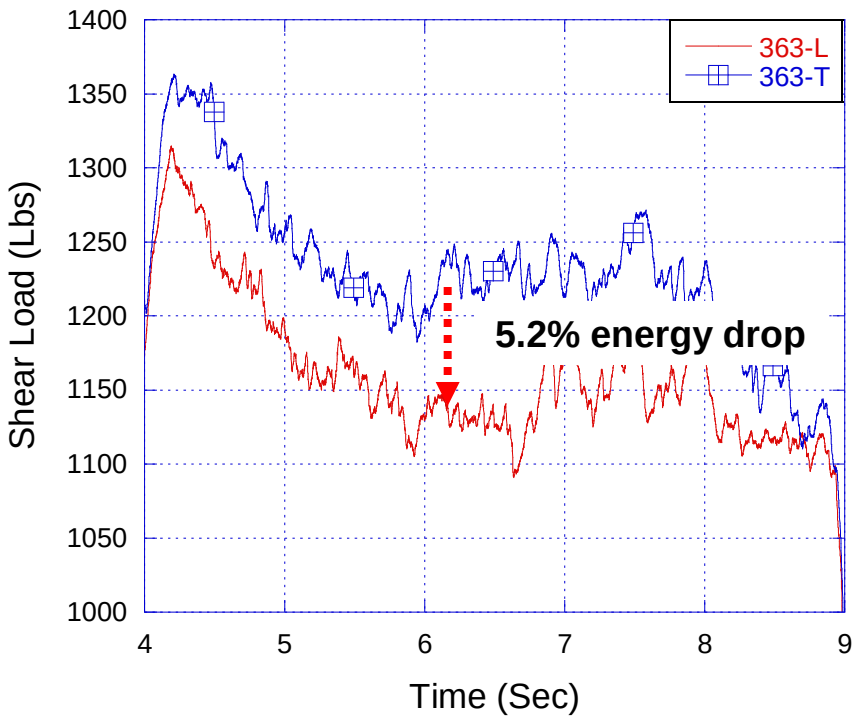
Comparison of the Shear Load

$(\theta_1, \theta_2, \theta_3) \rightarrow \theta_1$: Lower Blade Rake Angle θ_2 : Upper Blade Rake Angle θ_3 : Shear Rake Angle

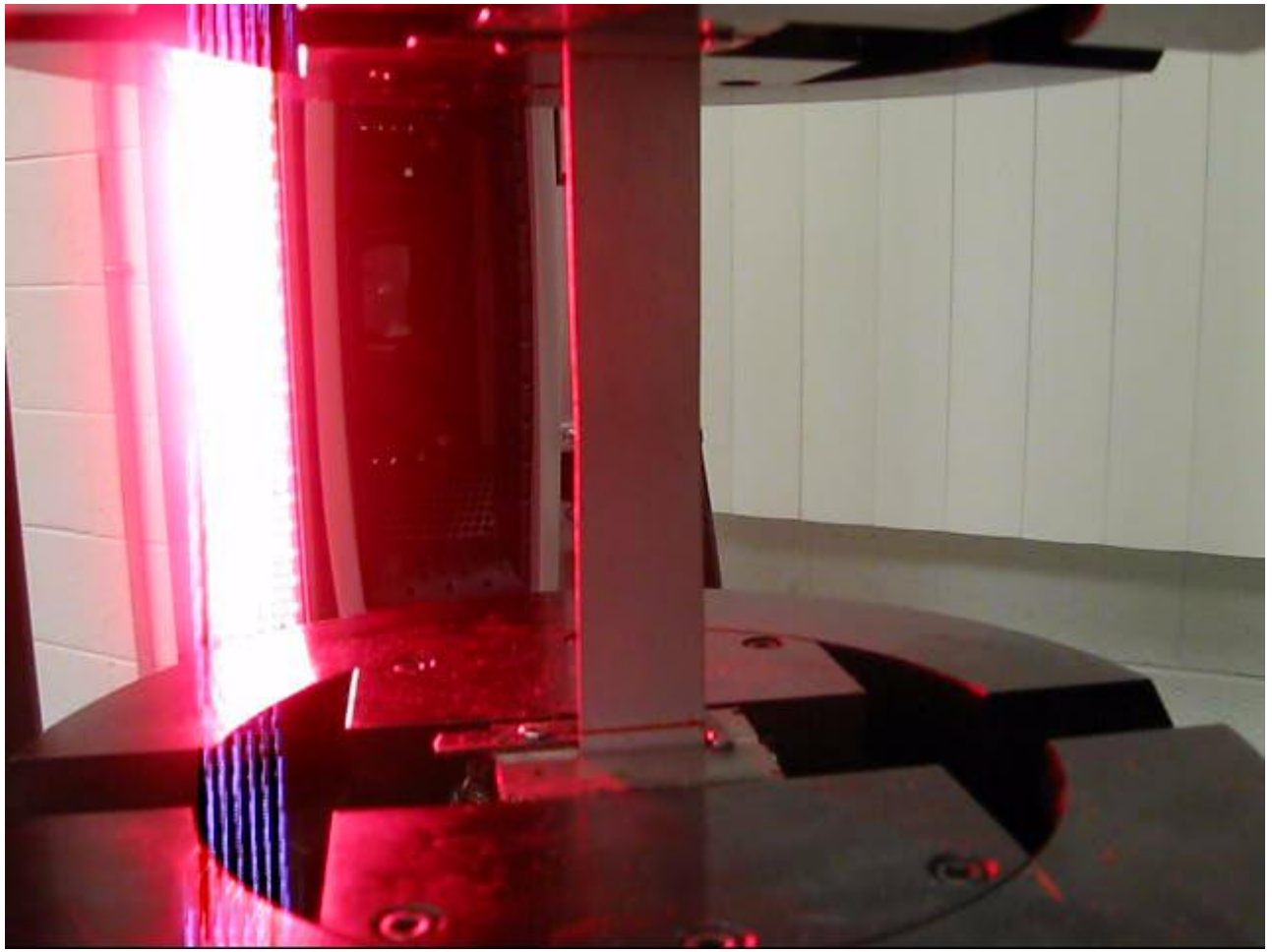
Different Die Clearance



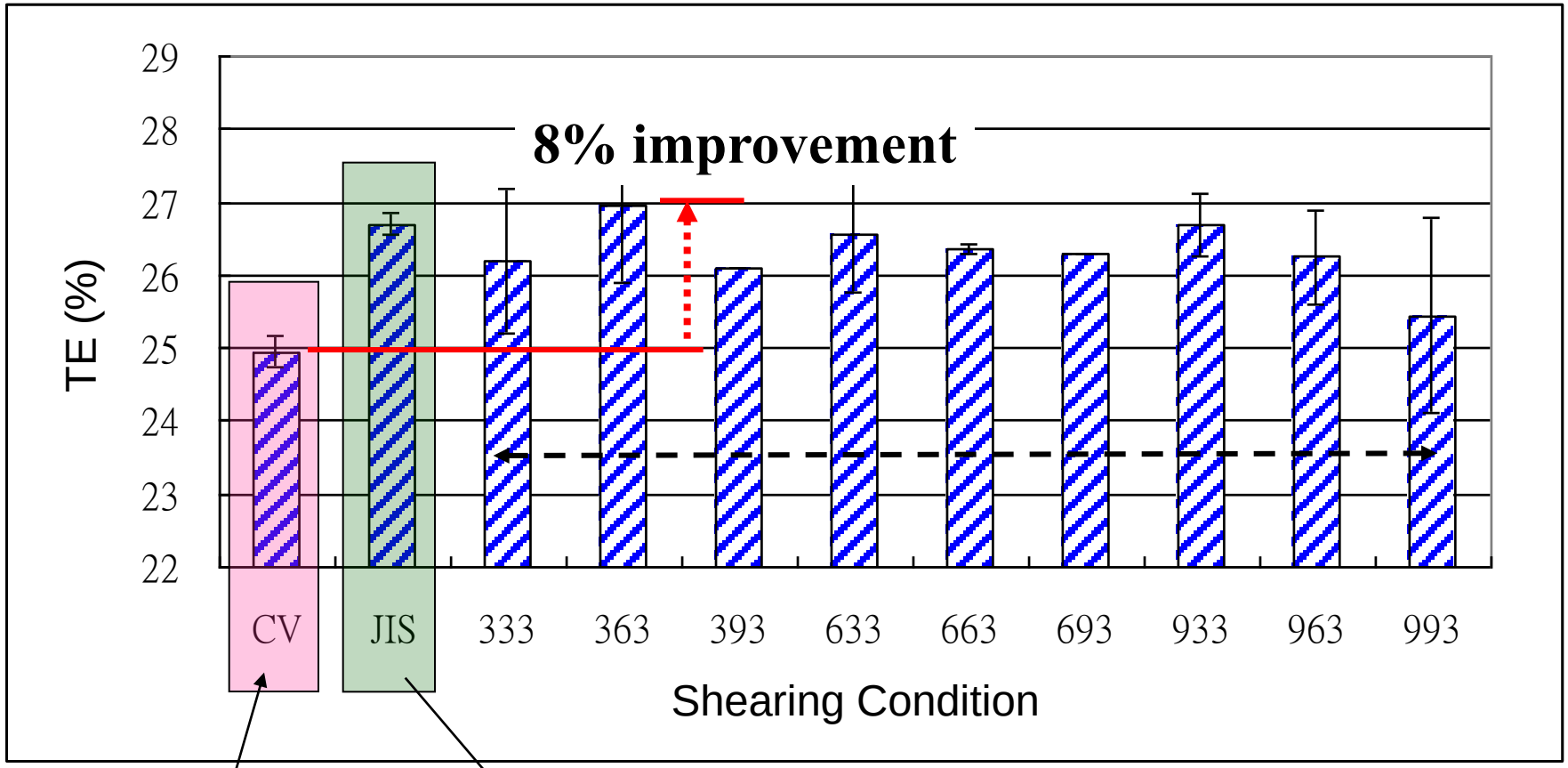
Different Shearing Direction



Sheared Edge Tension (SET) Test



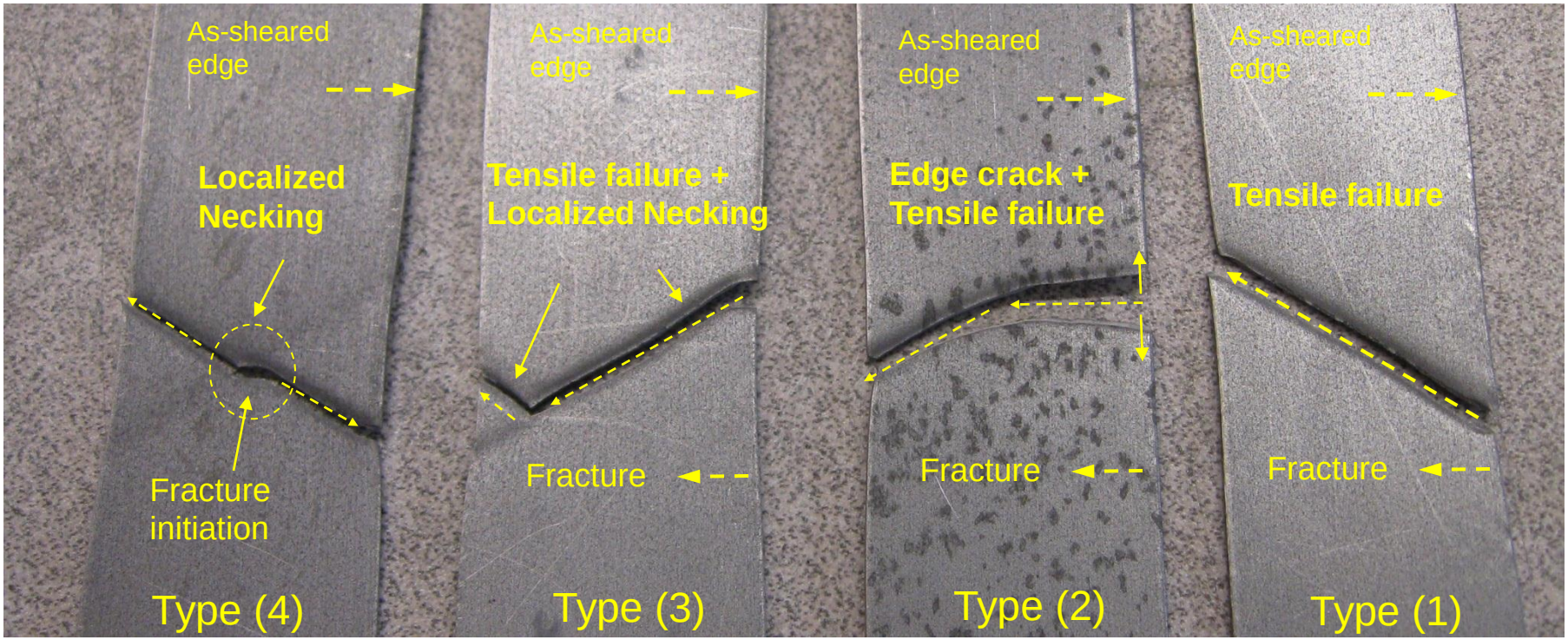
Total Elongation (TE) Between Different Shearing Conditions



Conventional Shearing

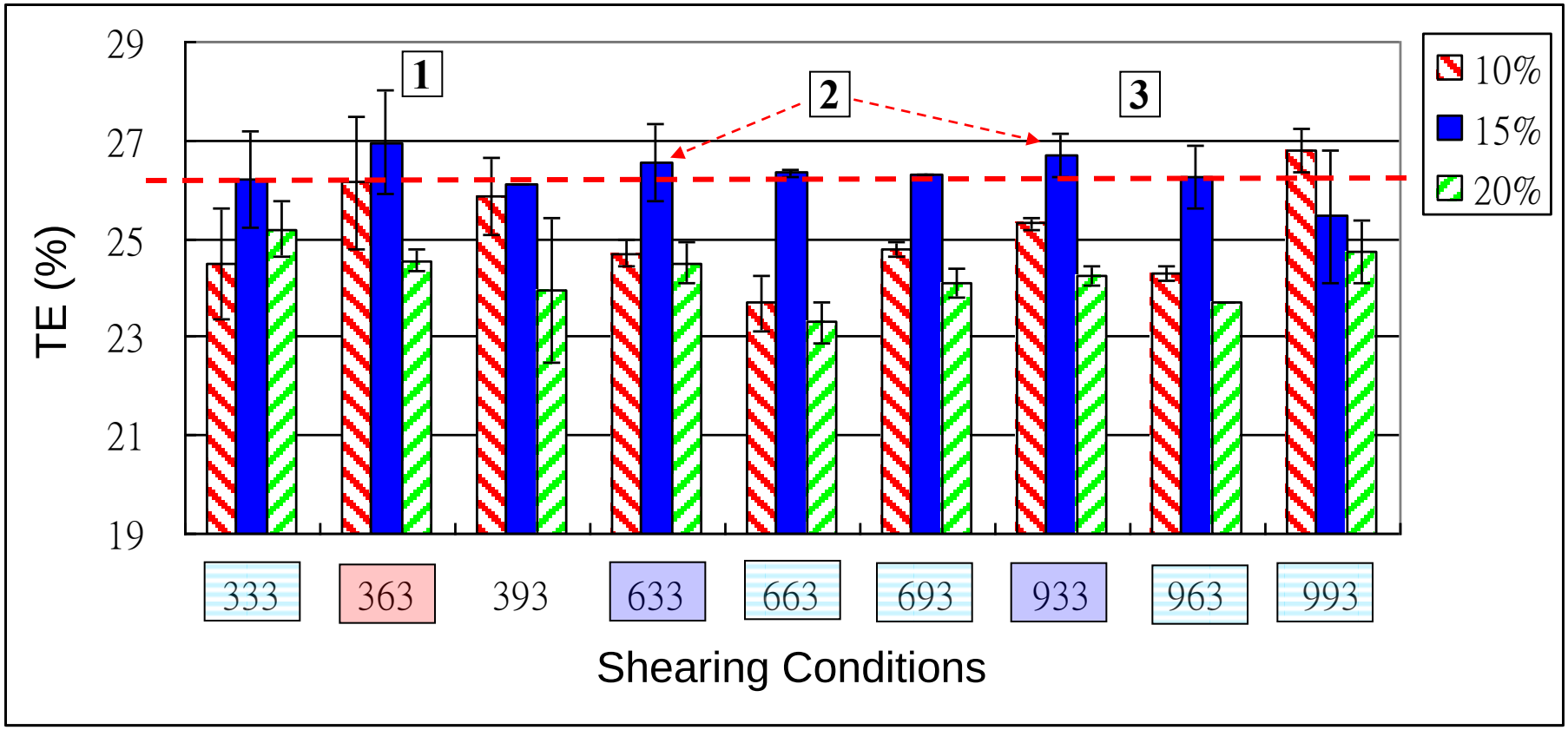
JSTM Milled

Different Failure Modes in the SET test

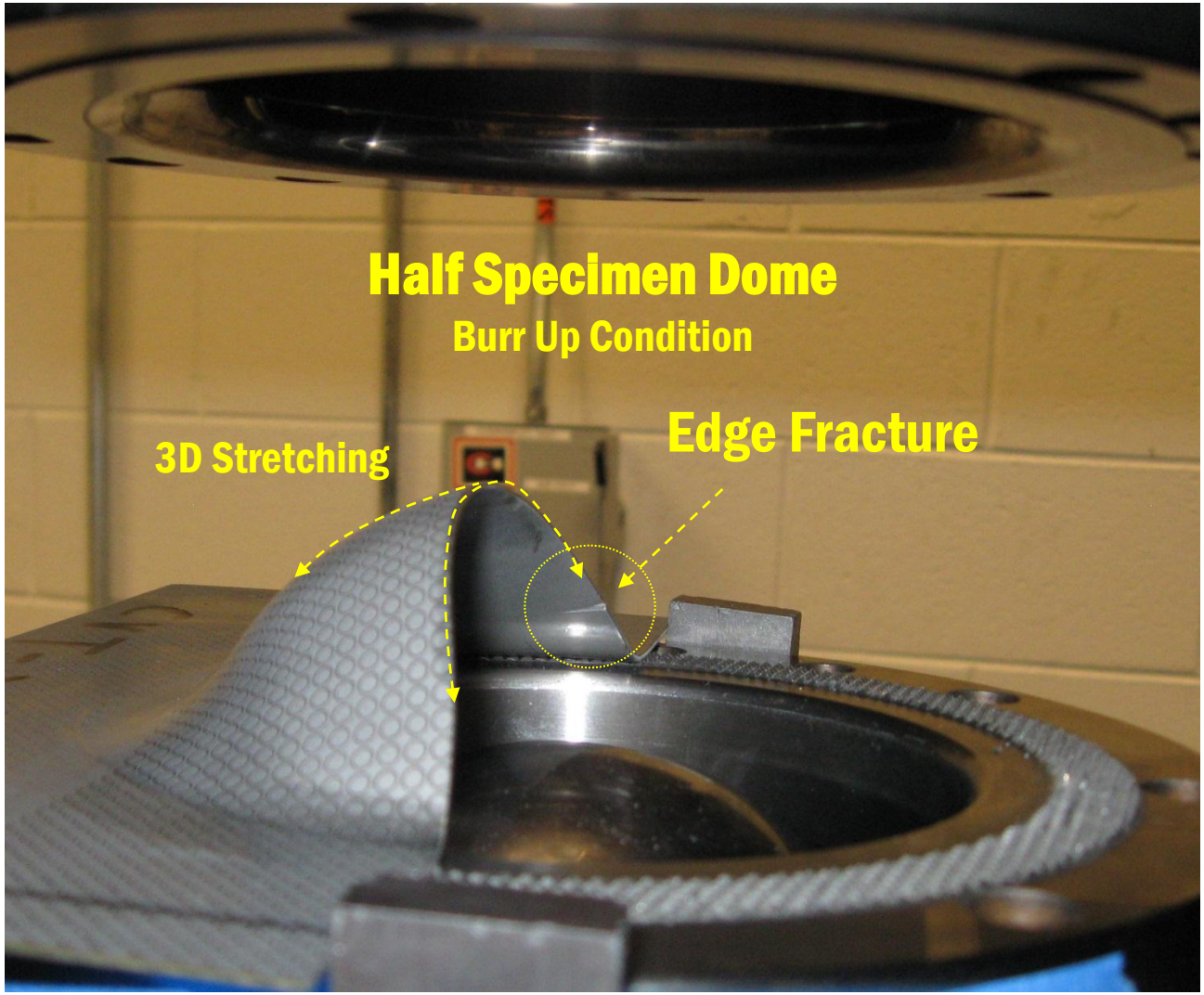


Effects of Die Clearance

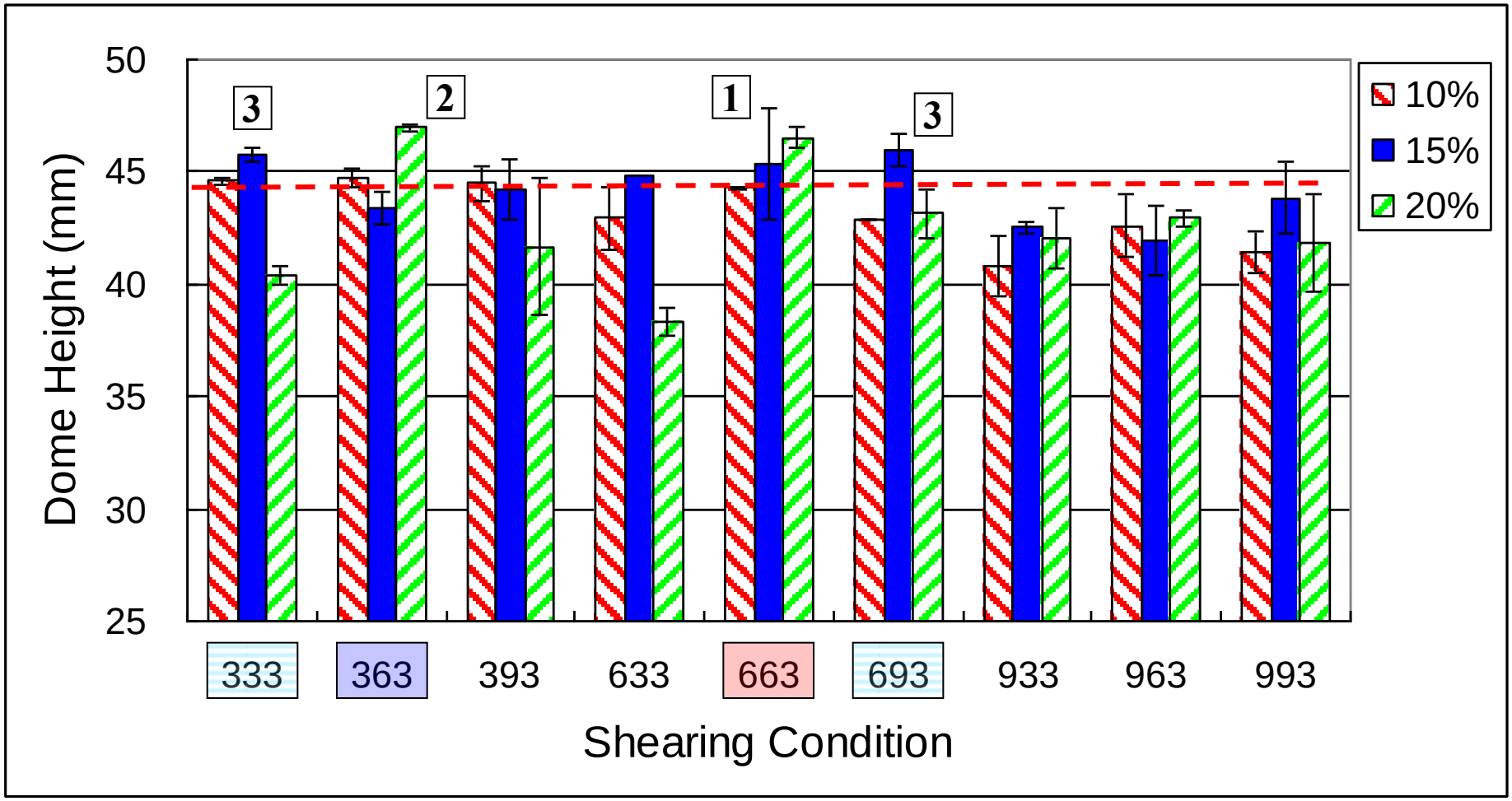
DP600, 1mm



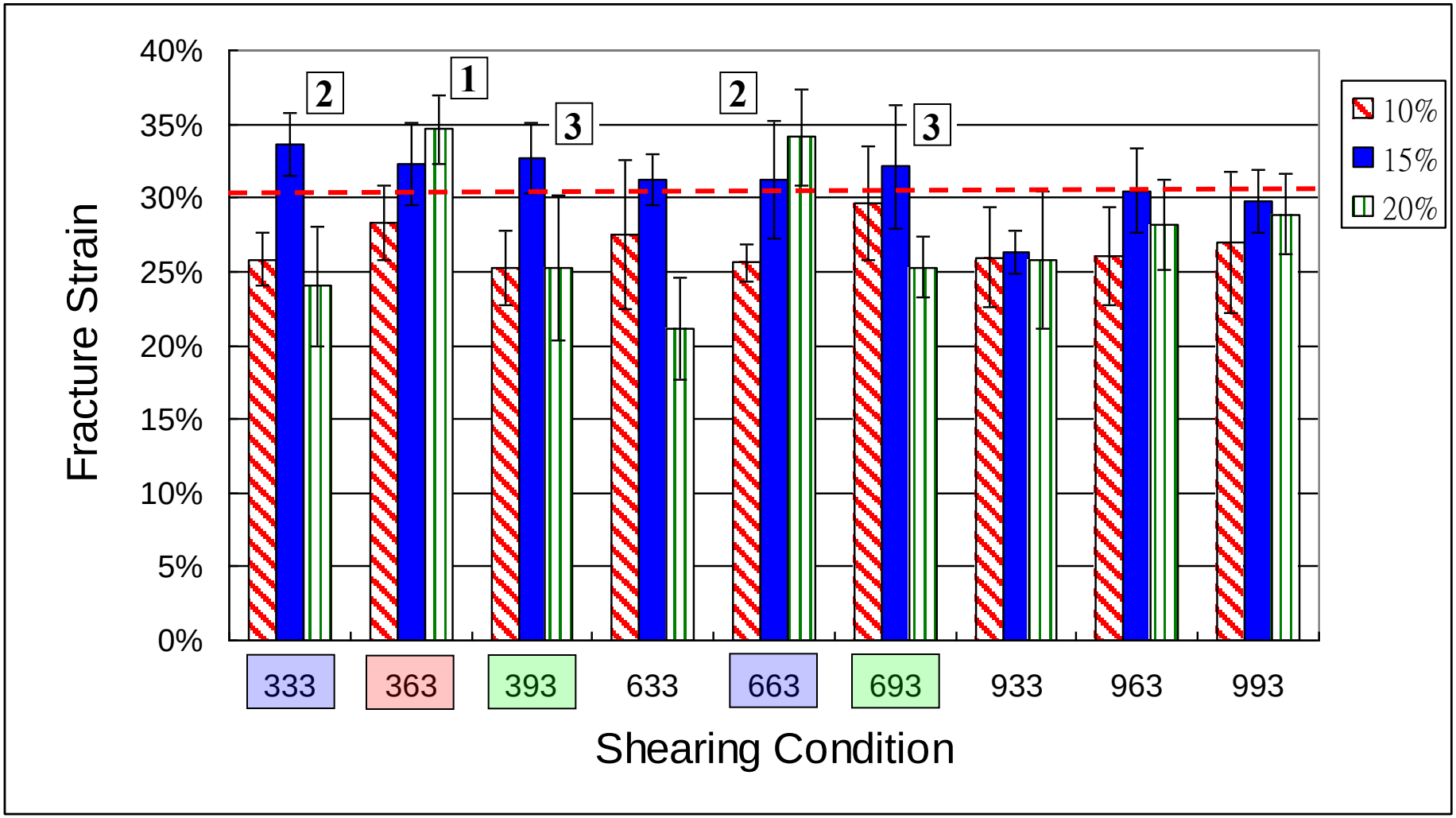
Sheared Edge Dome Test



Comparison of the Dome Height



Comparison of the Strain at Failure



Sheared Edge Limit Strain (SELS)

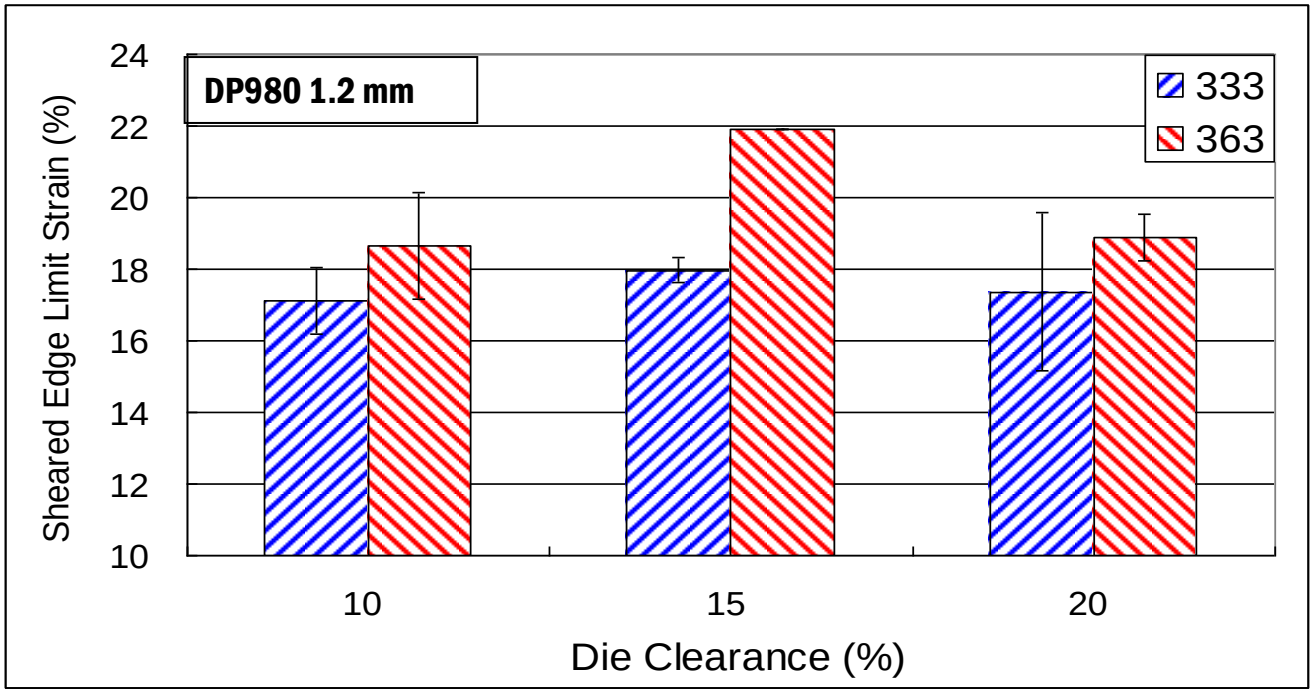
Best Shearing Conditions: 363, (333 or 663) with 15% die clearance

(Methodology: Wang, J. et al. 2008, International Conference on New Developments in Advanced High-Strength Sheet Steels)

Criterion

- The first through-thickness crack at the edge
- The onset of local necking

$$q = \frac{A_o - A_f}{A_o} \qquad SELS = \frac{q}{1-q} \times 100$$



Conclusions

- The experiments confirmed that the use of the optimal hole shearing condition can result in significantly better edge stretchability for all AHSS.
- A computer controlled adjustable straight edge shearing device was successfully developed based on the findings from the beveled shear hole piercing process.
- The maximum shearing force and applied energy can be significantly reduced when proper shear variables are used during shearing.
- The shearing force also depends upon the die clearance, and the larger die clearance tends to the decrease the shear force.
- The sheared edge tension test and dome test confirmed that the optimal setup of the rake angles in the straight edge shearing process would result in a significant improvement of edge stretchability for test AHSS.
- The optimal shearing condition for AHSS is using the rake angle setup (3,6,3) with 15% die clearance.

Thank you

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