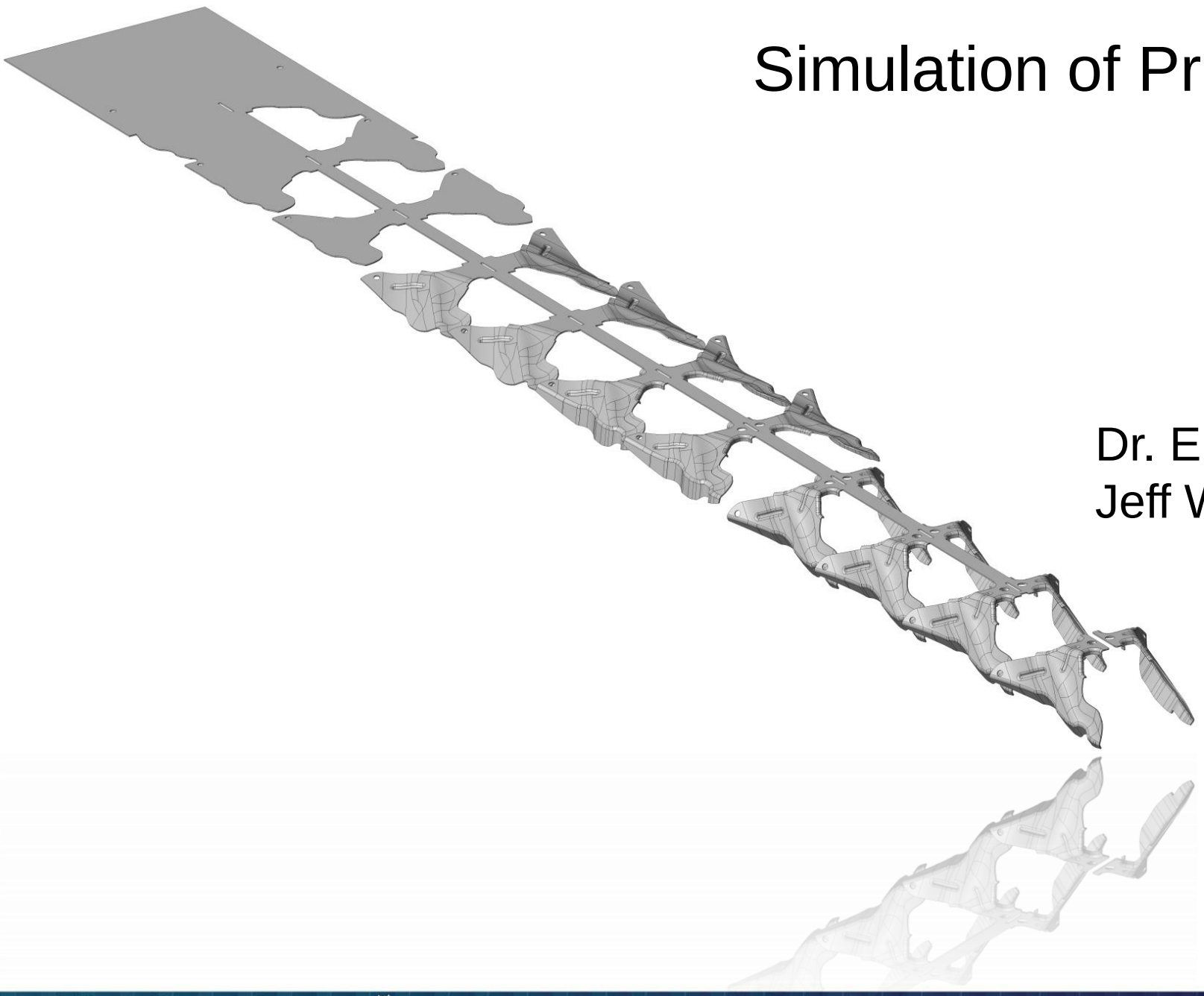
MetalForming LIVE

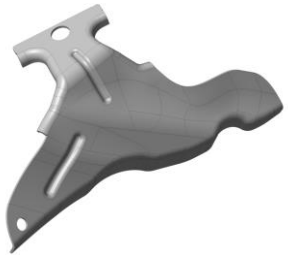
JULY 2022

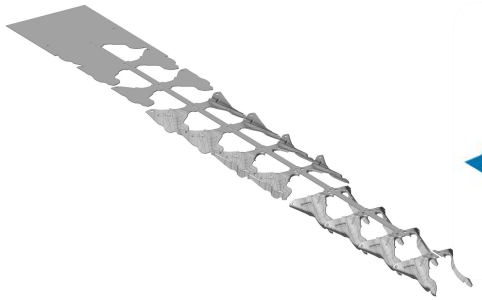
Simulation of Progressive Die Designs

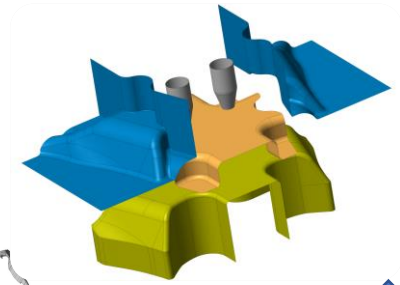


Dr. Eren Billur, Billur Metal Form Ltd.
Jeff Werkema, Die CAD Group

When, why and where to use simulation







Product design

Process design

Die design

Die building

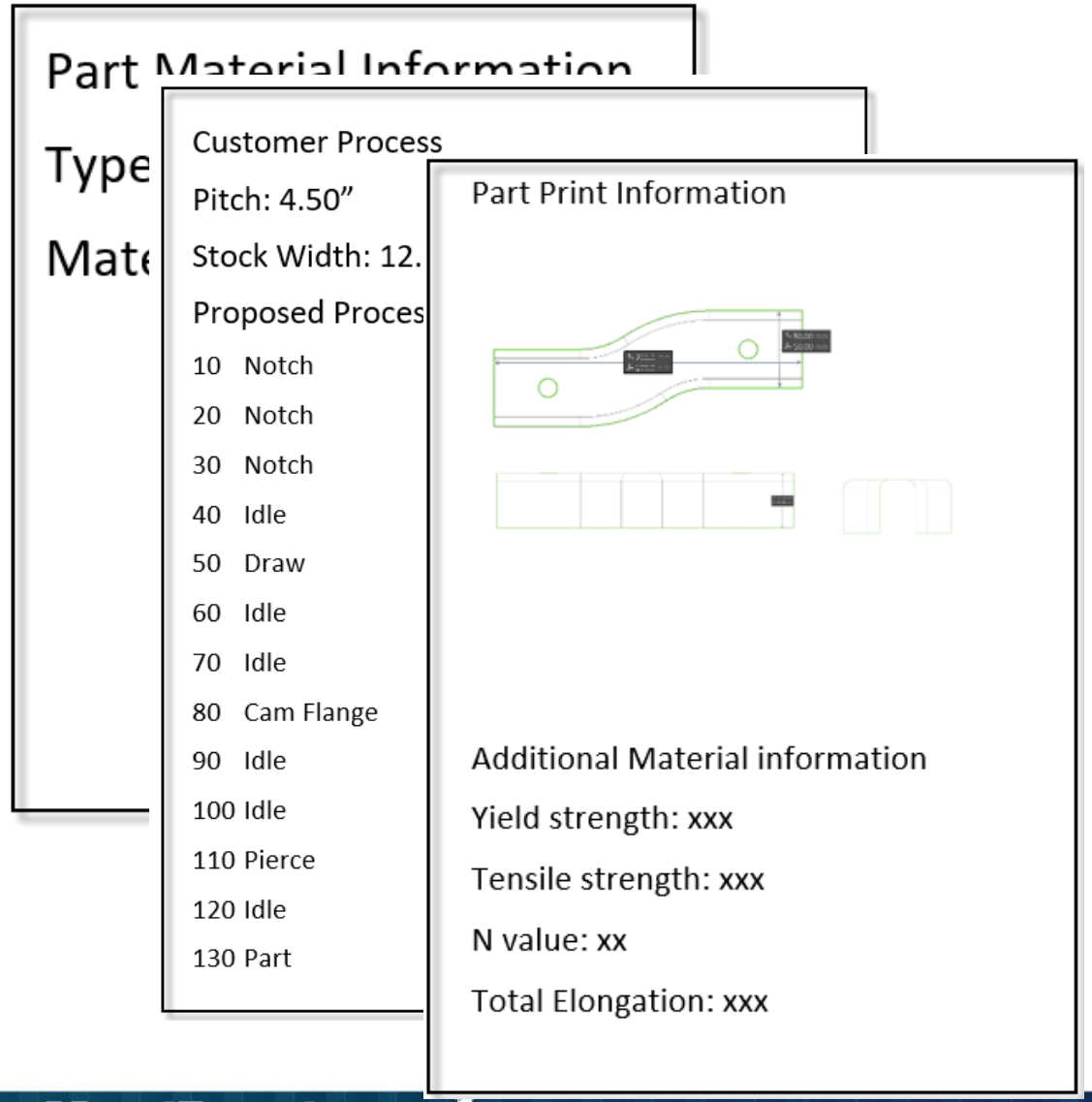
Die spotting

Production

Prototype Die

Recuts

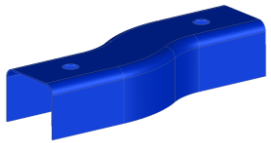
Progressive die design process @ DieCAD



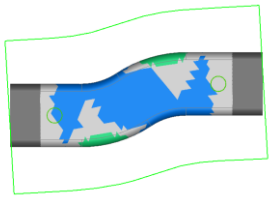
Gathering and reviewing project information

1. CAD part data
2. Part material information
3. Material spec’s
4. Part data with G D & T
5. Customer proposed process
   - Estimated pitch & stock width
6. Press information (if available)
7. Feed direction
8. Any standards\templates needed to be followed.

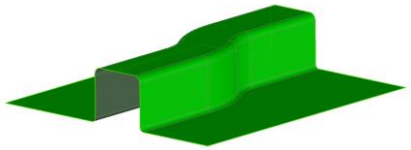
Progressive die design process @ DieCAD



Review CAD Part Data



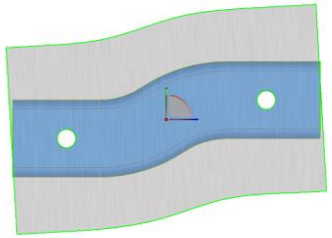
Calculate a proposed blank and review early feasibility study



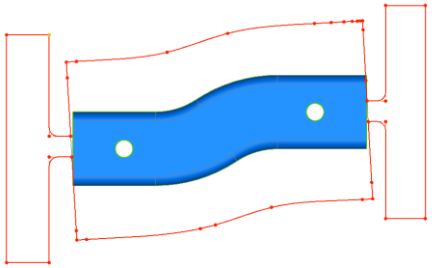
Create the form tools for the preliminary process

- 1st step simulate with no carriers to prove the part can be formed
- Tweak the development process until you get a formable part.
- If product changes are required, you will need to get approval.

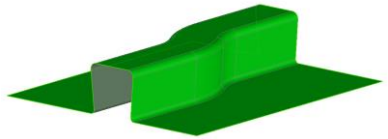
Progressive die design process @ DieCAD



Trim optimize the blank to get a close starting blank shape to add carriers to it.

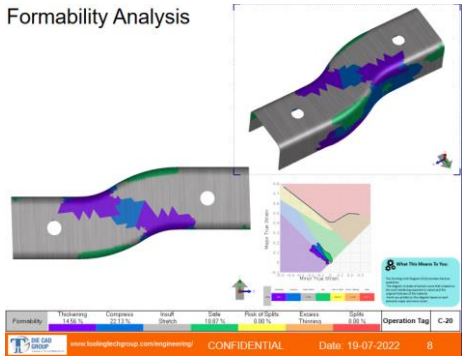


Add carriers and web attachments. Updates form tools to include lifter support tools.

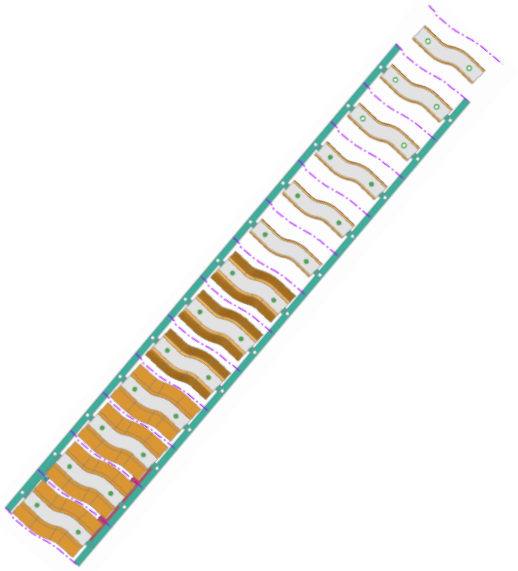


Develop a compensation tool skin to get the part in tolerance

Progressive die design process @ Die CAD



Review process and formability with the development team

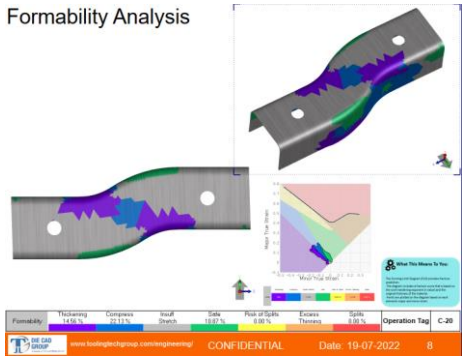


Then put a 2D and 3D strip together

Progressive die simulation @ BMF

Parts are already in production, but:

1) Have high scrap rates (splits/neckings),
2) Out of tolerances parts (springback)
3) Gage/Grade will change due to customer requirement.



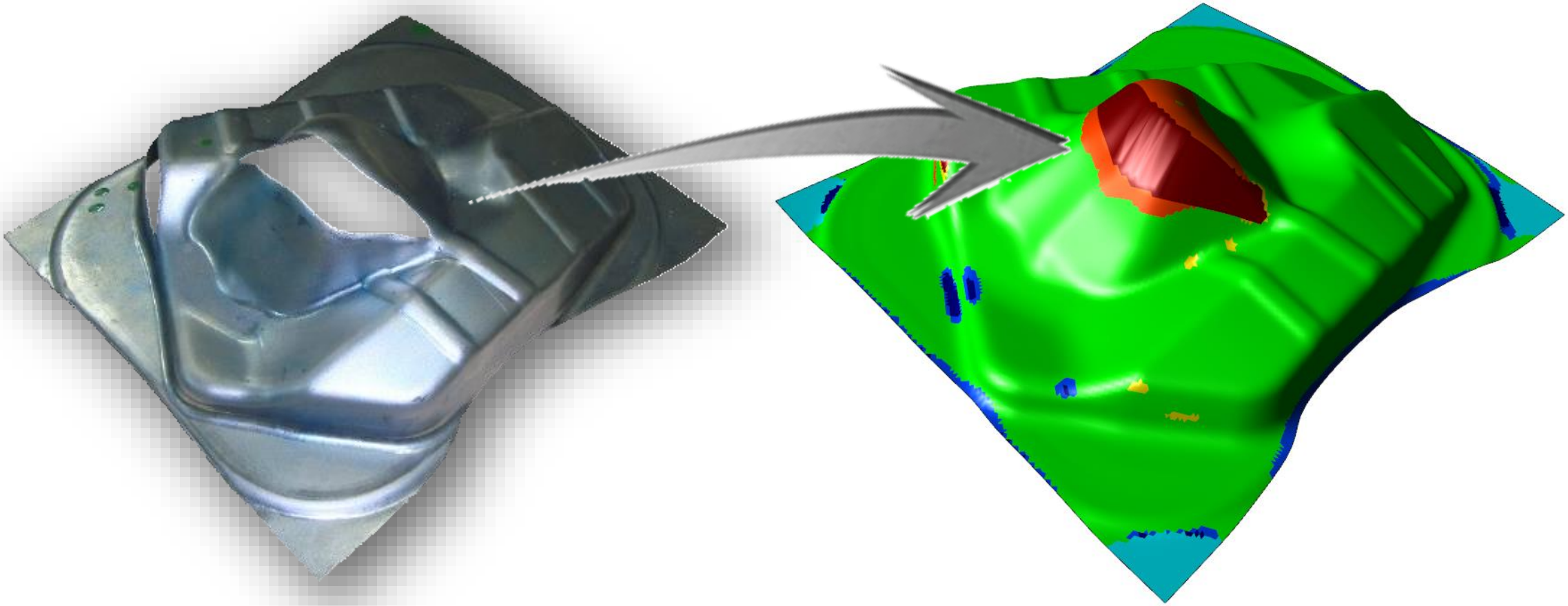
The process has already been designed.

There may be a former formability analysis to check (most of the time this shows all green)

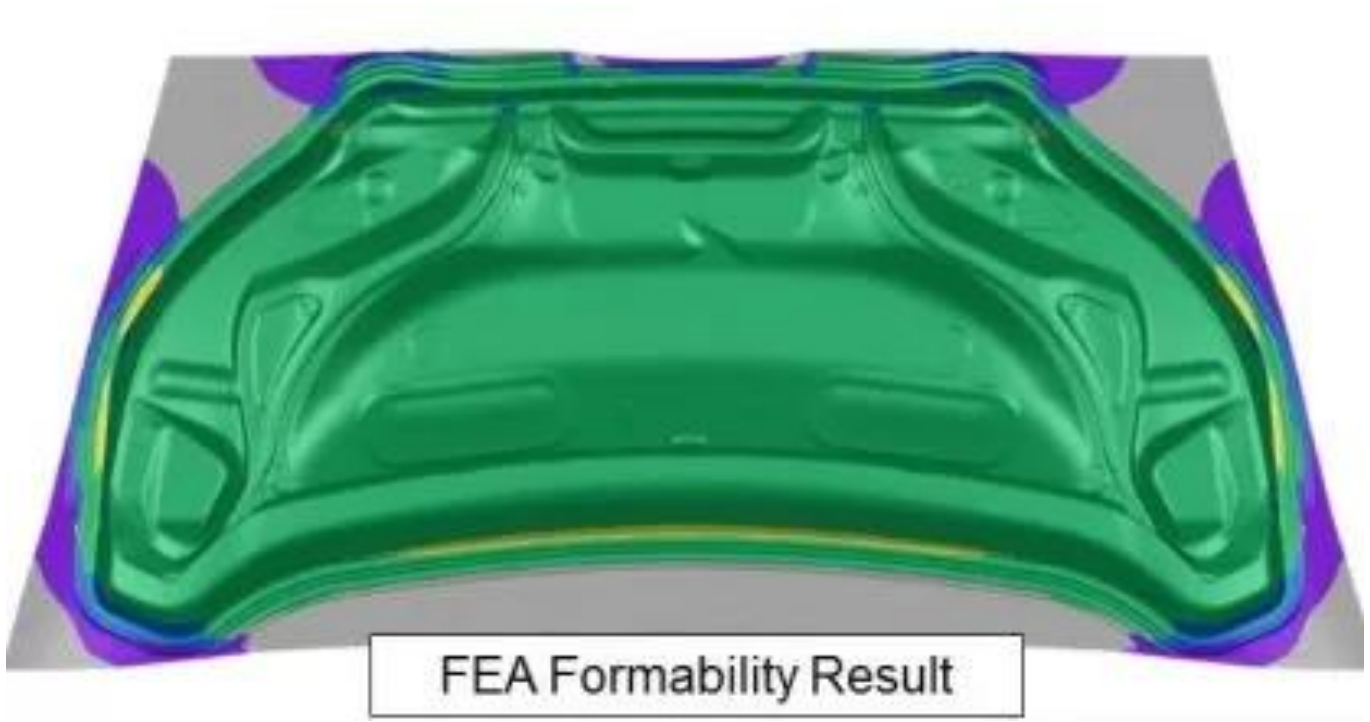
There may be further modifications on the die that are not very well documented.

Verifying simulations with real world

A simulation without real world validation is just an animation.



Why simulations may fail?

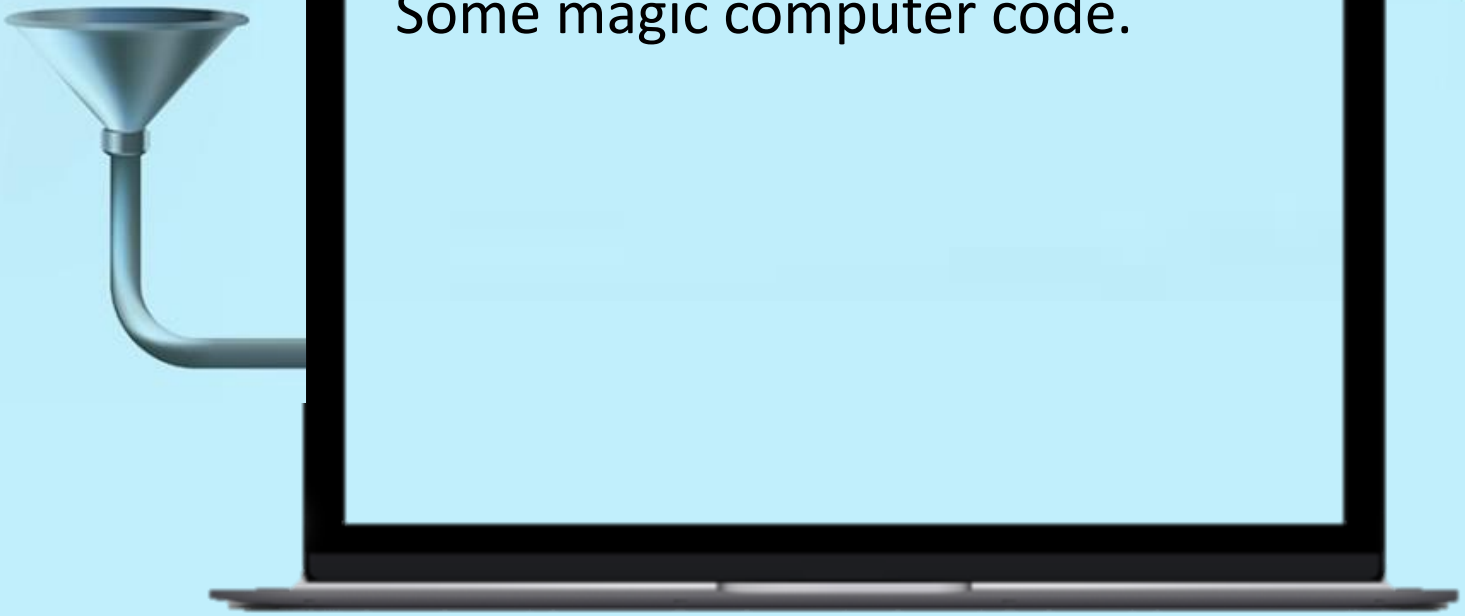


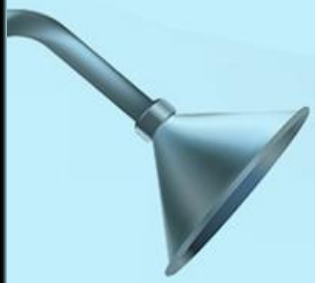
FEA Formability Result

Try-out Result

Image source: https://formingworld.com/ford-triboform-friction-analysis/

Why simulations may fail?





What could be the garbage input?

Any difference between the real-world conditions and computer screen:

Do the actual die surfaces match simulated surfaces?

How were the binder/pad forces applied?

Does the material card represent the coil?

What is the press type and speed?

How is the friction modeled?

Are heating up effects considered?

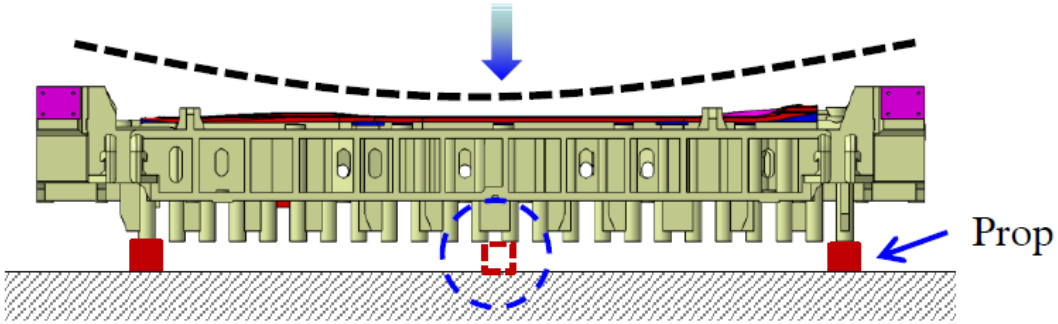
Was the die spotted? If so, did the draw-in match in real-world and simulation?

Are there any simulation work-arounds, that may cause a big variation in the results?

Why simulation results may be misinterpreted?

There are limitations of computer codes.

Press and tool deflections are ignored.



Pierce and trim tools are not modeled. Neither their shocks during the break.

Up-stroke is not modeled: part sticking on upper tool, effects to springback…

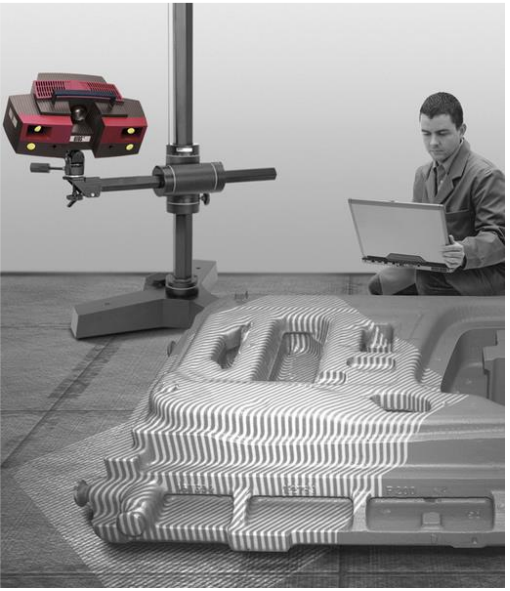
Progressive dies are modeled one operation at a time.

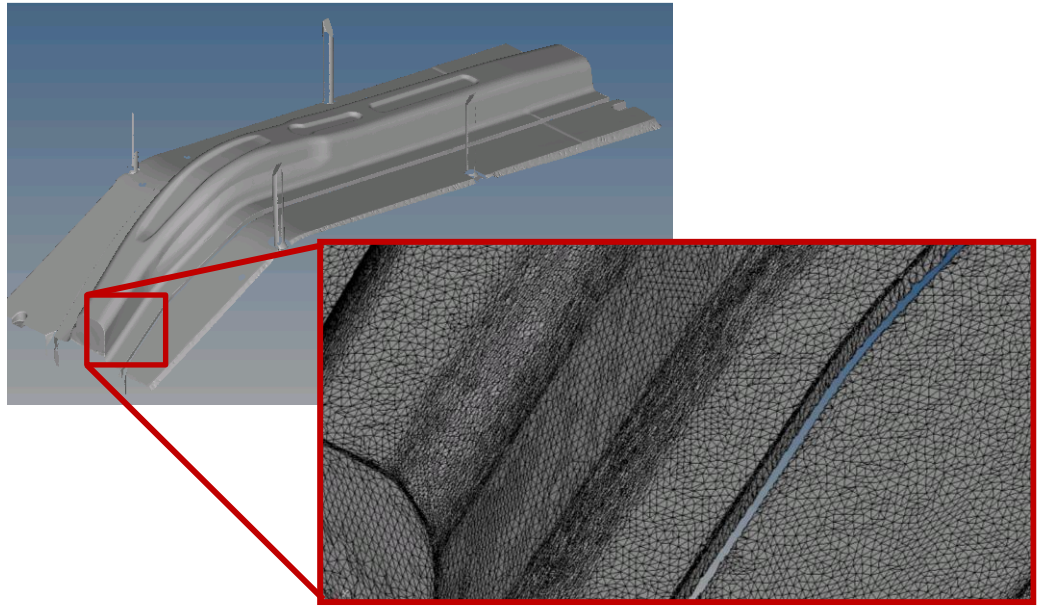
Input data for simulations

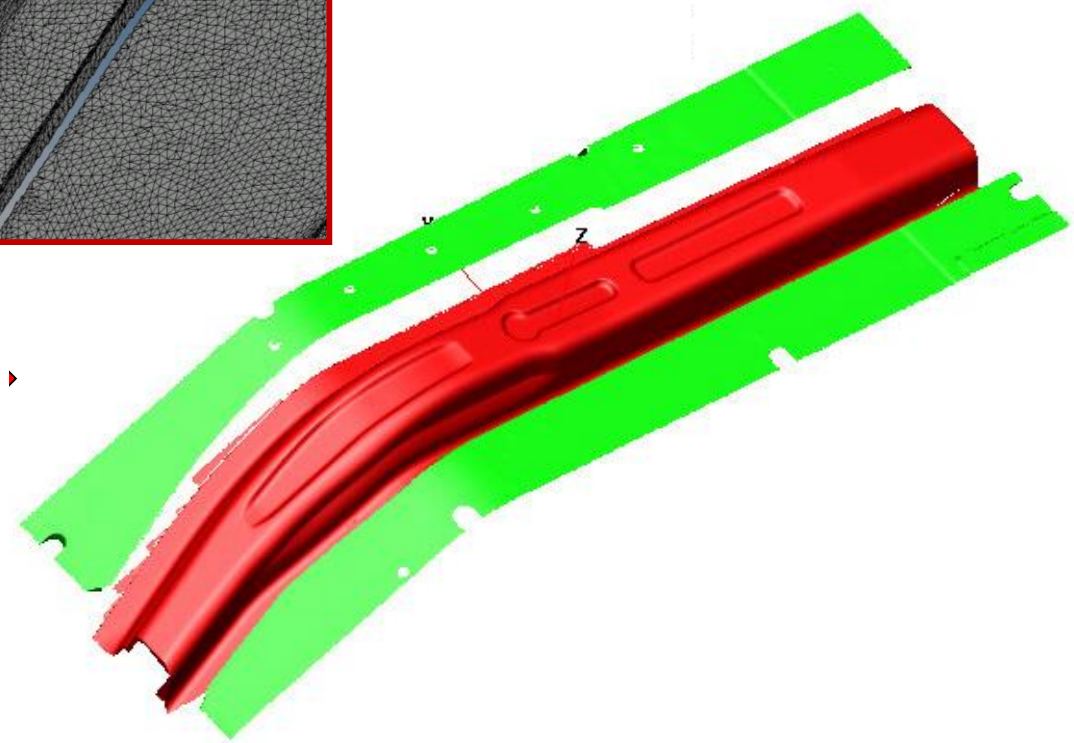
Process	Initial Blank Outline
	Tool Surfaces
	Binder / Pad Forces
	Friction Model
	Press Model

Material Card	Hardening Curve
	Yield Locus
	FLC (or TFC)
	Strain Rate / Temperature dependent data
	Kinematic Hardening
	Failure / Fracture Max Edge Strain

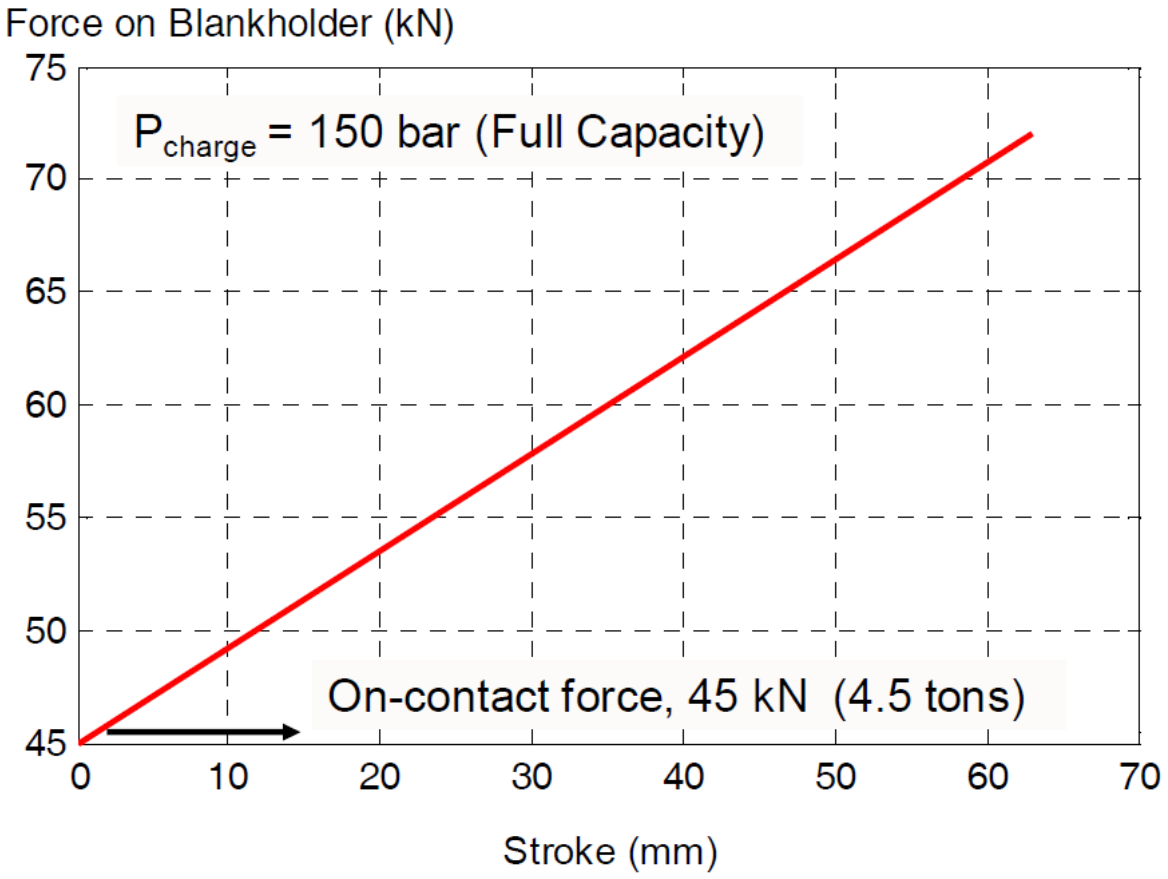
Tool surfaces can be 3-D scanned as a service







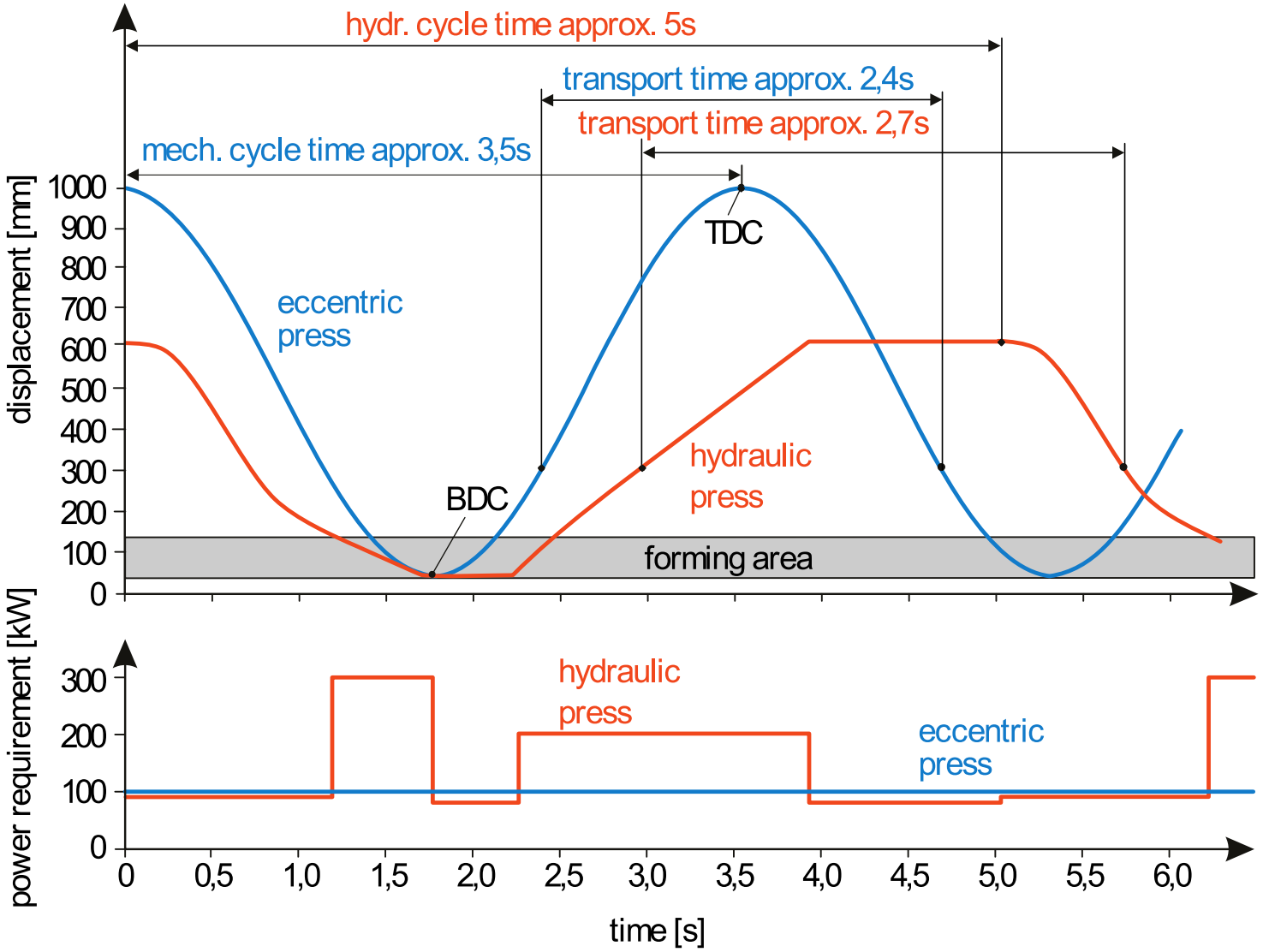
Binder and pad forces should be clearly defined



If nitrogen cylinders are used, the compression must be considered!

It is also critical to check if the on-contact force is overshoot…

Press motion curve can now be added



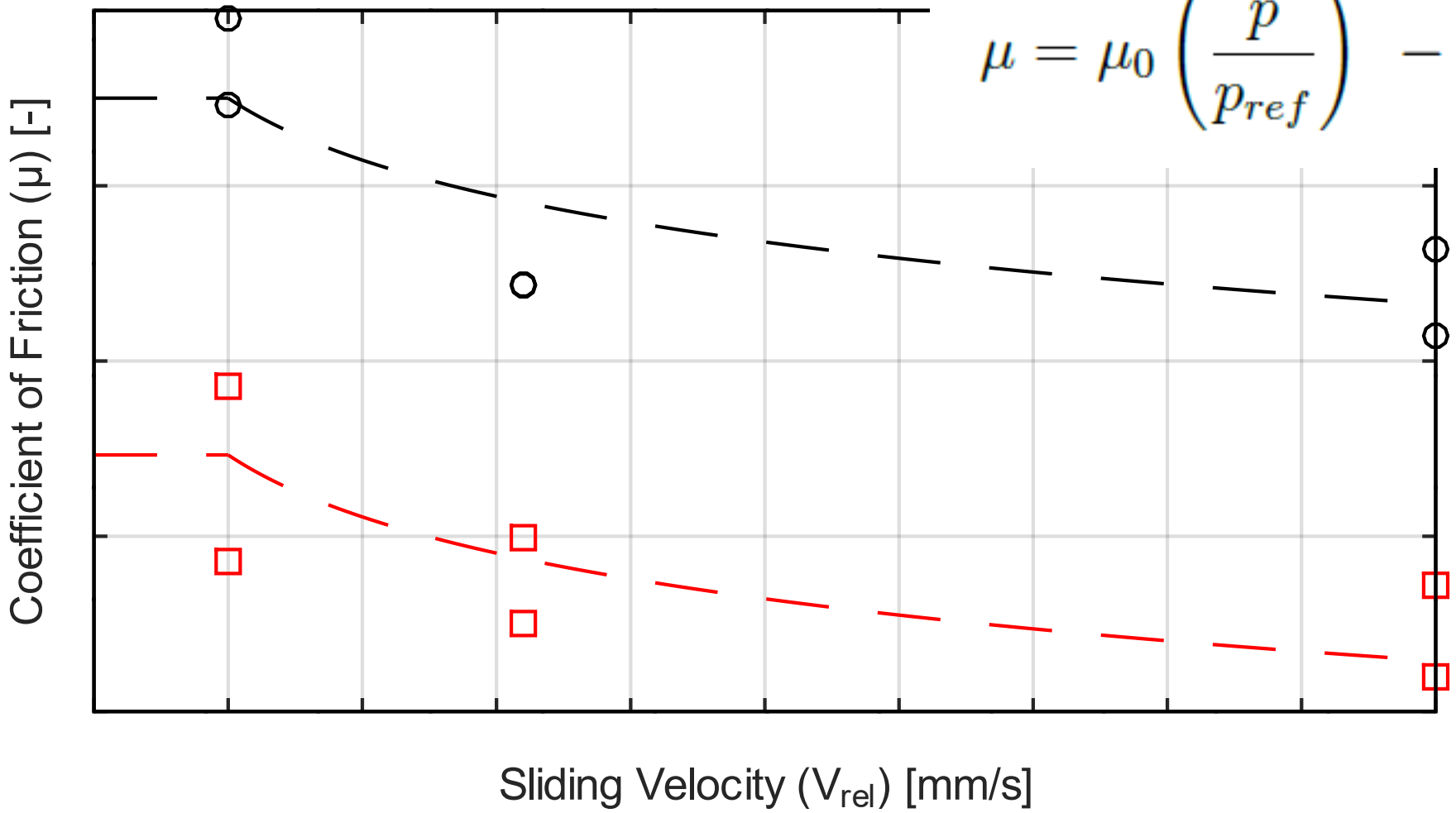
In real-world press profile changes formability!

In simulation, to see this, you need to model:

1) Strain rate dependent material
2) Friction as a function of sliding velocity.
3) Heating up of the material.

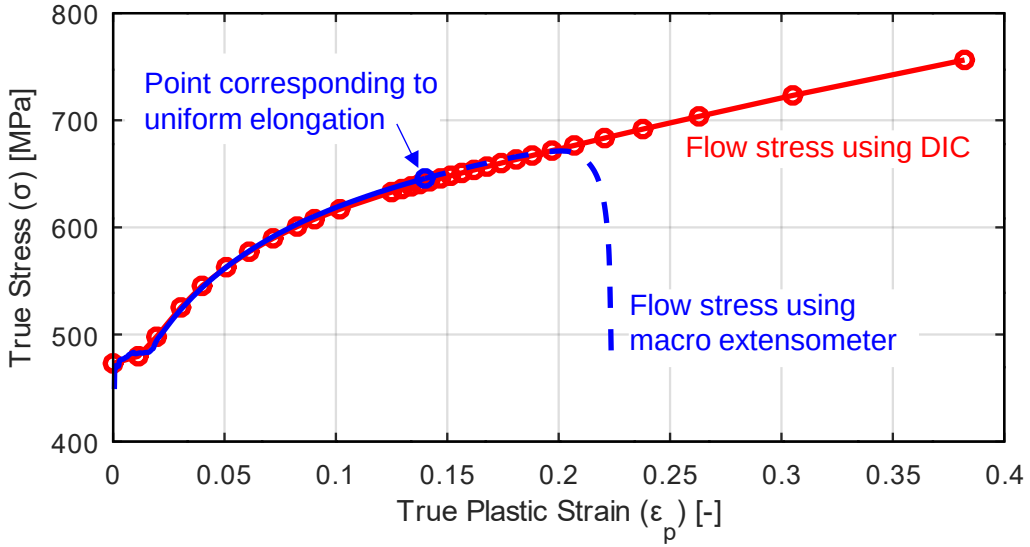
Friction models

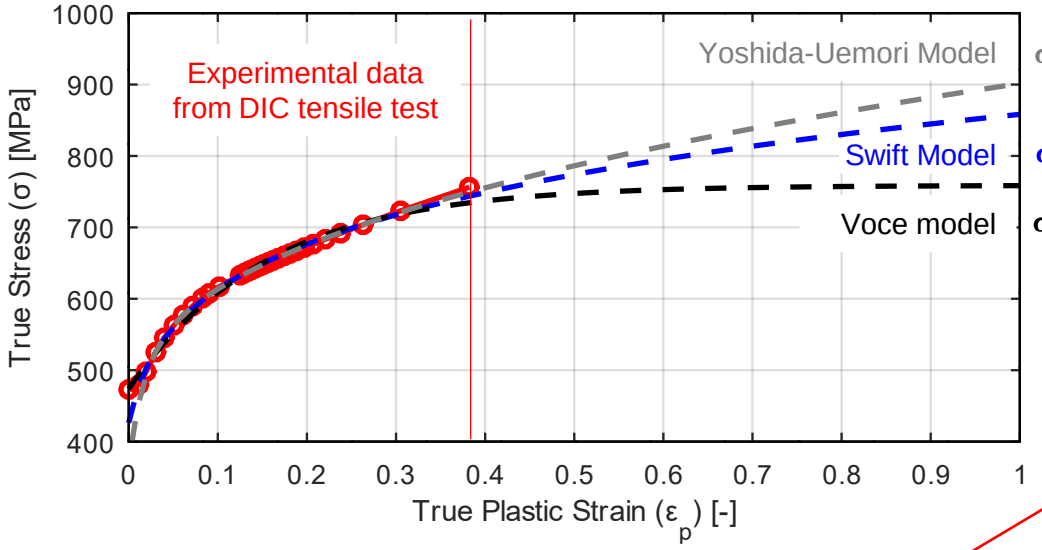
$$\mu = \mu_0 \left(\frac{p}{p_{ref}} \right)^a - b \, ln \left(\frac{max(v_{ref}, v)}{v} \right)$$



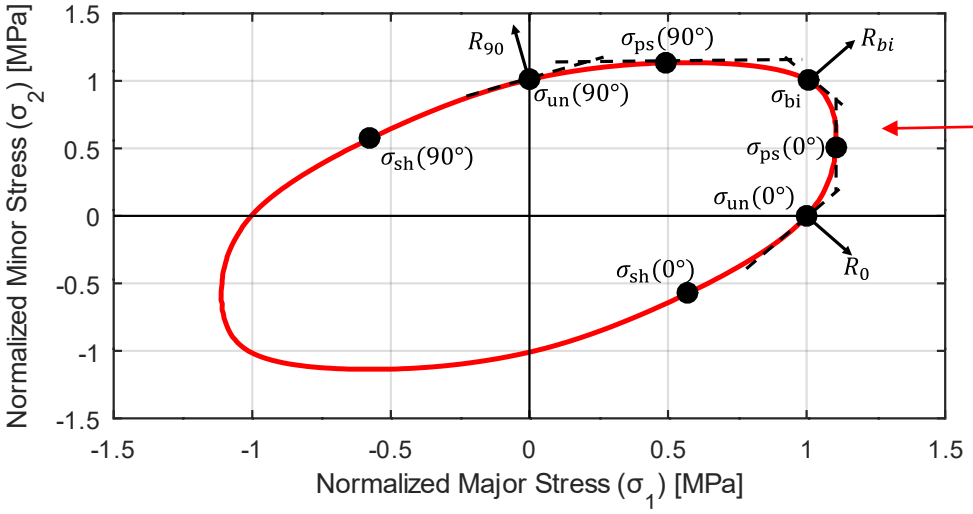
By putting in only 3 data you can model friction!

Material Card

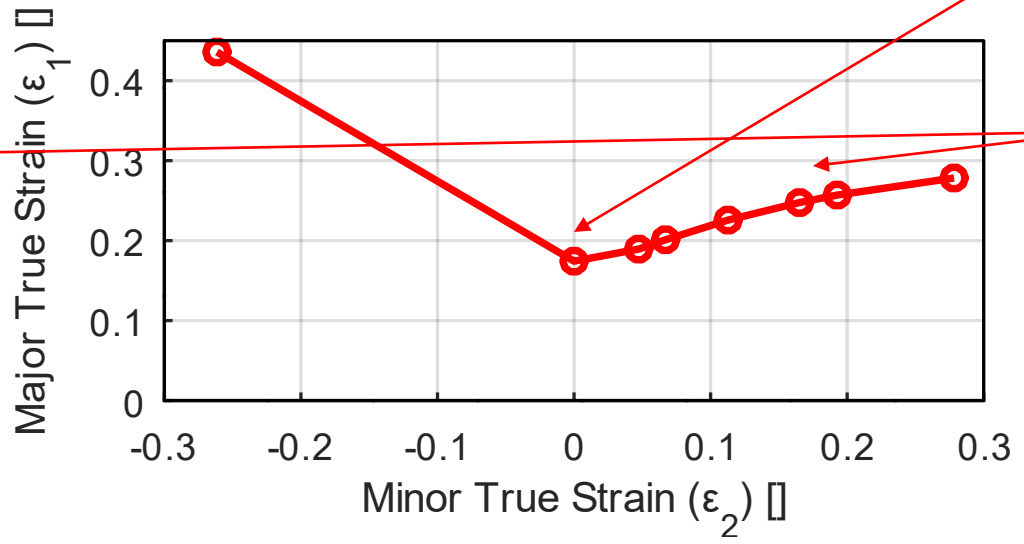




n-value



r-values



Material Variations

Coil to coil

Steel maker A to B

Slitted coils: Right hand and left hand.

Hot days vs cold days

Coil head to tail

And avoid using steel equivalency tables.

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QUESTIONS
ANSWERS