合肥工業大學
HEFEI UNIVERSITY OF TECHNOLOGY

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Spring-back Control in Automotive Door Inner Panel Stamping

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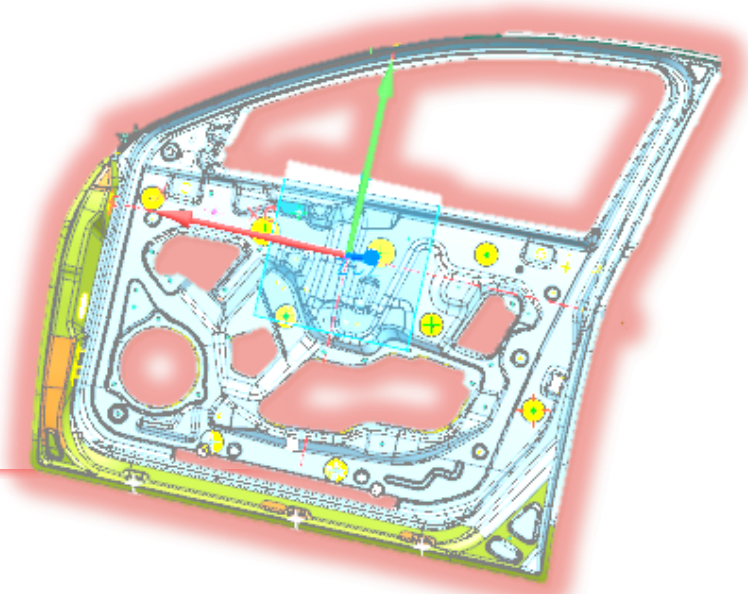
Outline

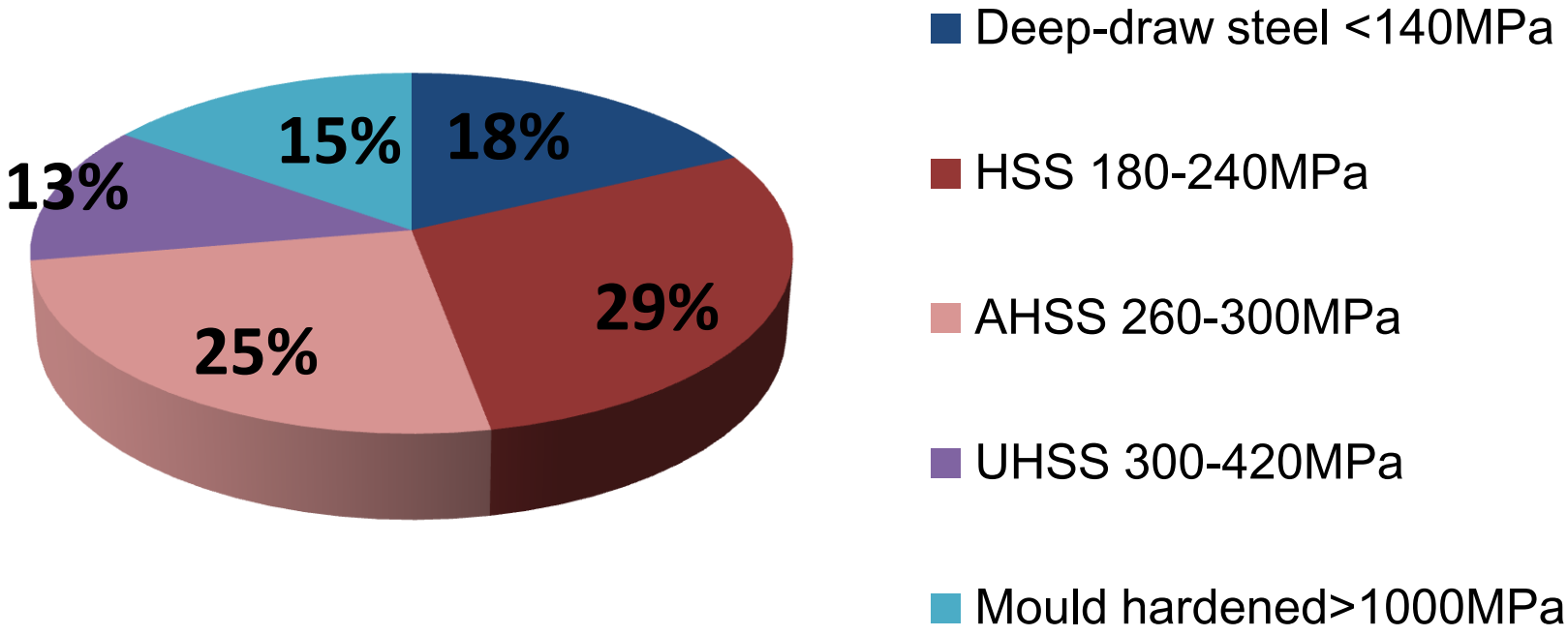
1. Background
2. Inverse Approach (IA)
3. Two-step forming process & results
4. Optimization method & results
5. Conclusions



Background

Find innovative ways to meet requirements of Safety & fuel economy

Material used on the Volkswagen Passat



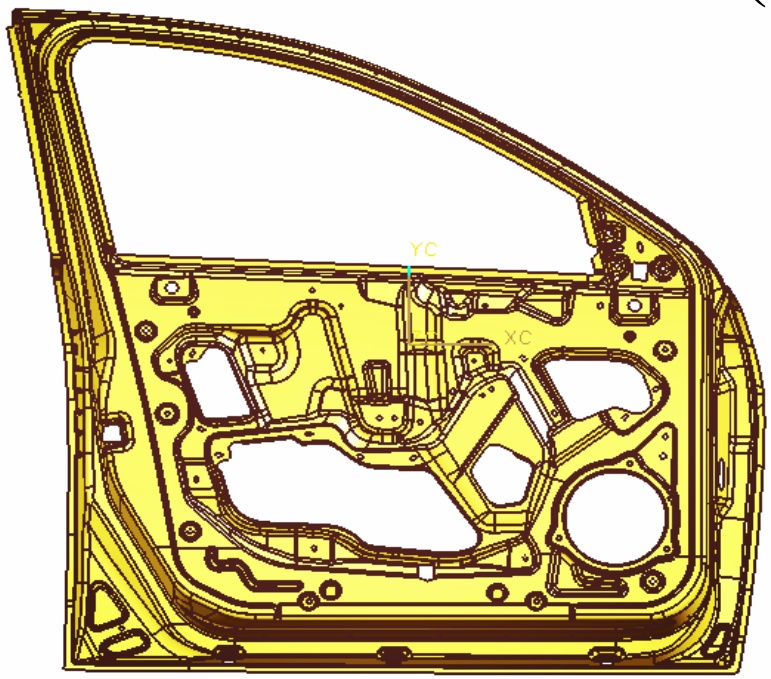
Background

Springback value $S \propto (\sigma_f)_0 / E$

$(\sigma_f)_0$ ——**Yield stress**

E ——**Modulus**

Complex structure with irregular holes and narrow strip



Front door inner panel

Control springback and other forming defects(cracking, wrinkling)

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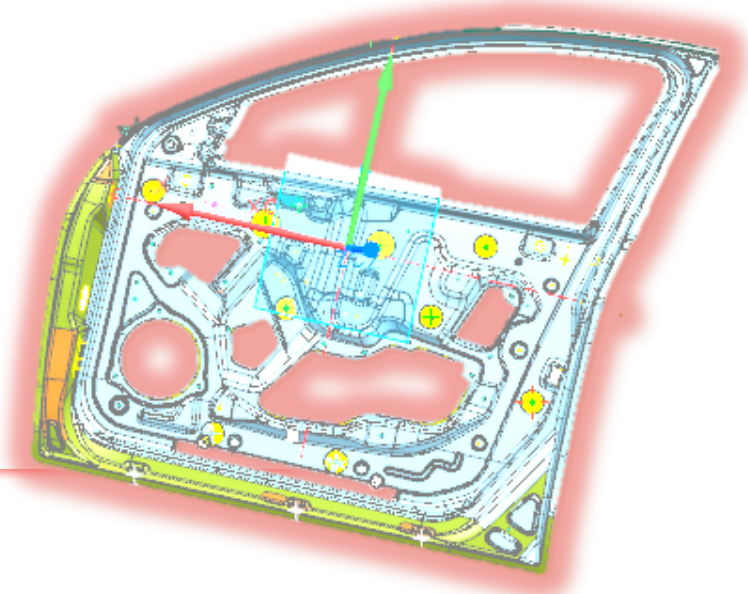
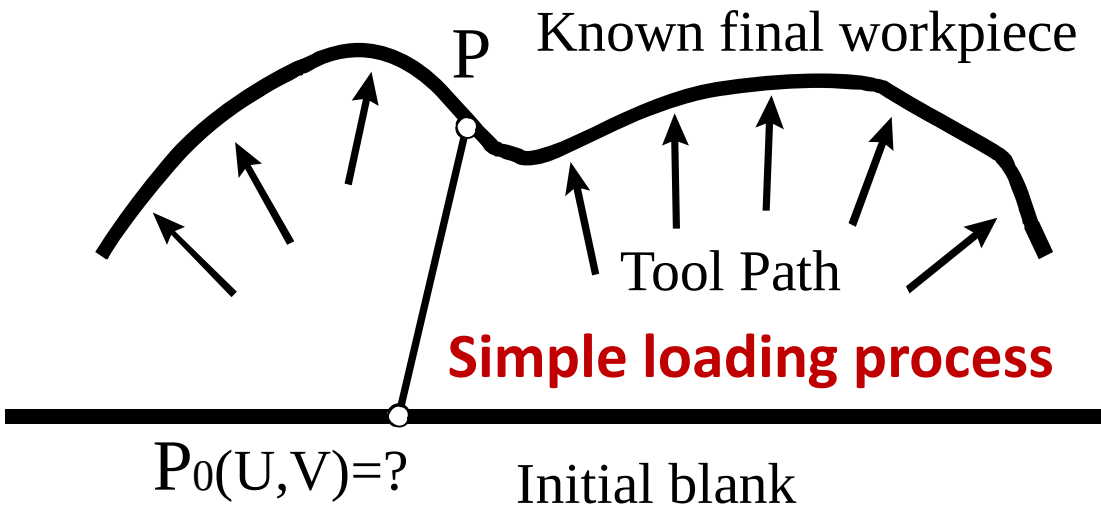


Inverse Approach (IA)

Blank Engineering
- Incremental approach
- Inverse approach (IA)



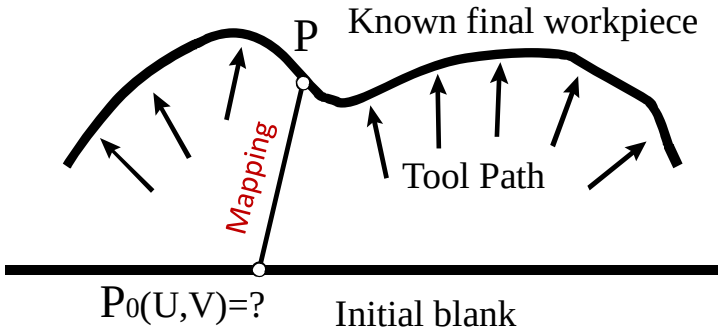
Only consider the initial blank configuration and final workpiece configuration. Omit the intermediate steps. Time saving and high efficiency

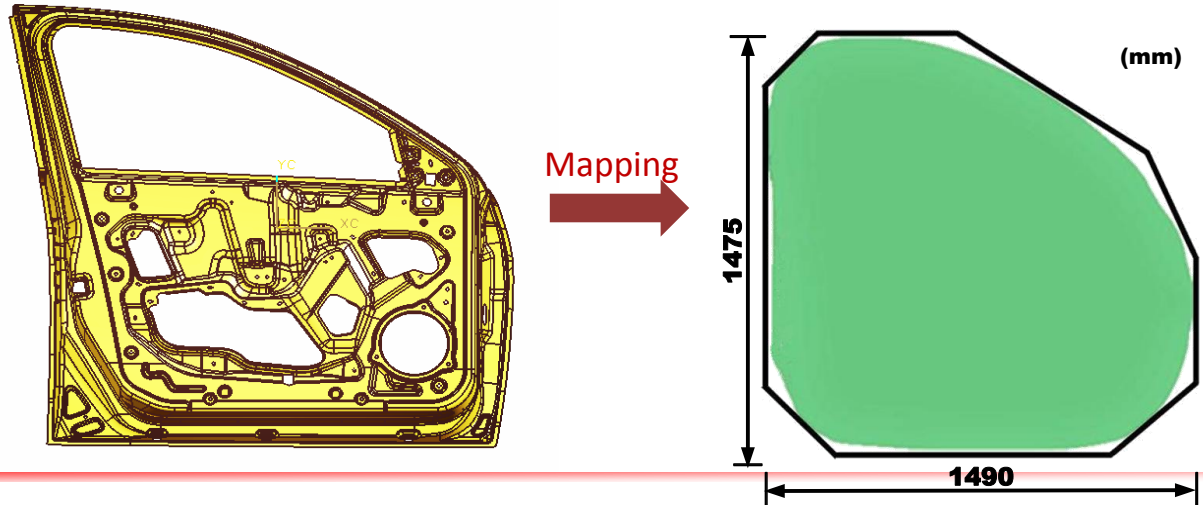
To predict
- Calculate the stamping force
- Stress & strain distribution on the finial workpiece(FLD)
- Thickness reduction diagram
- Initial shape of the blank

Inverse Approach (IA)

- **Estimate Initial Blank configuration**

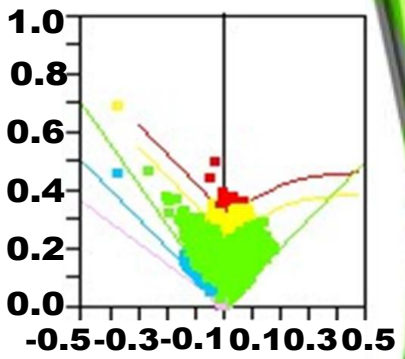
  Mapping the workpiece nodes and meshes to the plane along the tool path

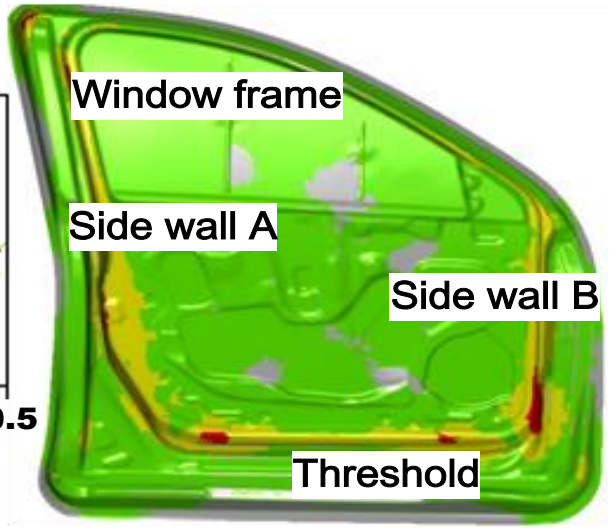




Results of One-step FEM

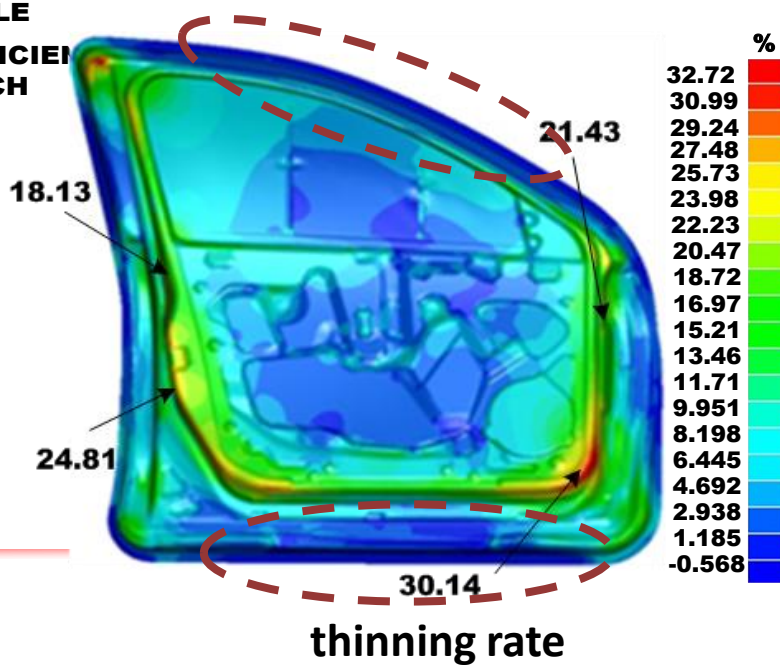
- *σ , ε and thickness* distribution of the final configuration





Thinning at sidewall

Thickening at frame and threshold



thinning rate

- Risk of fracture
- Insufficient stretch

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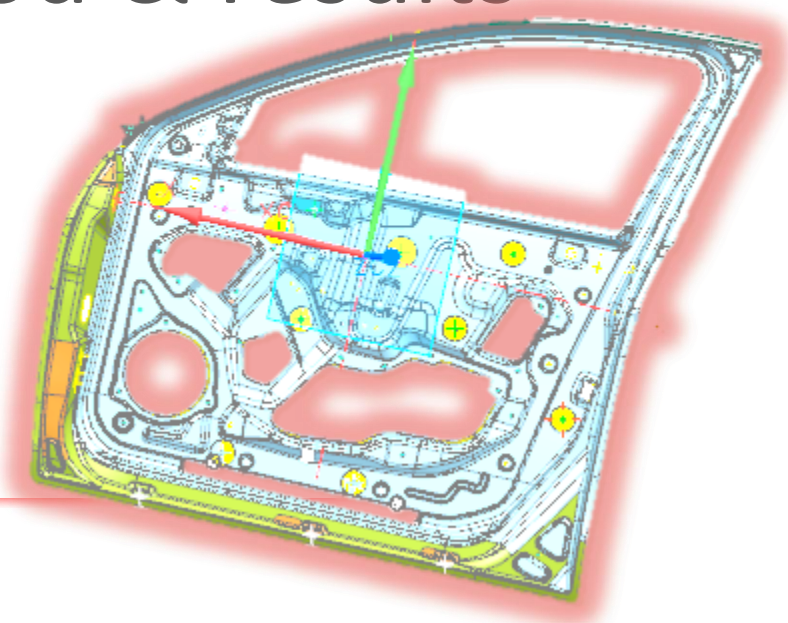
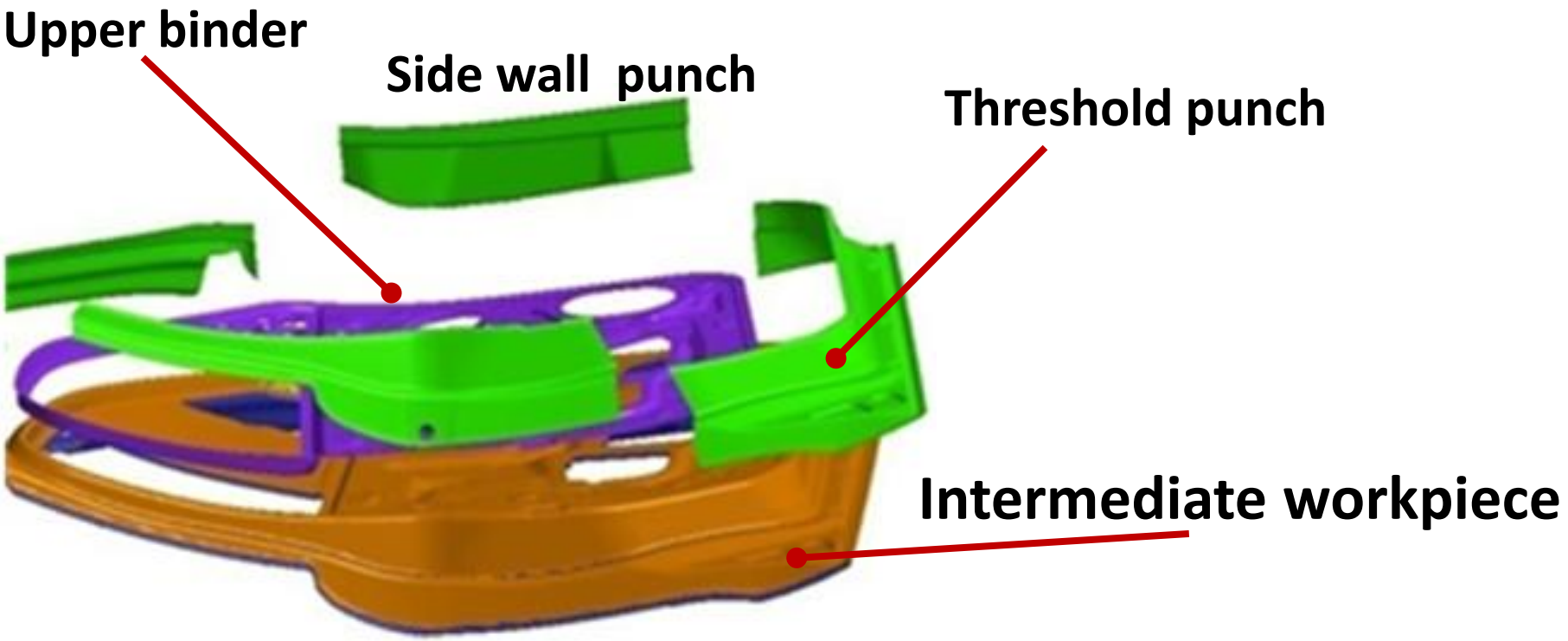


Two steps forming process

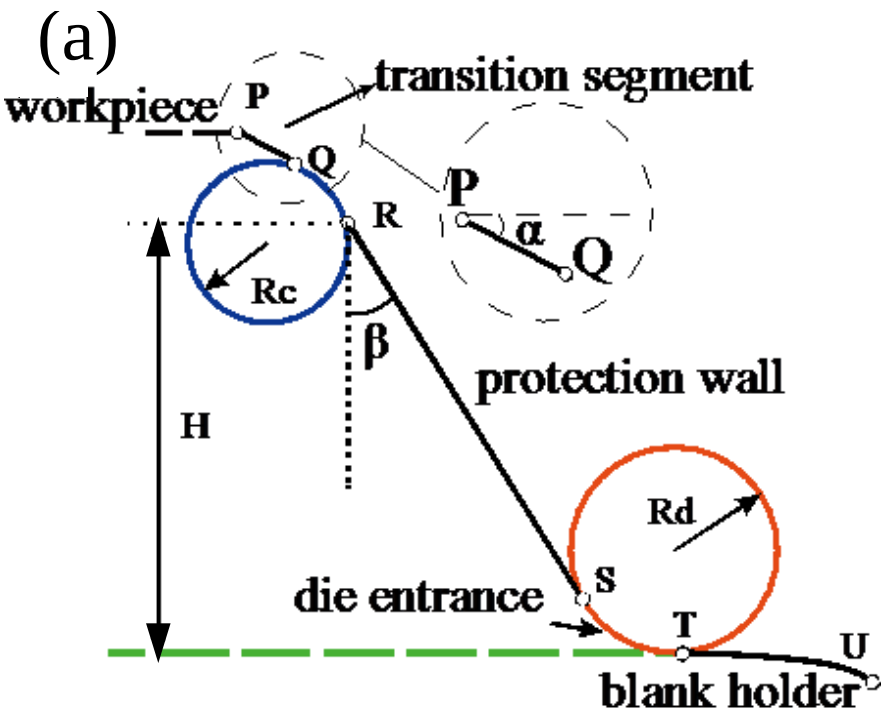
Step 1
Preform the risk zone

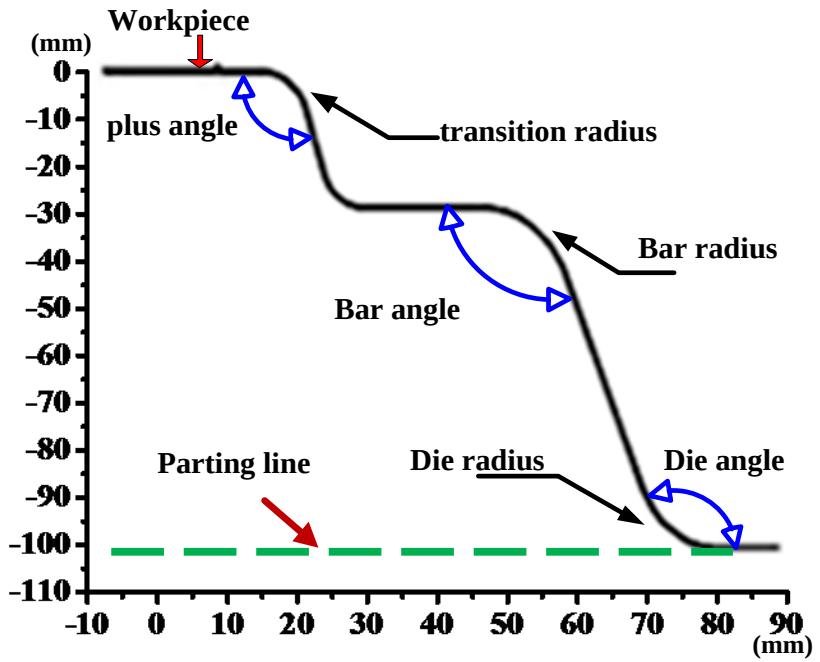
Step 2
Stamping the entire shape



The second forming step

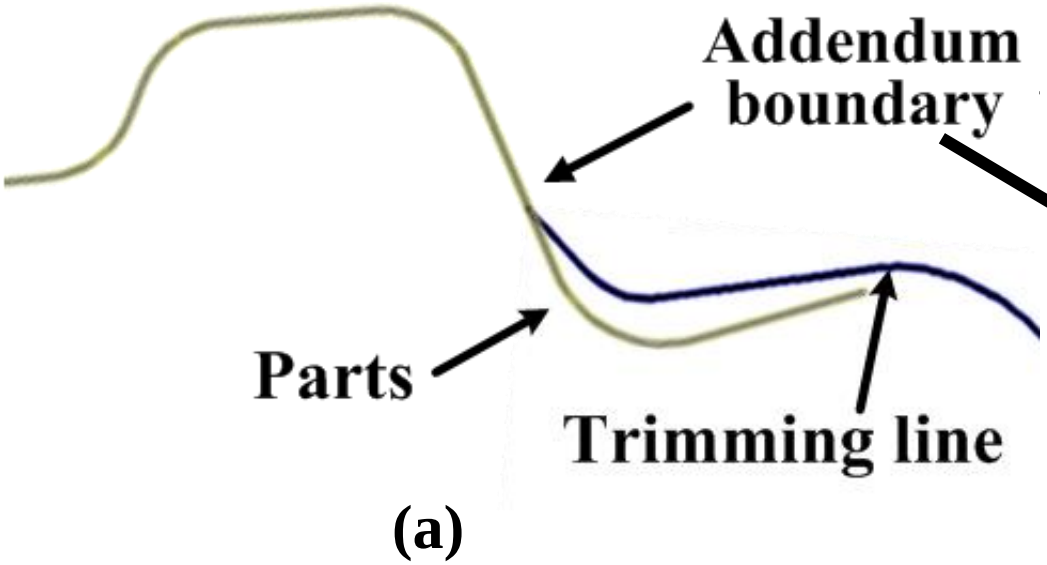
Parametric design of addendum surface



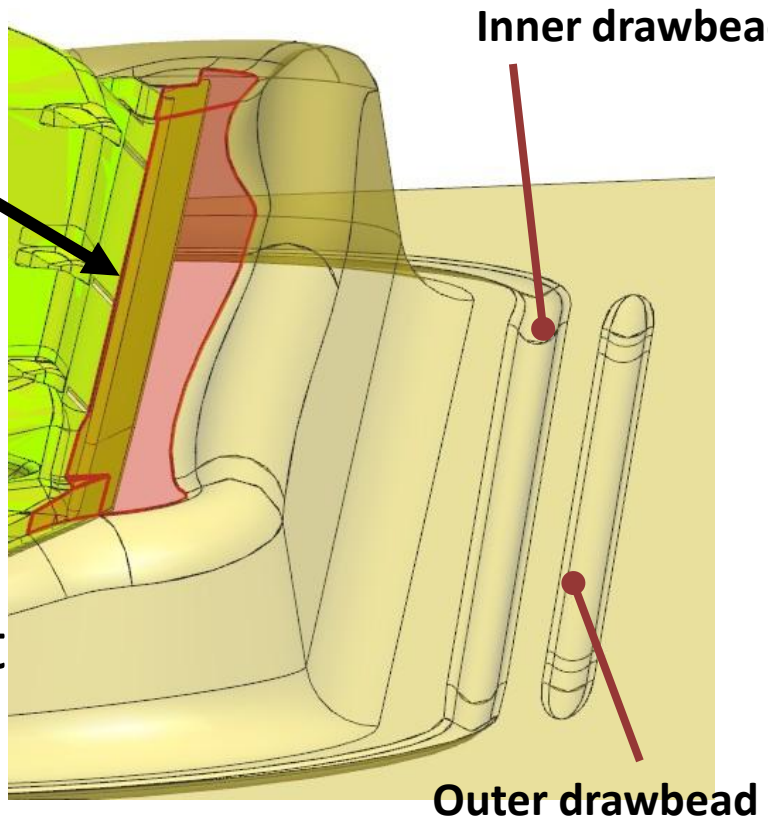


Typical addendum surface (cross-section) Modified addendum surface

Addendum Surface Generation——threshold



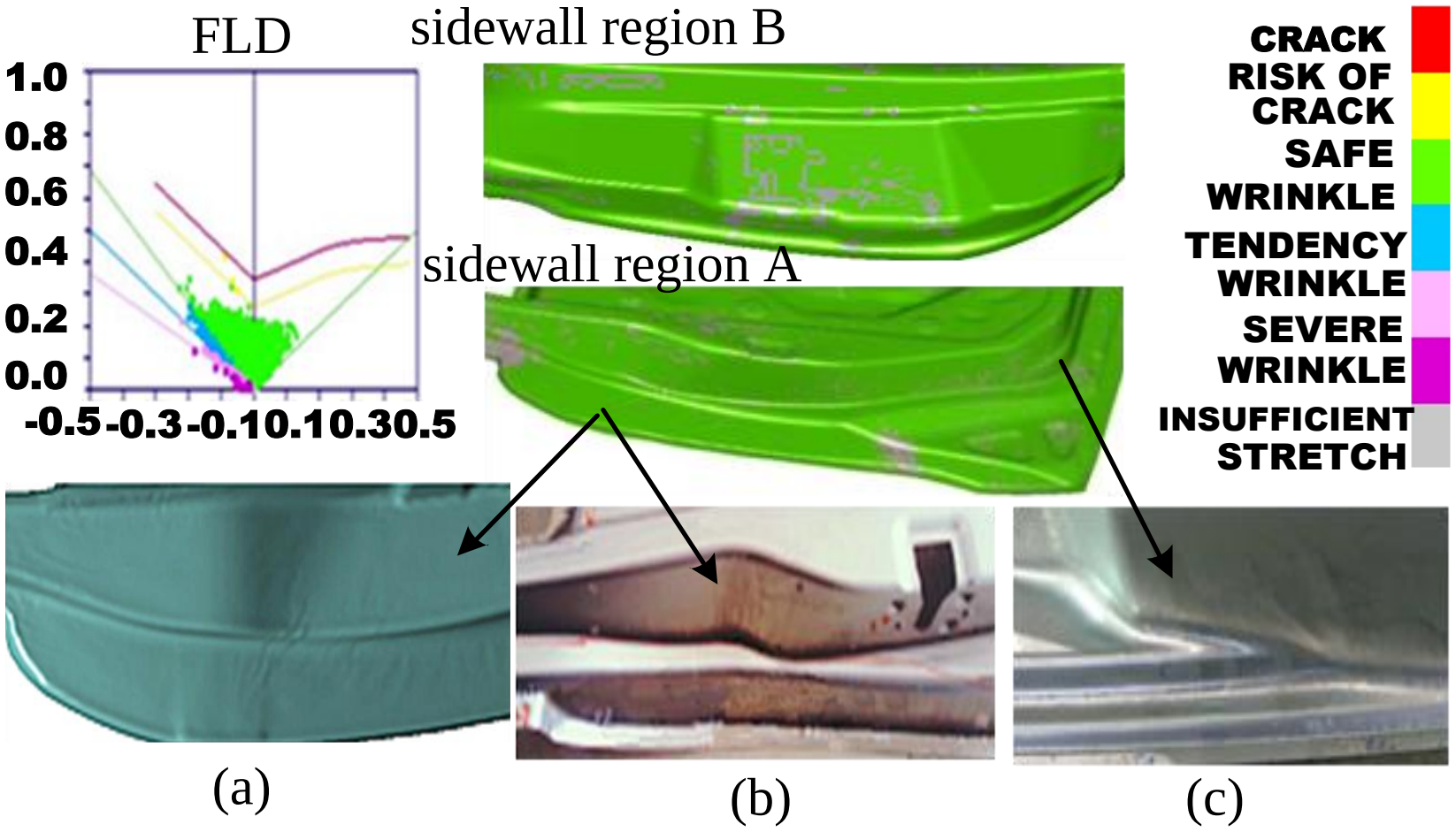
(a)



Increase the plastic deformation at threshold region

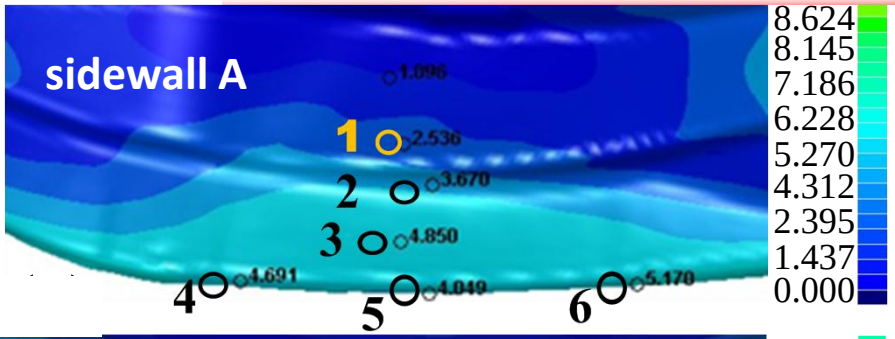
Two draw beads distribute at the threshold region

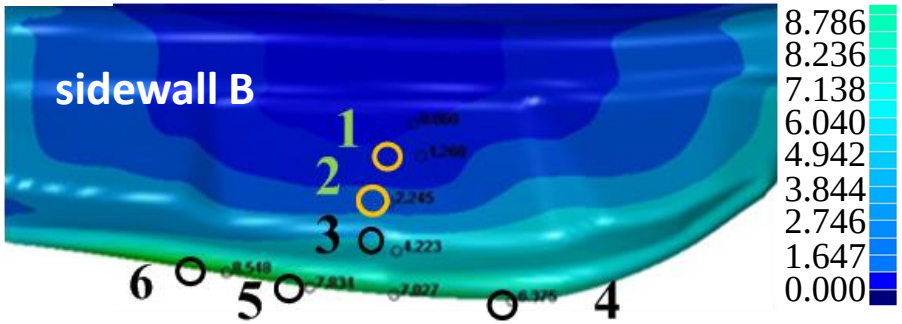
The second step forming result

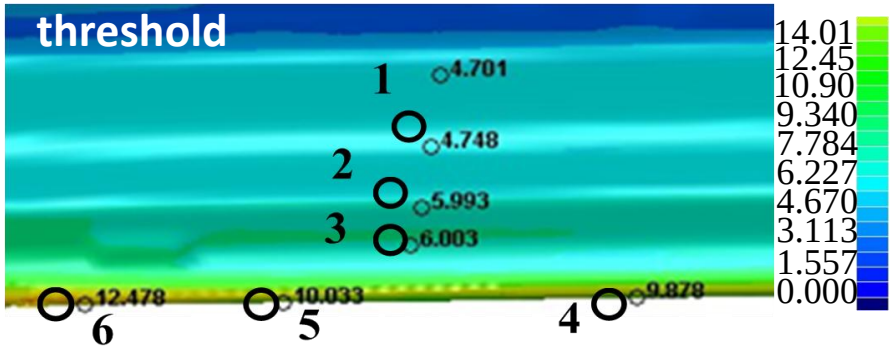


Wrinkle and Ripple

The second step forming result







Spring-back of the 6 key points at the threshold, sidewall A & side wall B

	1	2	3	4	5	6
Sidewall A	2.536	3.678	4.850	4.691	4.909	5.479
Sidewall B	1.268	2.245	4.223	6.375	7.834	8.548
Threshold	4.748	5.993	6.003	9.878	10.03	12.48

Exceed the limit of product tolerance

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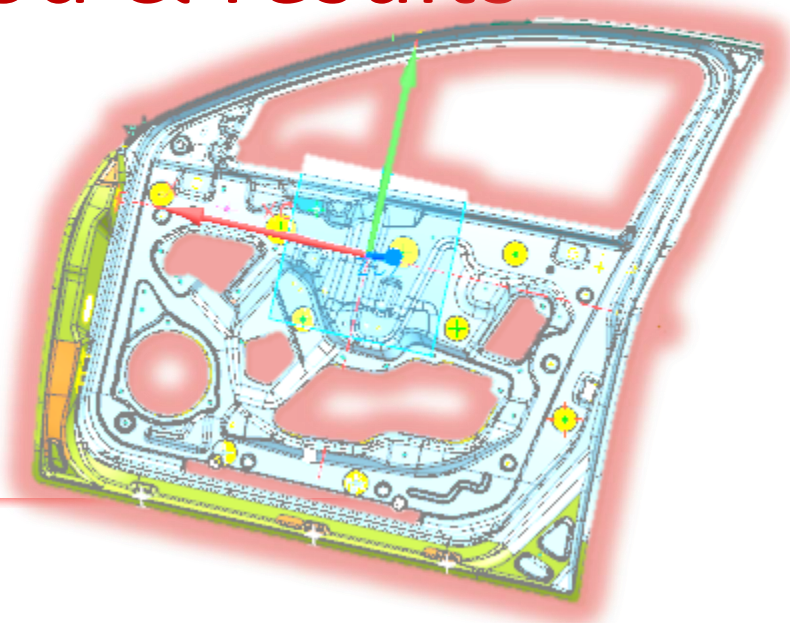
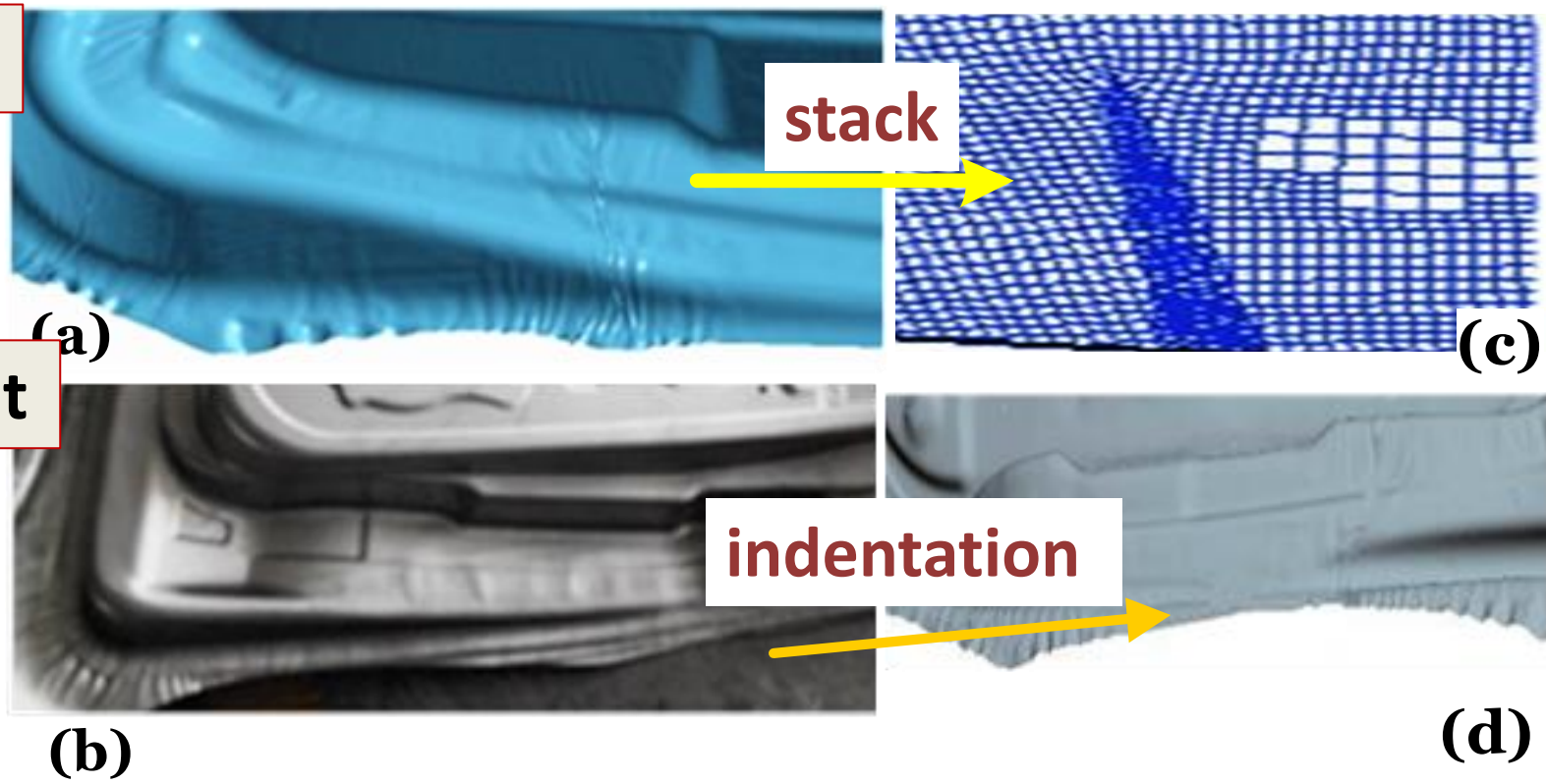


Optimize drawbead——side wall

Drawbead height h → h/2

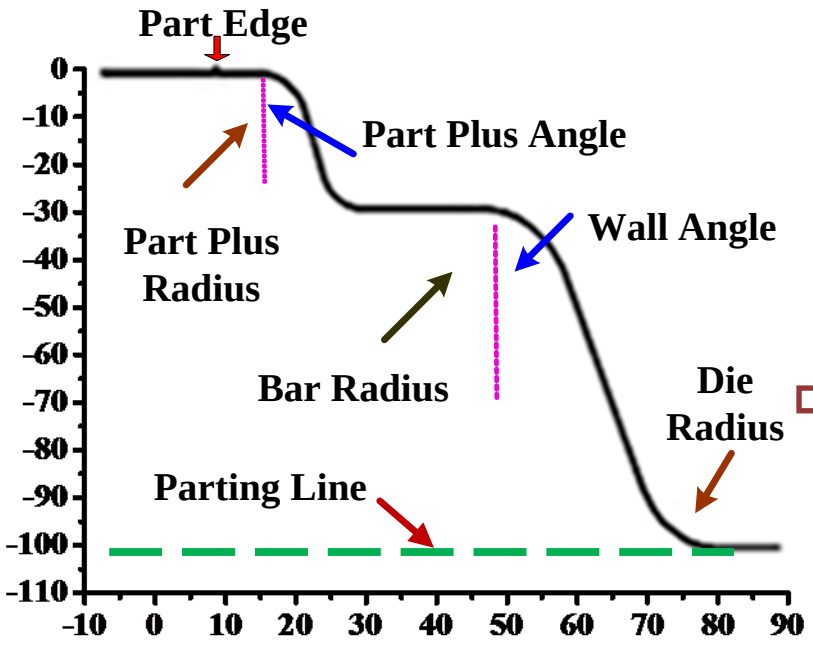
FEM

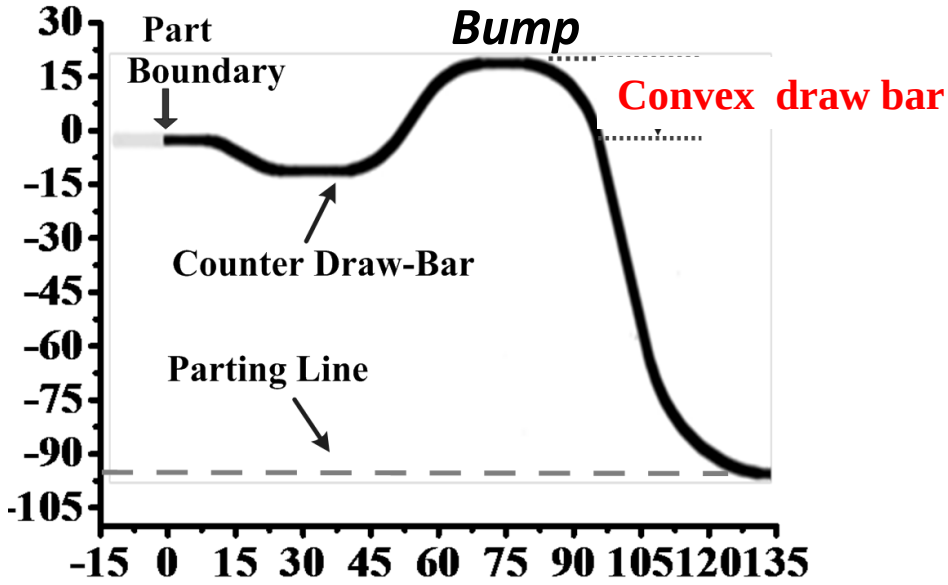
Experiment



Material stacks at the edge of the panel and indentation of drawbead flows to the panel

Optimize addendum Surface





Convex draw bar(Bump) treated as a drawbead

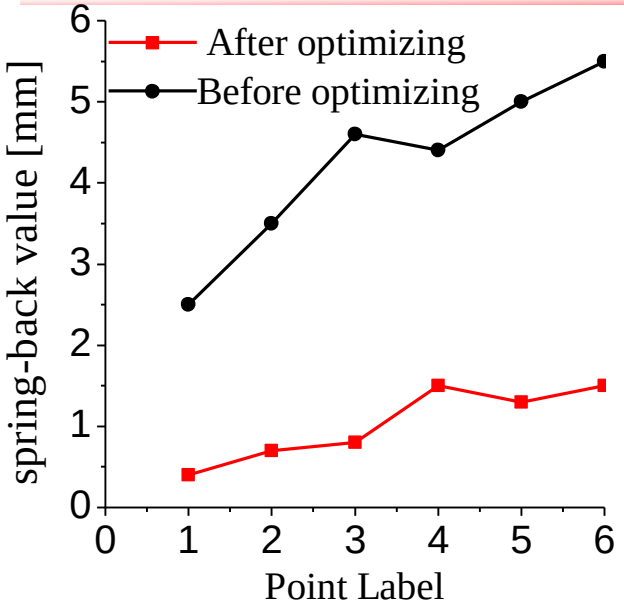
Counter draw bar treated as a radius of the drawbead

draw depth can be reduced significantly *Balance the material flow*

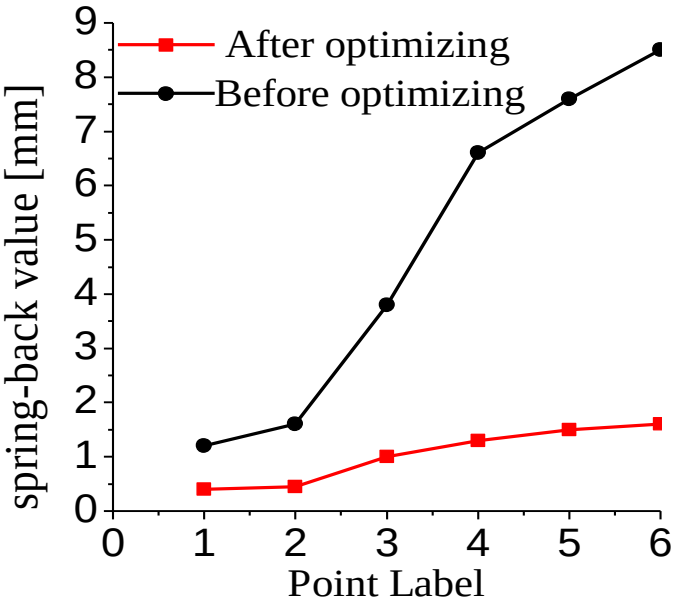
Increase the contact area of blank and the tools *More material stretched sufficiently*

Comparison of Springback value

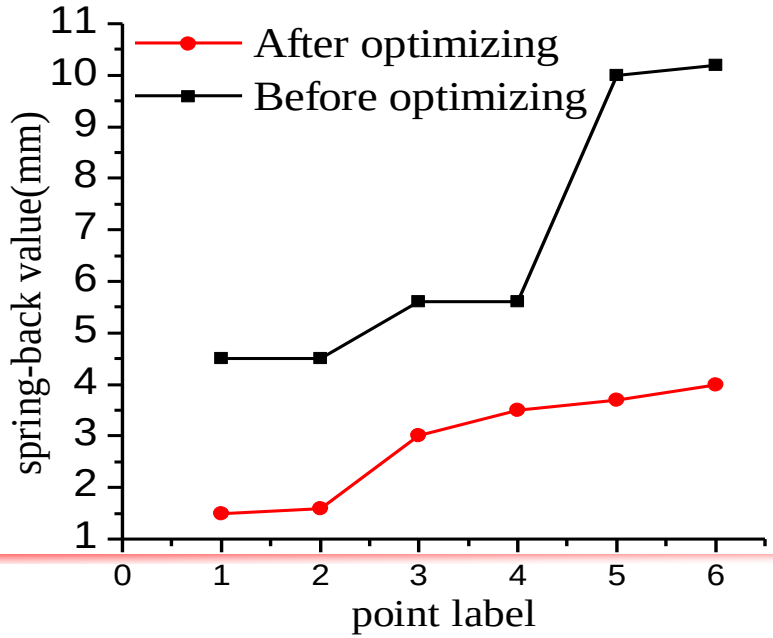
Side wall A



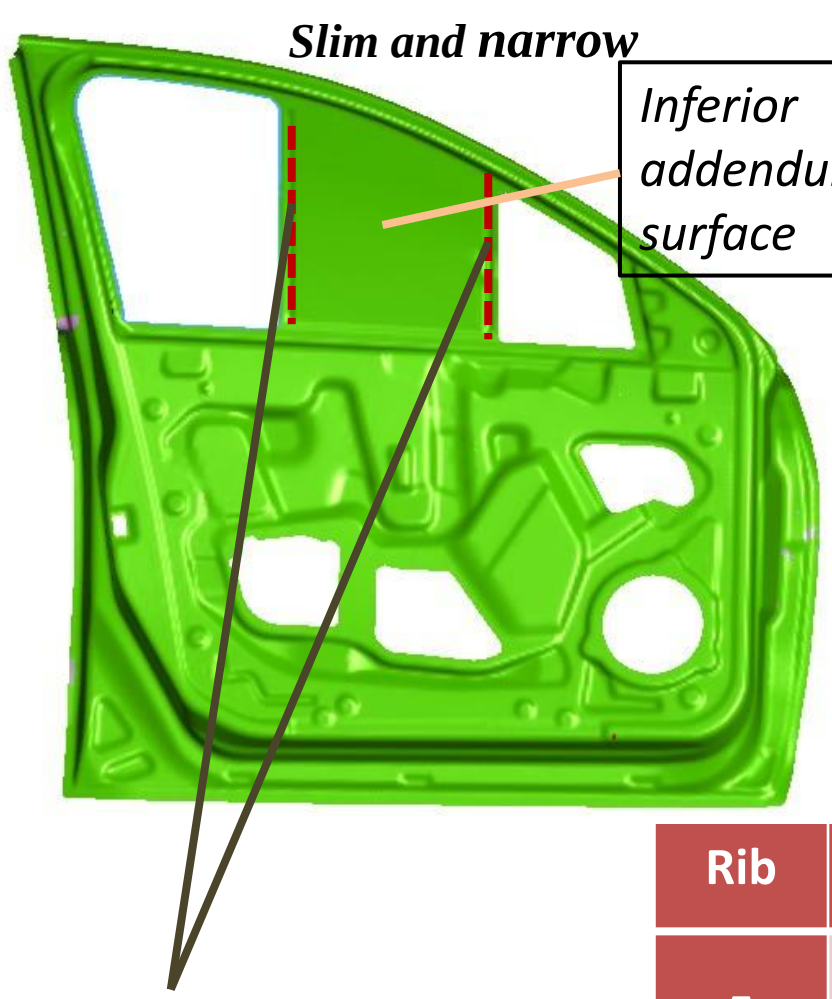
Side wall B

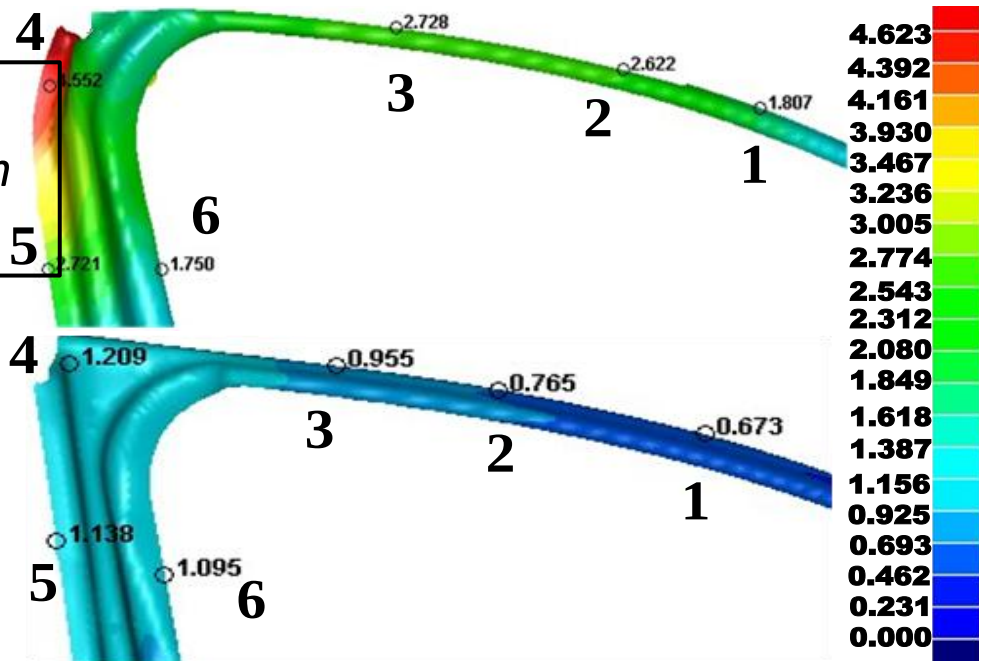


Threshold



Optimize——window frame

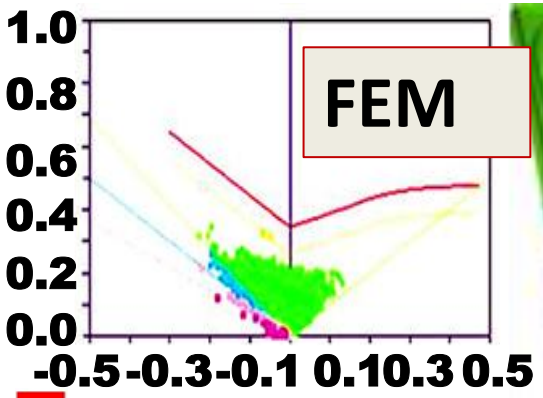




Spring back value of window frame

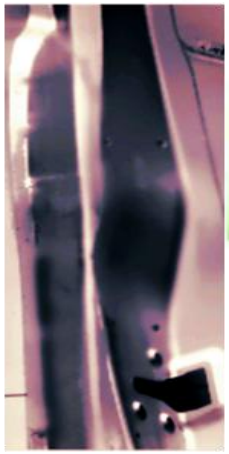
Rib	1	2	3	4	5	6
-	1.807	2.622	2.728	4.552	2.721	1.750
Yes	0.673	0.765	0.955	1.204	1.138	1.095

Result of optimized forming scheme



FEM

CRACK
RISK OF CRACK
SAFE
WRINKLE TENDENCY
WRINKLE
SEVERE WRINKLE
INSUFFICIENT STRETCH



Threshold

Side wall A

Side wall B

Experiment

acceptable product

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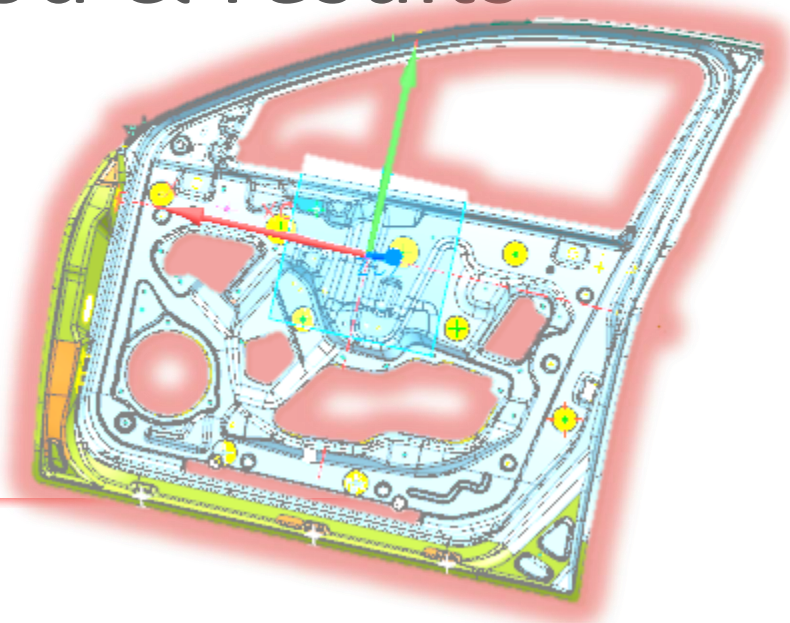

Conclusions

1. The convex addendum surface can decrease the spring-back of the sidewall region

2. The outer open draw bead decrease the spring back of the threshold region

3. Added stiffening rib on addendum surface of the window frame can enhance the resistance of spring-back

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