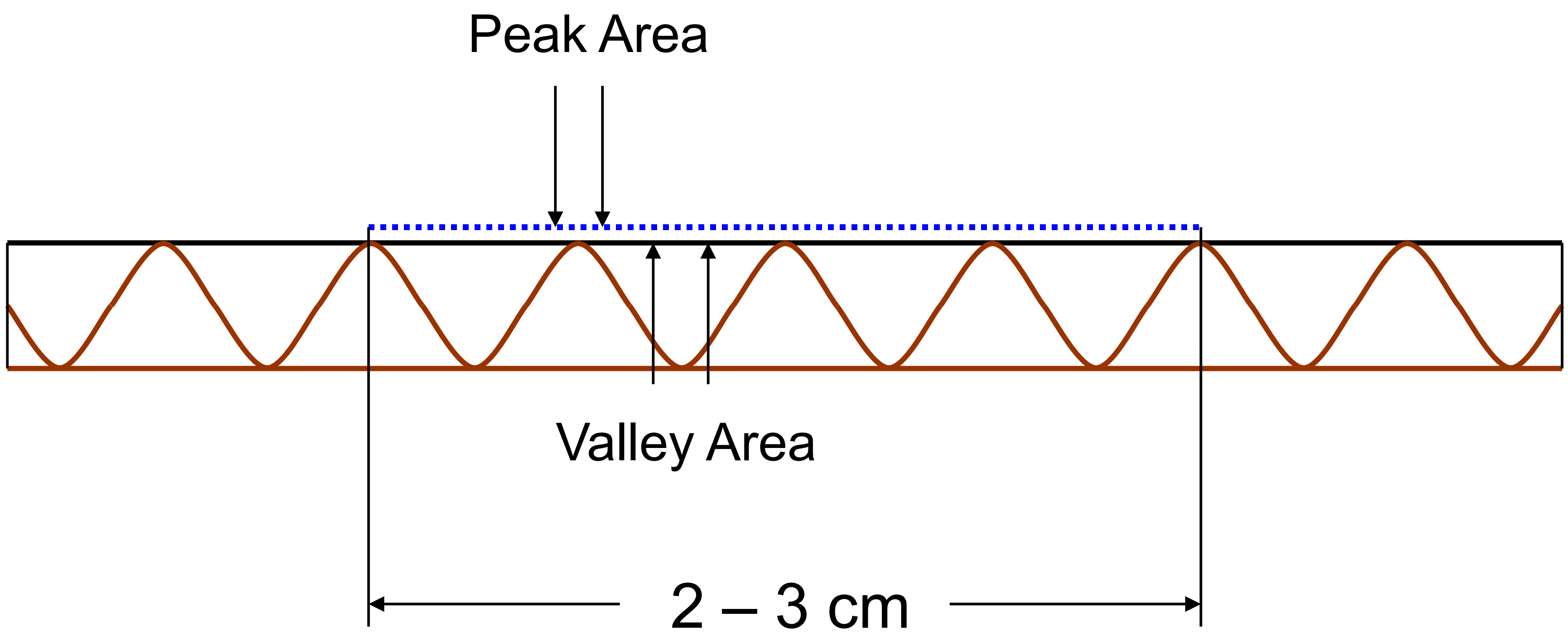
Nothing ventured, nothing Gained

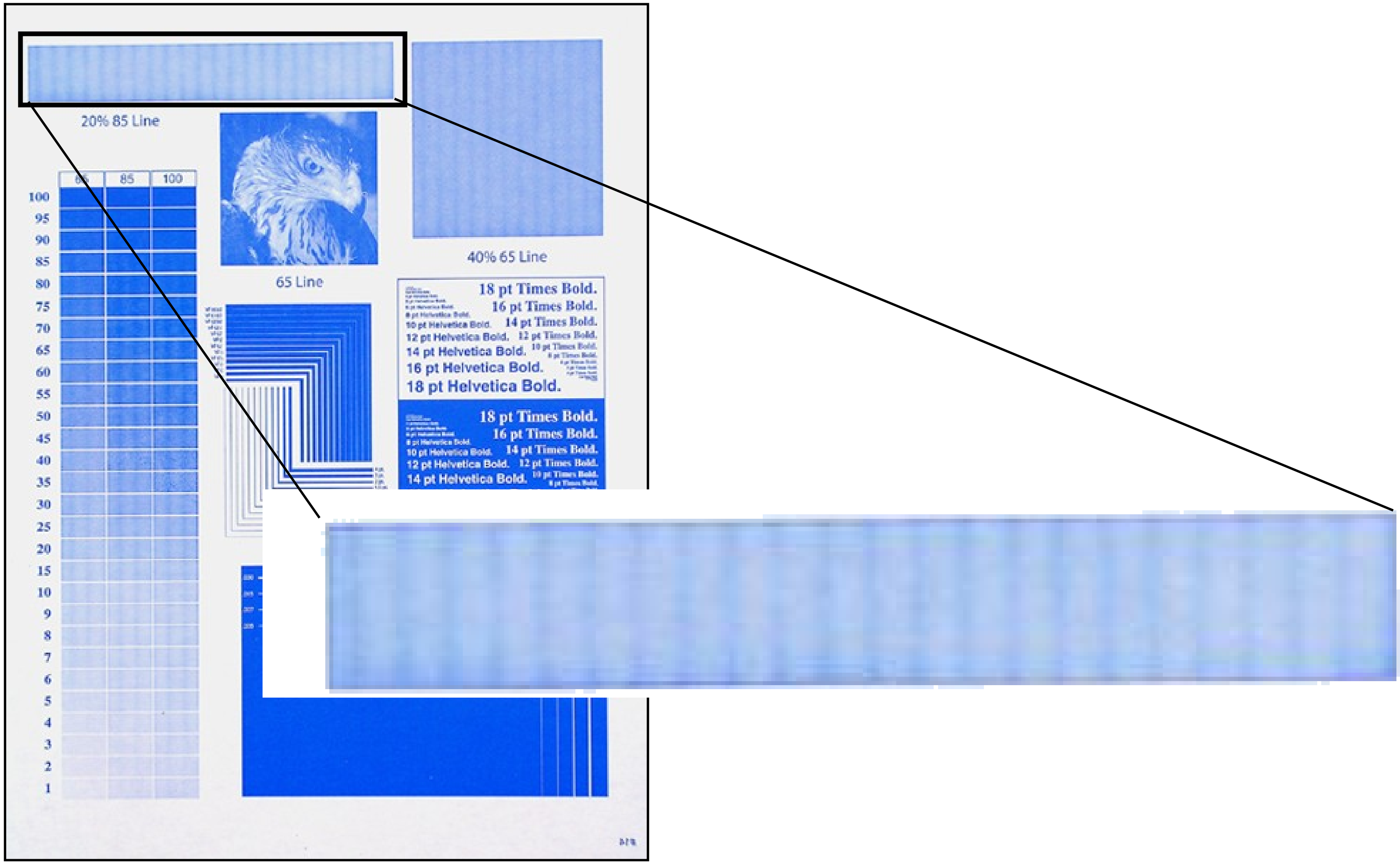
An Examination of Mechanical Gain Models and Causes in Flexographic Printing of Corrugated Board

Timothy Gotsick
March 4, 2013
MacDermid Printing Solutions

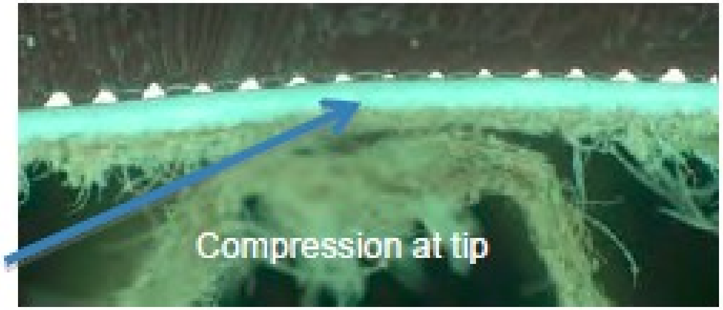
Corrugated Structure



The Problem


20% 85 Line
65
85
100
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
9
8
7
6
5
4
3
2
1
65 Line
40% 65 Line
18 pt Times Bold.
16 pt Times Bold.
14 pt Times Bold.
12 pt Helvetica Bold.
14 pt Helvetica Bold.
16 pt Helvetica Bold.
18 pt Helvetica Bold.
18 pt Times Bold.
16 pt Times Bold.
14 pt Times Bold.
12 pt Helvetica Bold.
14 pt Helvetica Bold.

Board vs Dot



- Board structure changes the impression level experienced by dots across the surface of the board
  - Dots printing on flute ‘tip’ are harshly compressed
  - Dots printing on flute ‘valley’ are minimally compressed

Pressure Variation Effect

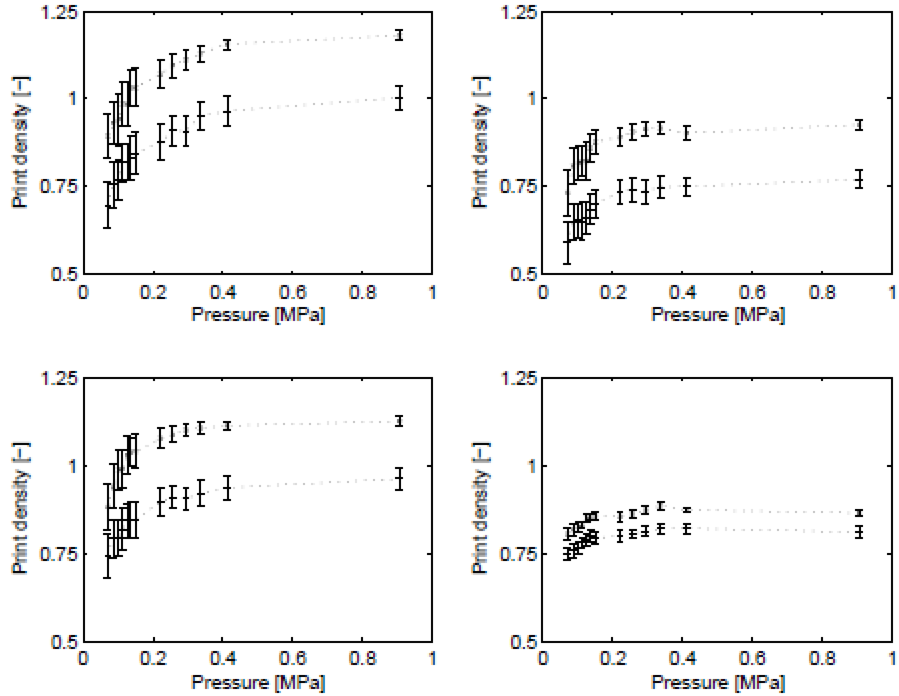


Figure 15. Print density as a function of pressure for the four different liner board grades.

"Striping on Flexo Post-printed Corrugated Board"
Martin Holmvall, Thesis
Fibre Science and Communication Network, Department of Natural Sciences, Mid Sweden University, SE-851 70 Sundsvall, Sweden, 2007

Pressure Variations

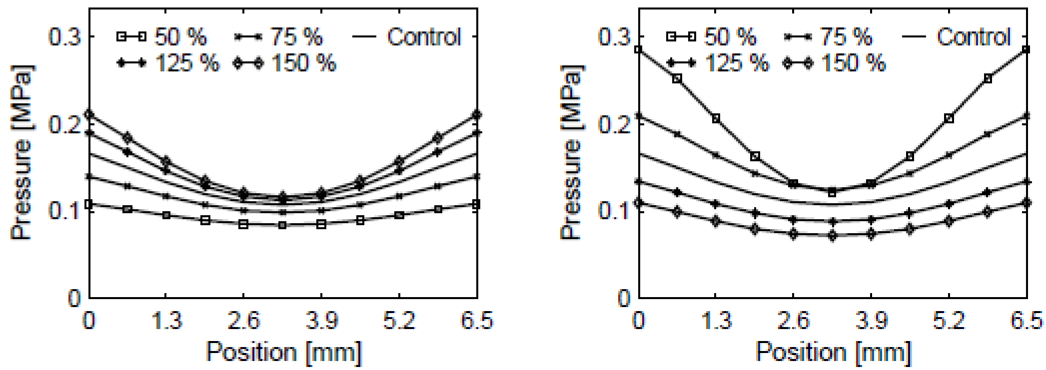


Figure 17. Pressure distributions for different photopolymer stiffnesses (left) and thicknesses (right).

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Martin Holmvall, Thesis
Fibre Science and Communication Network, Department of Natural Sciences, Mid Sweden University, SE-851 70 Sundsvall, Sweden, 2007

Print Pressure Variations

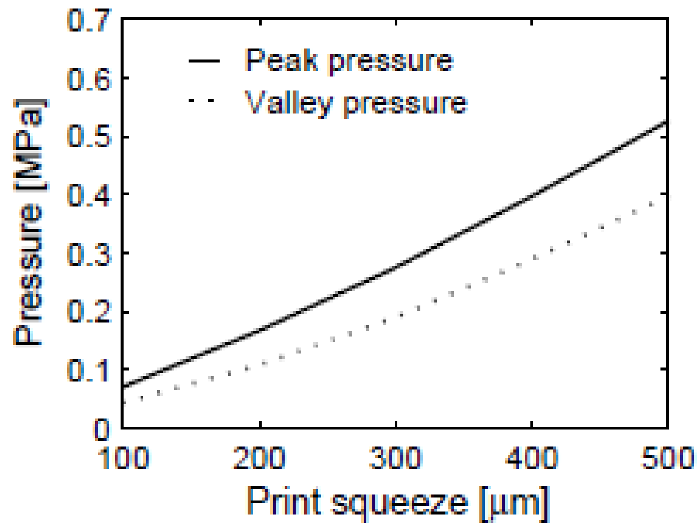

Figure 20. The relationship between the pressure at the ridges and in the valley.

“Striping on Flexo Post-printed Corrugated Board”
Martin Holmvall, Thesis
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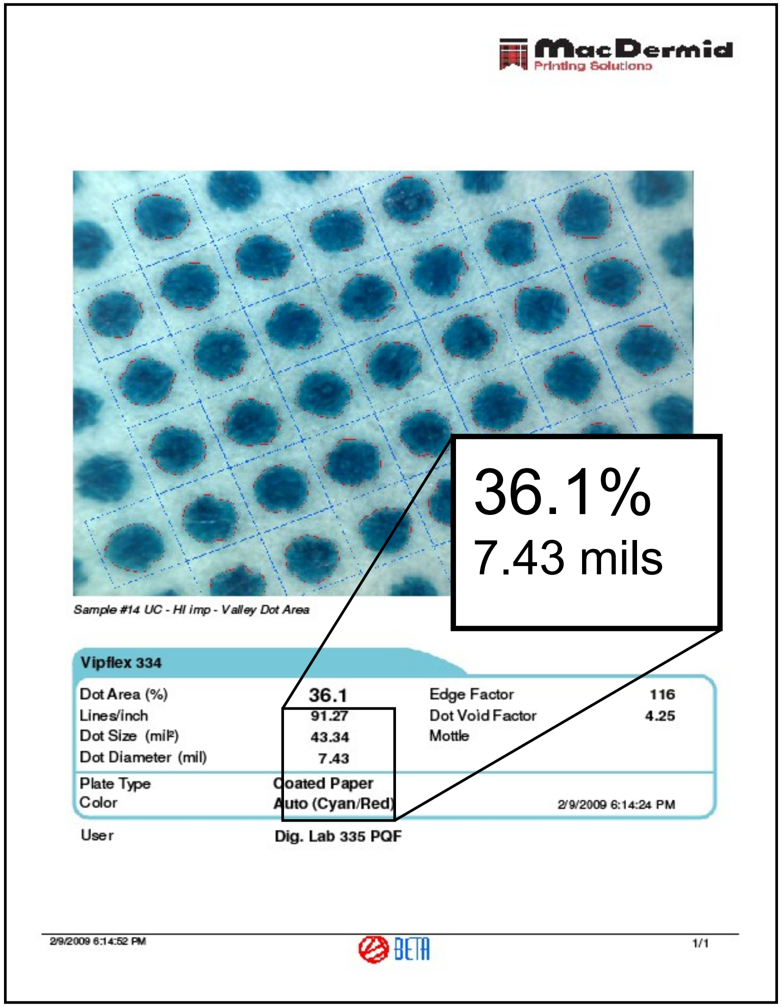
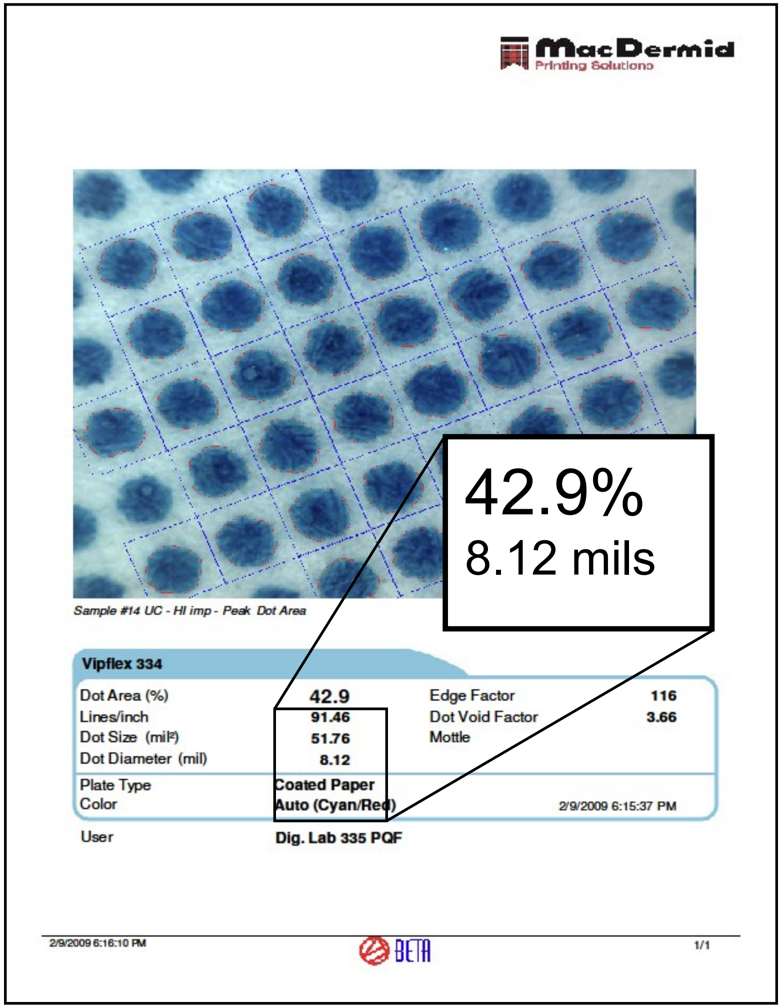
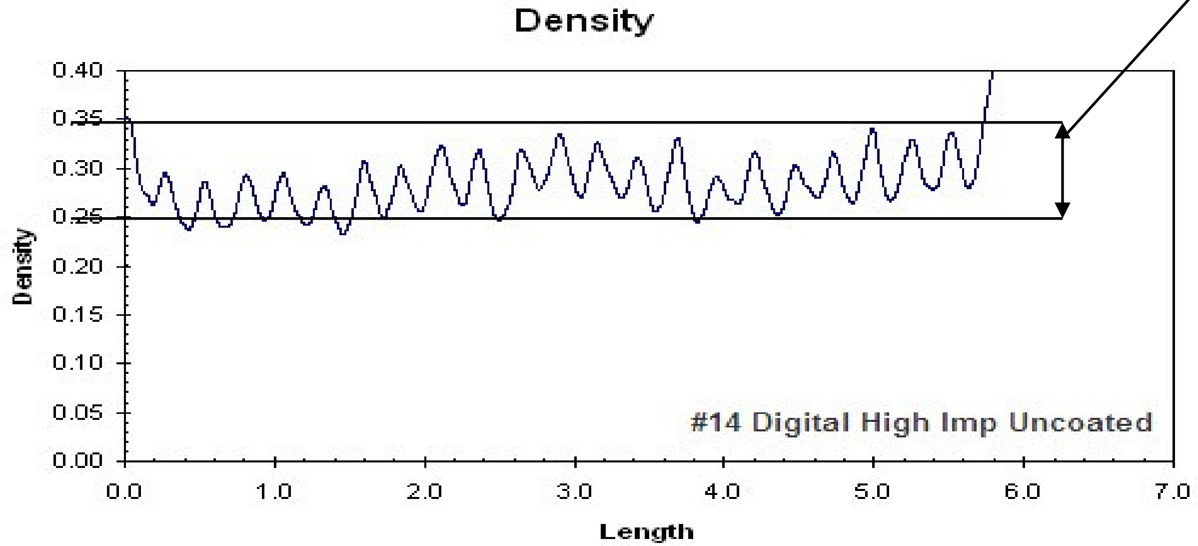

MacDermid Printing Solutions
36.1%
7.43 mils
Sample #14 UC - HI imp - Valley Dot Area
Vipflex 334
Dot Area (%) 36.1
Lines/inch 91.27
Dot Size (mil²) 43.34
Dot Diameter (mil) 7.43
Edge Factor 116
Dot Void Factor 4.25
Mottle
Plate Type Coated Paper
Color Auto (Cyan/Red)
2/9/2009 6:14:24 PM
User Dig. Lab 335 PQF
2/9/2009 6:14:52 PM
BETA
1/1


MacDermid Printing Solutions
42.9%
8.12 mils
Sample #14 UC - HI imp - Peak Dot Area
Vipflex 334
Dot Area (%) 42.9
Lines/inch 91.46
Dot Size (mil²) 51.76
Dot Diameter (mil) 8.12
Edge Factor 116
Dot Void Factor 3.66
Mottle
Plate Type Coated Paper
Color Auto (Cyan/Red)
2/9/2009 6:15:37 PM
User Dig. Lab 335 PQF
2/9/2009 6:16:10 PM
BETA
1/1

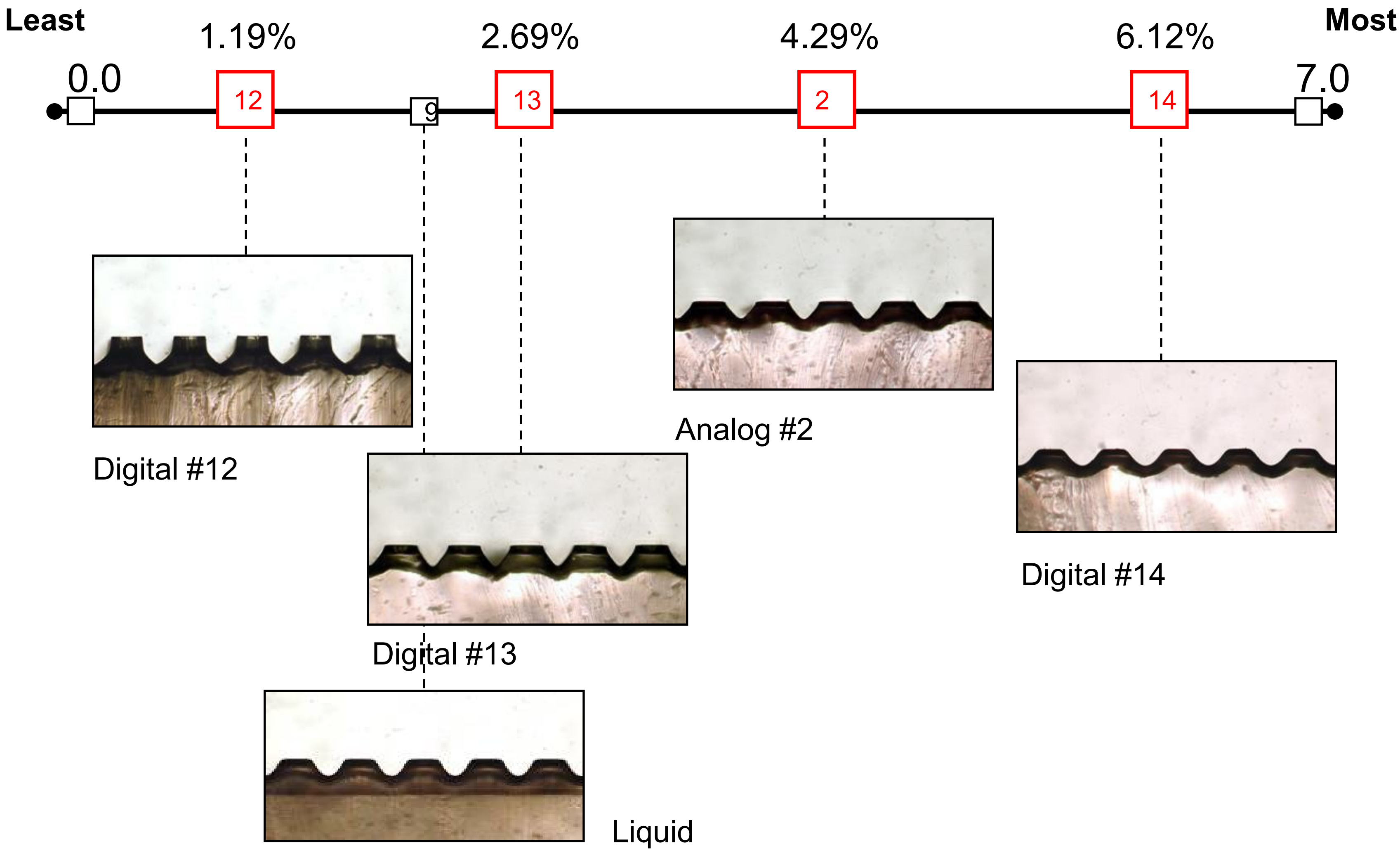
Quantifying Fluting

Flute Analysis

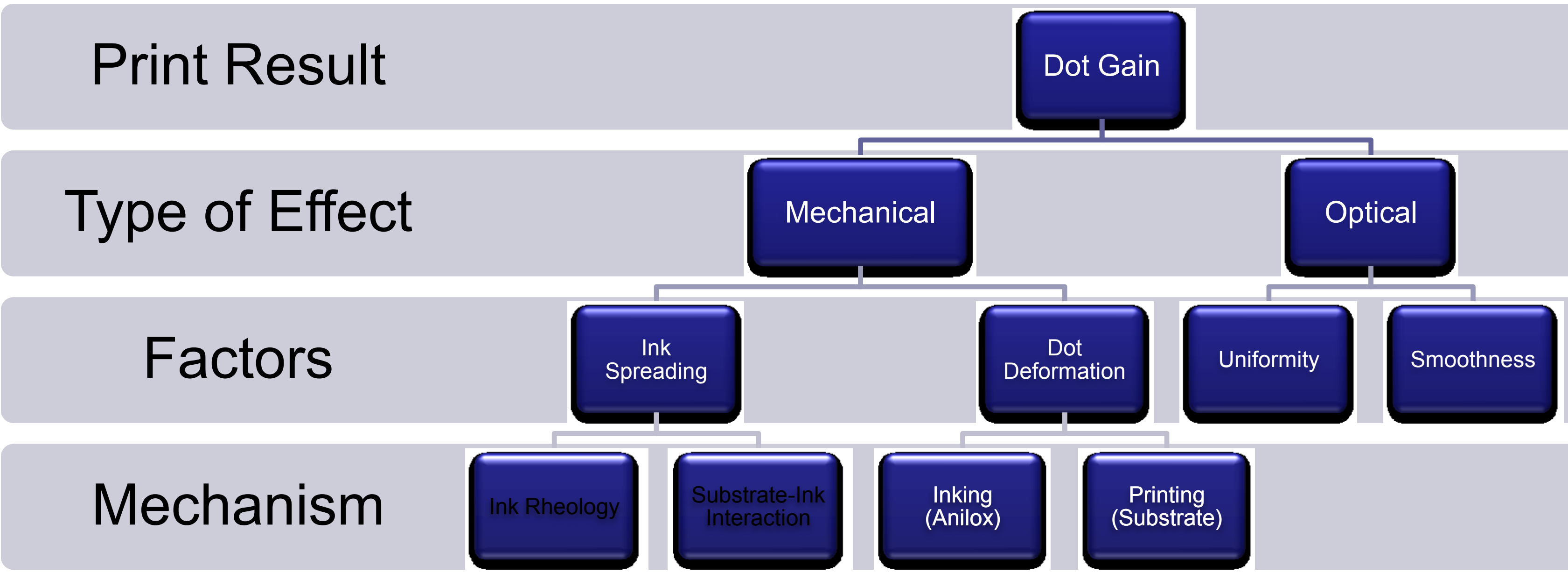
Average Density	0.2842		Flutting Wave Length	0.2705	in	
Peak-to-Valley Avg.	0.0481		Flutting Amplitude	0.0240		
Average Dot Area	52.7272	%				F-Factor
Peak Dot Area	55.7980	%	Valley Dot Area	49.4817	%	6.32



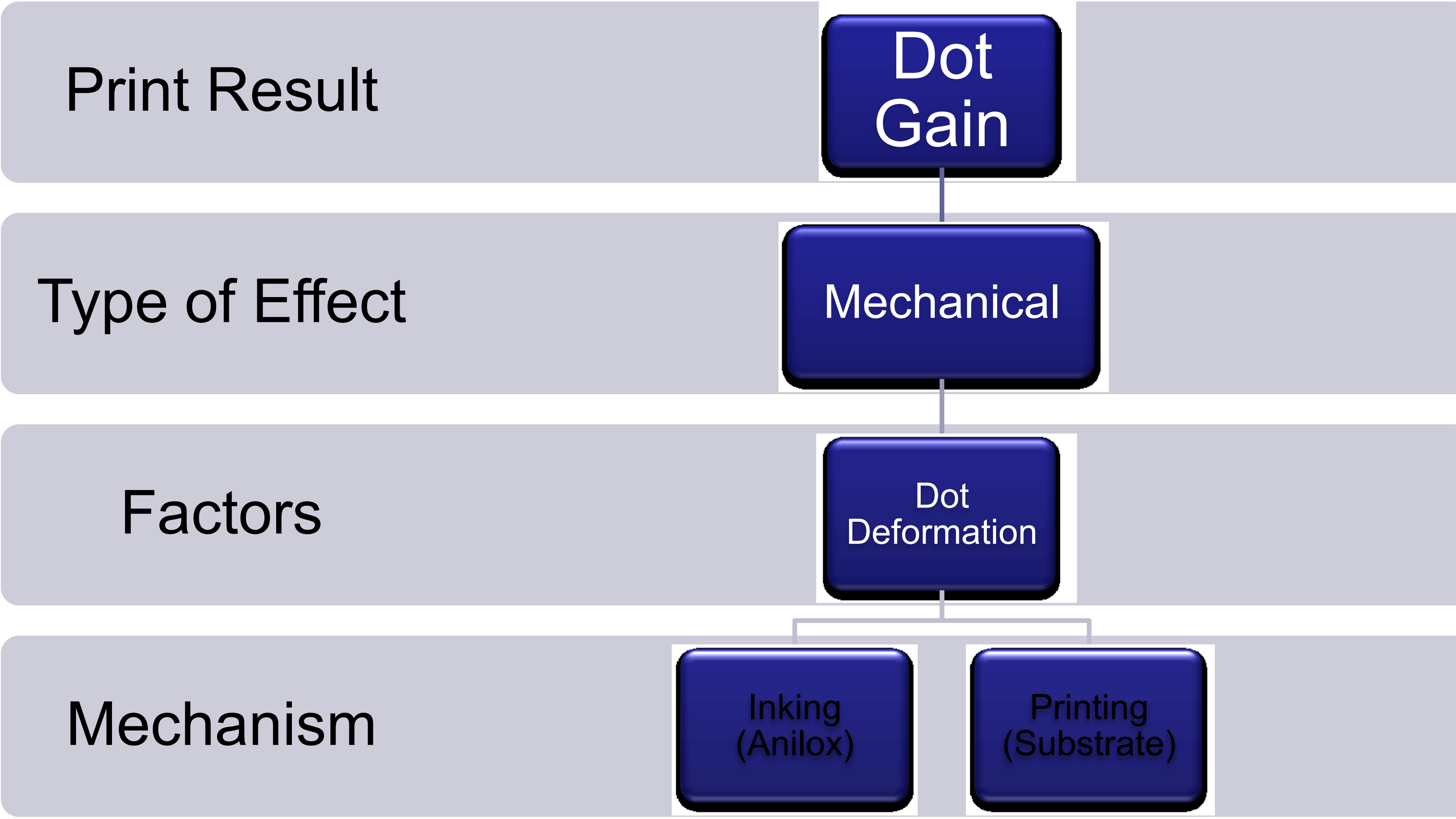
Dot Shape affects Fluting



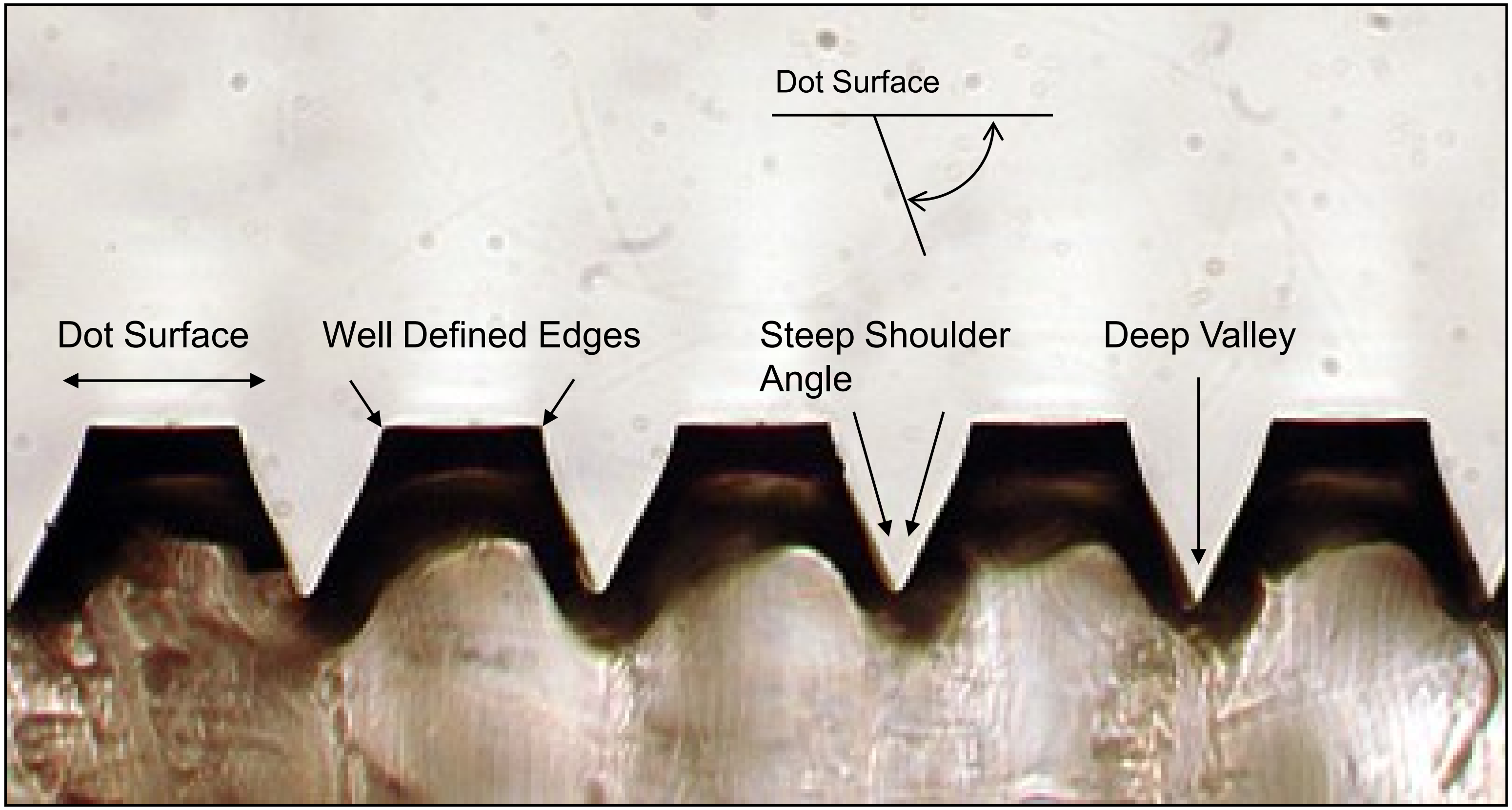
Root causes of dot gain



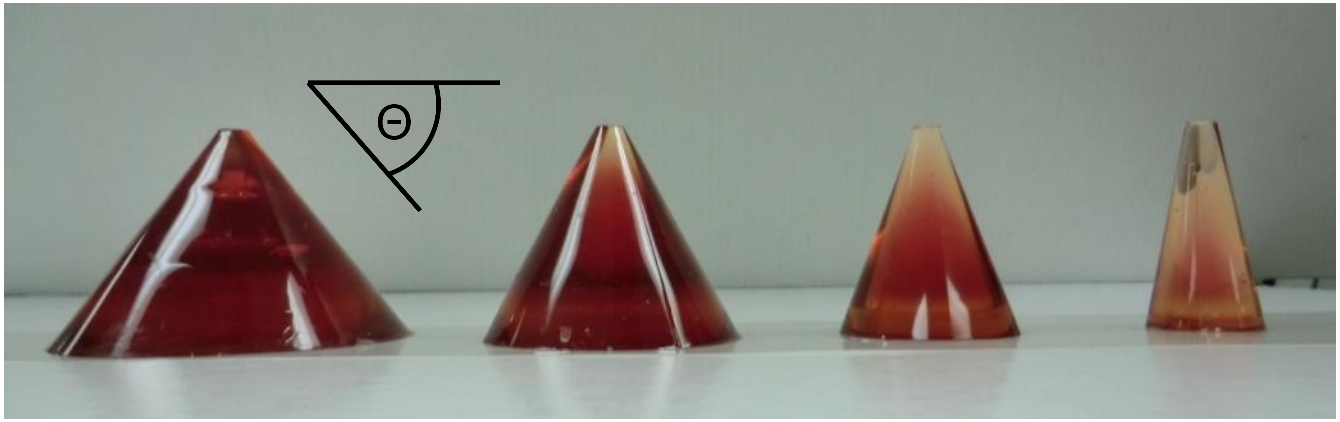
Root causes of dot gain?



Factors that Influence Dot Gain

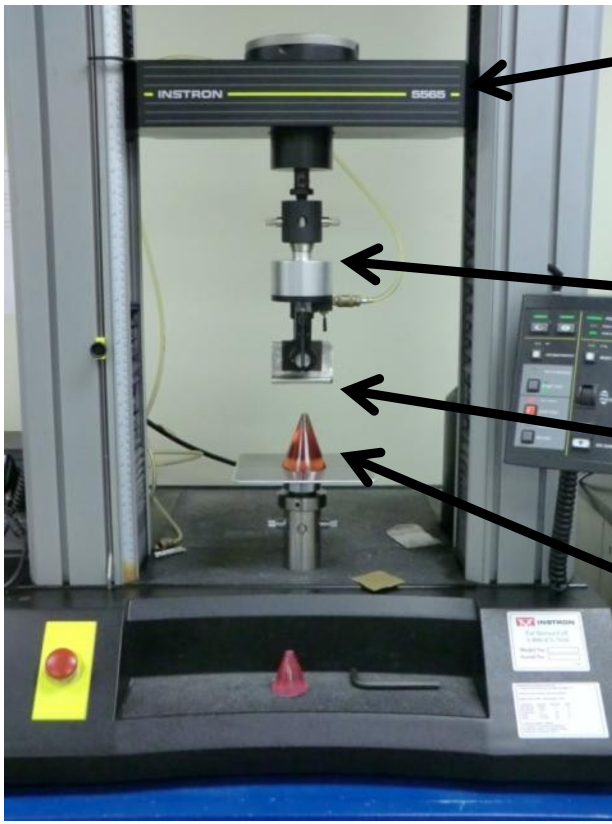


Truly Big Dots



- Molded from 32 Shore A photopolymer
- 7 cm tall
- 1 cm tip
- Θ = 53°, 62°, 71°, 79°

Dot Compression Analyzer

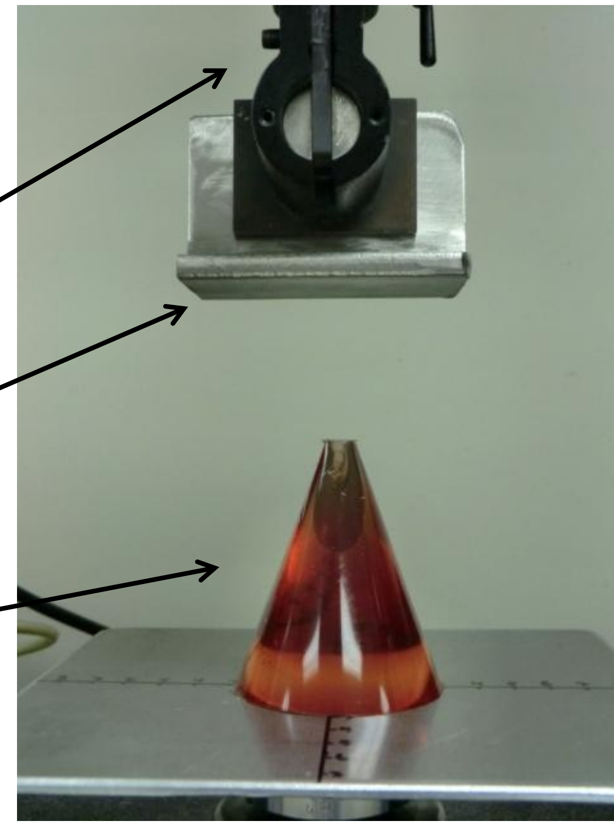


Compression adjustment mechanism

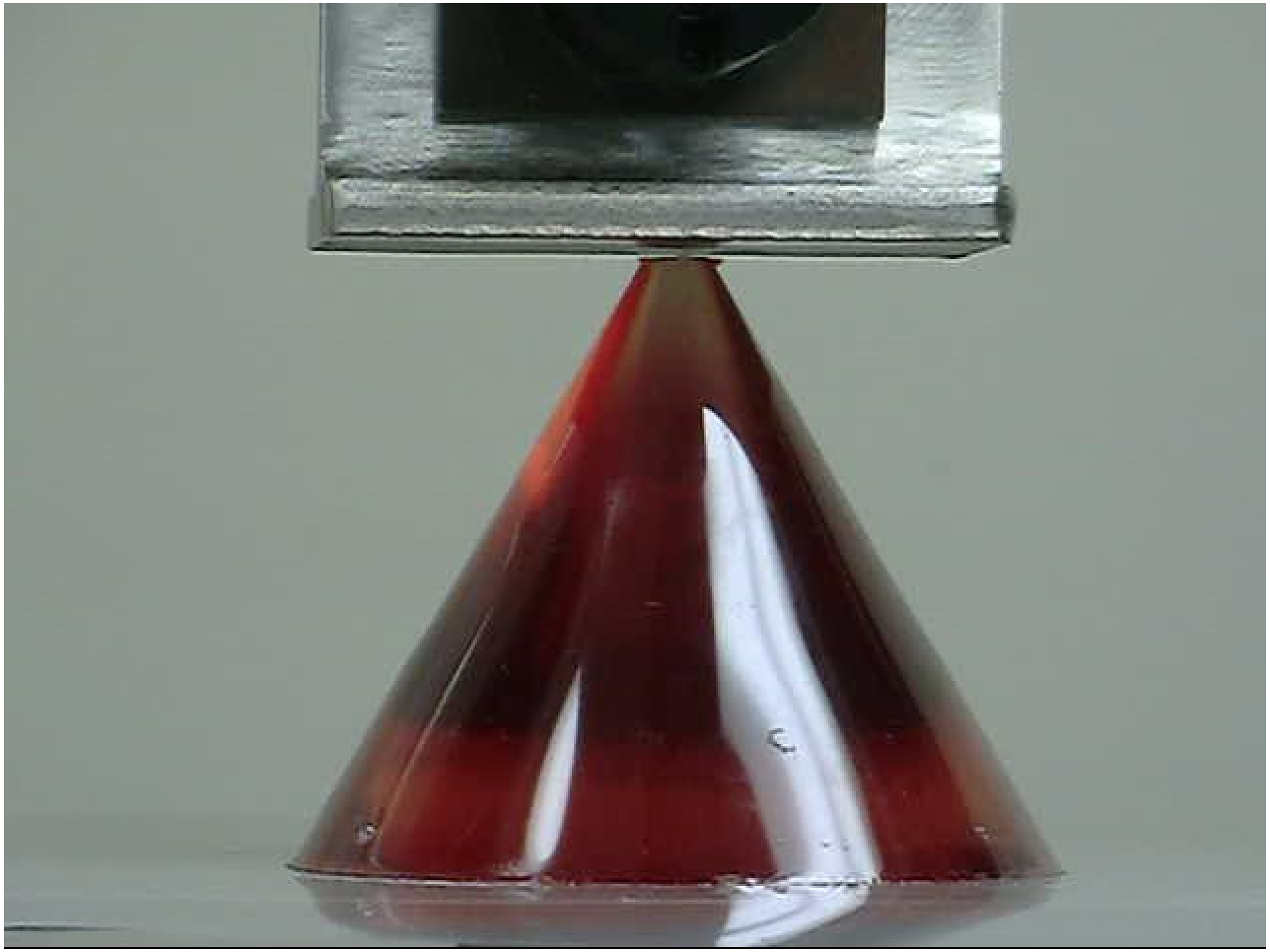
Digital force gauge

'Print' surface

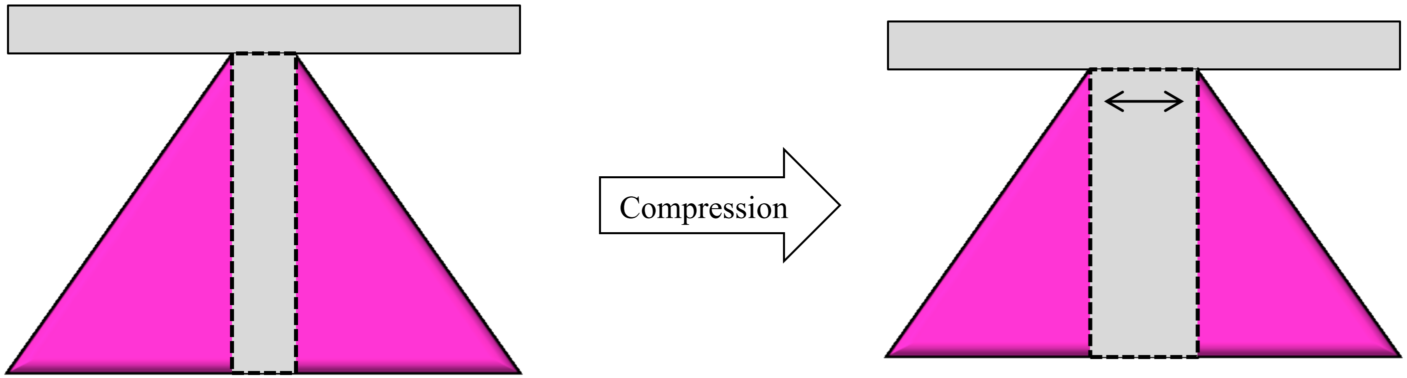
The Dot



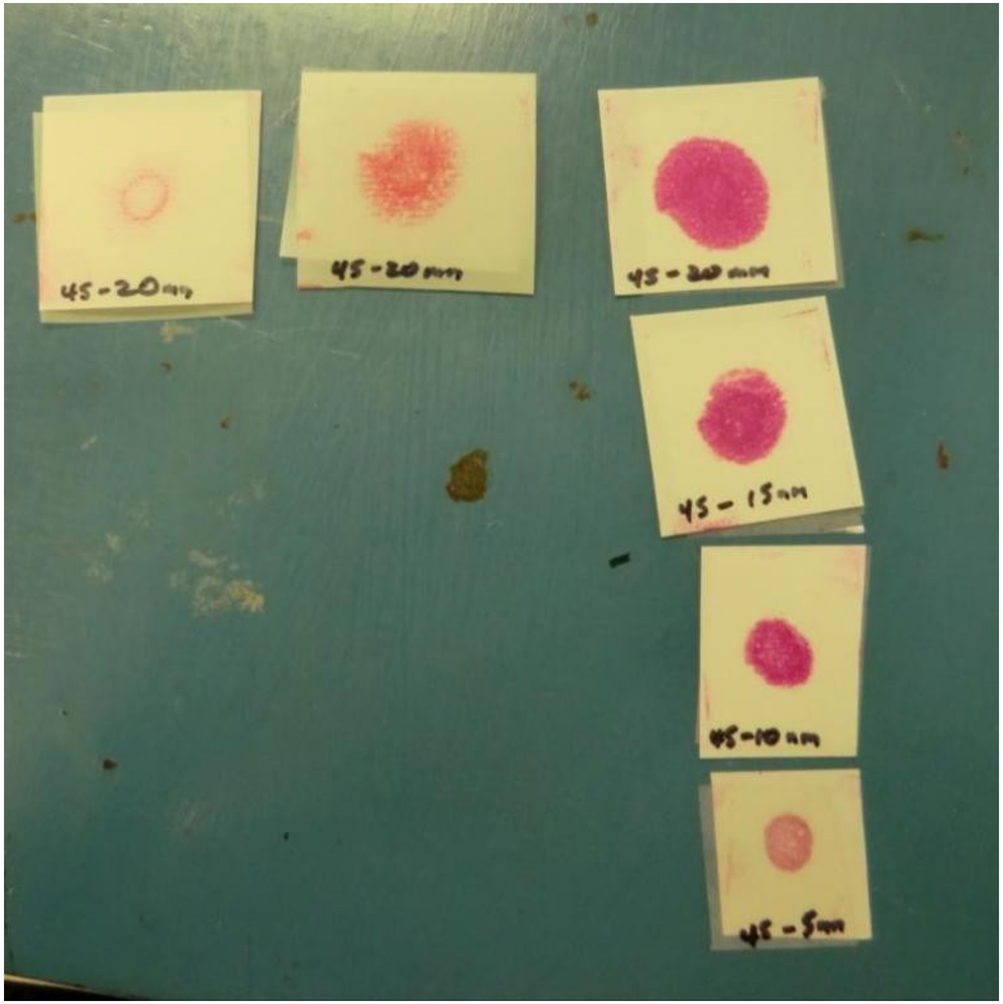
Dot Compression LIVE!



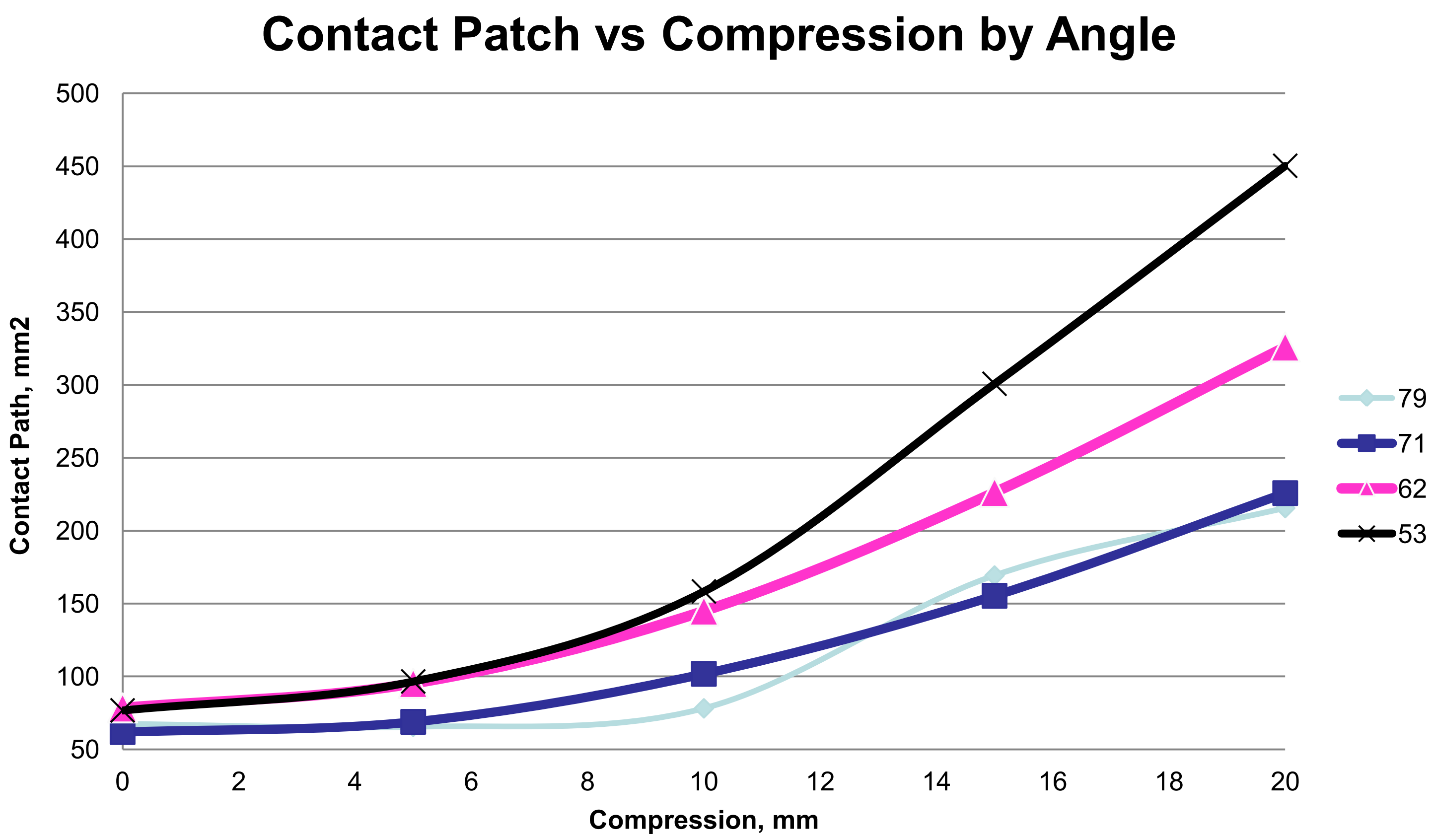
Contact Patch Expansion



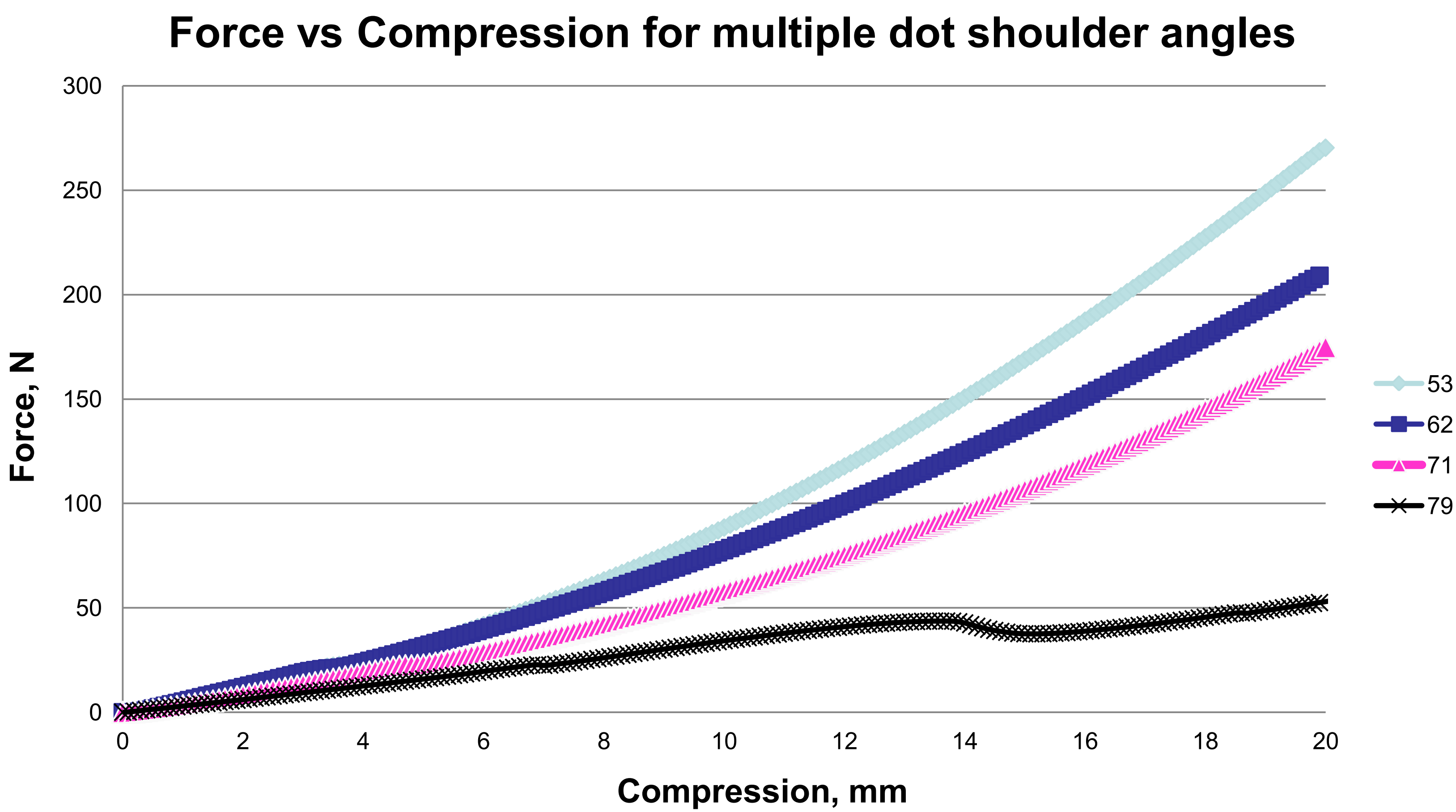
Contact Patch Measurement



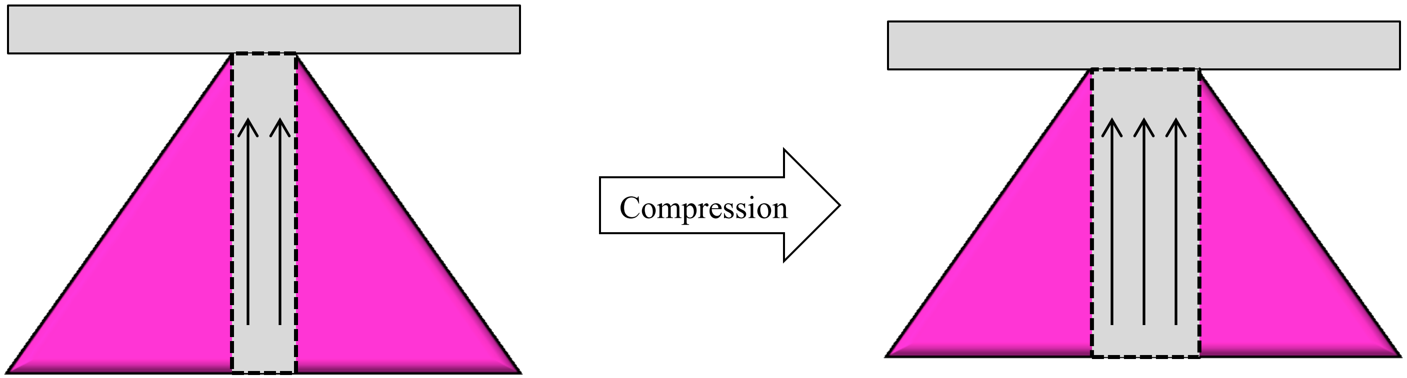
Contact Patch Growth



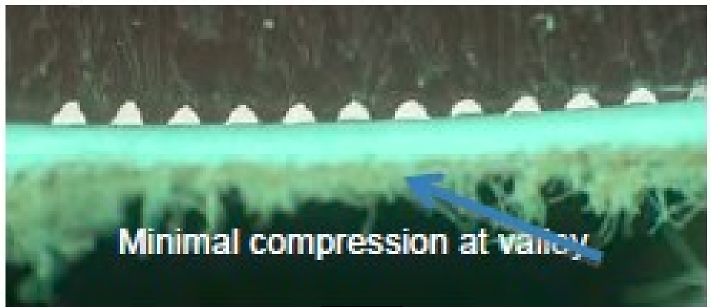
Dot Force vs Compression

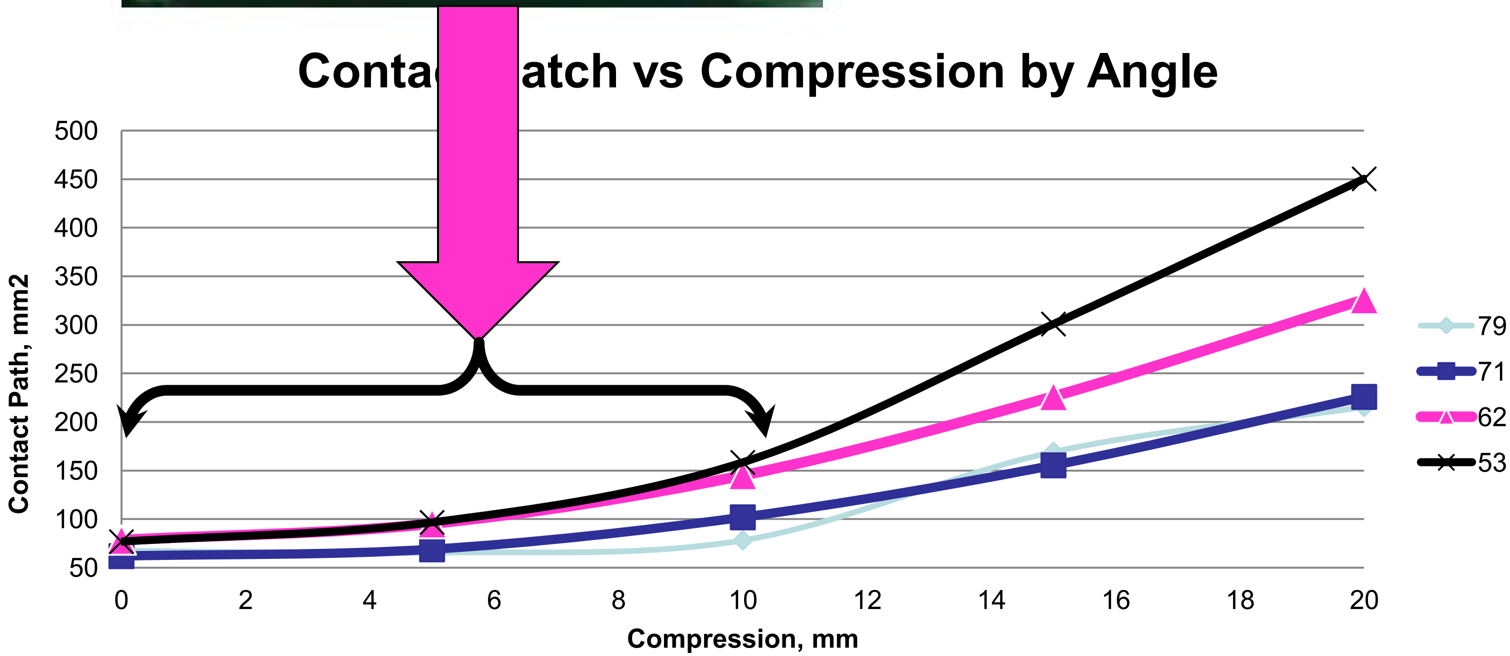


Dot Force Increase

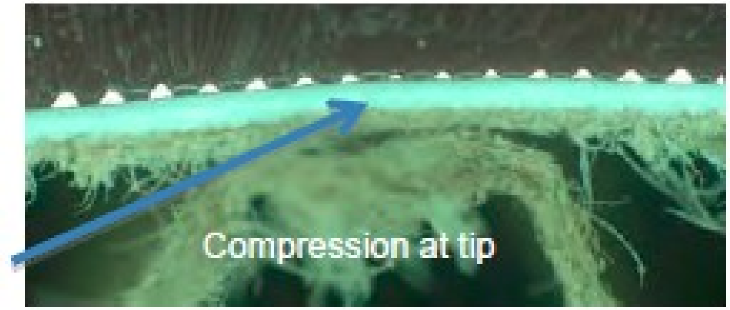


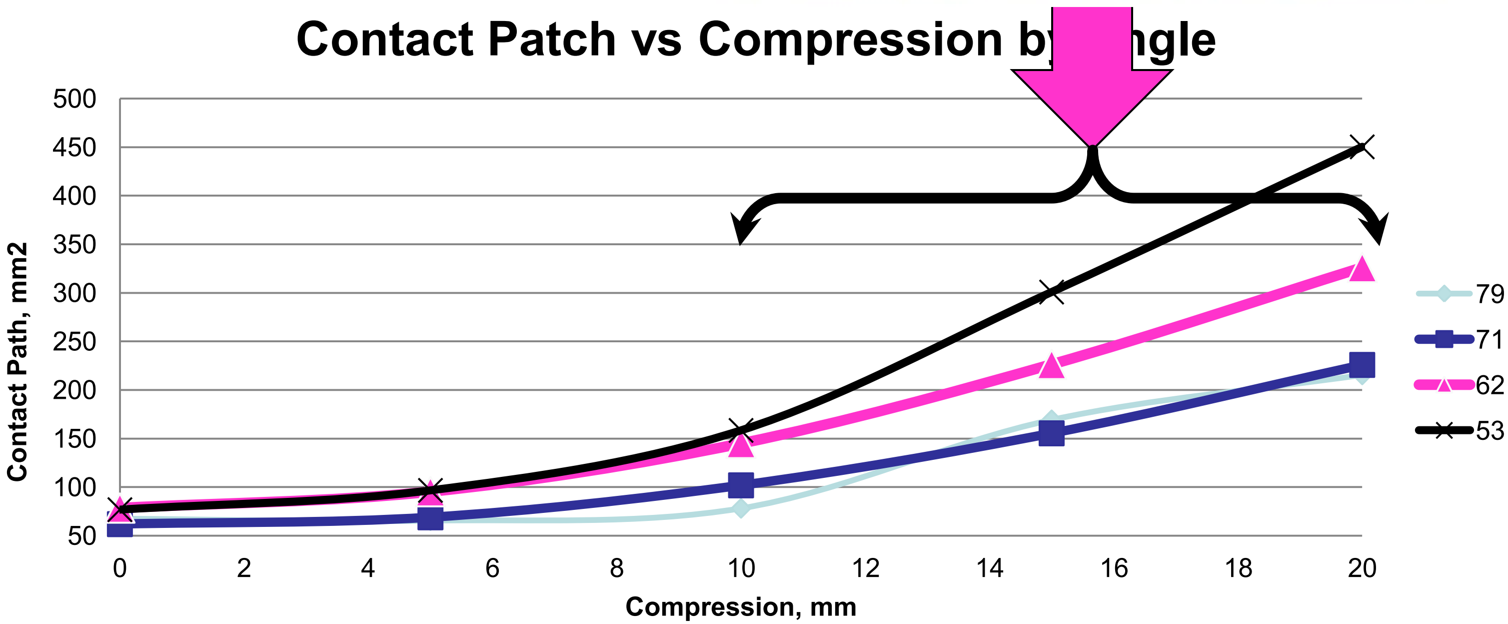
Light Compression in Valleys



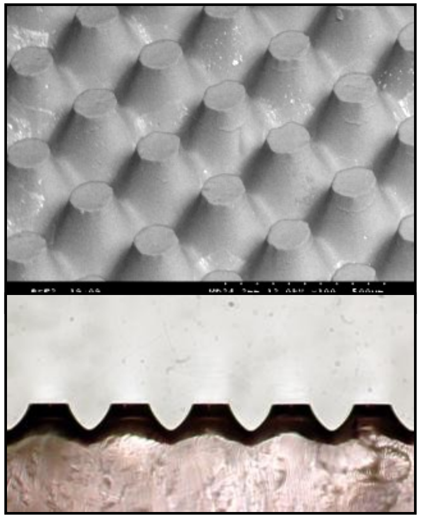


High Compression at Tips

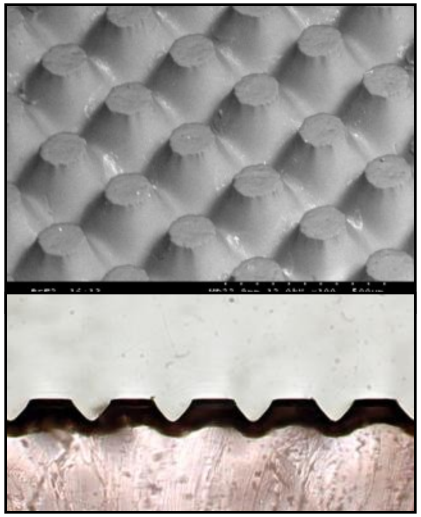




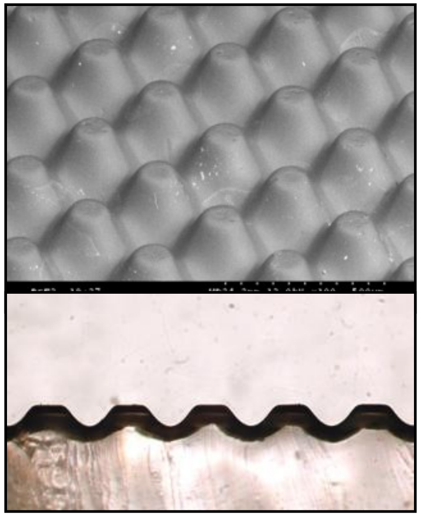
Platemaking Effects on Dot Shape



LUX Digital
52° with 3.60 mils



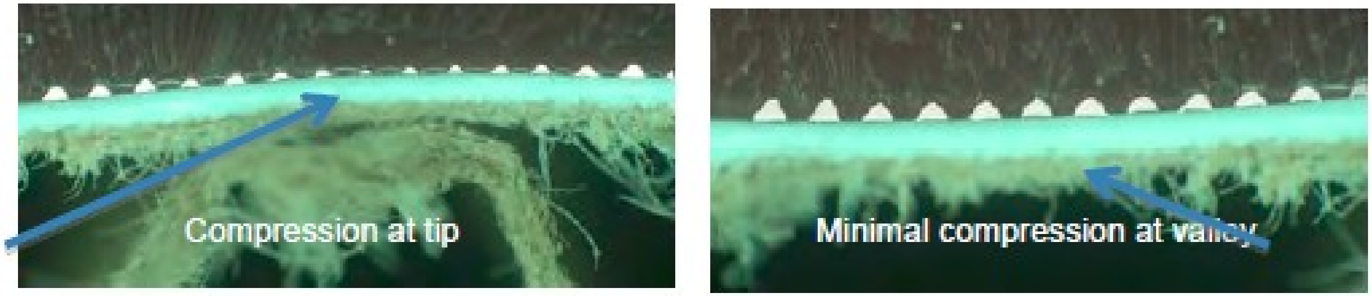
Analog
46° with 2.95 mils



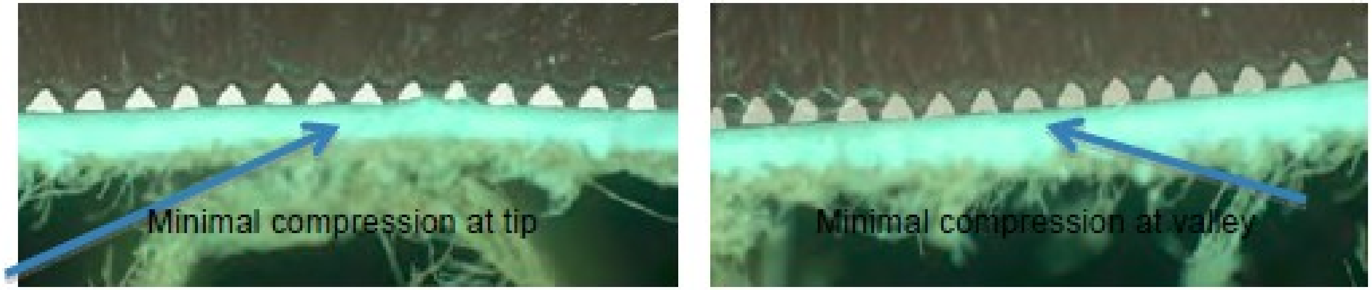
Standard Digital
41° with 2.80 mils

Dot shoulder angle, valley depth are strongly influenced by platemaking method

Dot Shape sets Compression Response

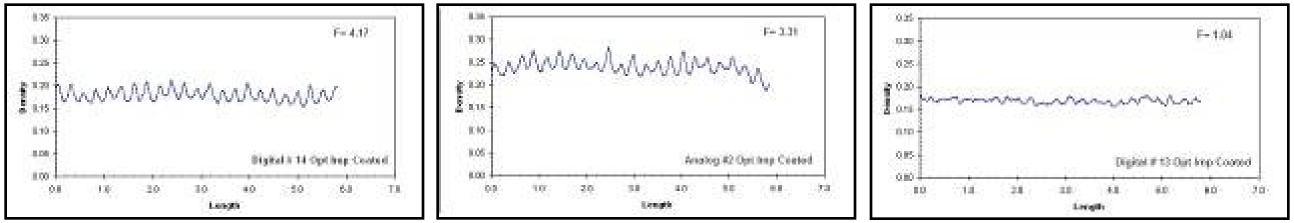


Standard Digital

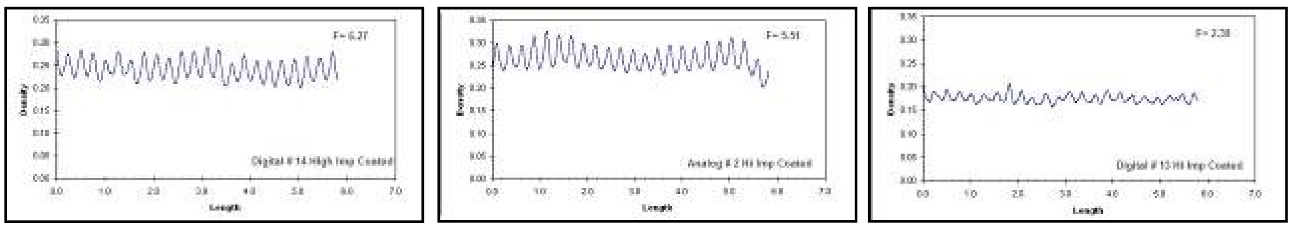


LUX Digital

Reduced Fluting Sensitivity



Optimum Impression



Higher Impression

Std Digital	Analog	LUX Digital
Δ=2.10	Δ=2.38	Δ=1.35

Coated B flute board

Conclusions

- Fluting is caused by differences in the impression environment the dots are subjected to at the flute tips and valleys
- Dot shoulder angle influences dot gain because:
  - Contact patch size (gain) increases with impression, but it increases less for dots with shallower shoulder angles
  - Impression force increases with impression, but it increases less for dots with shallower shoulder angles
- Platemaking technology strongly influences dot shoulder angle, and thus the fluting tendency of plates made by different techniques
- The dot shoulder angle model of gain prediction seems to explain empirical results well

LUX™ by MacDermid Printing Solutions

Conclusions

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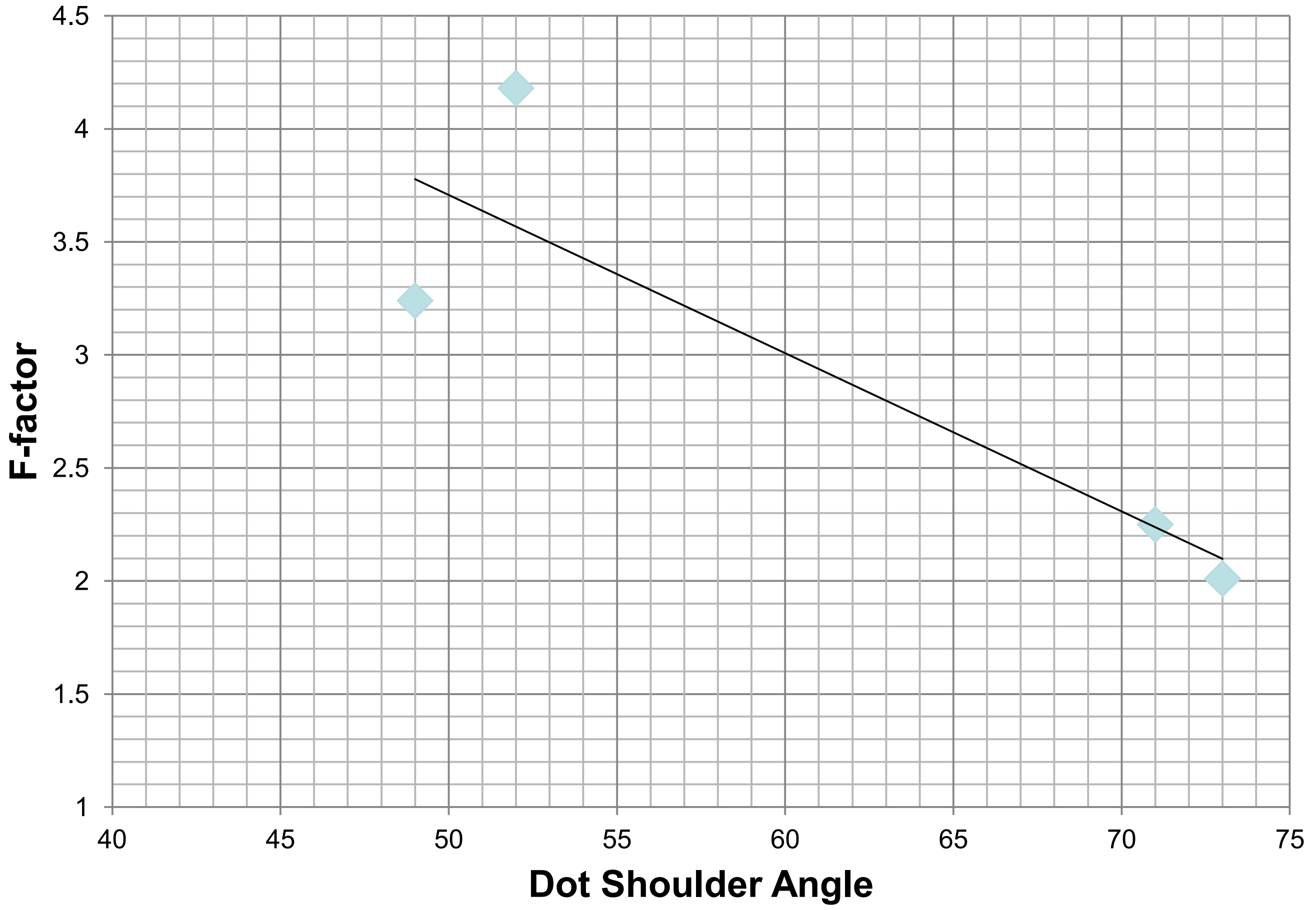
- Dot shoulder angle influences dot gain because:
  - Contact patch size (gain) increases with impression, but it increases less for dots with shallower shoulder angles
  - Impression force increases with impression, but it increases less for dots with shallower shoulder angles

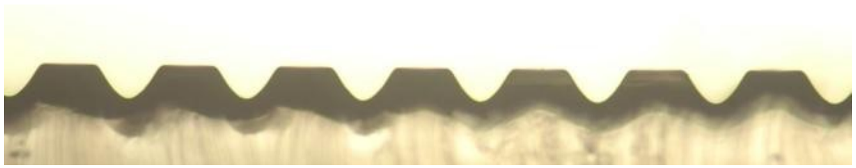
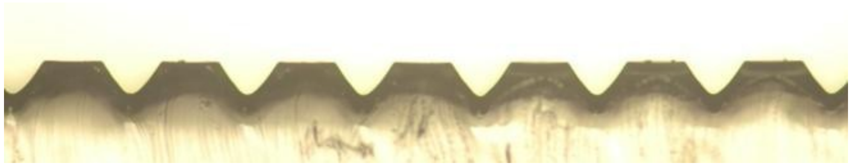
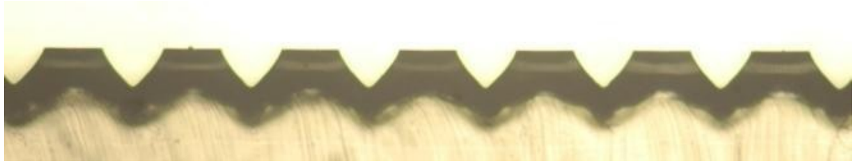
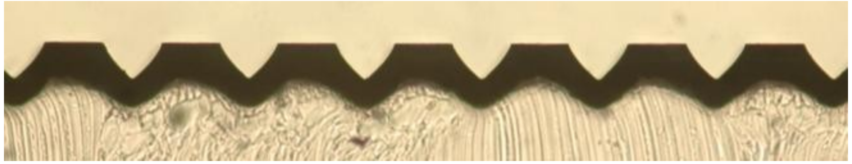
Except when it doesn't.

- Platemaking technology strongly influences dot shoulder angle, and thus the fluting tendency of plates made by different techniques
- **The dot shoulder angle model of gain prediction seems to explain empirical results**

F-factor vs Dot Shoulder Angle

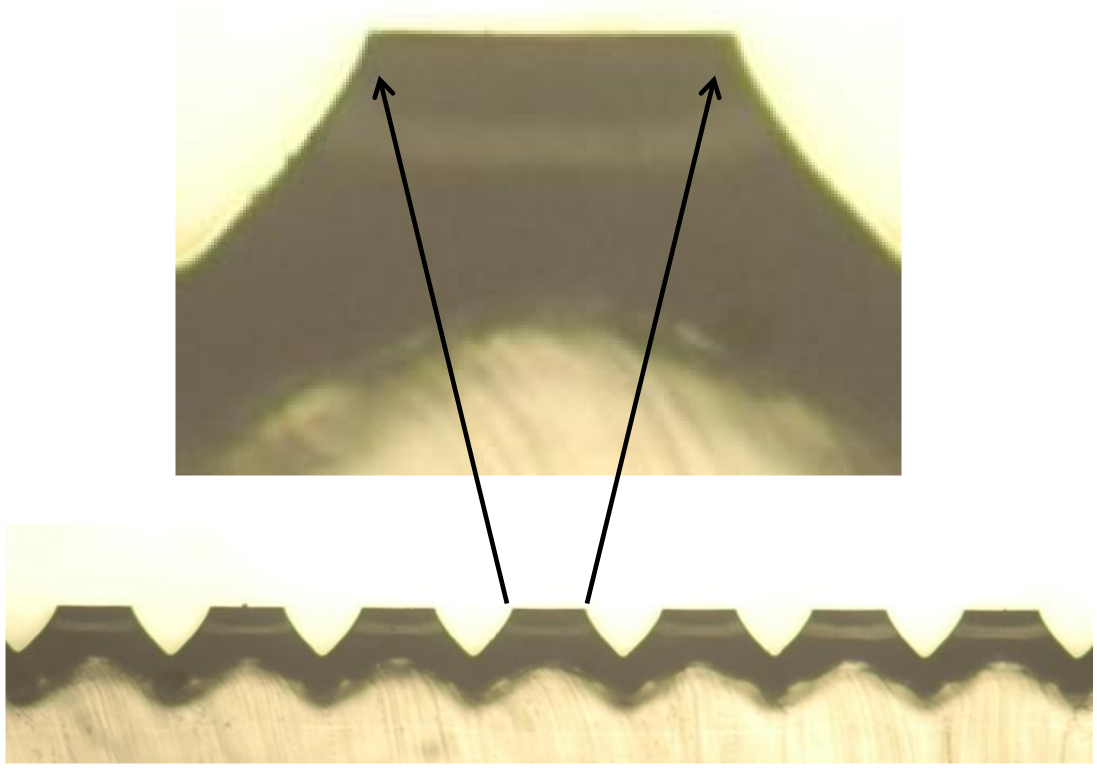


Dot shapes

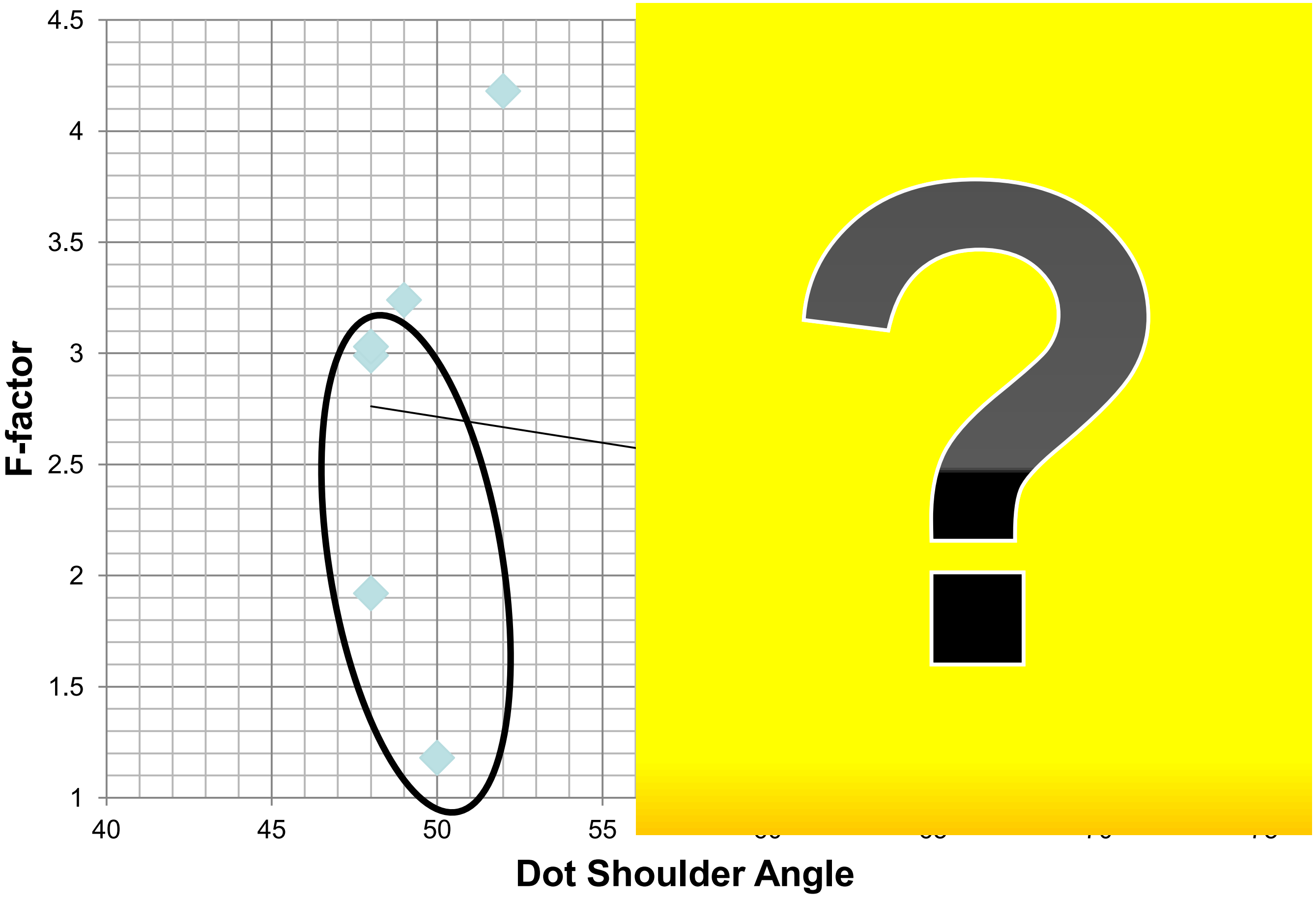
Dots	Angle → F-factor
	49 → 3.24
	52 → 4.18
	73* → 2.01
	71* → 2.34

* Near dot top

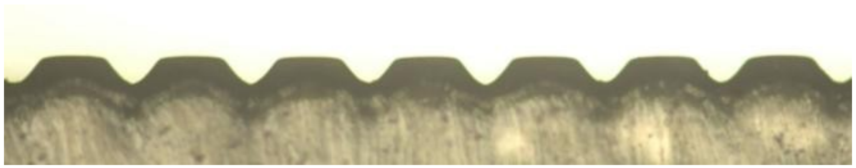
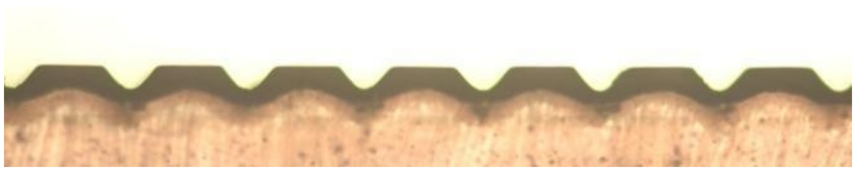
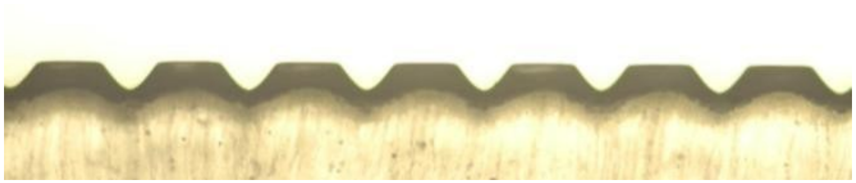
Compound Shoulder Angle



F-factor vs Dot Shoulder Angle



Dot shapes

Dots	Angle → F-factor
	48 → 2.99
	48 → 3.03
	48 → 1.92
	50 → 1.18

What is going on?

Another great theory shot to hell by reality!

Not quite. We just need to improve the theory.

A mystery explained?

Dots

Cap → F-factor

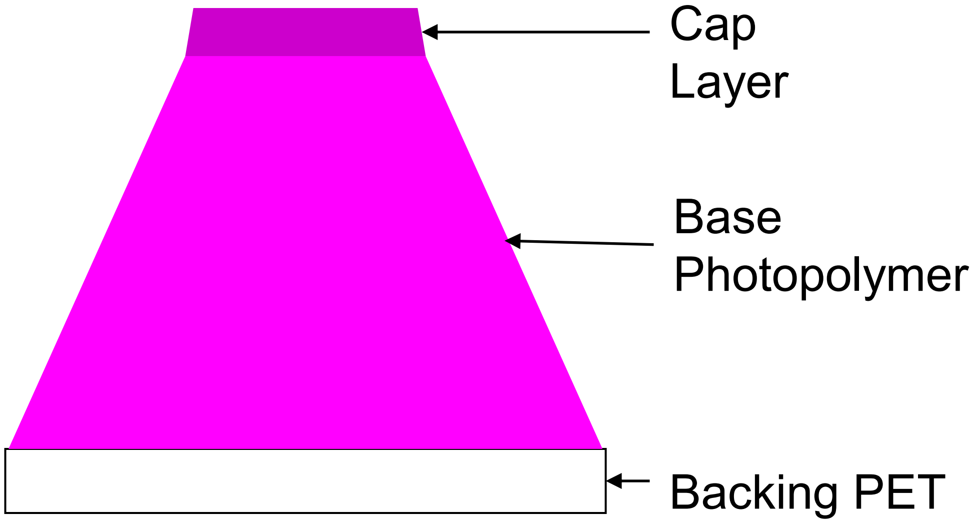
none → 2.99

35d → 3.03

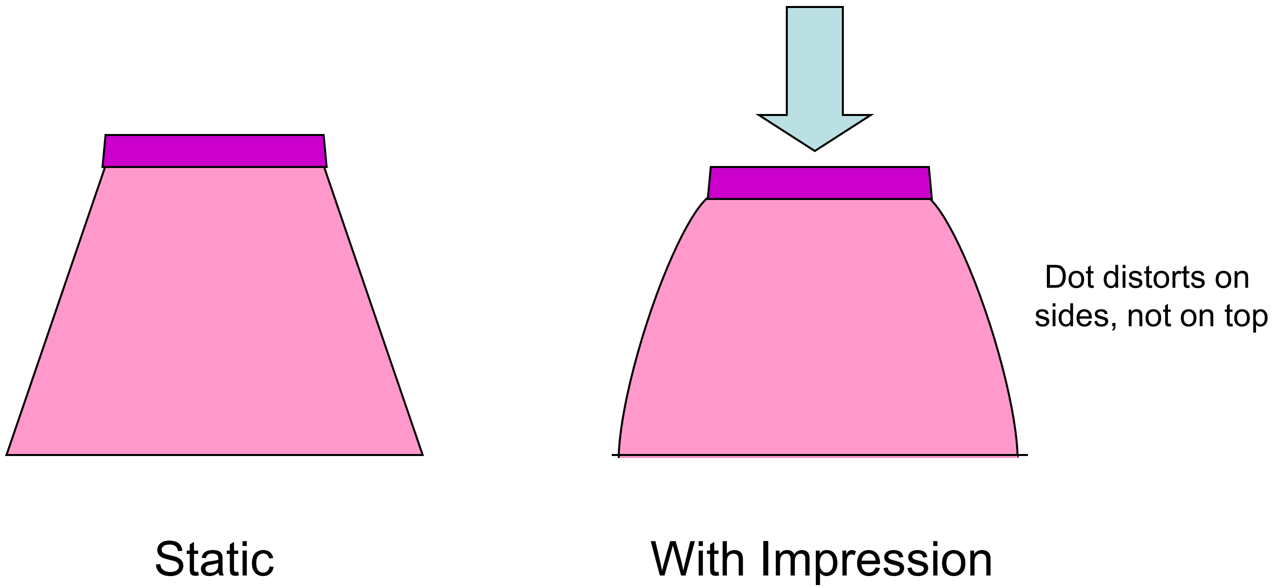
45d → 1.92

55d → 1.18

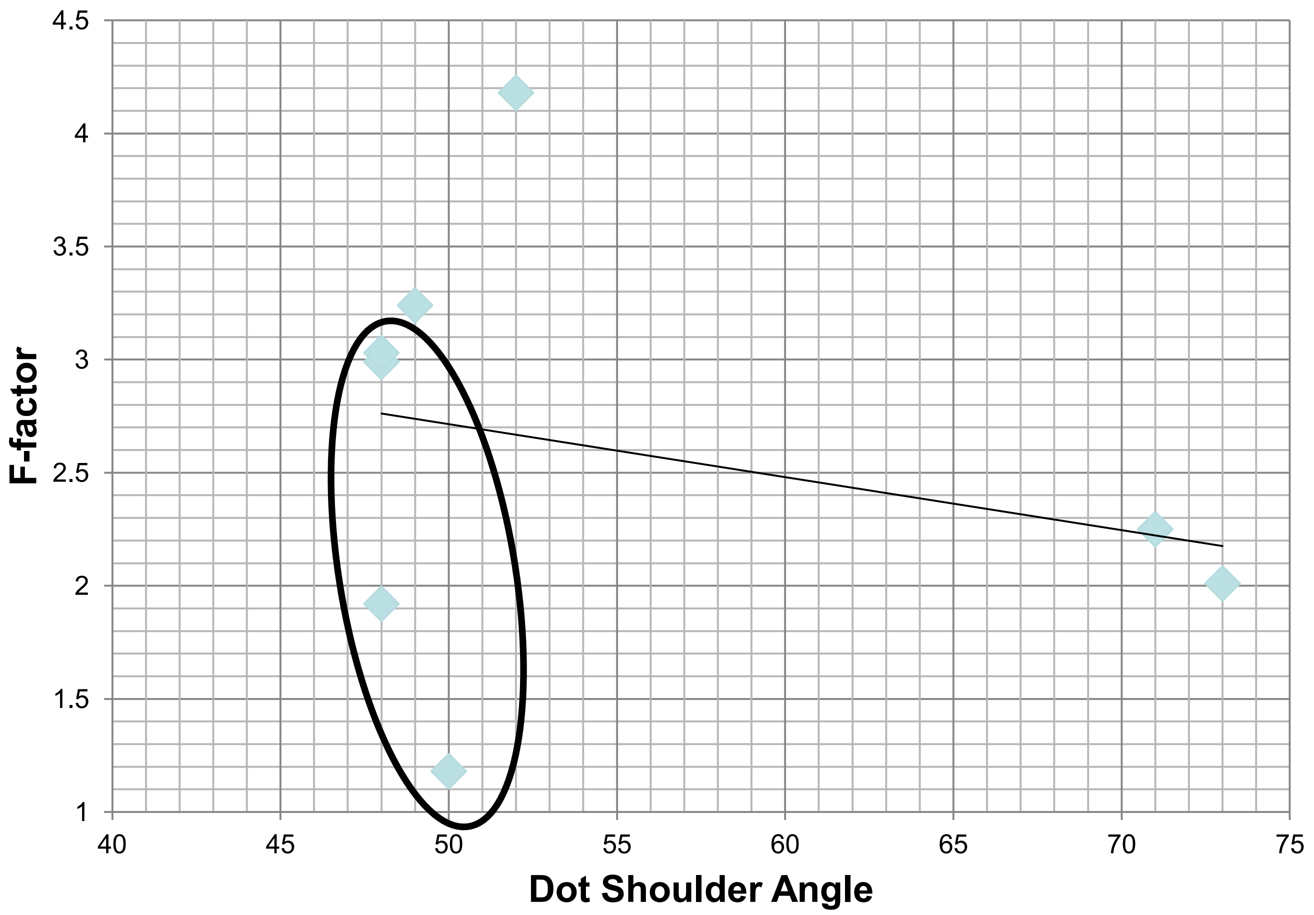
Review: Capped Plate Construction



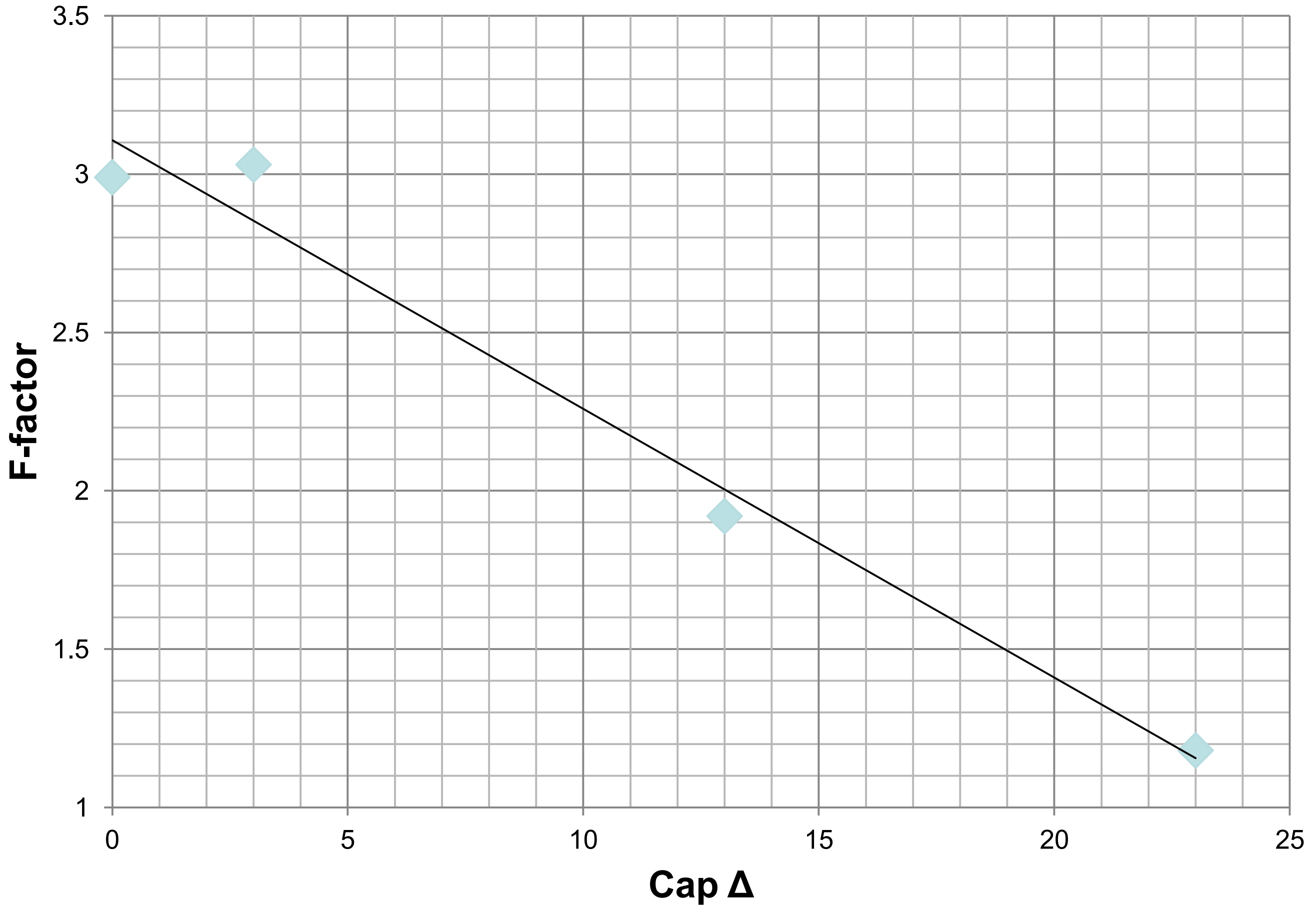
A different response to impression



F-factor vs Dot Shoulder Angle



F-factor vs Cap Δ



The Revised Theory

- The dot shoulder angle model of gain prediction seems to explain empirical fluting results *for single layer photopolymer systems.*
  Lesson: Use dots with the steepest shoulder angle to minimize fluting.
- For two-layer photopolymer systems, gain seems to be best predicted by the difference in durometer between the two layers.
  Lesson: Capped liquid plates can deliver exceptionally low fluting, and use the highest durometer cap feasible.

Thank You

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