

THE EFFECT OF MESH DENSITY ON THE ACCURACY OF MELD LINE PREDICTIONS

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Class Summary

In this class you will be presented with what problems knit lines create in the development of a vehicle and why accurate prediction is required. Several meshing variables that do and do not effect the weld and meld line prediction plot will be presented and how those predictions match actual molded samples will be shown.

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Learning Objectives

At the end of this class, you will be able to:

- Better understand the effects of mesh on meld line prediction
- Utilize chord angle controls and mesh match setting to improve prediction
- Interpret additional plots to better predict meld line quality

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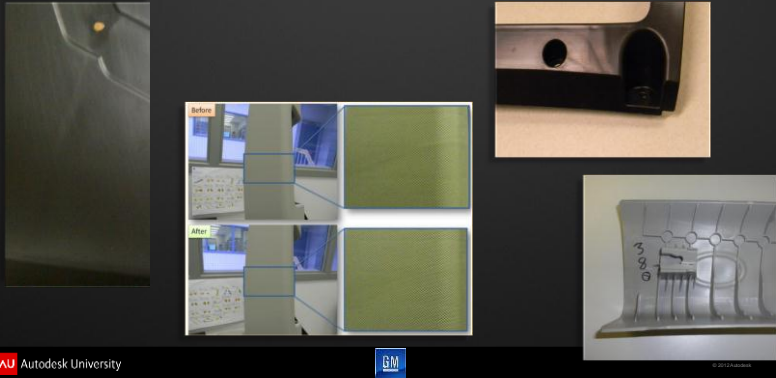
Problem Statement

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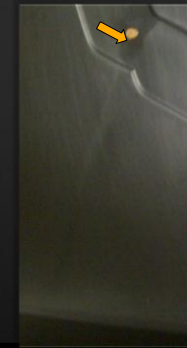
Poorly placed meld lines cost GM time and \$



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Prediction of knit line ending behind a feature



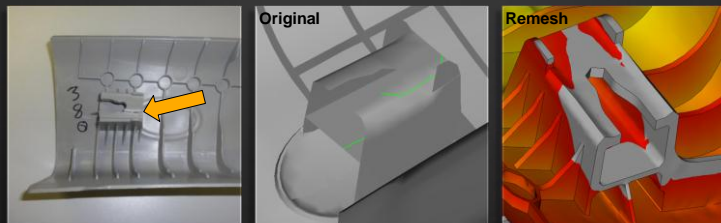
- Length and position are incorrect
- Several processing trials
- Remove pins in tool
- Add secondary punch

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Acceptable Prediction / Inadequate Interpretation?



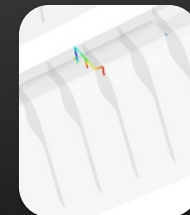
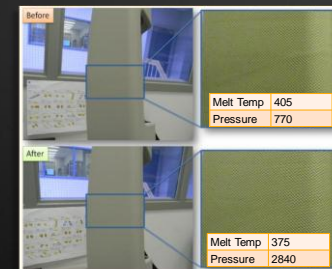
- Additional Validation
- Several additional processing trials
- Several tool "tunings"

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Predicting Quality and Length

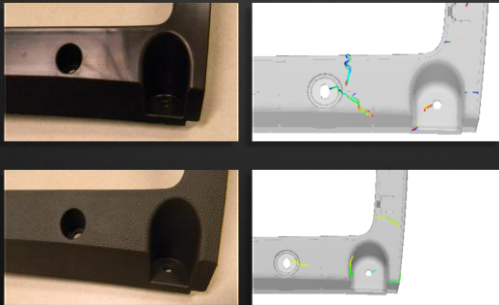


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No upfront analysis on engineering change

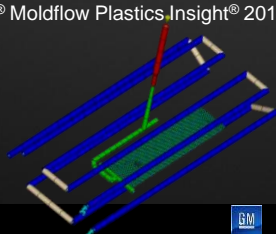


- Several processing trials
- Several buyoff meetings
- Runner system changes

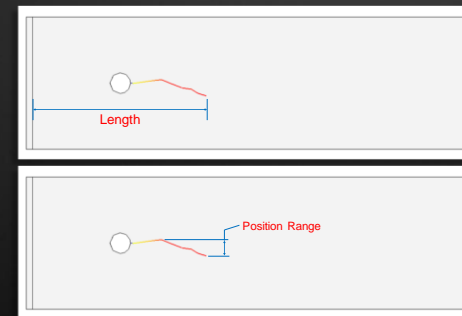
Project Outline

Effects on Knit Line Length and Position

- Compare molded samples to simulation
- GM R&D 3x10 Plaque
- Autodesk® Moldflow Plastics Insight® 2012



Knit Line Length and Position Definition



- Length
 - Distance from part edge to end of objectionable appearance
- Position
 - +/- range from linear knit line

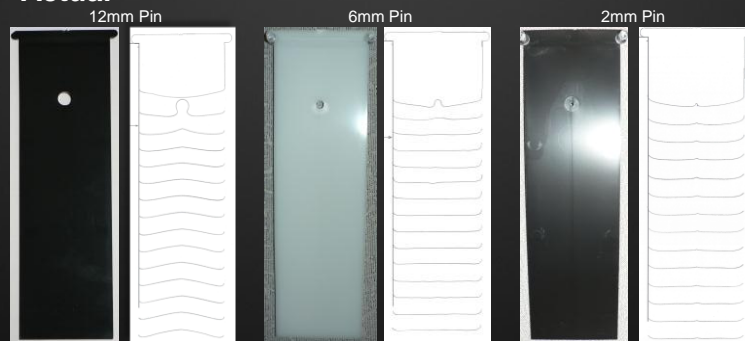
GM R&D 3 x 10 Plaque

- 27 Sample Runs
 - 3 Materials: TPO (15% Talc), PP (Unfilled), PC+ABS
 - 3 Fill Speeds: 3in/sec, 1in/sec, 0.4in/sec
 - 3 Pin Diameters: 12mm, 6mm, 2mm
- 15 short shots per combination
- 10 plaques run at equilibrium

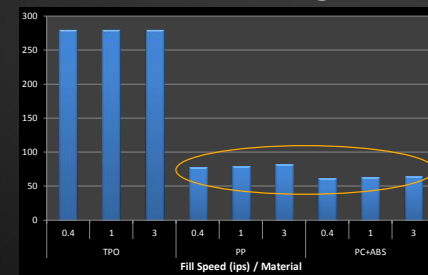
Simulation Variables

- Mid-Plane, Dual-Domain, 3D
- 12 – 1mm Global Edge Lengths
- 60 - 4 Chord Angle
- Analysis Sequence
- Solver Settings
 - Flow & temp convergence, single noded growth, # of layers

Actual



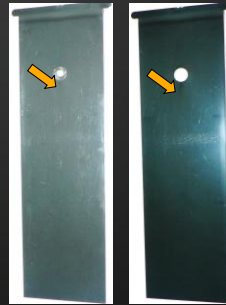
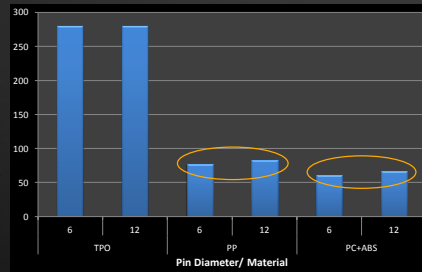
Visible Knit Line Length – 6mm Pin



- 17mm average difference between PP and PC+ABS
- TPO: Objectionable appearance runs entire length of plaque.



Visible Knit Line Length



- 6mm average difference between 12mm and 6mm pins

Predicted Results

DOE

- Looked at 6 possible Factors
- Dual Domain Model

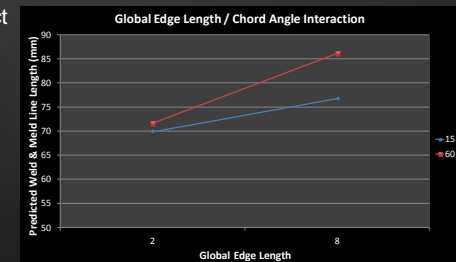
- 2 Significant Factors
- Global Edge Length
- Chord Angle

Factors	Low Value	High Value
Single Node Growth	Multiple	Single
No. of Layers	12	20
Global Edge Length	2	8
Chord Angle	15	60
Temp Convergence Setting	Tight	Default
Flow Convergence Setting	Tight	Default

Run #	Treatment	Factors							Measurement
		Single Node Growth	# of Layers	Global Edge Length	Chord Angle	Temp Conc.	Flow Conc.		
1	(1)	-1	-1	-1	-1	-1	-1	69.8	
2	an	-1	-1	-1	-1	-1	-1	69.8	
3	ba	-1	-1	-1	-1	-1	-1	69.8	
4	ab	-1	-1	-1	-1	-1	-1	69.8	
5	ca	-1	-1	-1	-1	-1	-1	76.7	
6	ac	-1	-1	-1	-1	-1	-1	76.7	
7	bc	-1	-1	-1	-1	-1	-1	76.7	
8	abca	-1	-1	-1	-1	-1	-1	76.7	
9	acba	-1	-1	-1	-1	-1	-1	71.6	
10	cbac	-1	-1	-1	-1	-1	-1	71.6	
11	cbca	-1	-1	-1	-1	-1	-1	71.6	
12	baca	-1	-1	-1	-1	-1	-1	71.6	
13	cbca	-1	-1	-1	-1	-1	-1	86.1	
14	acba	-1	-1	-1	-1	-1	-1	86.1	
15	abca	-1	-1	-1	-1	-1	-1	86.1	
16	abacba	-1	-1	-1	-1	-1	-1	86.1	

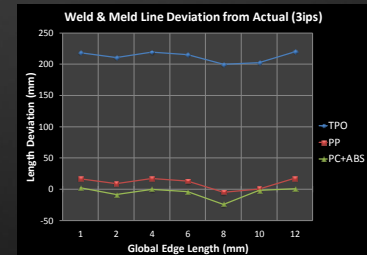
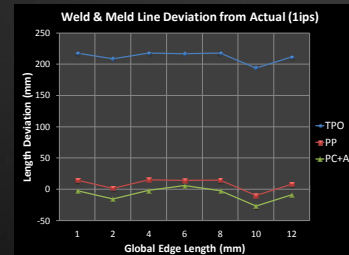
DOE Results

- Significant Interaction Effect
- Global Edge Length
- Chord Angle
- Lower chord angle reduces the effect of global edge length



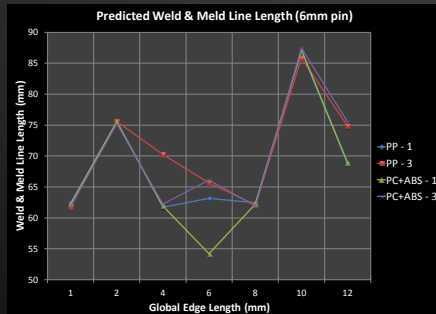
Dual-Domain (DD) Mesh Results

DD Default Settings – 6mm Pin



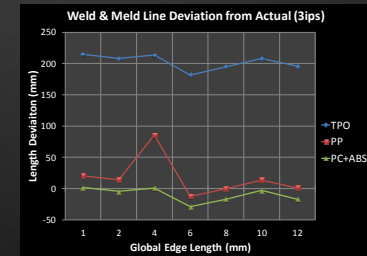
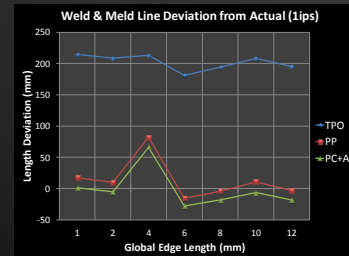
- Prediction deviates from actual -27mm to +17mm
- Deviation in TPO is 200mm +

DD – 6mm Pin – Material Difference



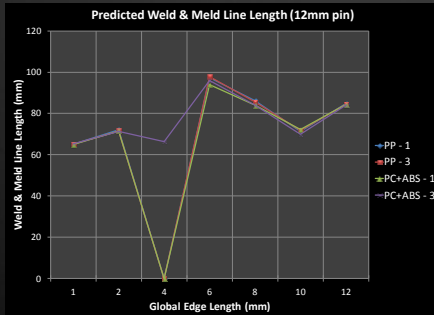
- Predictions do not capture difference between materials

DD Default Settings – 12mm Pin



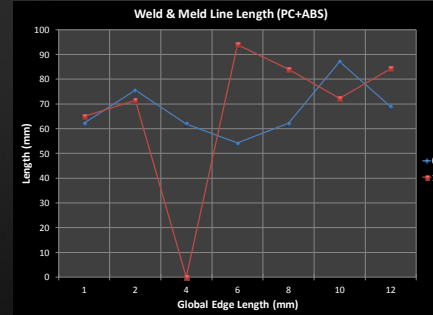
- Prediction deviates from actual -27mm to +85mm
- Deviation in TPO is 180mm +

DD – 12mm Pin – Material Difference



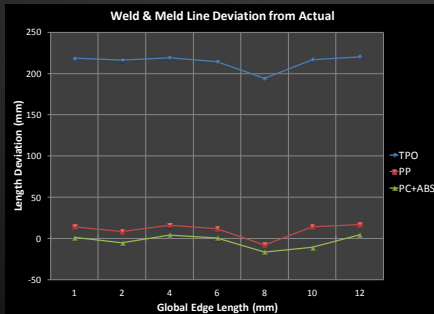
- Predictions do not capture difference between materials
- Knit line is not captured consistently at GEL = 4

DD – Difference Between Pin Diameters



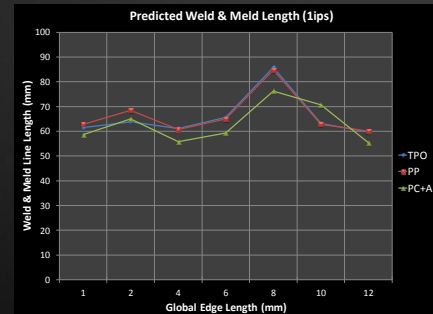
- With default mesh settings the length difference between pin diameters is not accurately captured
- Knit line not consistently captured at GEL = 4

DD – Chord Angle of 15



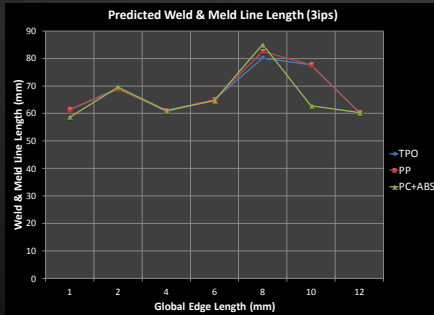
- TPO deviation is 200mm +
- Predictions deviate from actual -16mm to +16mm

DD – Chord Angle of 15 – Fill Speed 1ips



- A difference between PP and PC+ABS is captured in prediction

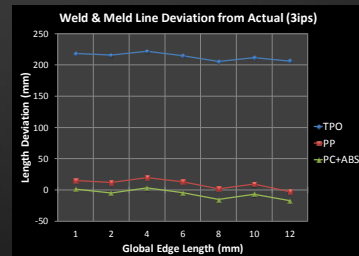
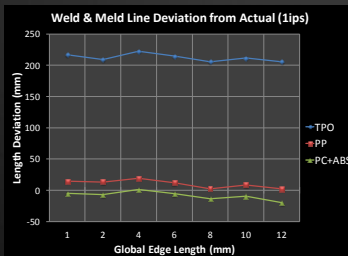
DD – Chord Angle of 15 – Fill Speed 3ips



- Difference between PP and PC+ABS is lost at the higher fill speed

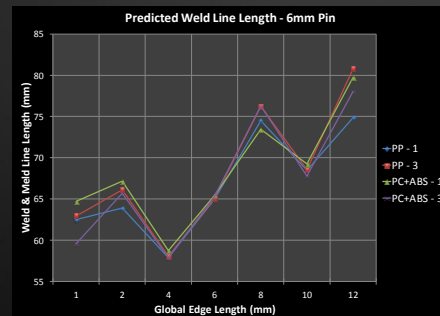
Mid-Plane (MP) Mesh Results

MP Default Settings – 6mm Pin



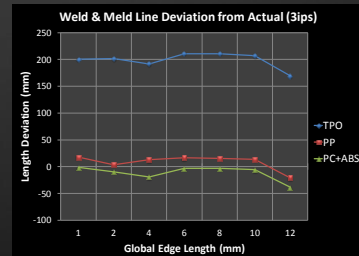
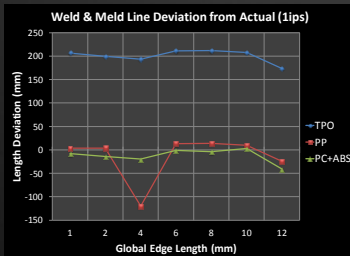
- Global Edge Length not effecting weld and meld predicted length

MP – 6mm Pin – Material Difference



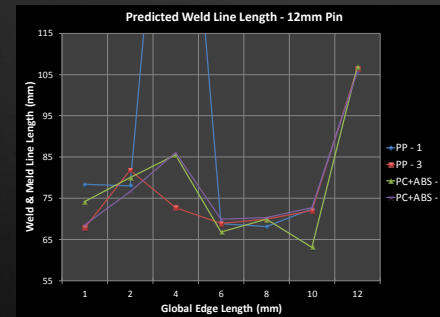
- Predictions do not capture difference between materials

MP Default Settings – 12mm Pin

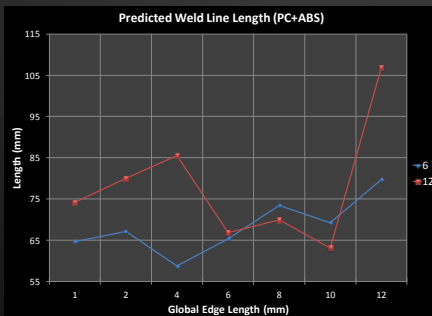


- Global Edge Length not effecting weld and meld predicted length

MP – 12mm Pin – Material Difference



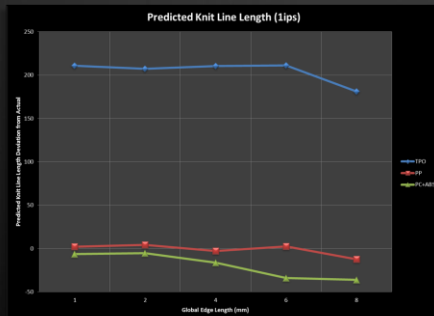
MP – Difference Between Pin Diameters



- GEL ≤ 6
 - Relative difference between pins captured
- GEL = 1
 - Error on difference is within 15% of length

3D Mesh Results

3D Mesh – 6mm Pin

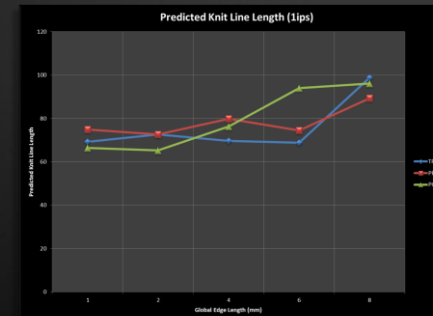


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3D Mesh – 6mm Pin



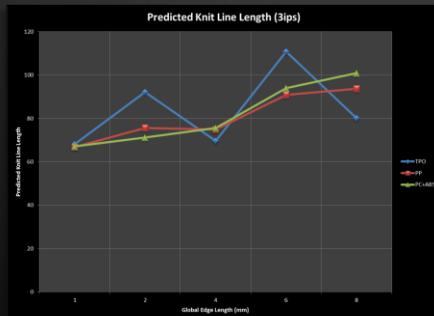
- At edge lengths ≤ 4 the difference between PP and PC+ABS is captured

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3D Mesh – 6mm Pin



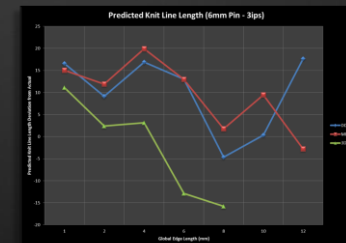
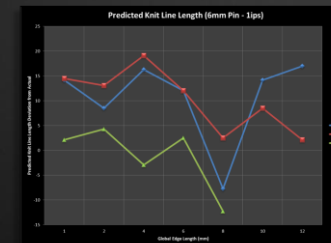
- Similar to the DD models, PP – PC+ABS difference is lost at higher injection speeds

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PP Summary



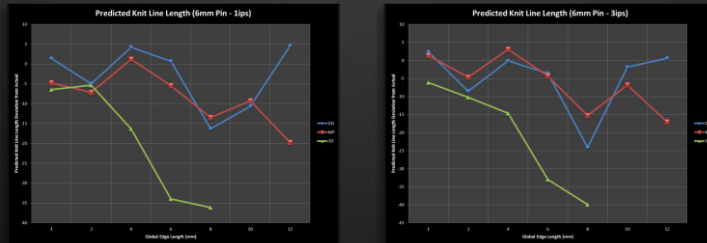
- 3D mesh results in less error than other meshes

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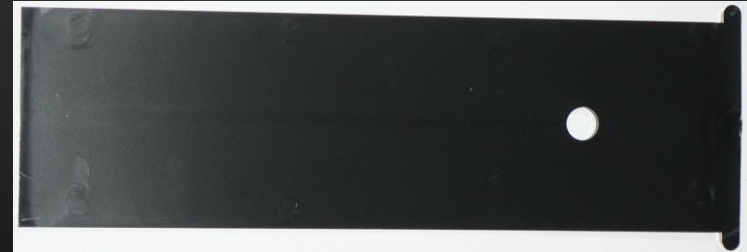
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PC+ABS Summary



- Most accurate regardless of mesh
- 3D results are sensitive to global edge length

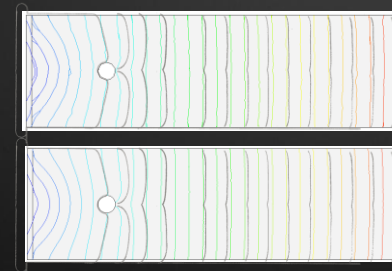
TPO Summary



- No mesh type captures the length

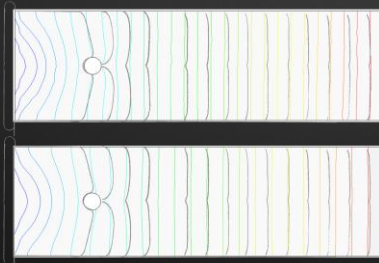
Contour Overlays

Dual-Domain Contour Overlays - TPO



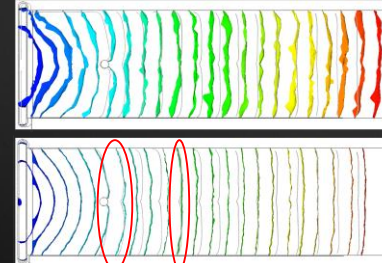
- 6mm vs 1mm mesh
- Better flow front refinement
- Does not capture slip at side walls
- Both contours "flat" at same distance

Mid Plane Contour Overlays - TPO



- 6mm vs 1mm mesh
- Better flow front refinement
- Does not capture slip at side walls
- 1mm mesh – longer distance to “flat”

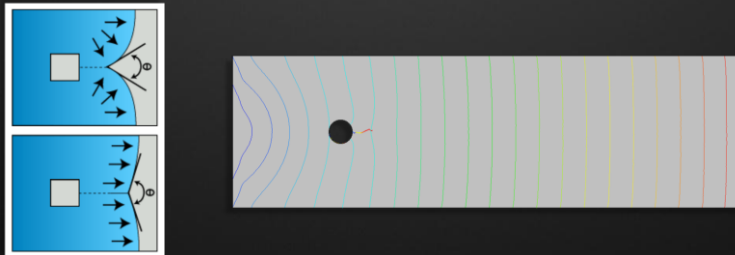
3D Contour Overlays - TPO



- 6mm vs 1mm mesh
- 8 layers thru thickness
- 6mm 3D – better than MP/DD
- 1mm mesh
 - Captures slip at pin very well
 - Slip at sidewall slightly captured
 - 1st contour – excellent correlation
 - Flow front flattens too quickly

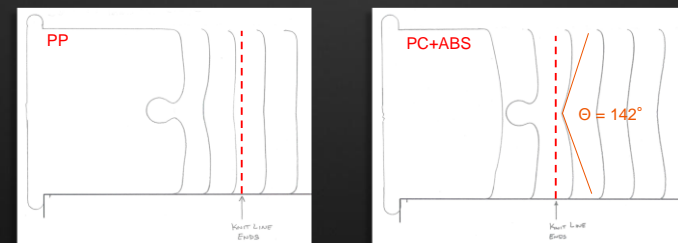
Why is the length not predicted as accurately as we would like?

- Prediction is based solely on the angle of the flow front at each node



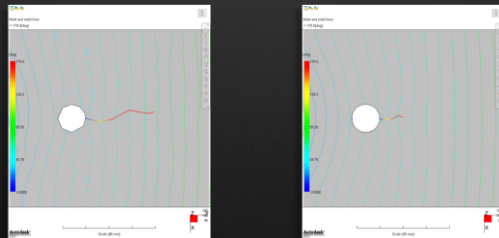
Why is the length not predicted as accurately as we would like?

- The actual visible knit line does not correlate to the flow front angle.

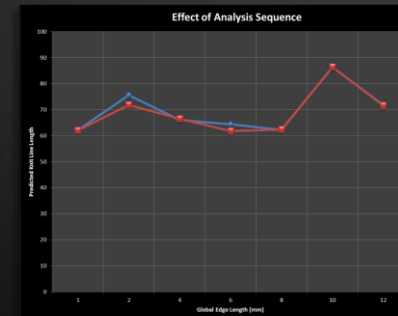


Why is the length not as sensitive to edge length as thought?

- While edge length improves flow front shape. The “angle” at each node is decreased, which the “Weld and meld lines” plot is based on.



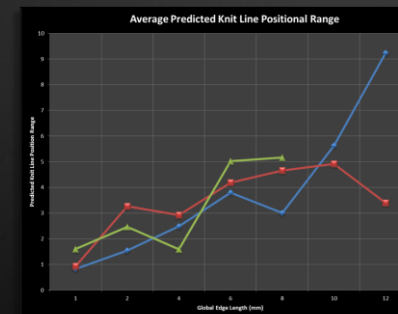
Analysis Sequence Effect



- No significant difference between:
 - Cool + Fill + Pack
 - Fill + Pack + Cool + Fill + Pack
- Finding may not transfer to more complicated geometries

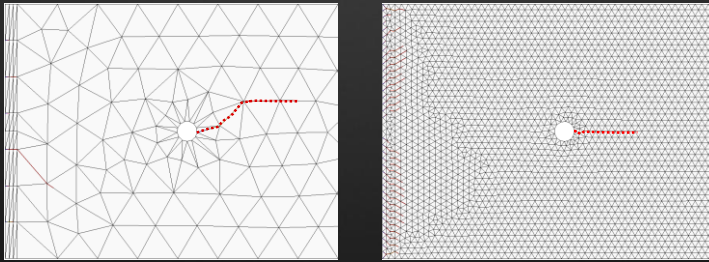
Knit Line Position

Mesh Type Effect on Predicted Position

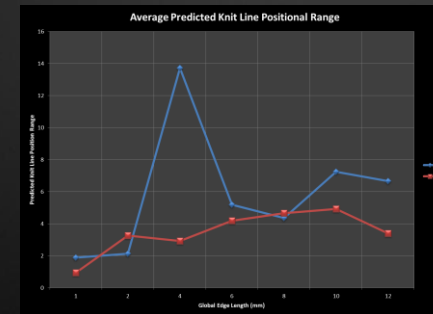


- Target is a range of zero
- Position is controlled by mesh size.
- Node location

Knit Line position follows the node



Chord Angle Effect on Predicted Position

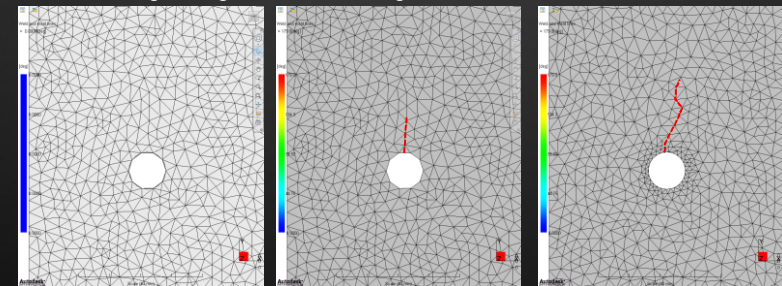


- Again, lower chord angle reduces the effect of mesh size.

Additional Mesh Issues

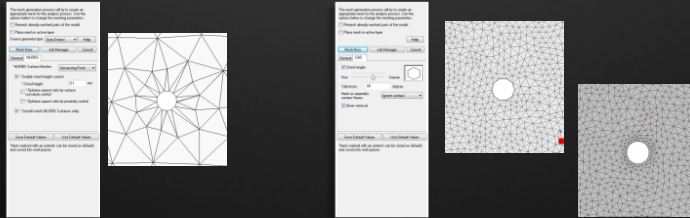
Missing the knit line all together

- Global Edge Length and Chord Angle



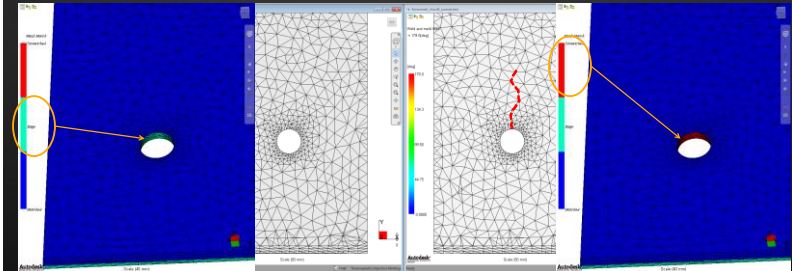
Prevent missing the knit line altogether

- Utilize the chord height or chord angle controls
- Chord angle default of 60 is too coarse. 15 is recommended.



Missing the knit line all together

- Edge vs Unmatched Dual-Domain Element



Recommended Best Practices

- Chord Angle ≤ 15
- Chord Height ≤ 0.1
- Global Edge Length \leq Feature Diameter

In Conclusion

- The meld and weld line plots cannot be used as an absolute answer
- The plots provide directional guidance on knit line location
- The chord angle or chord height mesh control are an efficient method to improve knit line prediction and prevent "false negatives"

Special Thanks

- Franco Costa
 - Autodesk
- Jeff Higgins
 - Autodesk
- Hanno Van Raalte
 - Autodesk

