THE EFFECTS OF AHSS SHEAR EDGE CONDITION ON EDGE FRACTURE

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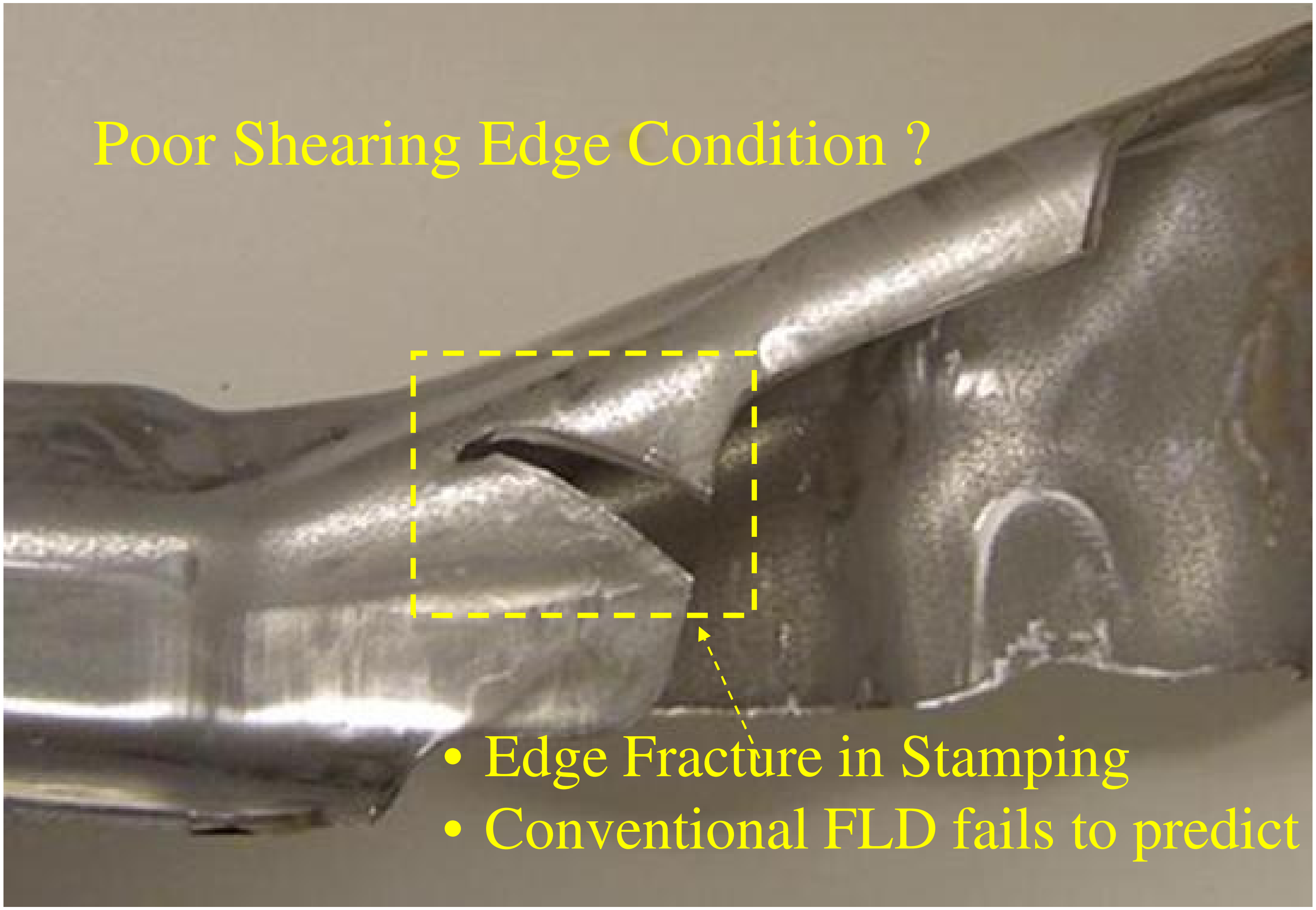
Edge Fracture

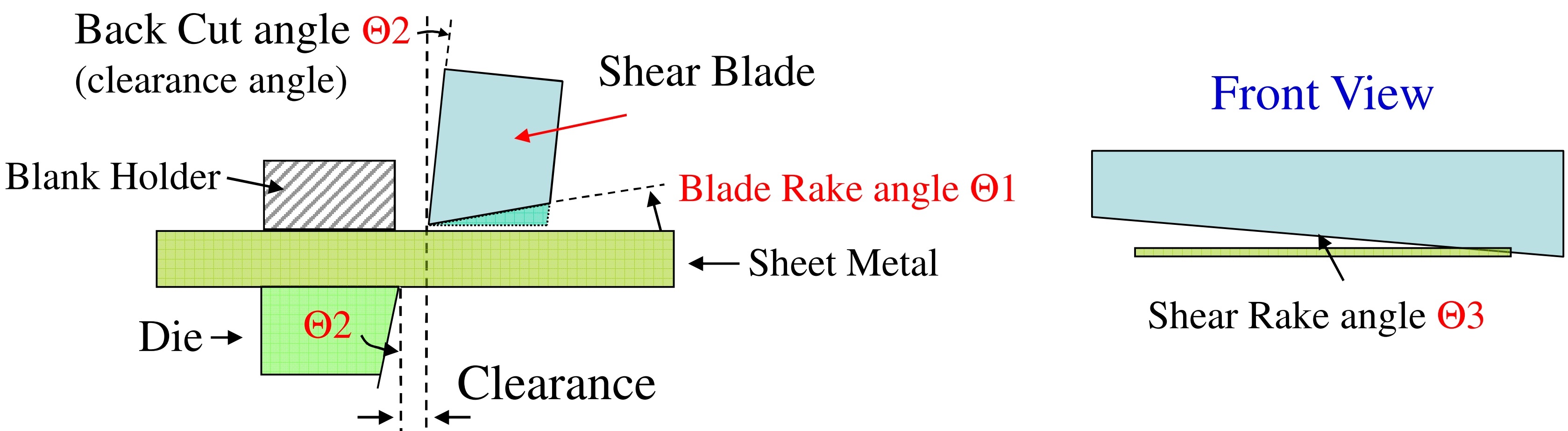


Outline

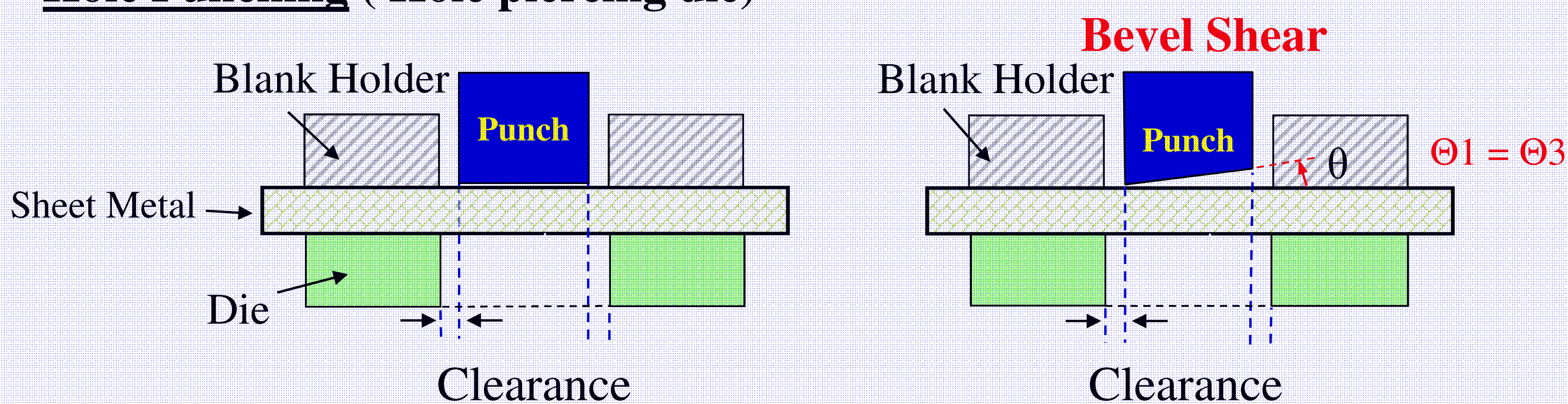
- Background
- Laboratory Shearing Test
  - Computer Control Hole Punch/Shear Process
- Evaluation of Punch/Shear Force
- Validation Edge Fracture Test
  - Hole Expansion Test
- Evaluation of Shear Edge Condition
- Conclusions

Background

Straight Edge Shearing (Blanking die , Trimming die)

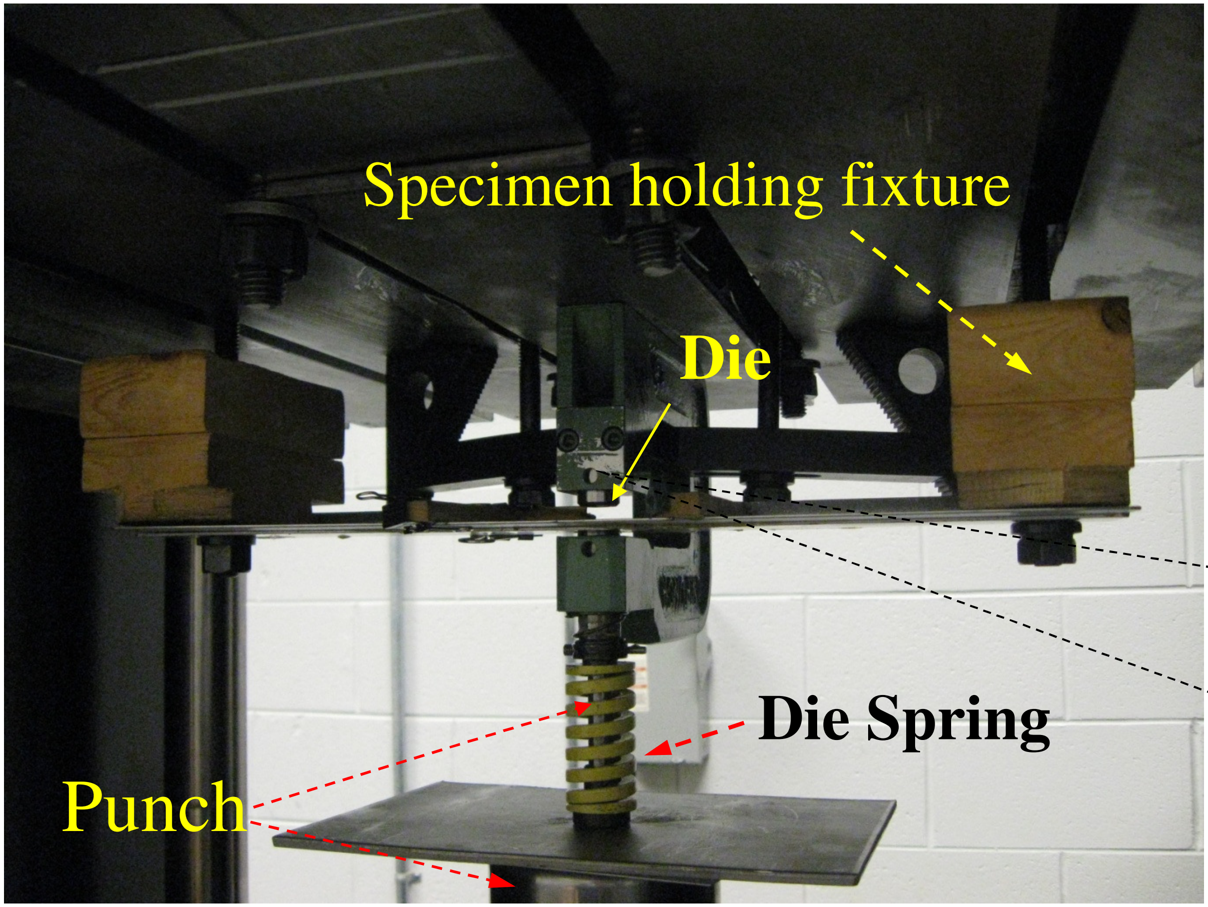


Hole Punching (Hole piercing die)

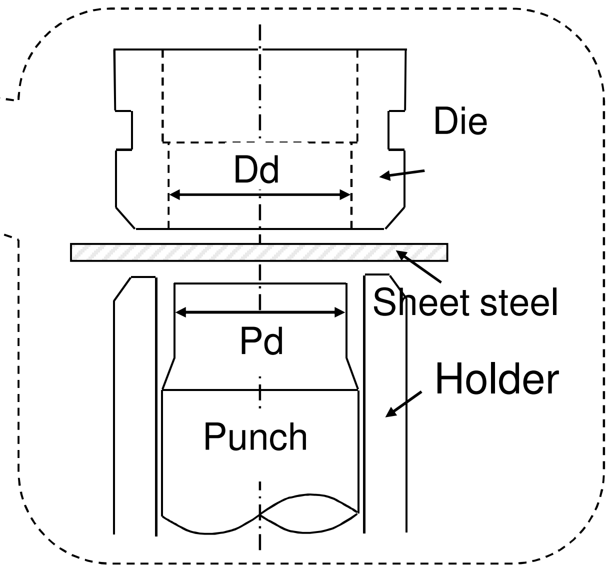


Laboratory Shearing Test

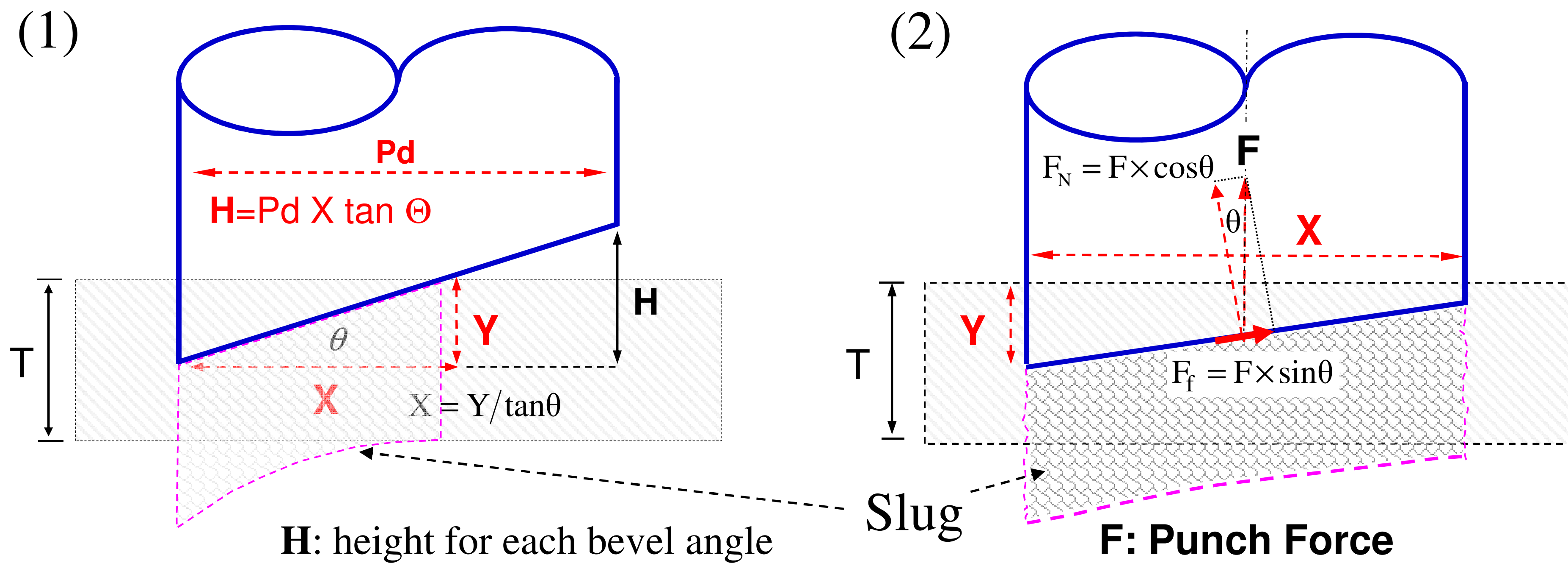
Computer control hole punch/shear process



- **Computer control**
- **Bevel angle**
- **Die clearance**
- **Shear speed**
- **Shear load**



Schematic of Bevel Shear



H: height for each bevel angle
Punch force **F ~ X ~ 1/ tan Θ**

Y: Punch Tip Penetration
When **Y-T=H** : penetration near completed

Shearing Test Conditions:

- Bevel Shear Angle: 0, 3, 6, 9, 12, 18, 24 degrees
- Die Clearance: 5, 10, 15, 20, 25, 30 % of test steel thickness
- Low speed

MECHANICAL PROPERTIES OF TESTED STEELS

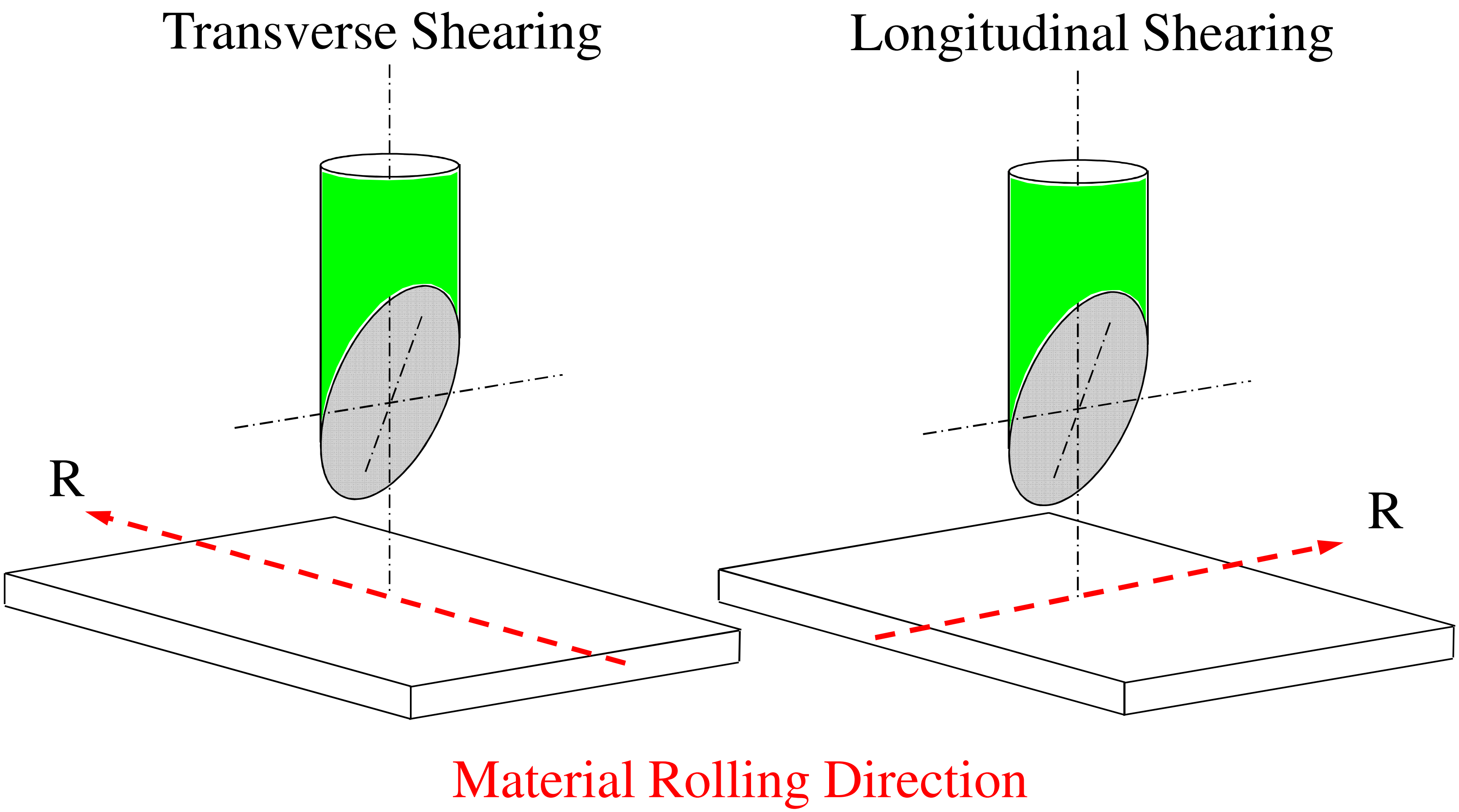
Material	Thickness (mm)	Yield Strength (MPa)	Tensile Strength (MPa)	Total Elong. (%)	n Value
DP780	1	511	876	16.9	0.118
DP980	1.2	573	1003	15.1	0.106

Hole Punch/Shear Conditions

Grade	Thickness [mm]	Punch diameter [mm]	Die diameter [mm]	Clearance [%]
DP780	1.0	10.0	10.1	5
DP780	1.0	10.0	10.2	10
DP780	1.0	10.0	10.3	15
DP780	1.0	10.0	10.4	20
DP780	1.0	10.0	10.5	25
DP780	1.0	10.0	10.6	30
DP980	1.2	10.0	10.2	8
DP980	1.2	10.0	10.3	13
DP980	1.2	10.0	10.4	17
DP980	1.2	10.0	10.5	21

$$D_{die} = 2Cl \times t / 100 + D_{punch}$$

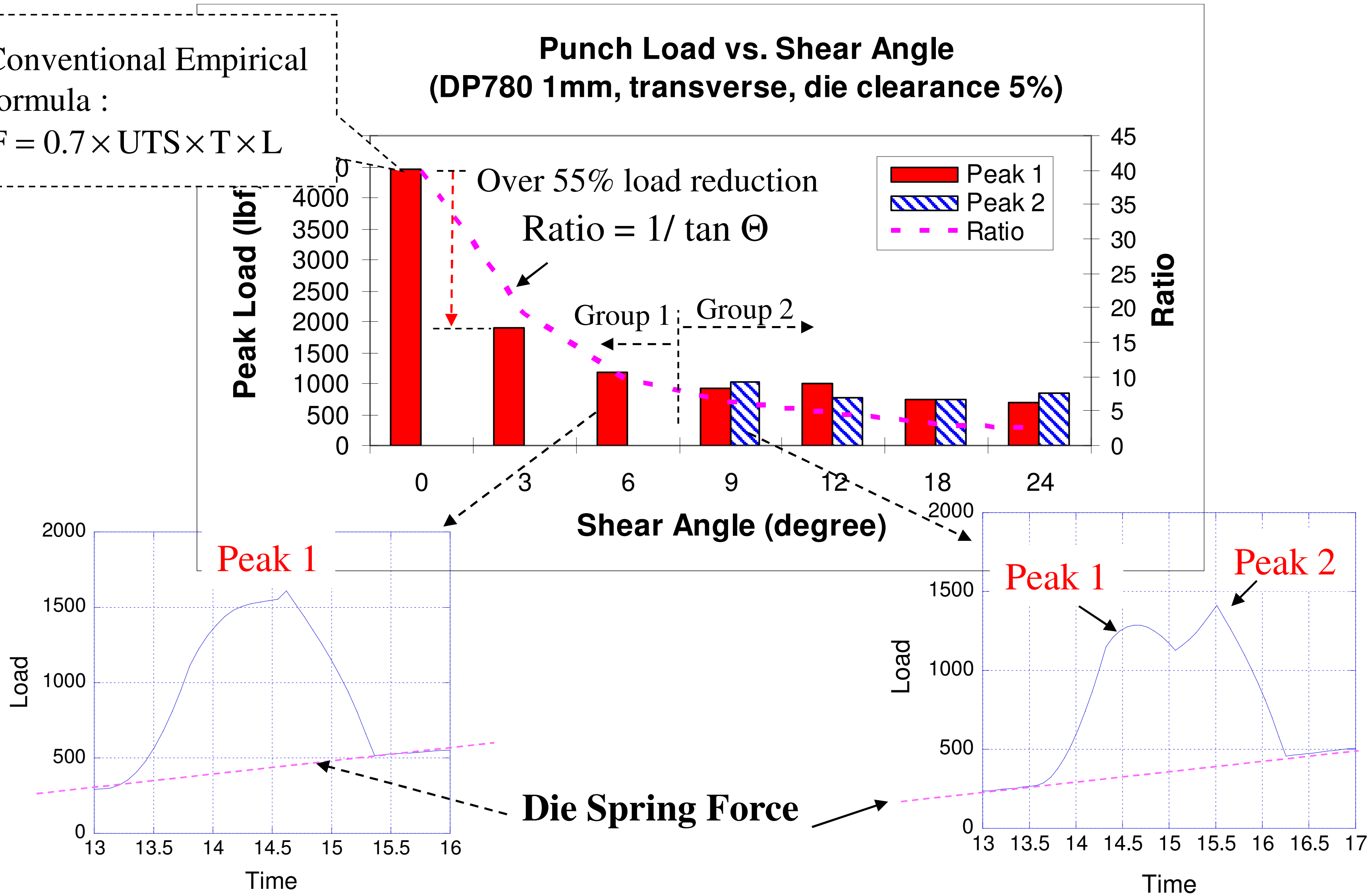
Hole Shearing Orientations

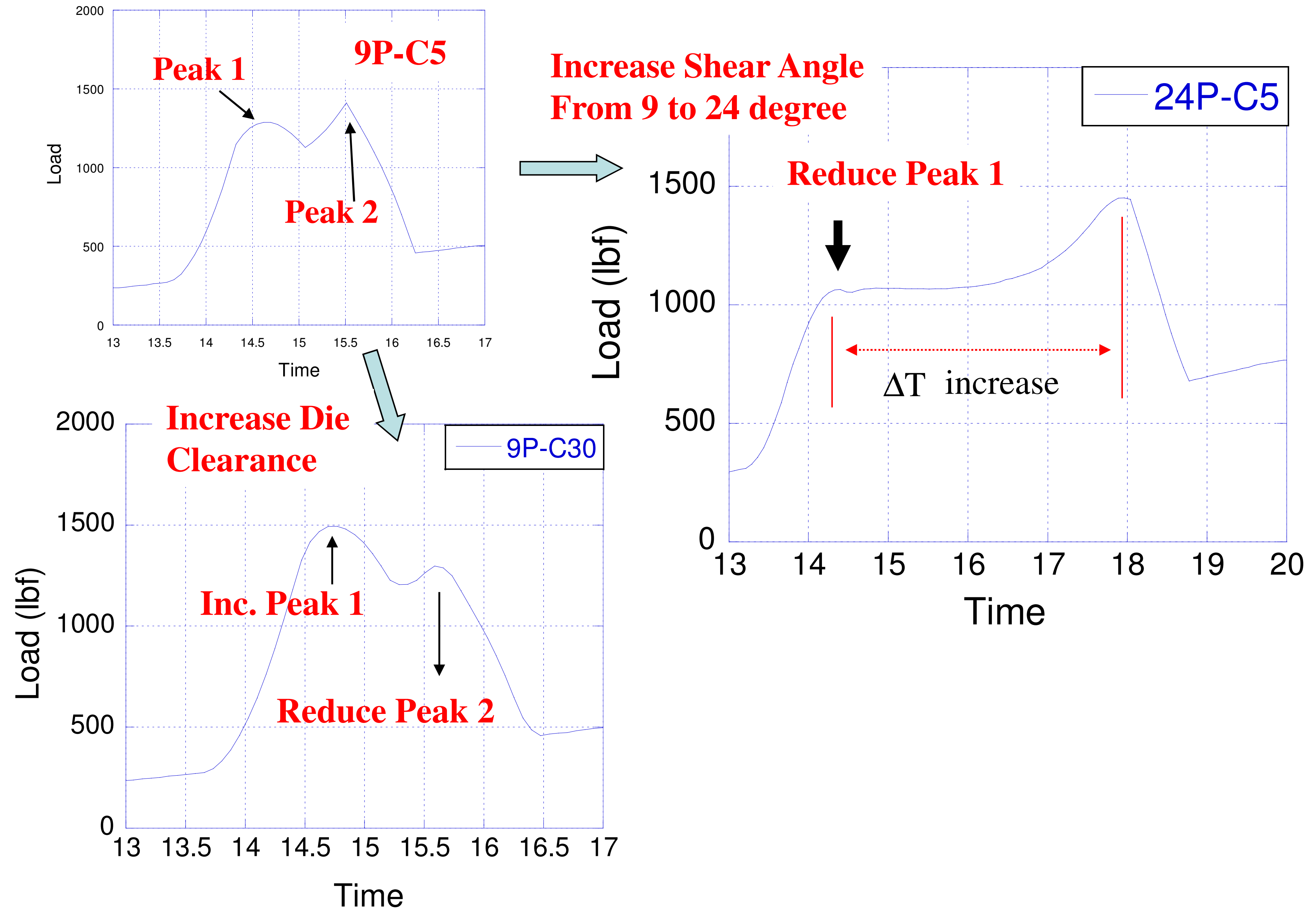


Evaluation of Punch / Shear Force

Conventional Empirical formula :

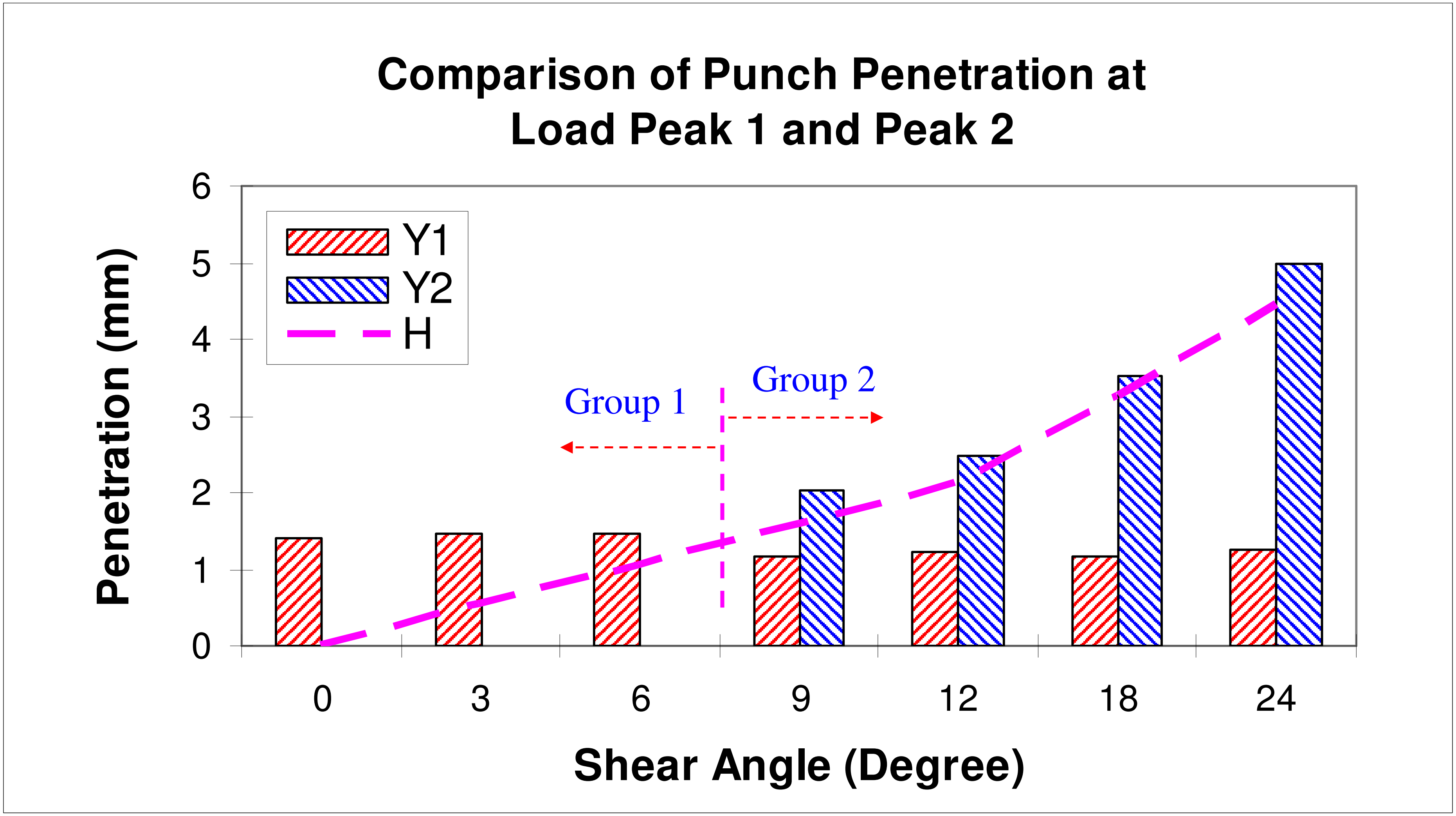
$F = 0.7 \times UTS \times T \times L$



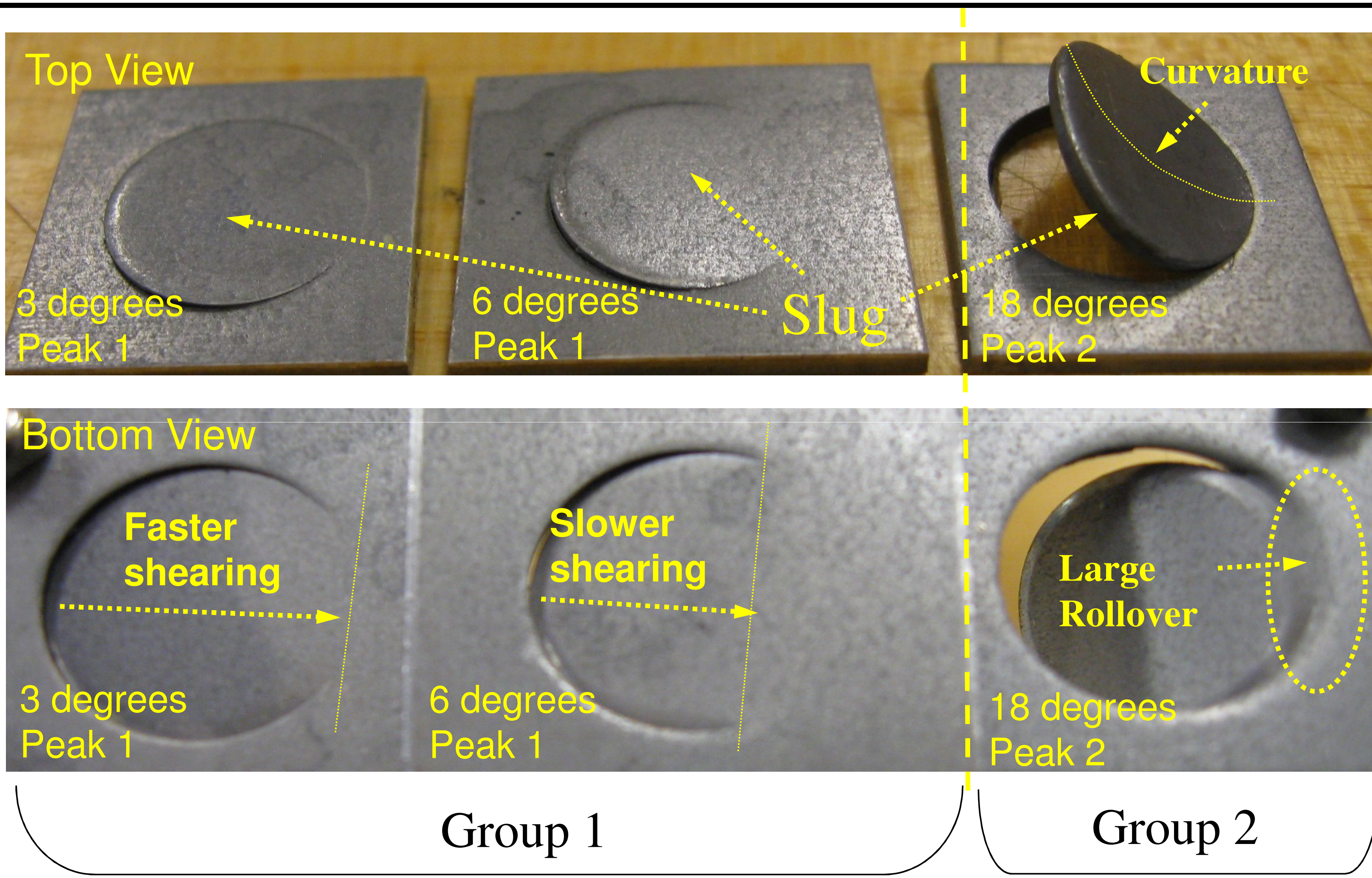


9P-C5
Peak 1
Peak 2
Load
Time
2000
1500
1000
500
0
13
13.5
14
14.5
15
15.5
16
16.5
17
Increase Shear Angle
From 9 to 24 degree
24P-C5
Reduce Peak 1
ΔT increase
Load (lbf)
Time
1500
1000
500
0
13
14
15
16
17
18
19
20
Increase Die
Clearance
9P-C30
Inc. Peak 1
Reduce Peak 2
Load (lbf)
Time
2000
1500
1000
500
0
13
13.5
14
14.5
15
15.5
16
16.5
17

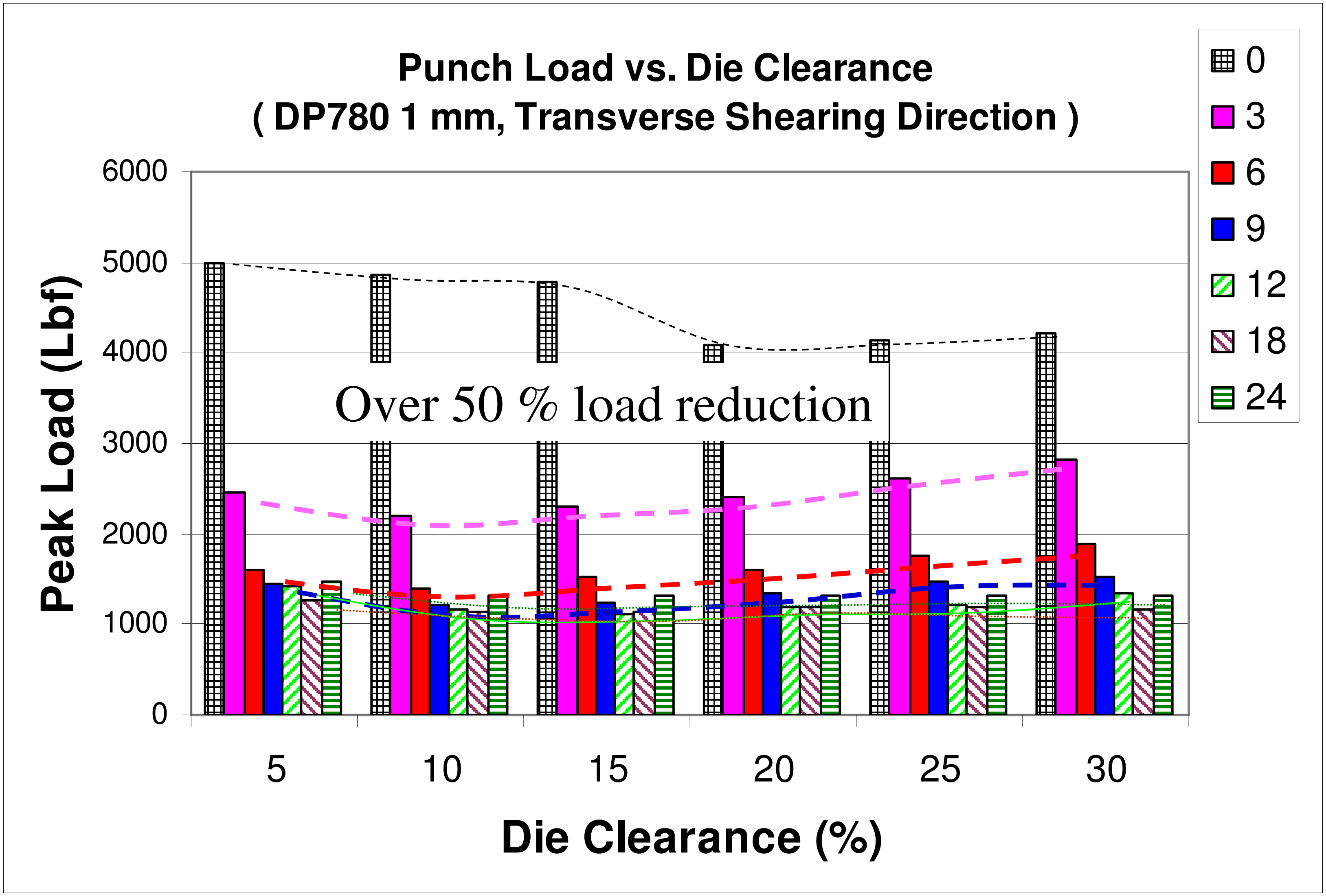
Punch Penetration



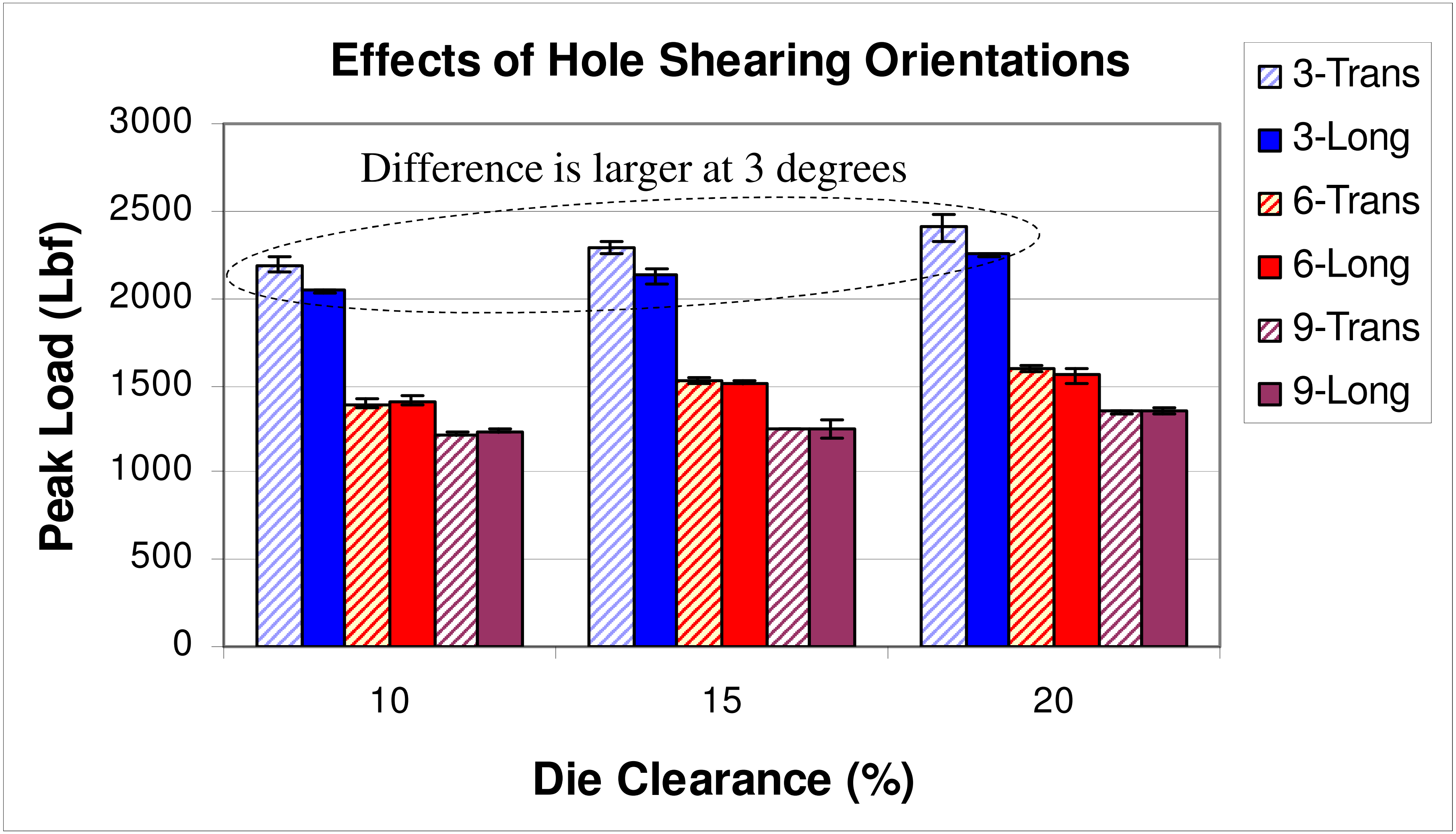
Photograph of Punch/Shear Samples



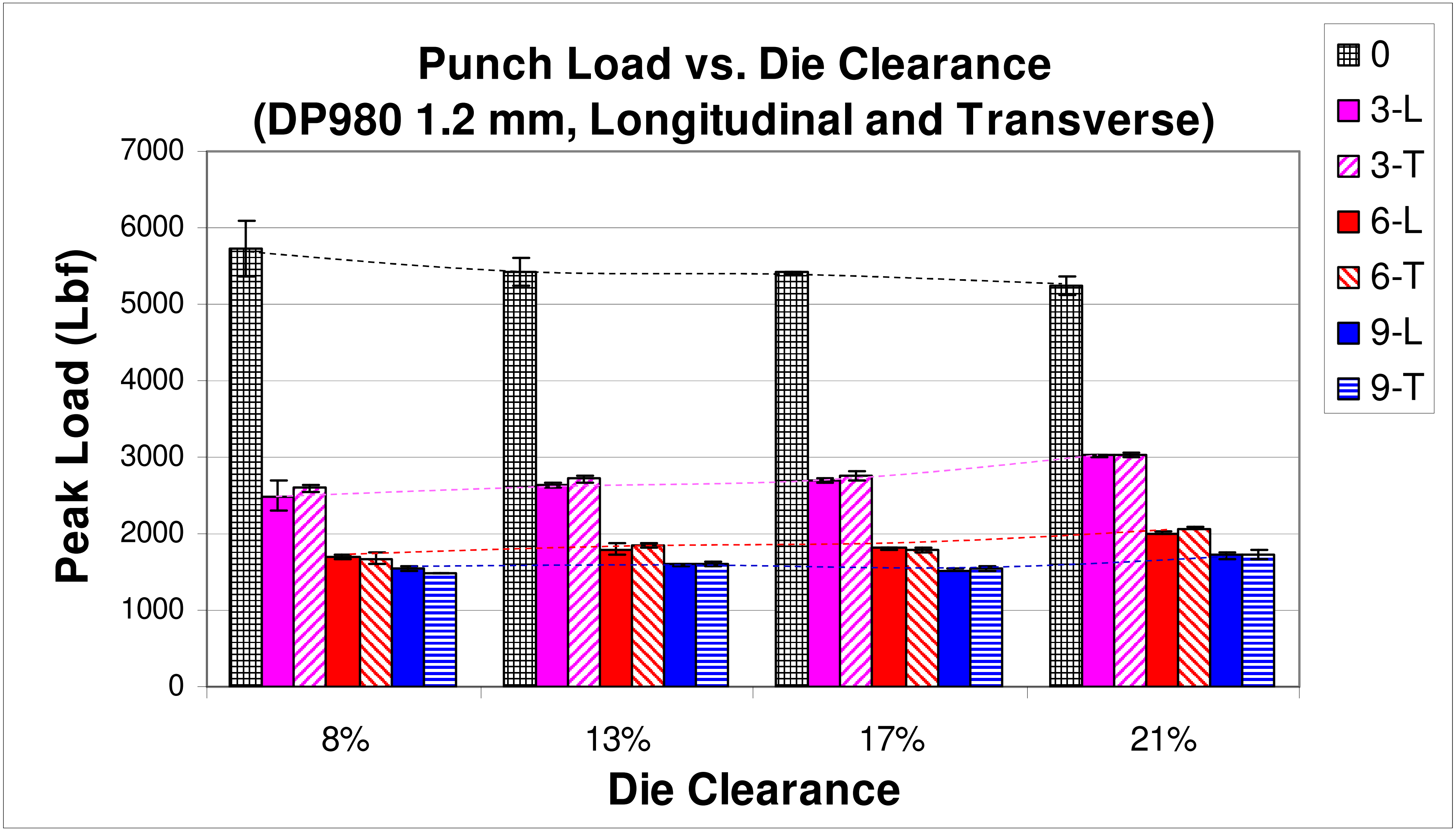
Punch Force – DP780 1mm



Punch Force – DP780 1mm

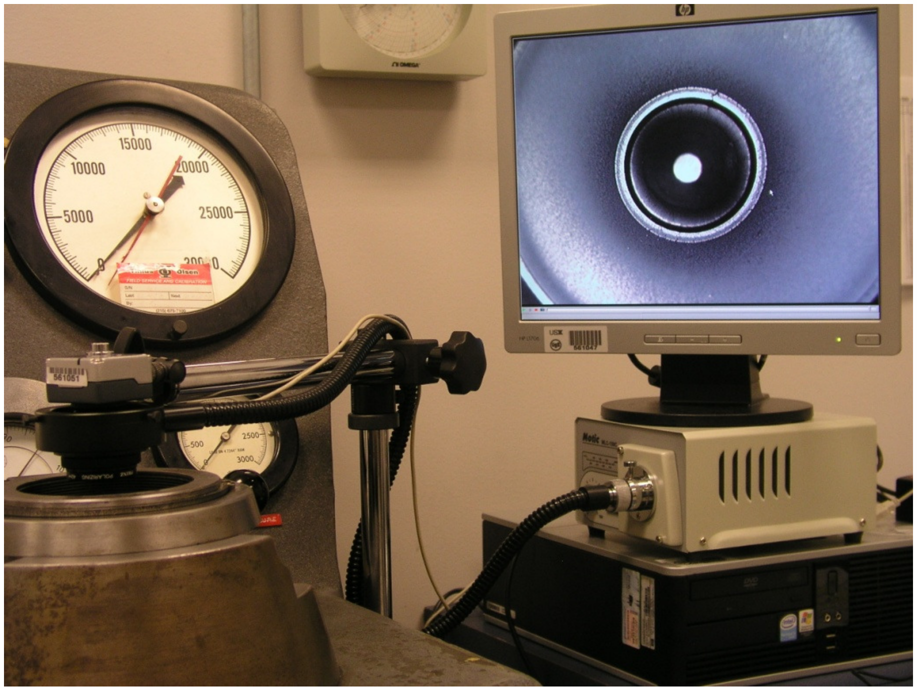


Punch Force – DP980 1.2 mm

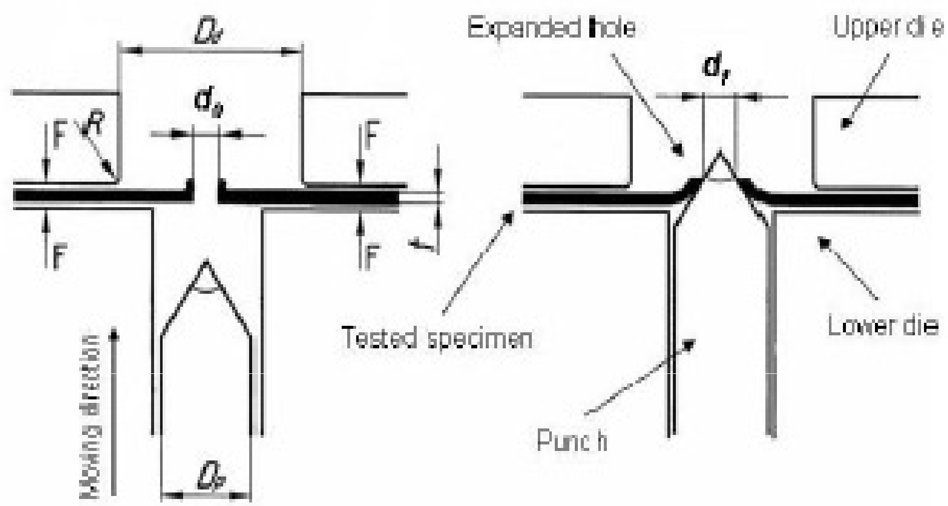


Validation Edge Fracture Test

Hole Expansion Test

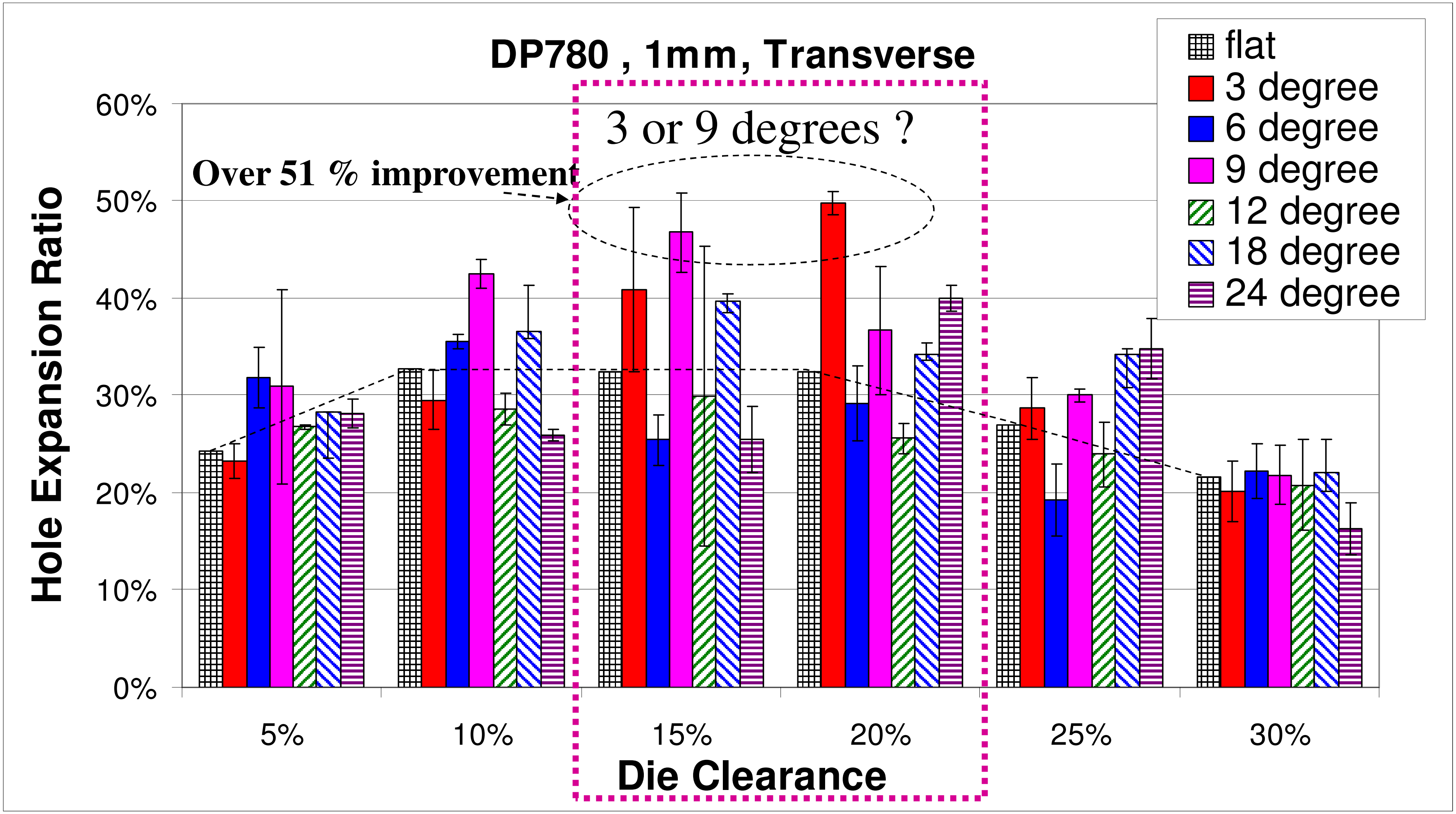


Tinus-Olsen formability machine

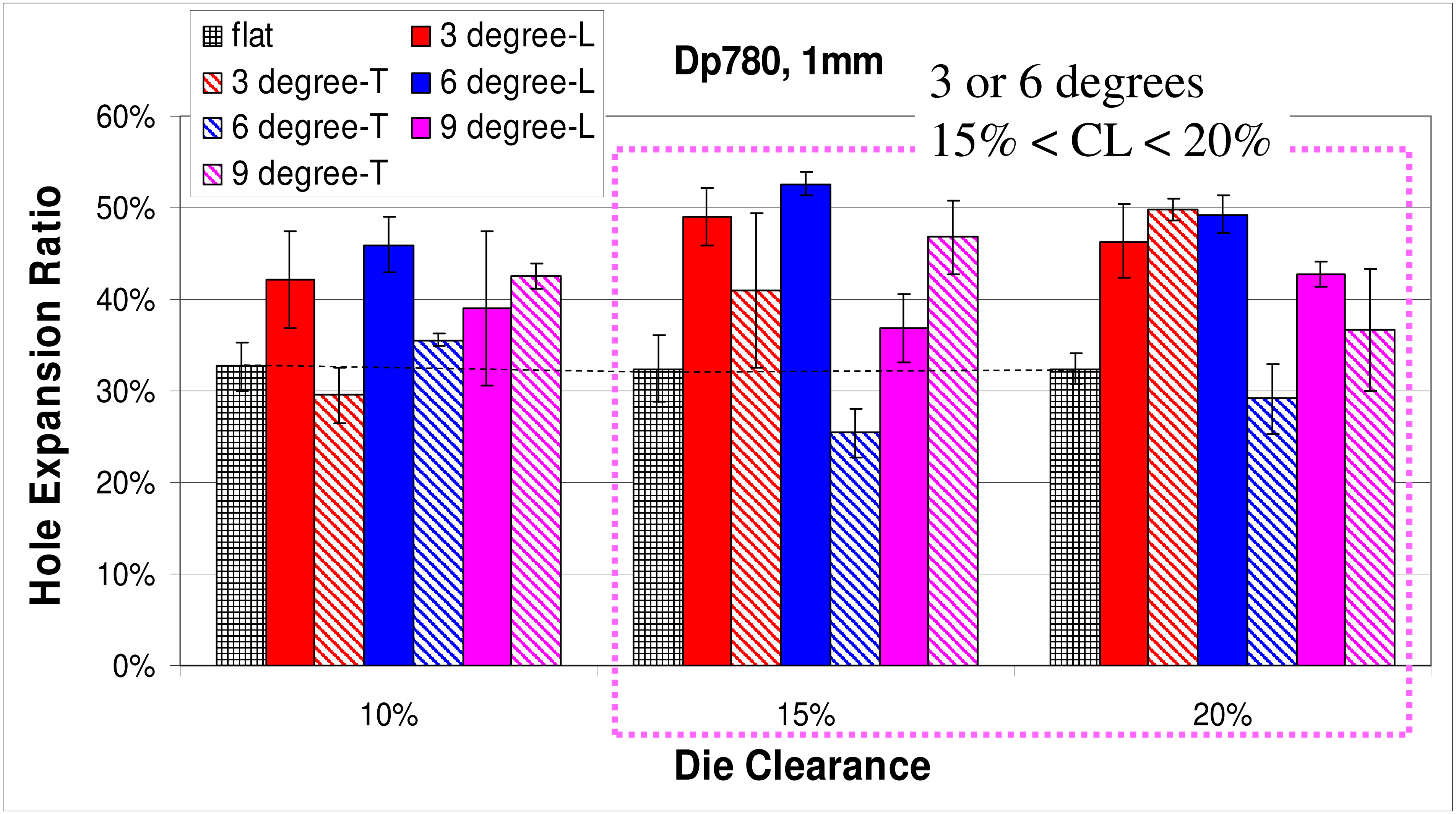


- Hole expansion test
- Specimen orientation : Burr Up
- Conical punch
- 1 inch/min

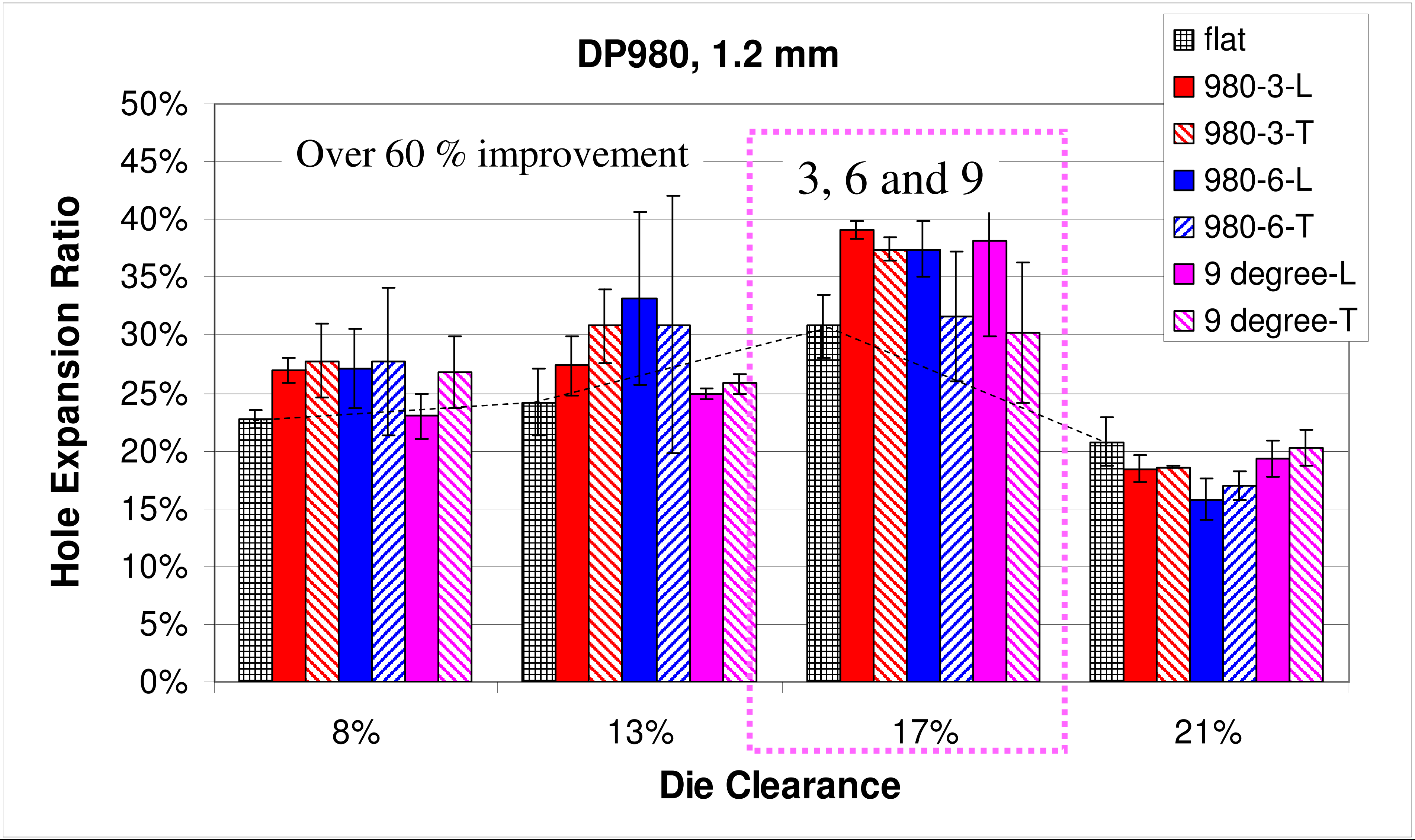
Effects of Bevel Shear Angle and Die clearance



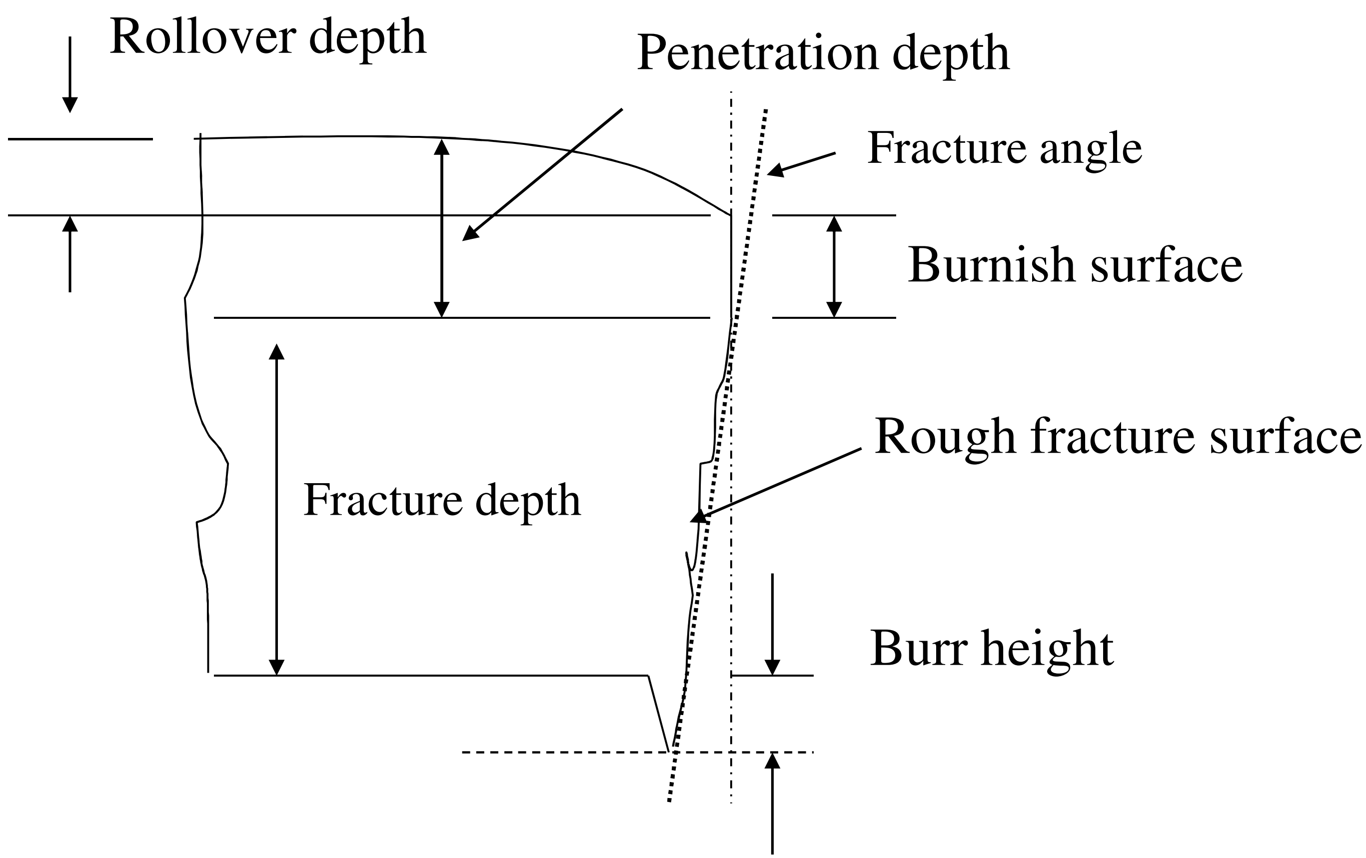
Effects of Material Shearing Orientations

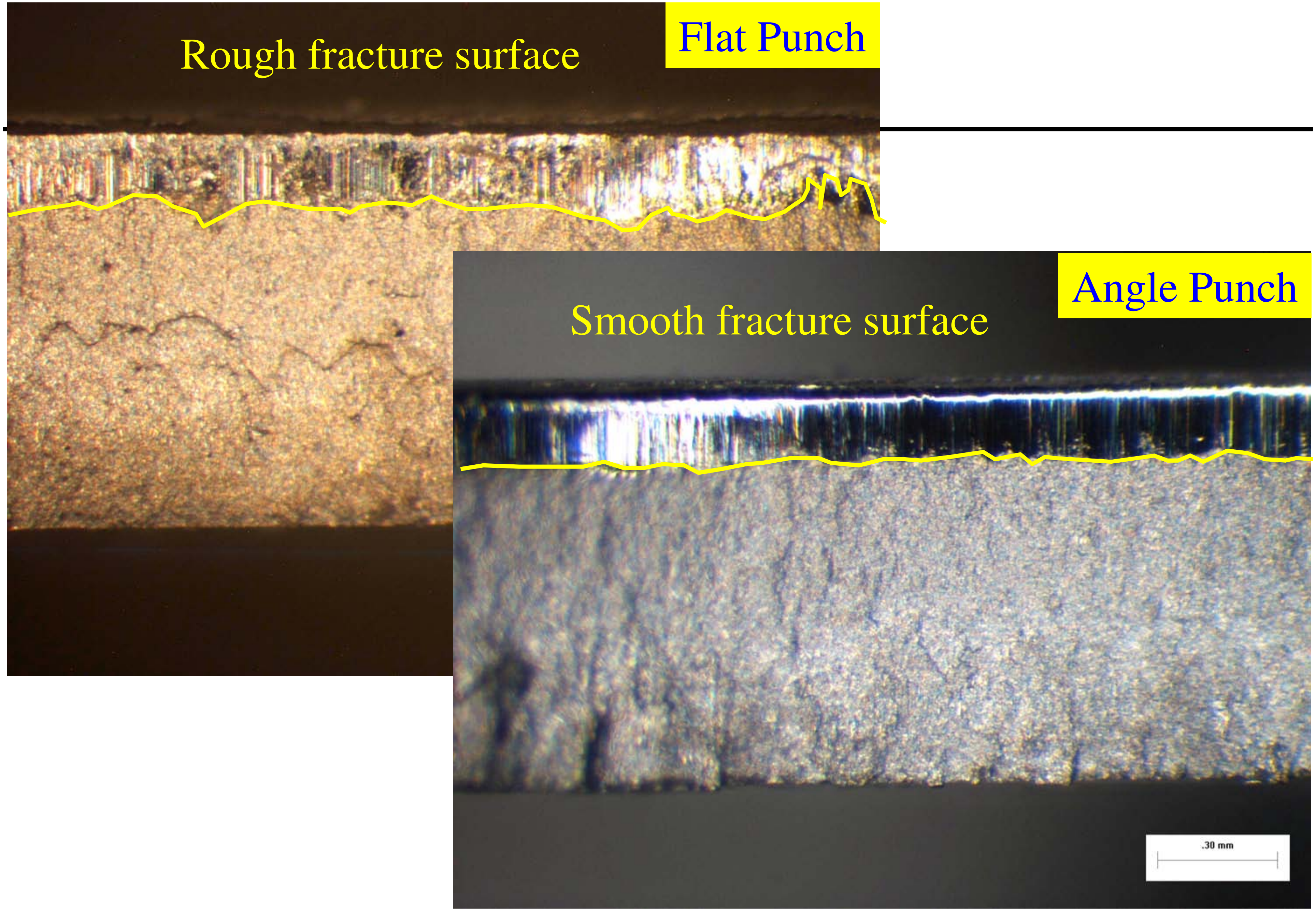


Effects of Material Shearing Orientations

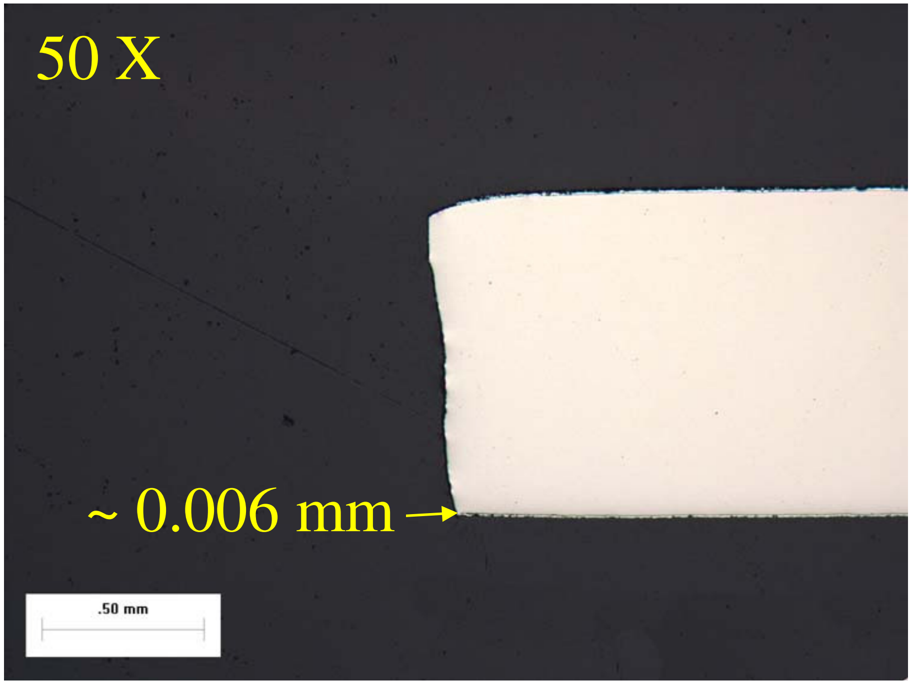


Evaluation of Shear Edge Condition




Flat Punch
Rough fracture surface
Angle Punch
Smooth fracture surface
.30 mm

No Visible Burr

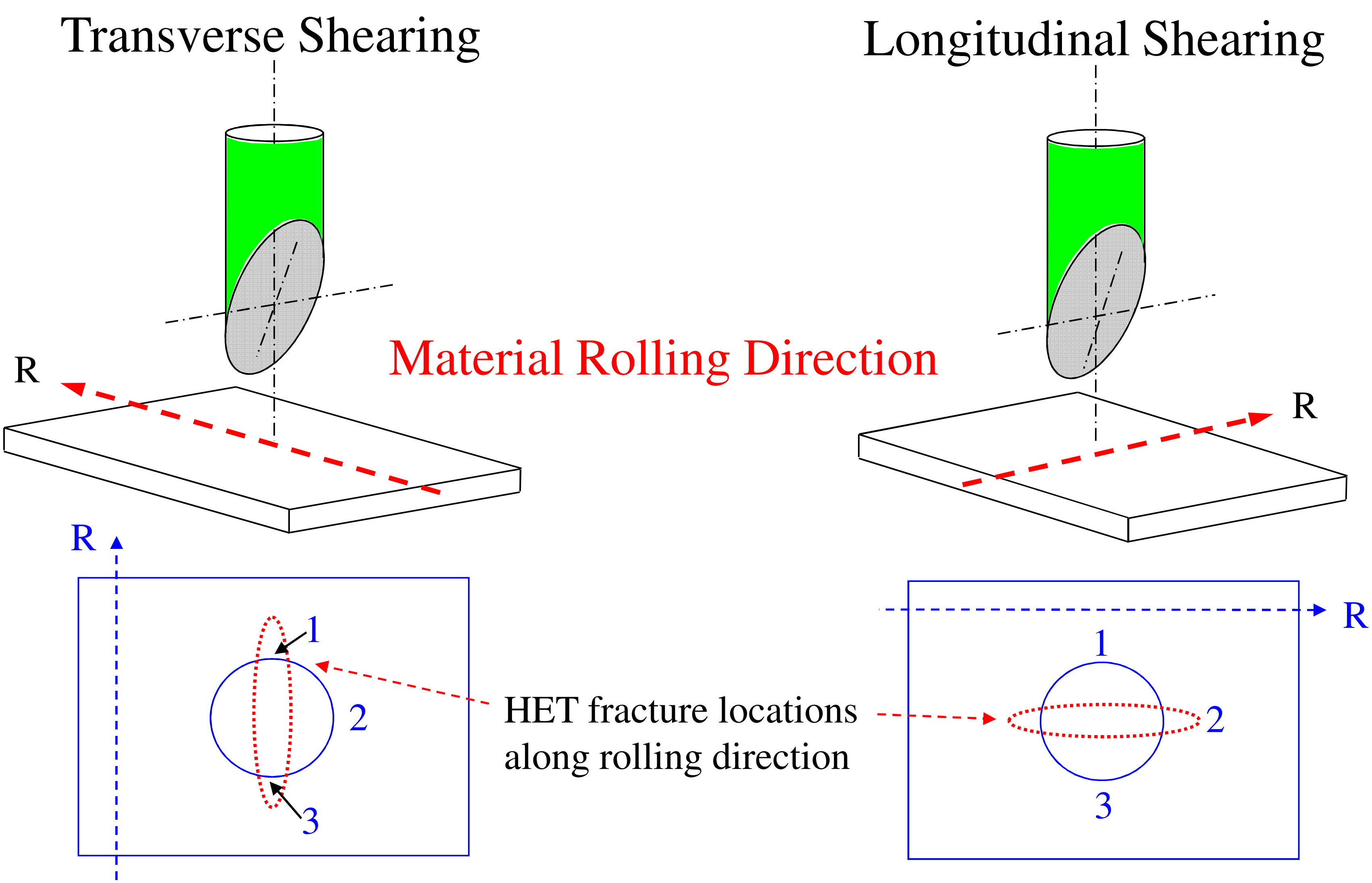


Die Clearance < = 20 %

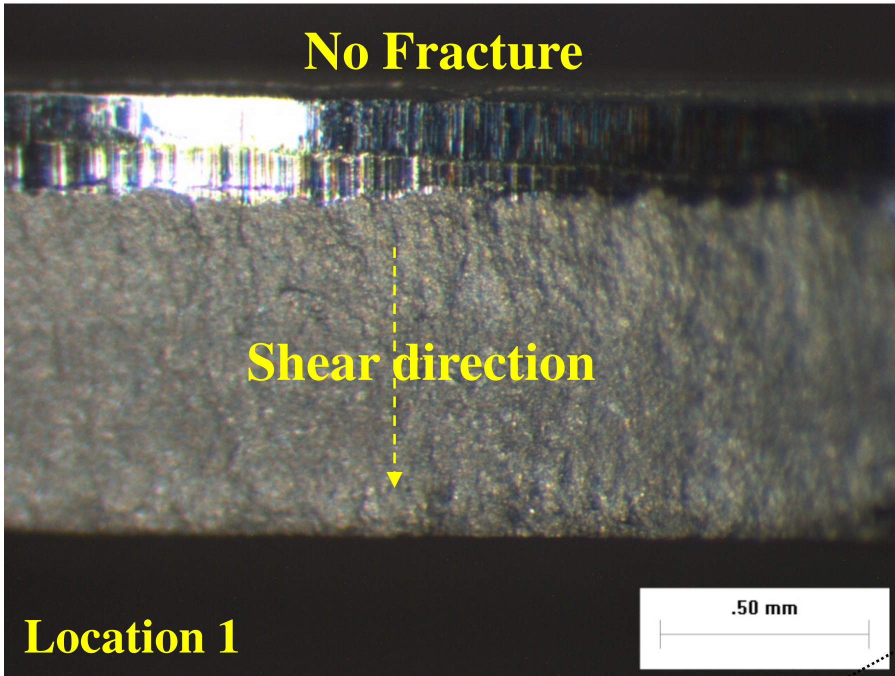
With Visible Burr

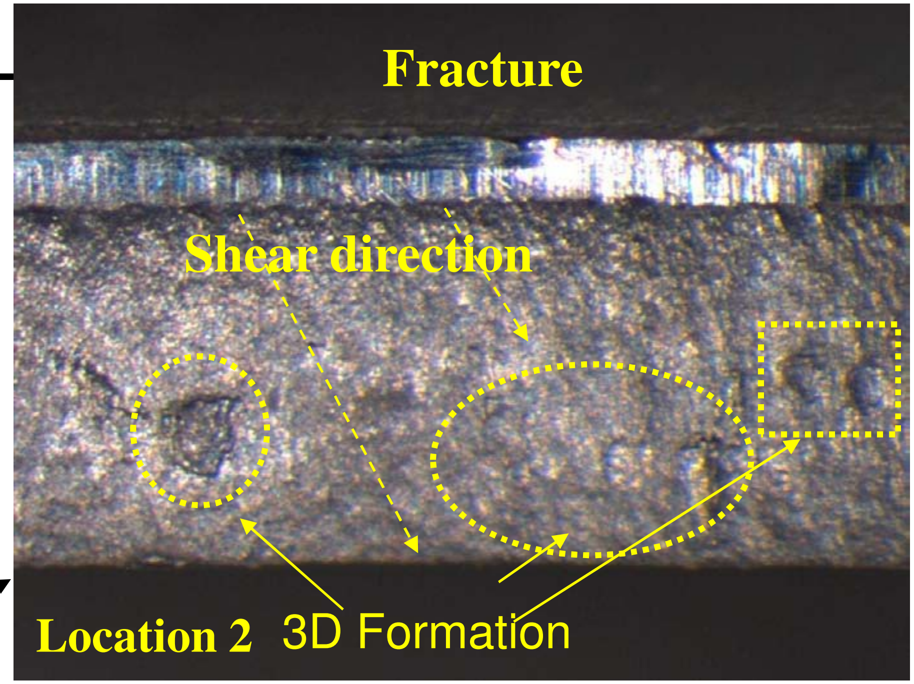
Die Clearance >=25 %

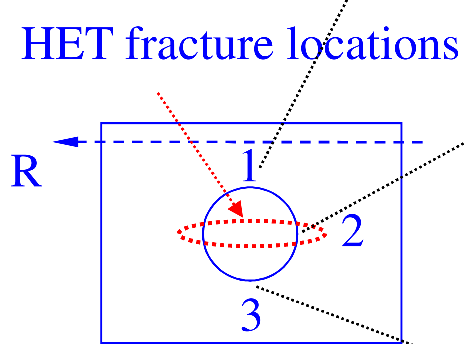
HET Fracture Locations / Surface

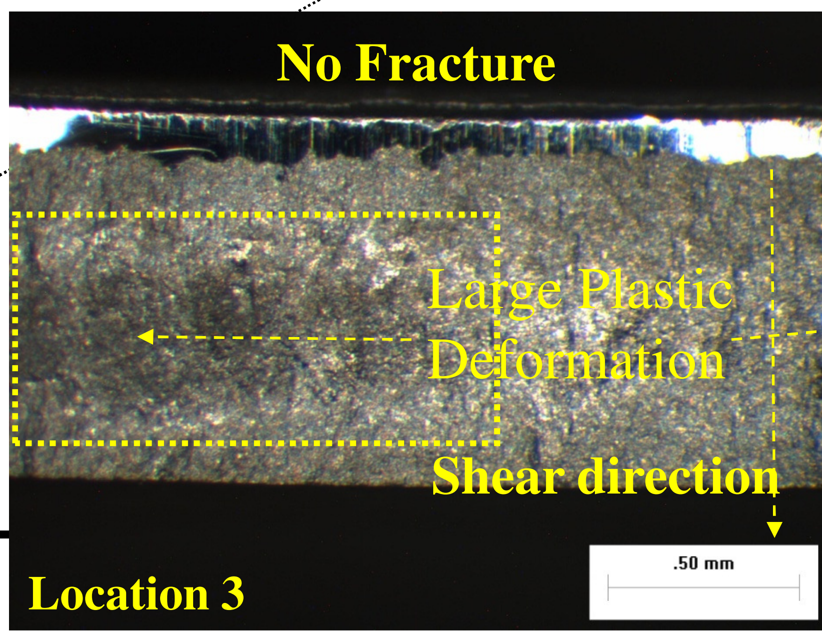


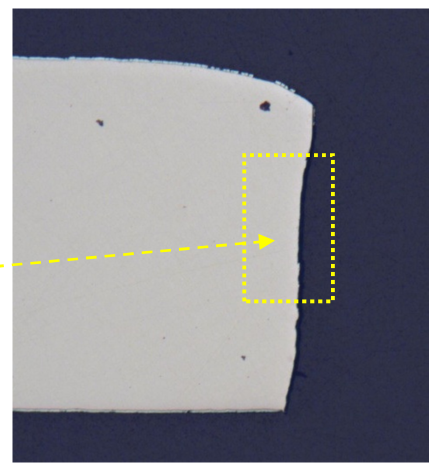
Longitudinal Shearing (9 degrees, 10% CL)

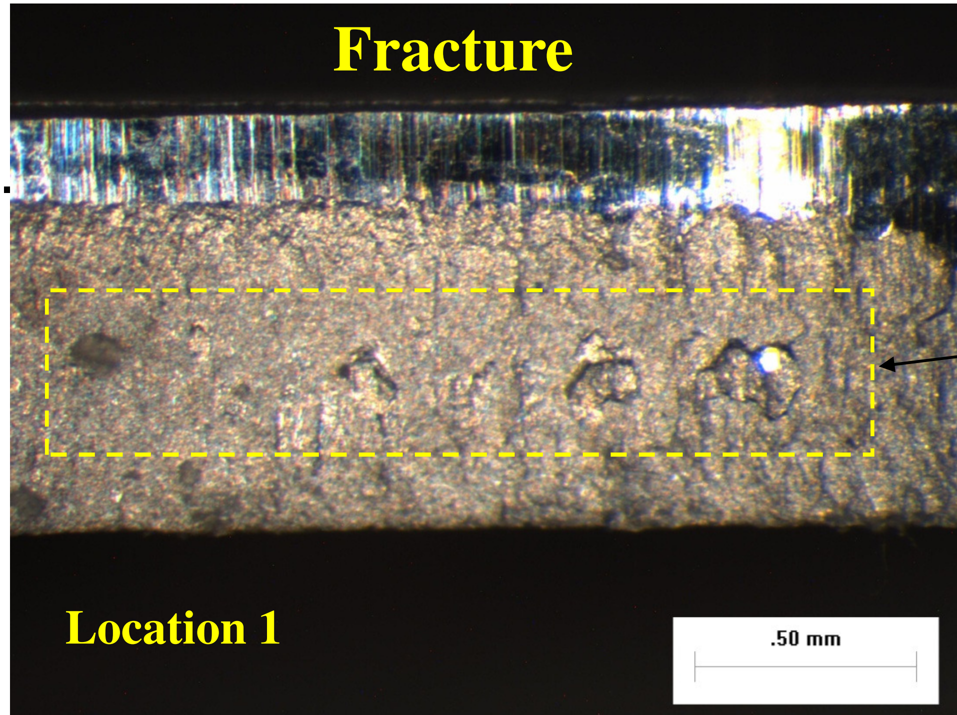








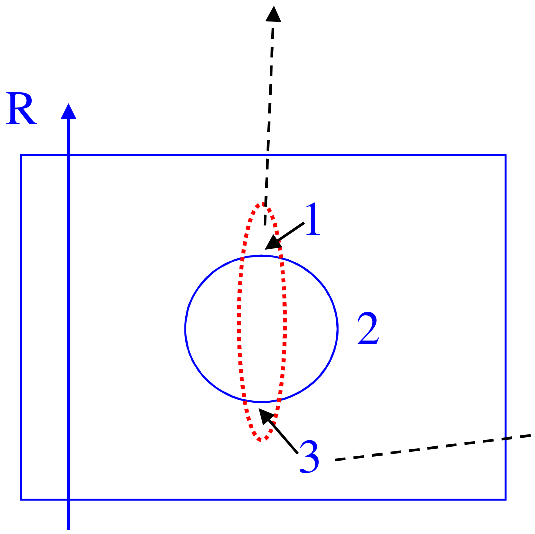


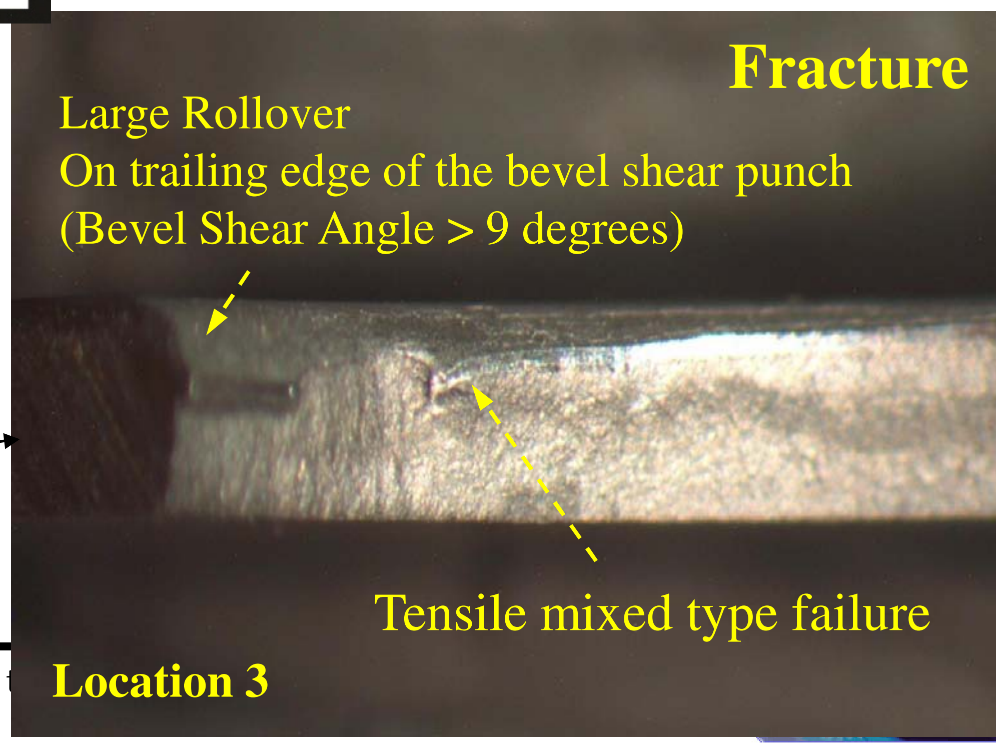


Transverse Shearing
(12 degrees, 15% CL)

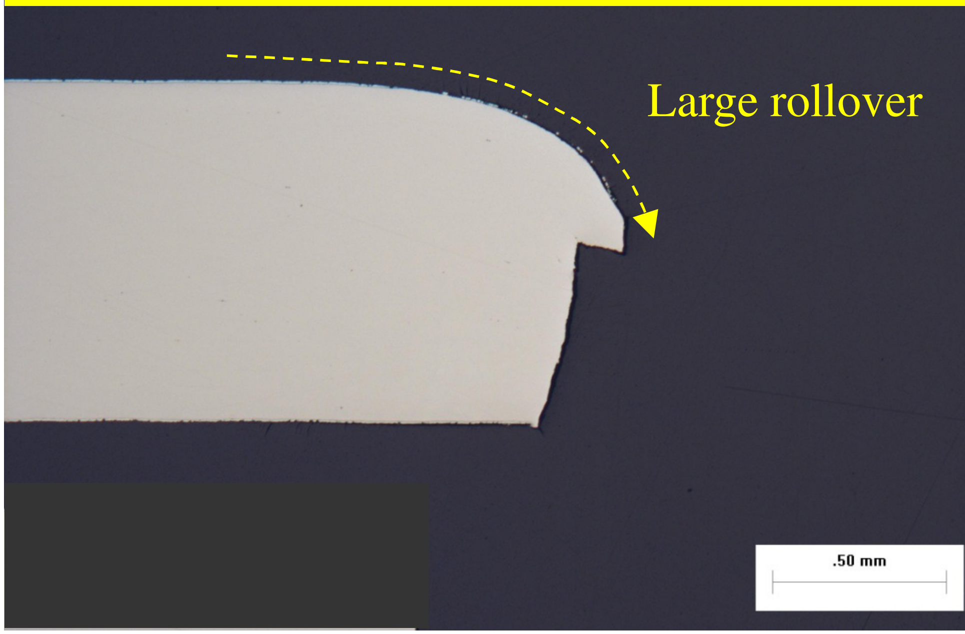
3D Formation

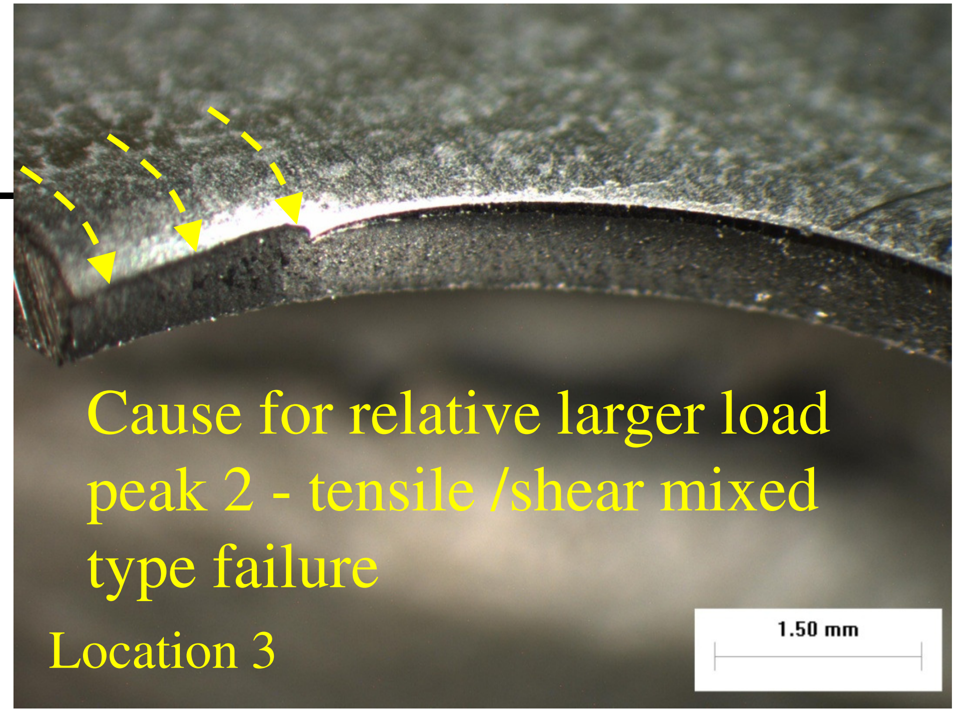
Fracture location
at 1 or 3



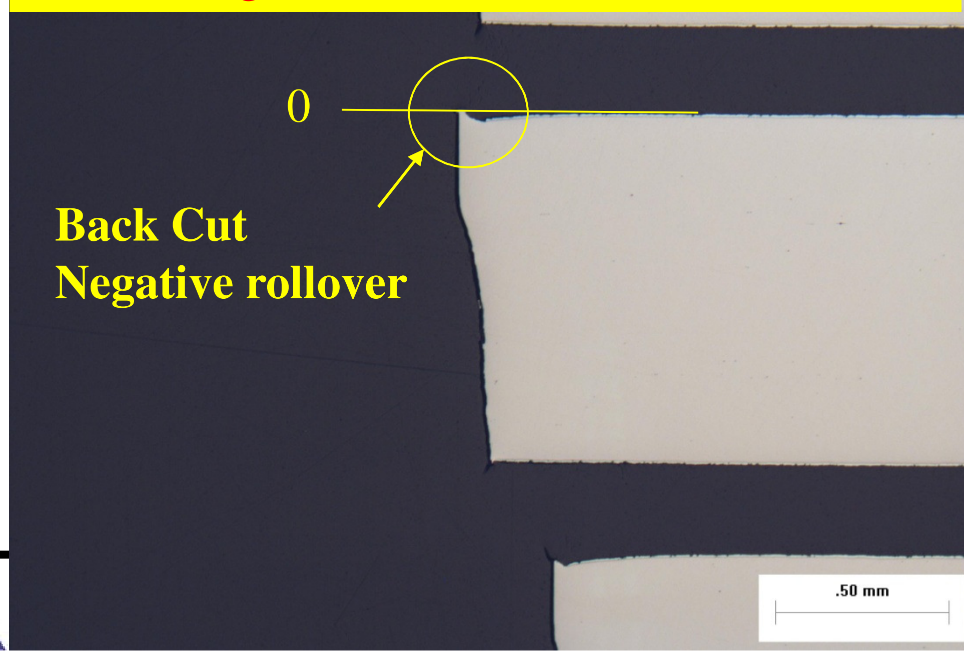


12 degree, 15 % clearance- Loc. 3

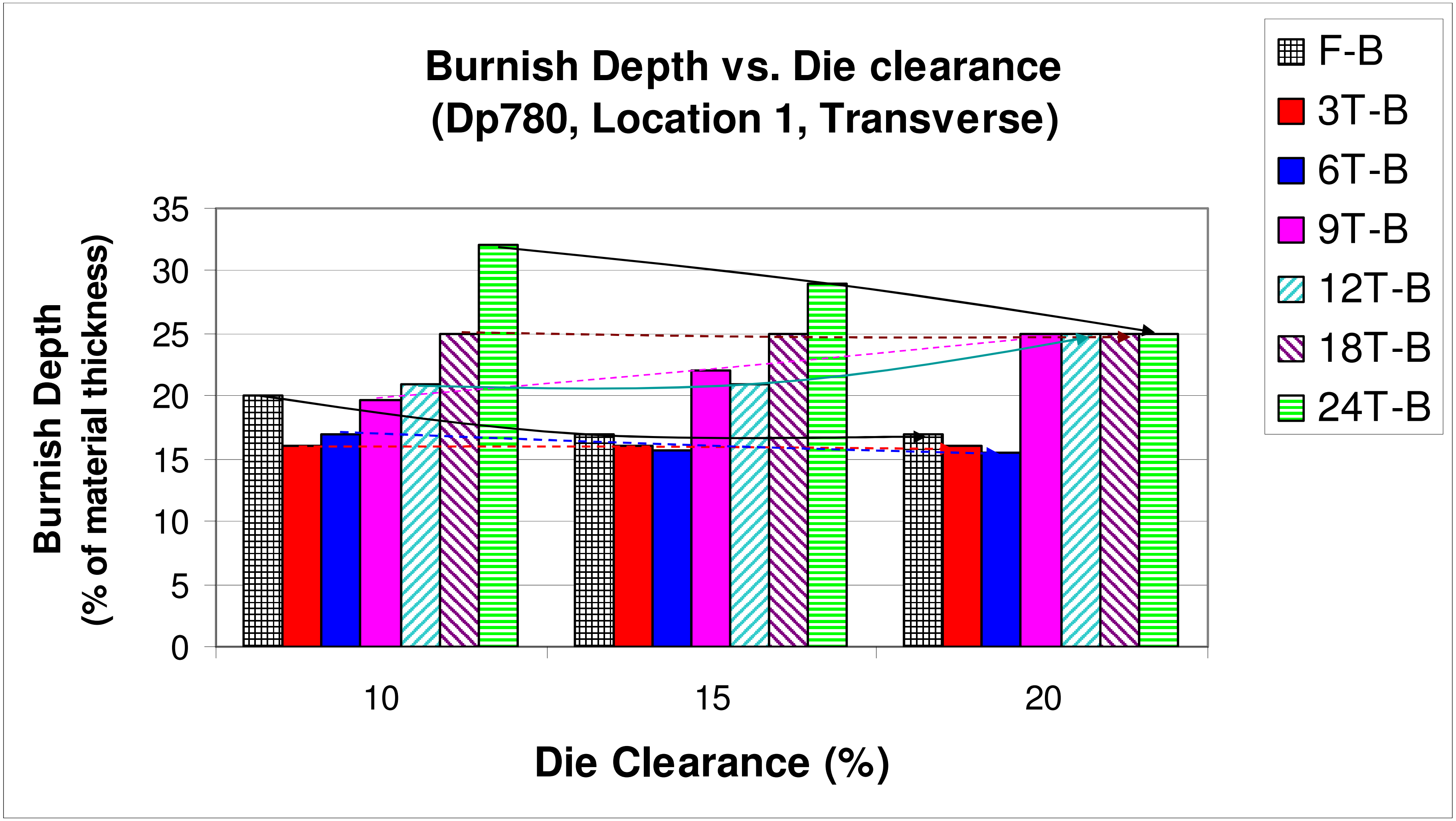




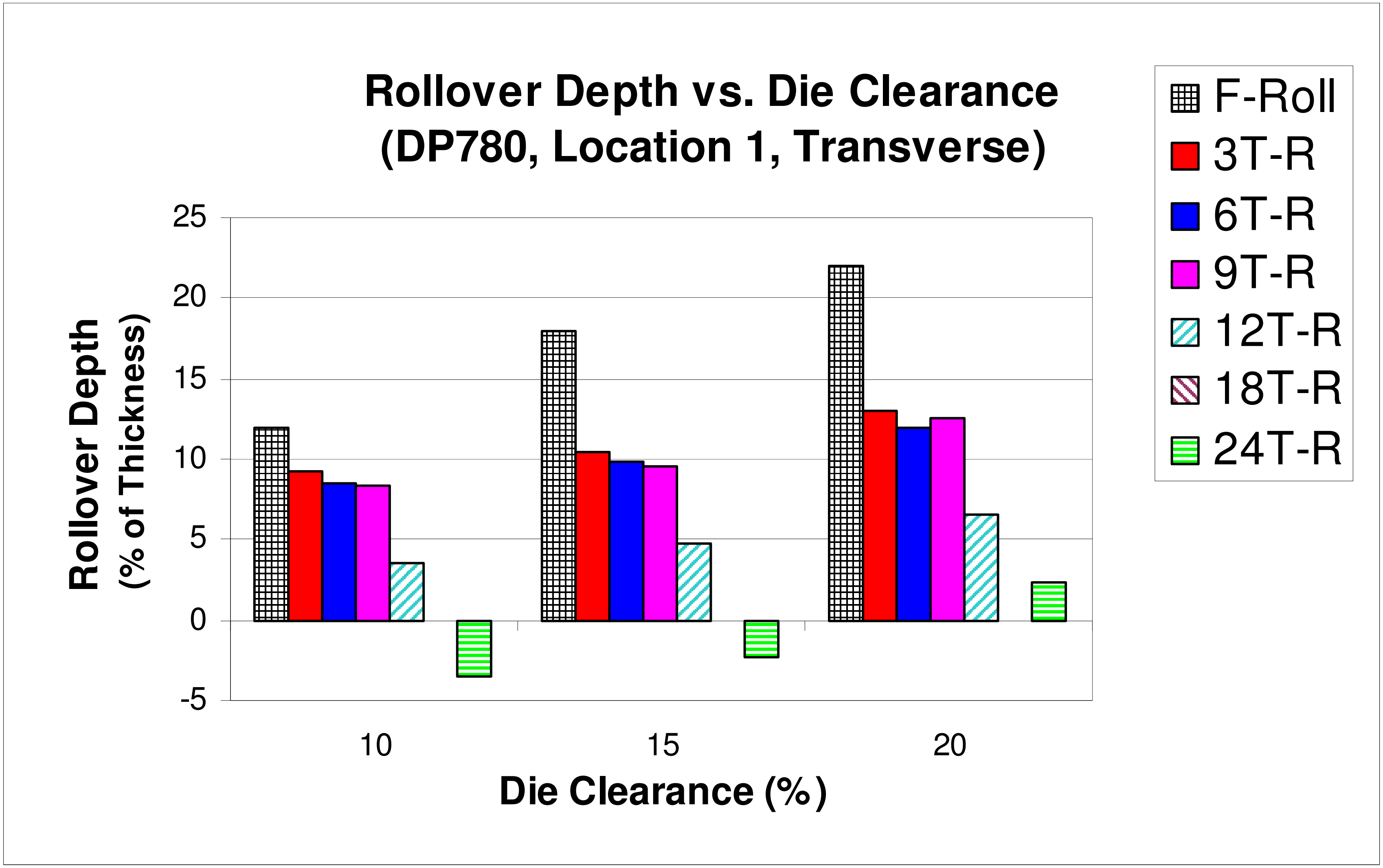
18 degree, 15 % clearance- Loc. 1



Burnish Depth



Rollover Depth



Conclusions

- Beveling shearing/piercing process has been developed at a lab base hydraulic press and has been successfully used for piercing holes for AHSS.
- The maximum shearing force can be significantly reduced more than 50% when a beveling angle is used during shearing. The shearing force depends also upon the die clearance during shearing.
- The optimal shearing condition results in more than 60% improvement in the hole expansion ratio when compared to conventional flat head punching process.
- The optimized shearing condition for piercing and shearing AHSS is the combination of a beveling angle between 3 and 6 degrees and a 17% die clearance and the shearing direction parallel to the material rolling direction.

Thank you