“Moldflow Does Not Match Reality!” Do You Know Why?

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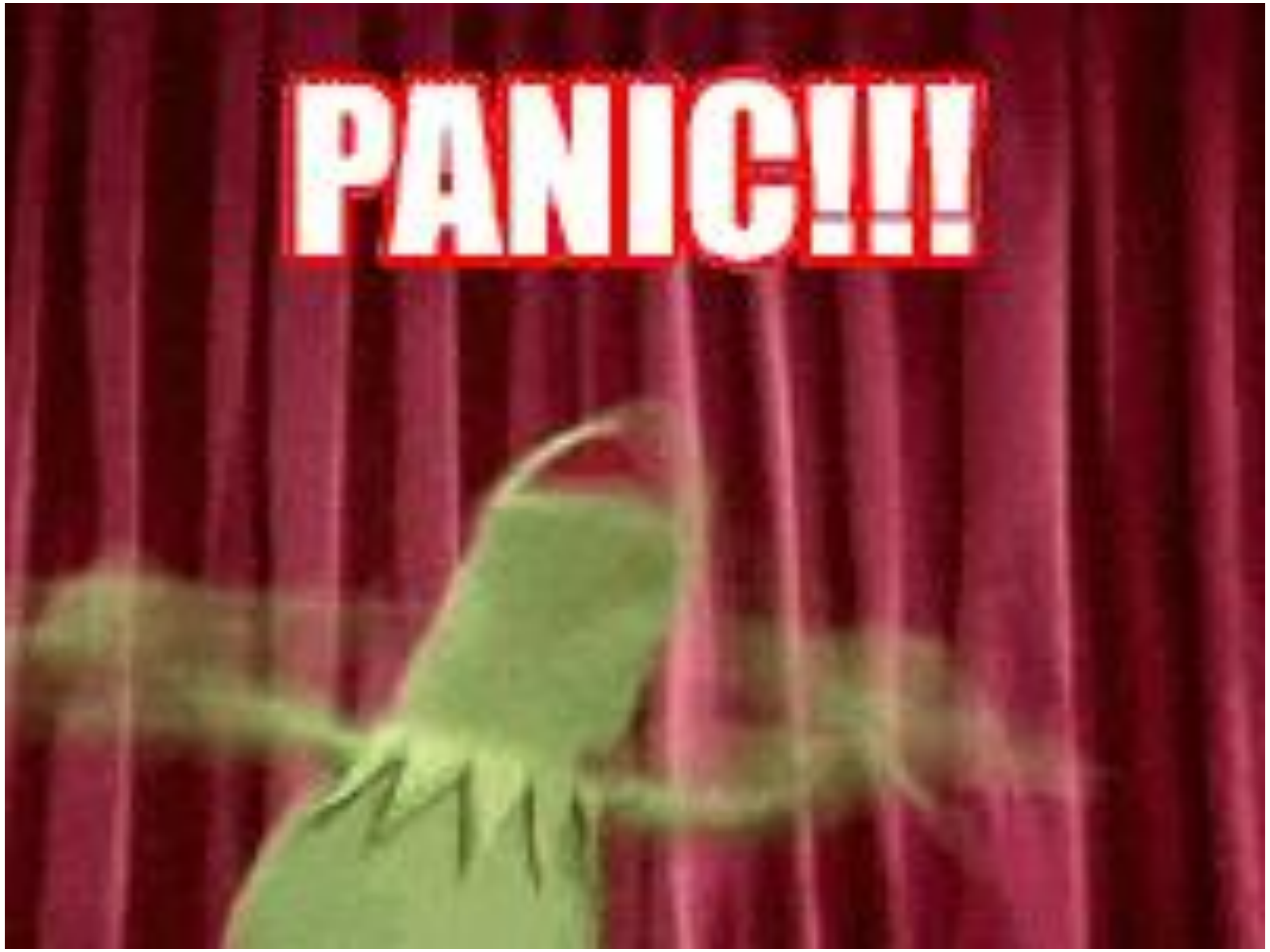
Synventive® molding solutions

Filling Analysis Mismatch?

- At Synventive, we do a lot of processing. We set up process conditions both within Moldflow and standing at the press. This often involves "cascaded" or "sequenced" filling of a part via sequential valve gates, with subsequent drops opening at desired times.
- Molders pay good money for Moldflow analyses before tooling is completed. So when first shots of the mold come around, they would like to see the process at the press approximately match the moldflow they used to build the mold. And for the most part, if all inputs are equal, they will match.
- More times than not, when reality and simulation do not match, it is because the conditions at the press do not match the inputs provided to the moldflow, or the resin data is not representative of what is at the press.
- Warp mismatch? Warp is a different story, for another time.
- For the filling stage of the analysis, these simulations have existed for decades. It pretty much just works.

- But what about when you have done your due diligence, and Moldflow still does not match reality? What does everyone do?

Panic!



Let's not panic. Let's experiment!

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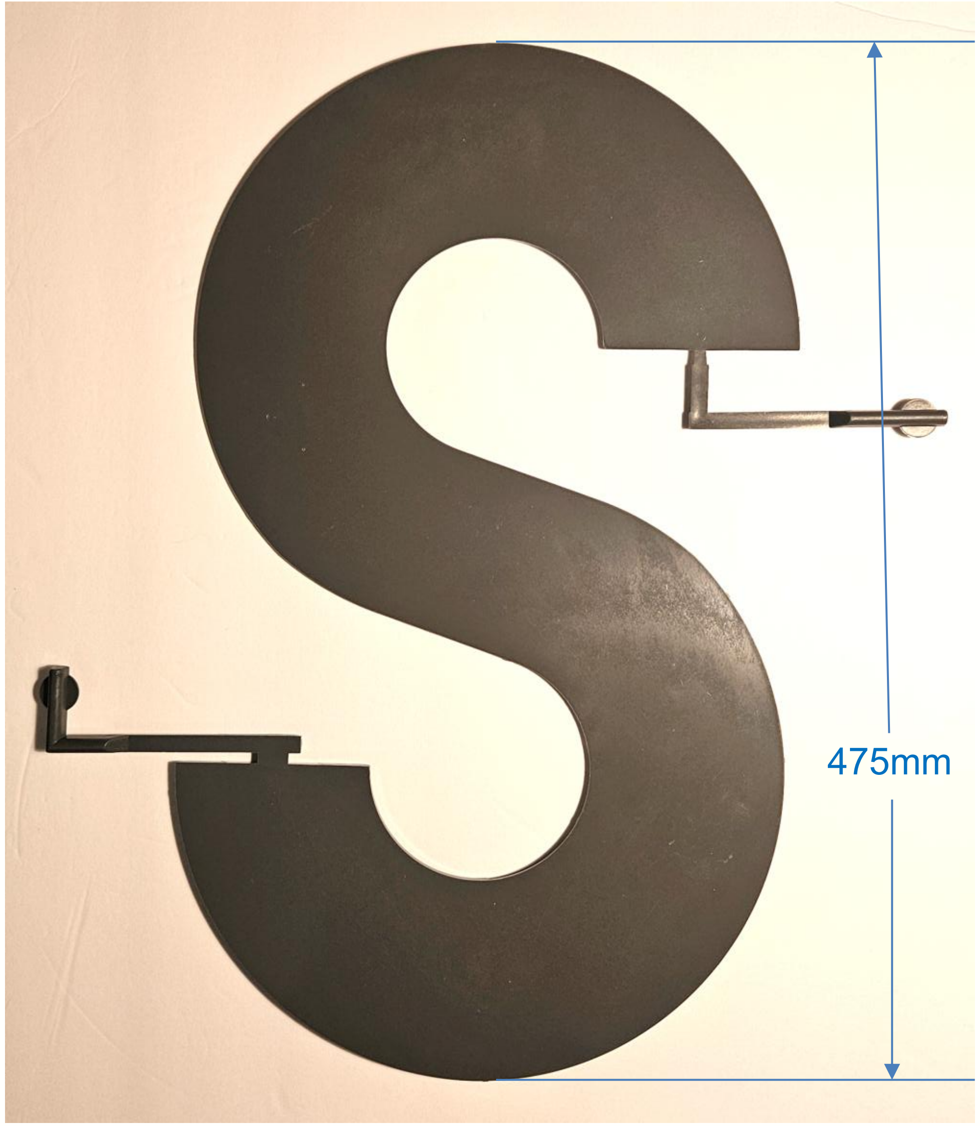
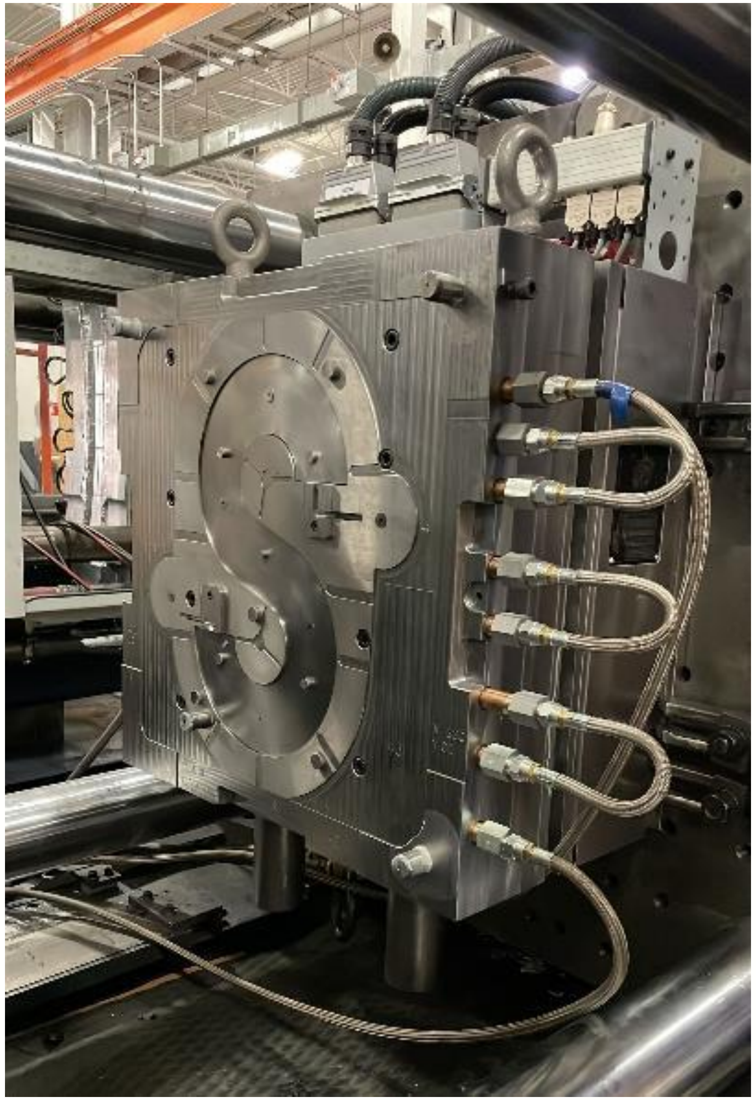
- “S” for “Synventive!”
- 2.5mm wall, constant.
- 3mm tall perimeter rib/flange at both ends.
- ~190g
- ~900mm flow length, end-to-end.
- ~90mm wide.
- Built for a 550ton-US press.
- 1.13mm x 14mm “large” edge gate, which will be our start of filling.
- Advanced Composites ADX 2149: Talc-filled PP, fully characterized.

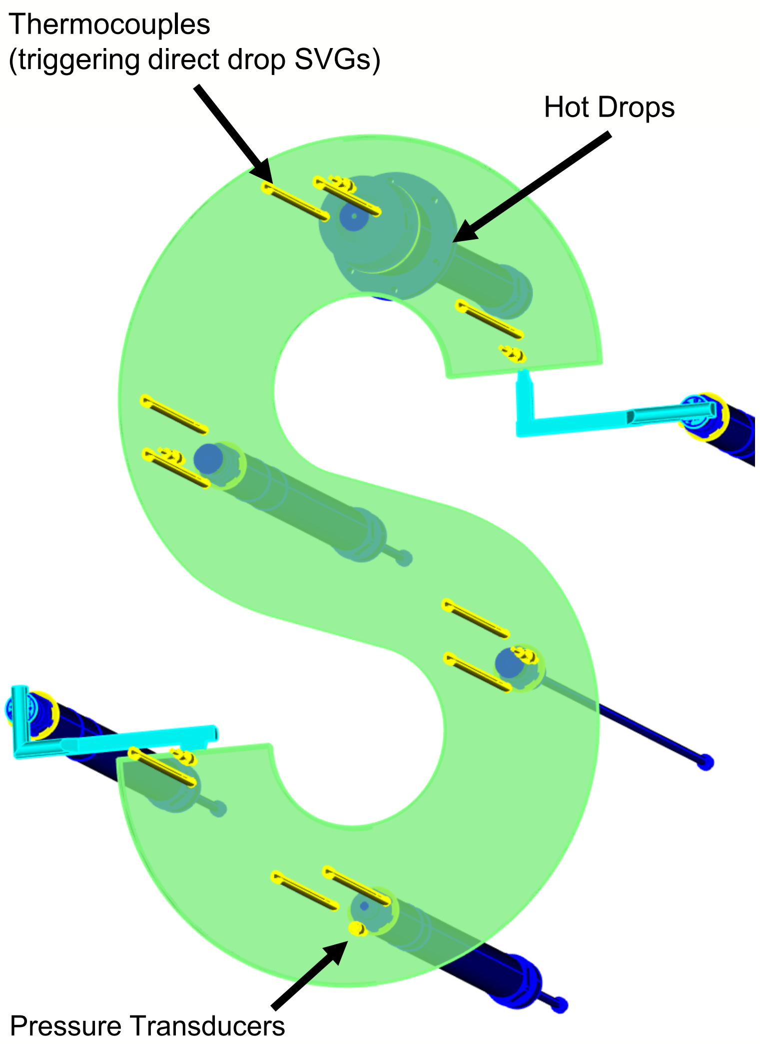
- Perfect for a Dual Domain (DD) or Midplane (MP) mesh!



The S Mold

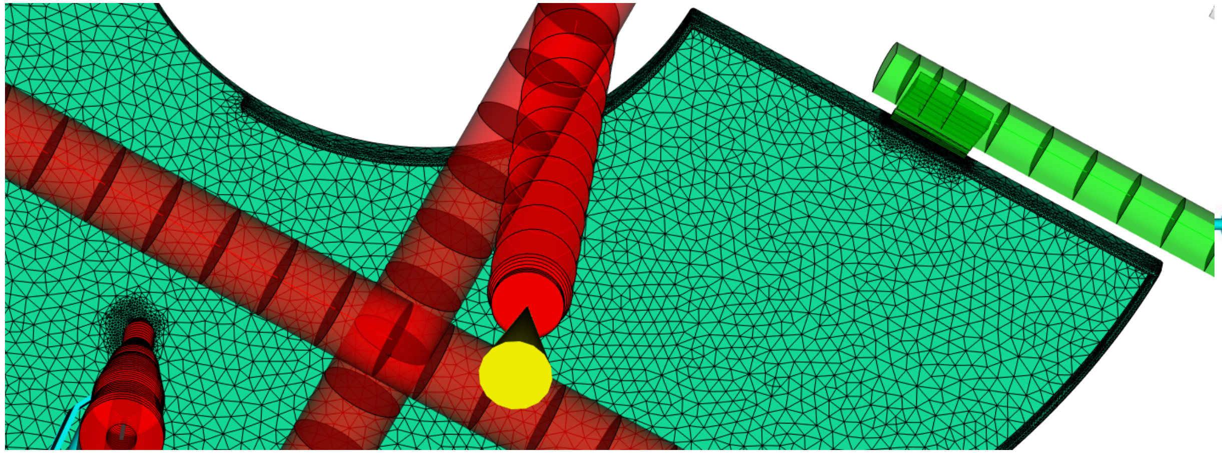
- Built by and sampled at PT Tech (MI).
- P20 cavity and core blocks.
- 6 valve gated hot drops, 4 of them are direct onto the part, 2 are into cold runners feeding edge gates.
  - Several different Synventive nozzle styles are used on the current mold.
  - Current manifold is an eGate Sync servo manifold. We will be sampling an Intelligate hydraulic manifold next.
- Stationary spring ejection.
- Moving half is a polished surface.
- Moving half has pressure transducers and thermocouples throughout for data collection.

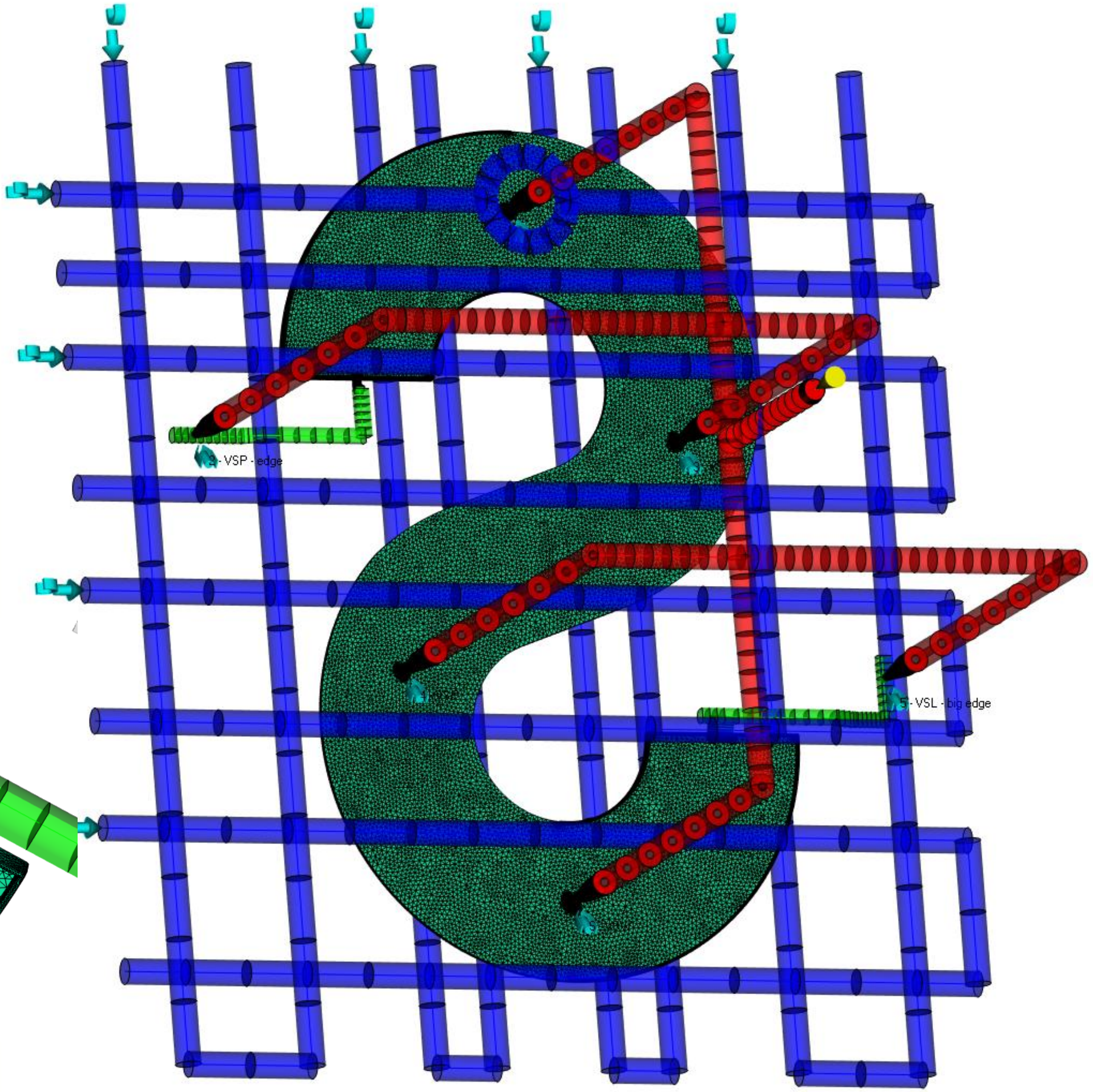




Part Mesh

- Dual Domain mesh, because DD ROCKS!
- 88,000 elements.
- ~2.5mm elements via 0.8 CAD mesh using Moldflow’s mesher.
- Refined 0.4mm mesh at all beam element interfaces… Just in case *someone* wants to try 3D later…
- Waterlines, manifold, and cold runners all come from tool CAD. All modelled as traditional beam elements.
- Synventive nozzle meshes.





Trial “T2_B0” - Information we are Given!

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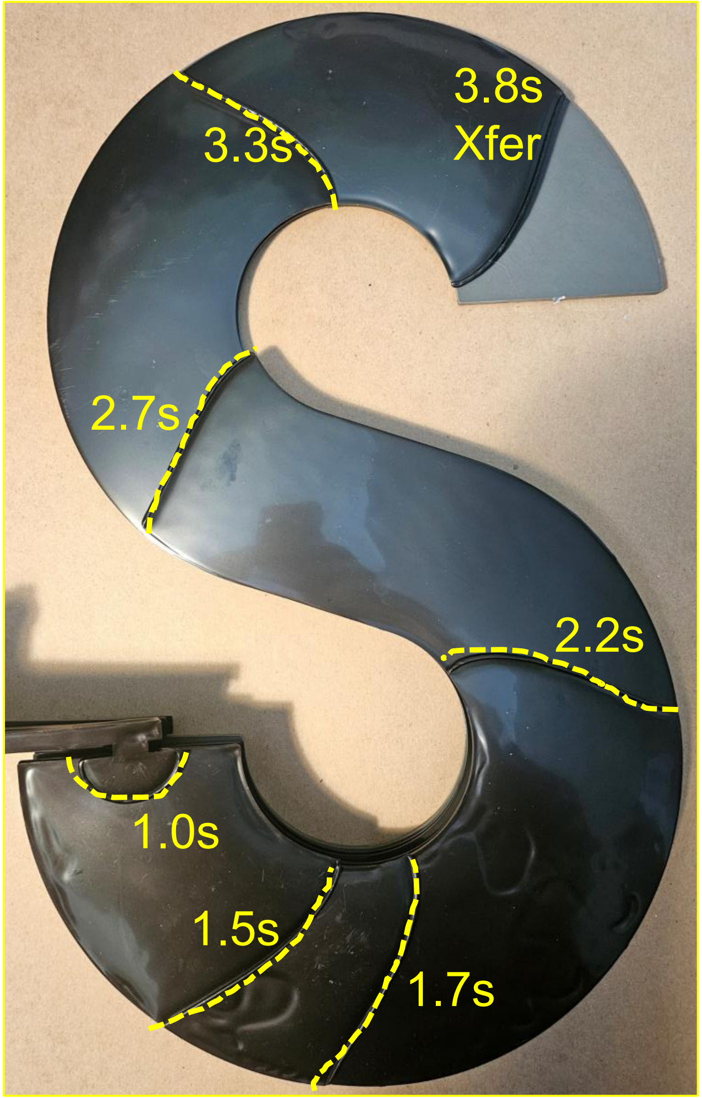
- Starting with the bottom edge gate “SVG5.”
- Triggering direct drop valve gates by Priamus cavity thermocouples.

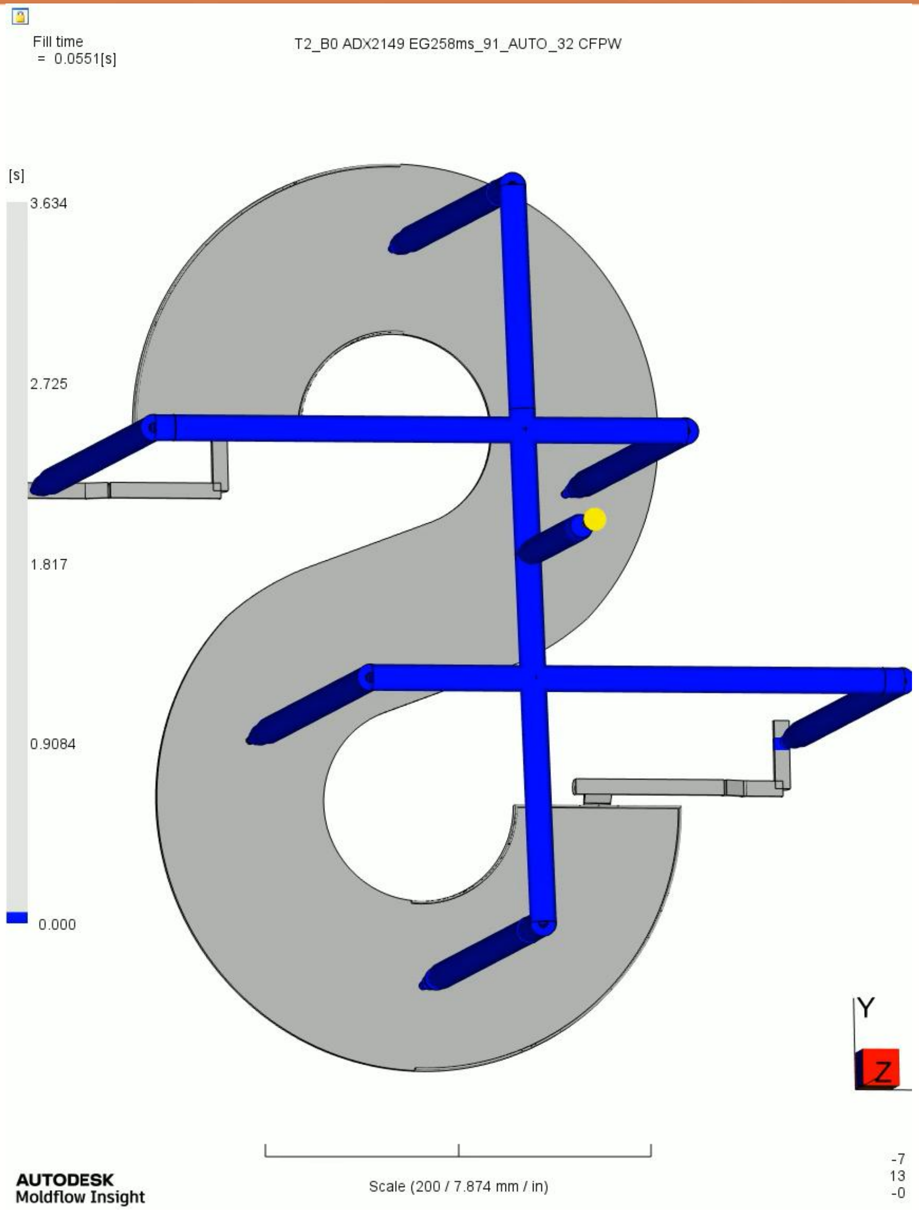
- Press:
  - 550 ton. Hydraulic ratio: 8.94 : 1
  - Air shot through the press nozzle was ~100 psi HYD (~900psi plastic) with a ~4 sec purge.

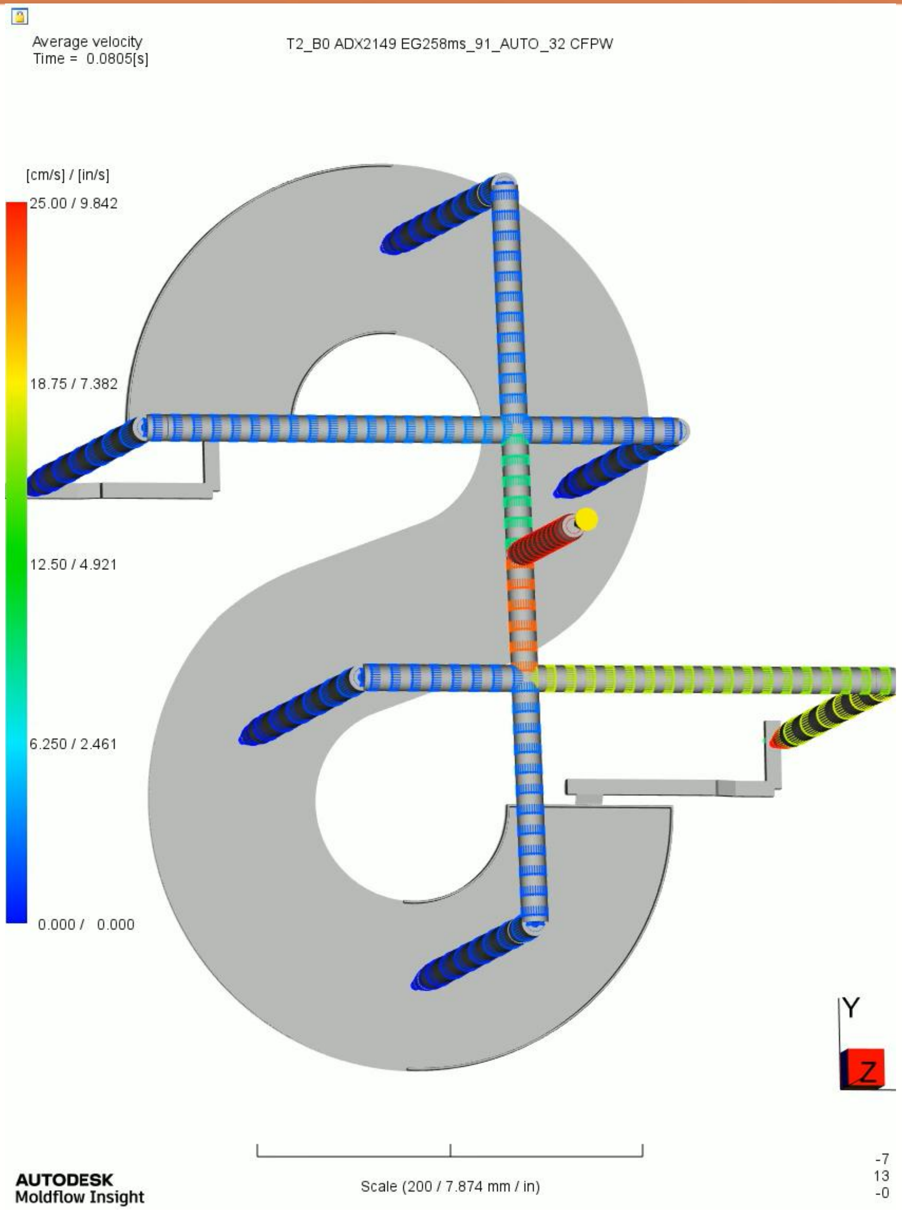
- Press Process:
  - Sequenced Fill, controlled by cavity sensors.
  - Flow past each of 4 direct drops before opening.
  - EOF edge gate not used.
  - 440F melt, 105F water.
  - 3.8s fill time to xfer.
  - 2.35” shot size +0.10” decompression.
  - 0.50” transfer, 0.25” cushion.

- Additional data provided:
  - Short shot parts throughout filling, with corresponding hydraulic pressures and fill times.
  - Valve gate open signal times (from Priamus sensors).
  - Cavity Priamus pressures and temperatures values.



Trial "T2_B0" – Filling Pattern

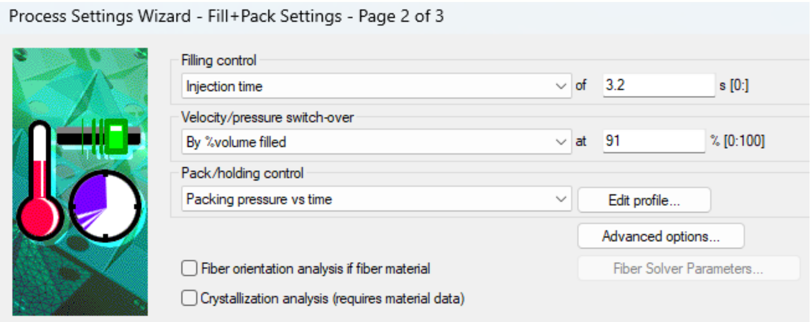


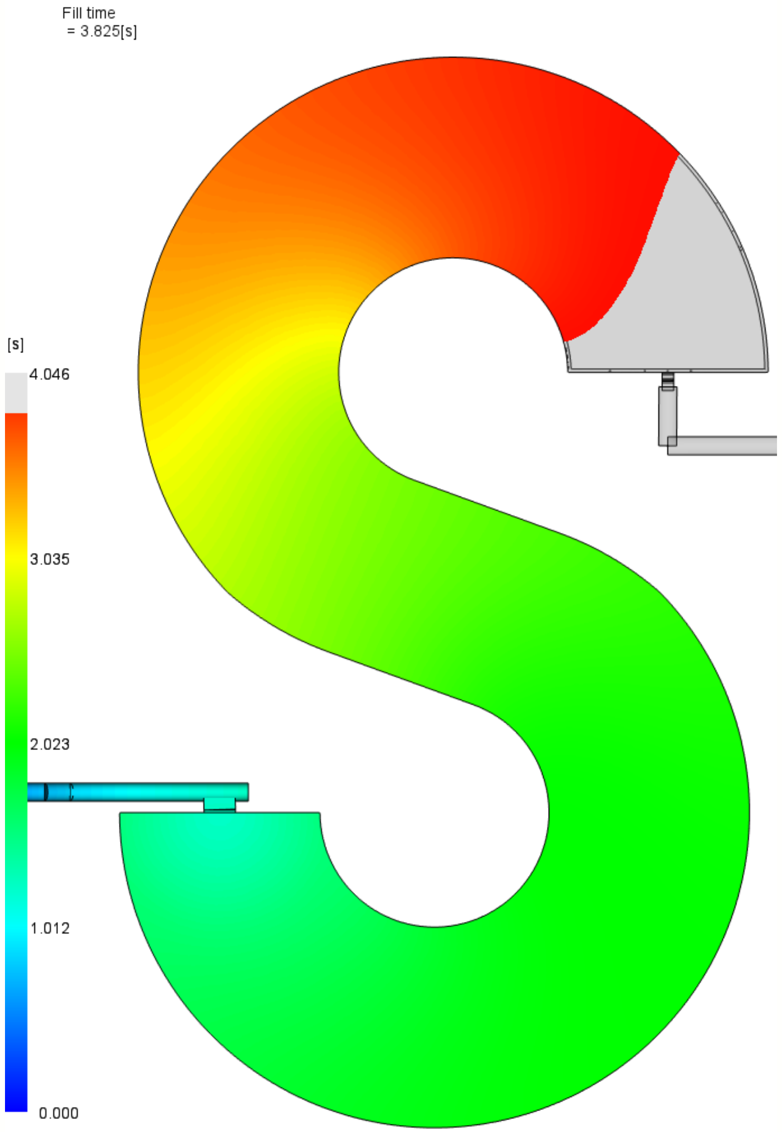


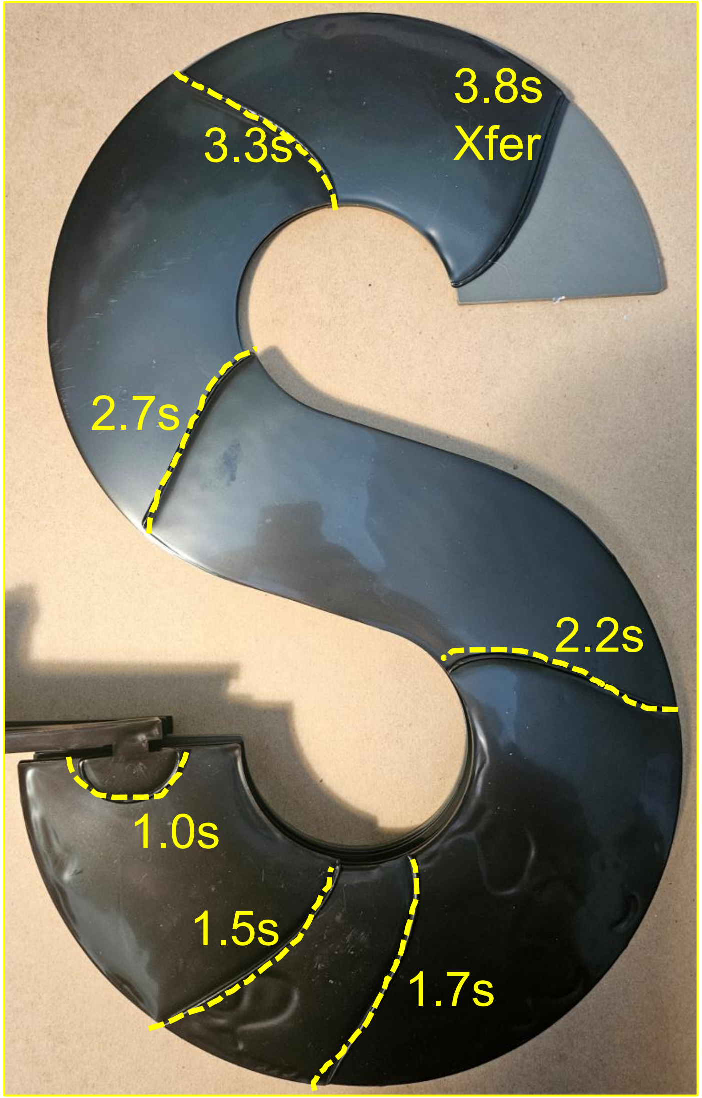
Let’s Run a Default Moldflow with Provided Variables

V/P Transfer at the press is at 3.8s.

To get the Moldflow to same transfer position at the same time, moldflow transfer set point needs to be set to 3.2s, and the percent filled set to 91%.







Let's Run a Default Moldflow with Provided Variables

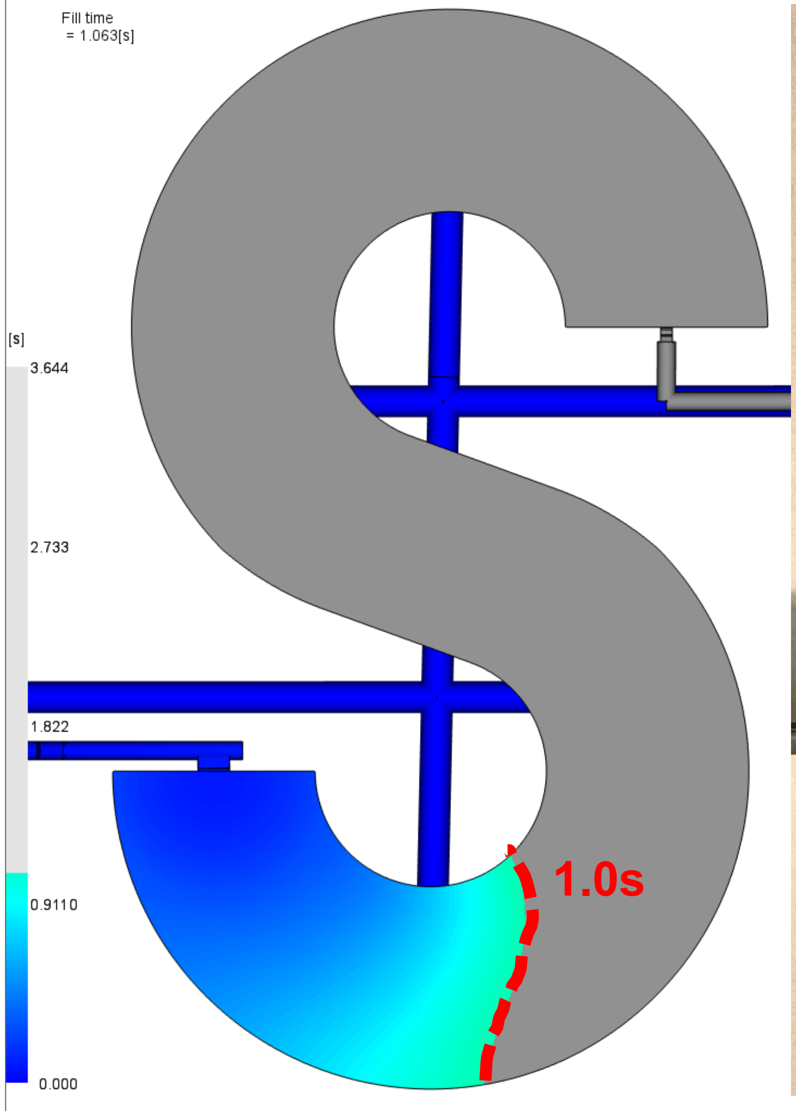
Huge mismatch at the start of filling!

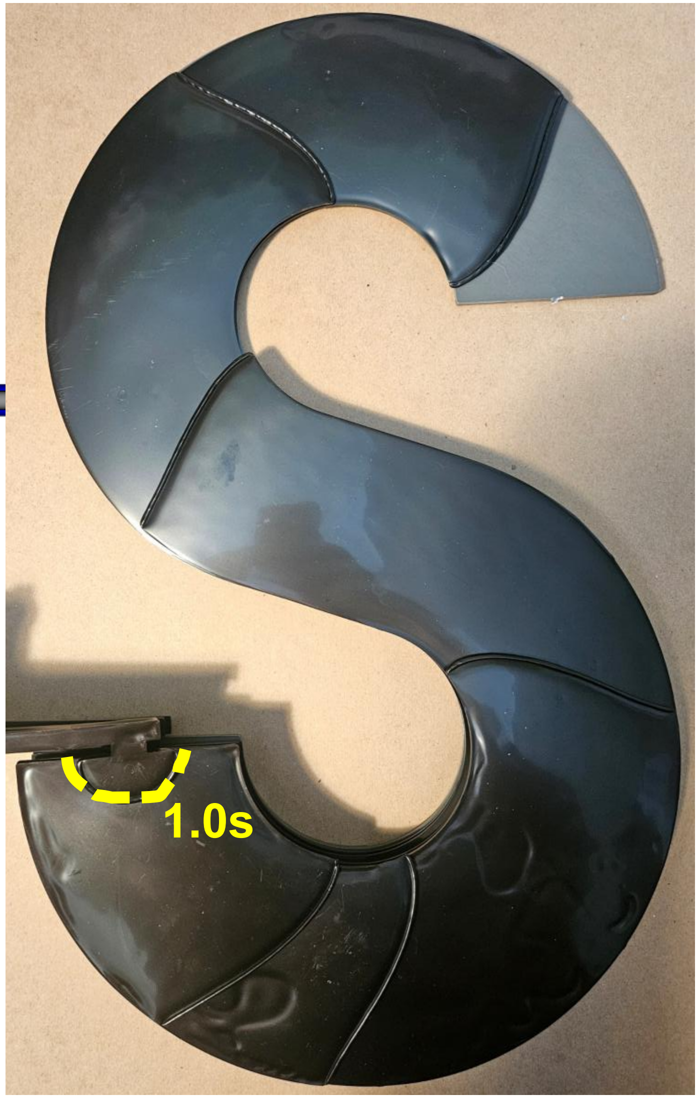
Why?

We entered everything correctly!

Answer: Moldflow hits the target injection fill rate almost instantly at the start of fill.

This is not how the plastic actually flows into the cavity for a variety of reasons…





Why Did That Not Work?

QUESTION: What is happening?

ANSWER: All the stuff happening OUTSIDE of, or up-stream of, the Moldflow.

Lets break it down:

A hydro-mechanical or servo-electrical system.

At injection “start”, you send a signal to a hydraulic pump and a hydraulic valve, or an electric motor, to tell them to start doing their thing.

They do not move instantaneously: they ramp up their movement from stop to the requested injection speed.

This starts moving a big plunger (the injection unit)

full of a compressible, non-Newtonian fluid (the plastic).

And do not forget: This viscoelastic molten plastic can vary from lot to lot in flow properties!

Inside the plunger, you have a screw tip non-return valve (which is actuated by the plastic movement around and through the valve during the injection forward motion of the screw with its own set of variables),

which does, by the way, allow for some plastic to back-flow during injection forward, thus causing the mass of plastic within the shot size to change.

But back to injection forward: You are pushing a pre-determined volume, yet potentially variable mass, of compressible, molten plastic we call the “shot size”, which also has been compressed to some higher density, via the back pressure setting, and then immediately

relaxed by melt decompression, effectively increasing the shot volume. **Which** of course is necessary for the

the non-return valve to do its thing, thus hopefully delivering a repeatable volume, and mass, of plastic through the

press nozzle, a narrow, restrictive passage, where it finally reaches the inlet of the mold. And then THIS is where your moldflow starts.

But wait! **If you** have a hot runner, your hot manifold becomes a continuous extension of the molten volume of plastic described above in the press injection unit.

Why Did That Not Work?

Variables NOT in the Moldflow:

- The entire injection unit.
- Compressibility and variability of the plastic within the injection unit.
- Screw tip non-return valve.
  - Effectiveness and repeatability of the valve are impacted by the type of valve selected, the design of the valve, the valve travel distance, the resin viscosity, the injection forward speed, the age and wear of the assembly, Barrel wall friction, and more.
- Melt decompression.
  - Melt decompression is the pulling back of the screw (plunger) after the shot size is achieved in the injection unit. It is typically required to help the non-return valve close quickly.
  - Not enough melt decompression, and the plastic flows backwards over the valve and back into the screw. Shot size loss.
  - Too much melt decompression, and you can get defects in the part like splay from gas pulled into the nozzle tip.

Can We Account for All of That?

Model the barrel in the moldflow?

- Adding any volume from the injection unit into the moldflow is really just a fudge factor: Even if you manage to precisely model the volume of the shot in the barrel and the volume within the press nozzle, you still do NOT account for MOST of the items we discussed above. So, you did a lot of work and still ended up in the same place.

- Yes, sure, you probably did increase the DISPLAYED pressure in moldflow. Is that a "win"? Or just a fudge factor so people can say the pressure is "closer to reality?"

- So how do we capture all of this? We cannot. And we really should NOT try.

Entering injection profile by screw diameter, position, and speed? Again, doing this extra work does not address most of the issues highlighted above.

But you know me…

...Let's Try Anyways!
How? Let's Change the Filling Profile!

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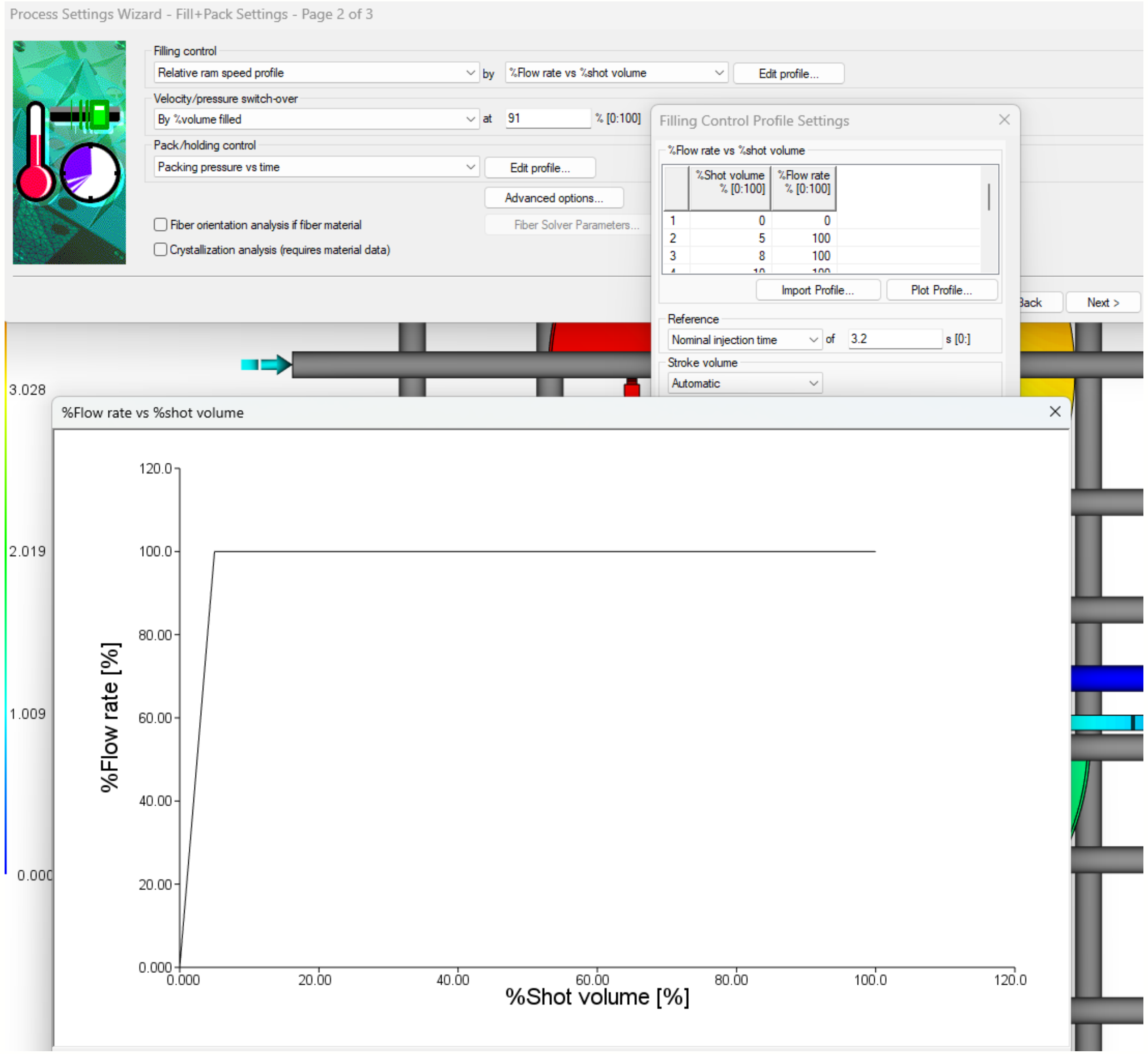
In the simulation, we need to:

1. Slow the initial fill rate.
2. Yet still hit the transfer position at the target fill time.

One approach: Relative Ram Speed Profile.

- Iterative process.
- Same 91% V/P Switchover.
- Same 3.2s fill setpoint.
- CHANGE: A 5% ramp-up from 0% to 100% speed.
- Result: 3.8s fill to transfer w/ 4.0s fill time (includes filling the cold runner at EOF).



Relative Ram Speed Profile Compare

The ramping-up of the injection rate seems to have the desired impact on the filling.

Recall: We are trying to allow for the variation inside the press barrel and nozzle!

Automatic

Filling phase: Status: V = Velocity control
P = Pressure control
V/P= Velocity/pressure switch-over

** WARNING 98634 ** The initial state of valve gate controller "5 -
is "OPEN". The open velocity profile will be i

Time (s)	Volume (%)	Pressure (MPa)	Clamp force (tonne)	Flow rate (cm^3/s)	Status
0.004	0.11	"5 - VSL - big edge" # 7 (Elem# 88882) opened.			
0.080	0.30	5.56	0.00	52.16	V
0.164	1.63	8.48	0.04	60.07	V
0.247	3.39	10.45	0.17	61.57	V
0.320	4.84	12.48	0.52	60.24	V
0.400	6.62	14.29	0.74	63.40	V
0.481	8.65	15.39	1.02	64.74	V
0.561	10.72	16.33	1.51	64.96	V
0.640	12.78	17.25	2.15	65.06	V
0.720	14.85	18.17	2.95	65.14	V
0.800	16.91	19.13	3.92	65.22	V
0.880	18.94	20.09	5.05	65.24	V
0.961	20.99	21.09	6.39	65.28	V
0.967	21.15	"6 - VSW" # 3 (Elem# 88692) started opening...			
1.040	22.99	22.09	7.88	65.38	V
1.120	25.02	23.12	9.59	65.43	V
1.200	27.72	21.66	12.10	76.52	V
1.281	30.85	18.87	13.32	69.84	V
1.360	33.23	18.52	15.17	67.40	V
1.441	35.43	18.86	17.59	66.62	V
1.521	37.54	19.38	20.37	66.52	V
1.600	39.62	19.93	23.48	66.71	V
1.628	40.35	"4 - VSP" # 6 (Elem# 88755) started opening...			
1.680	41.75	20.38	26.95	66.87	V
1.760	43.88	20.79	30.50	66.91	V
1.841	46.03	21.22	34.25	66.90	V
1.920	48.14	21.66	38.01	66.97	V
2.001	50.41	21.61	41.72	67.63	V

Ramp-Up Profile

Filling phase: Status: V = Velocity control
P = Pressure control
V/P= Velocity/pressure switch-over

** WARNING 98634 ** The initial state of valve gate controller "5 -
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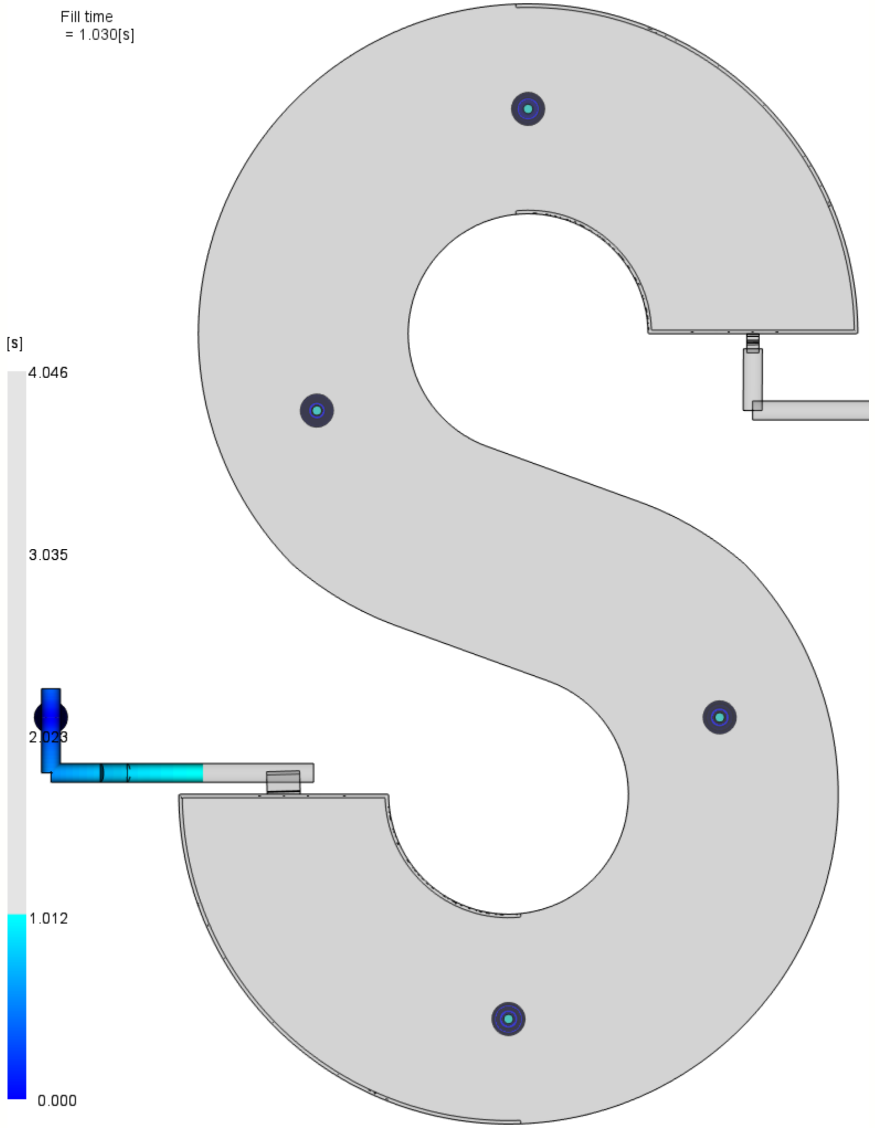
Time (s)	Volume (%)	Pressure (MPa)	Clamp force (tonne)	Flow rate (cm^3/s)	Status
0.057	0.11	"5 - VSL - big edge" # 7 (Elem# 88882) opened.			
0.185	0.13	0.59	0.00	2.58	V
0.273	0.16	0.79	0.00	2.65	V
0.327	0.19	0.93	0.00	3.02	V
0.400	0.25	1.14	0.00	3.74	V
0.486	0.34	1.45	0.00	4.92	V
0.582	0.48	1.88	0.00	6.81	V
0.630	0.57	2.15	0.00	8.05	V
0.644	0.61	2.23	0.00	8.45	V
0.744	0.87	2.98	0.00	11.95	V
0.806	1.10	3.56	0.01	15.05	V
0.890	1.52	4.56	0.02	20.80	V
0.974	2.10	5.93	0.05	28.81	V
1.042	2.75	7.36	0.09	37.79	V
1.123	3.85	9.60	0.18	53.46	V
1.200	5.08	12.99	0.56	68.70	V
1.280	7.04	15.59	0.84	74.53	V
1.360	9.40	17.01	1.27	76.42	V
1.440	11.84	18.17	1.96	76.91	V
1.520	14.29	19.27	2.87	77.11	V
1.601	16.76	20.39	4.02	77.15	V
1.681	19.19	21.52	5.40	77.26	V
1.745	21.14	"6 - VSW" # 3 (Elem# 88692) started opening...			
1.760	21.61	22.69	7.06	77.30	V
1.841	24.03	23.88	8.96	77.43	V
1.921	26.44	25.09	11.12	77.52	V
2.000	30.01	22.01	14.11	86.58	V

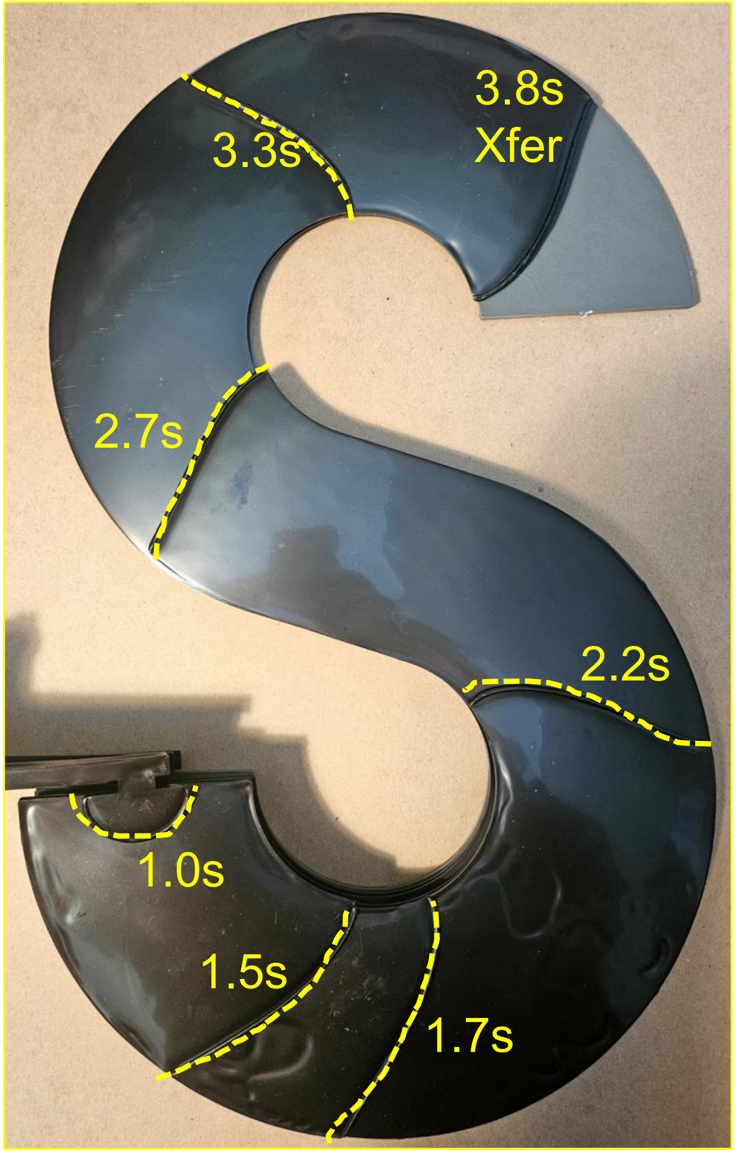
"B0" Baseline Sequenced vs. Moldflow T2_B0 (DD)

Moldflow lags a little bit.

Perhaps reality is a little ahead due to the Inertia of the melt front and barrel at start?

Was not able to tweak it much further without sacrificing accuracy elsewhere.



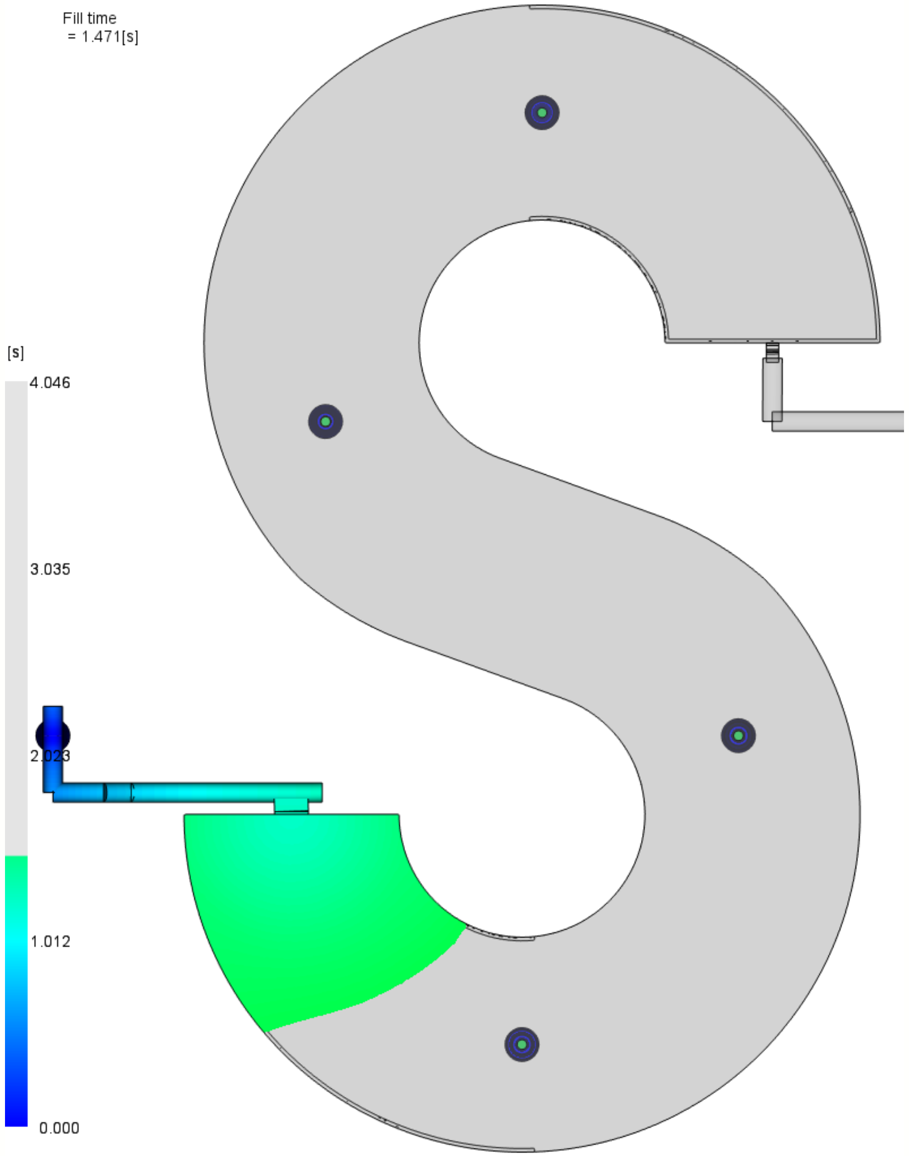


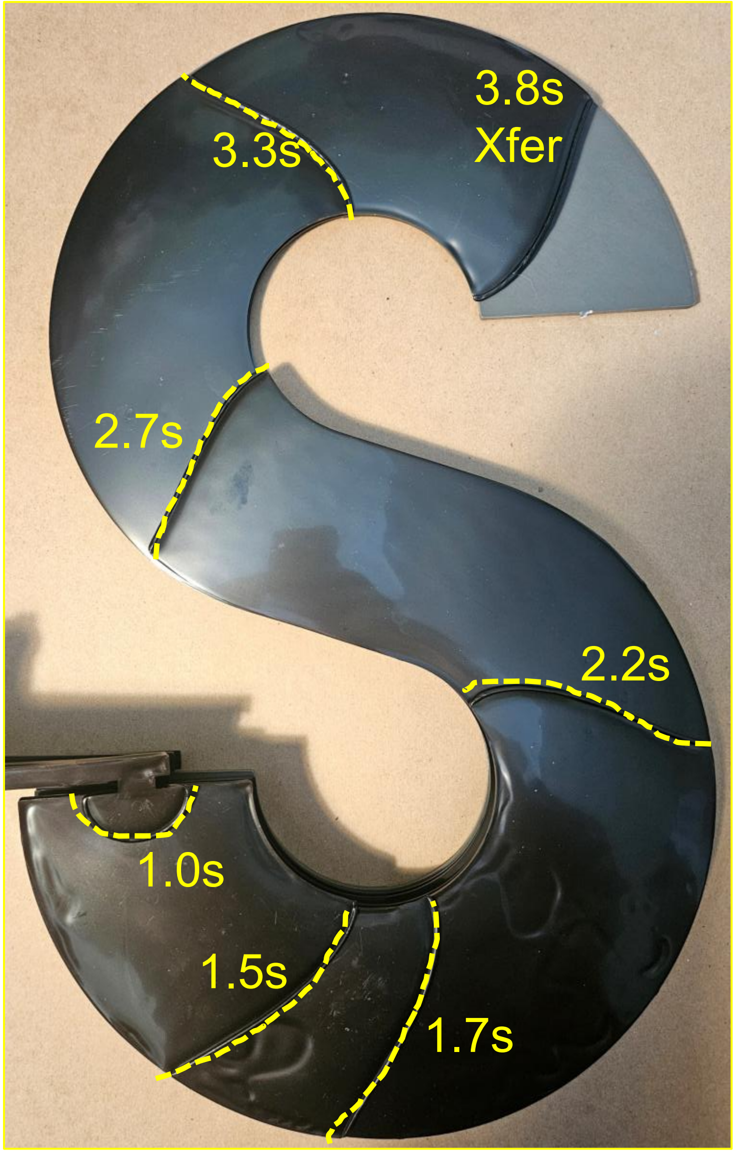
DD: "T2_B0 ADX2149 EG258ms_91_5_32 CFPW"

"B0" Baseline Sequenced vs. Moldflow T2_B0 (DD)

Very good!

Still filling from the first gate only.





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“B0” Baseline Sequenced vs. Moldflow T2_B0 (DD)

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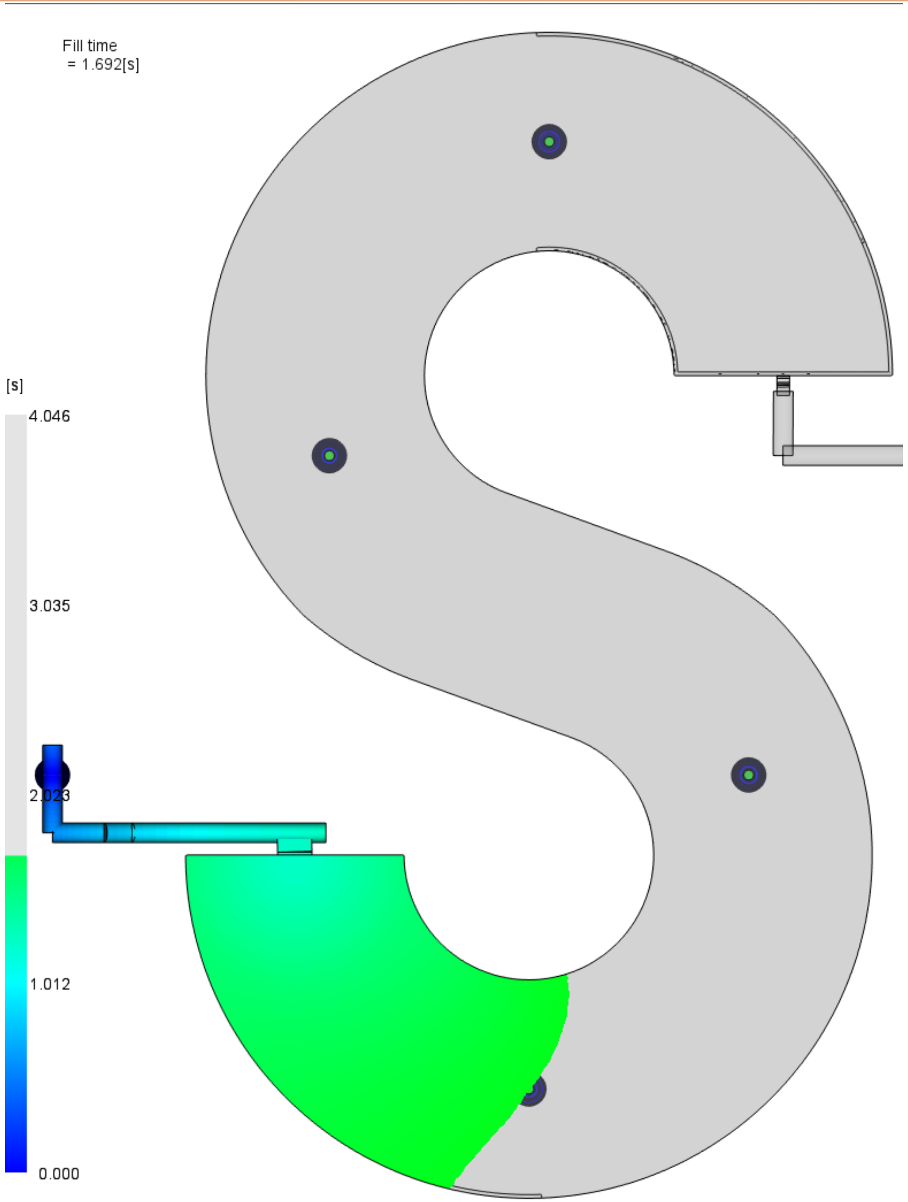
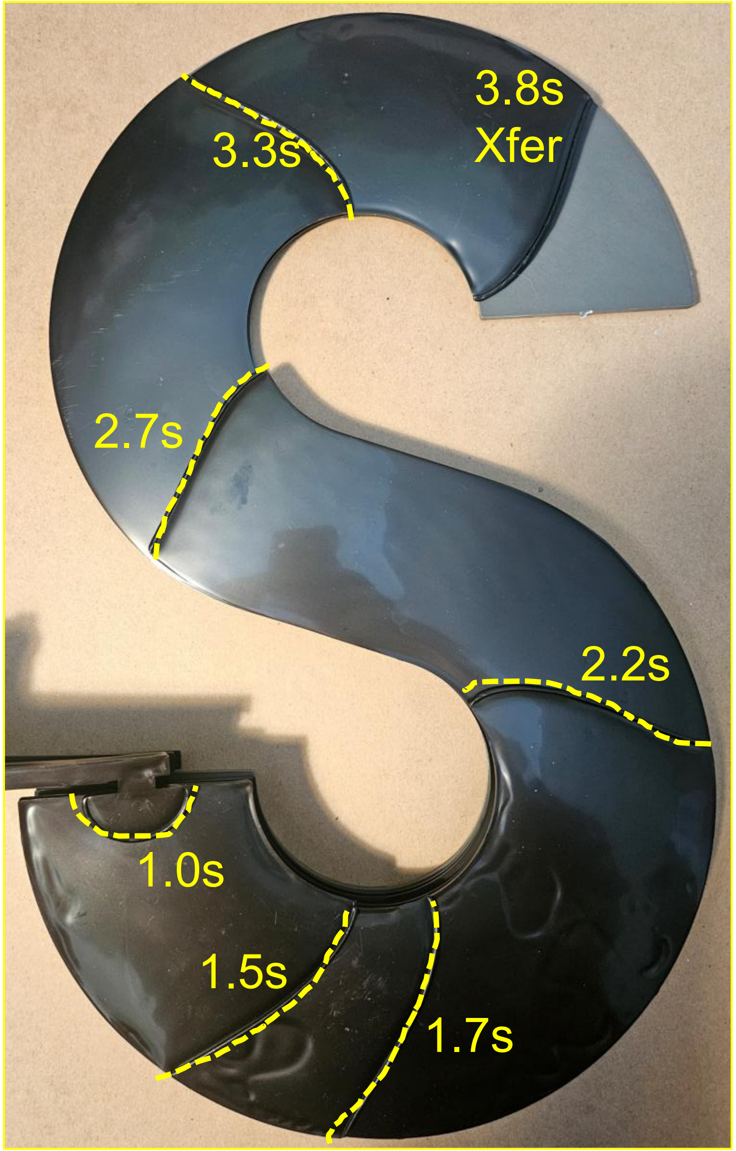


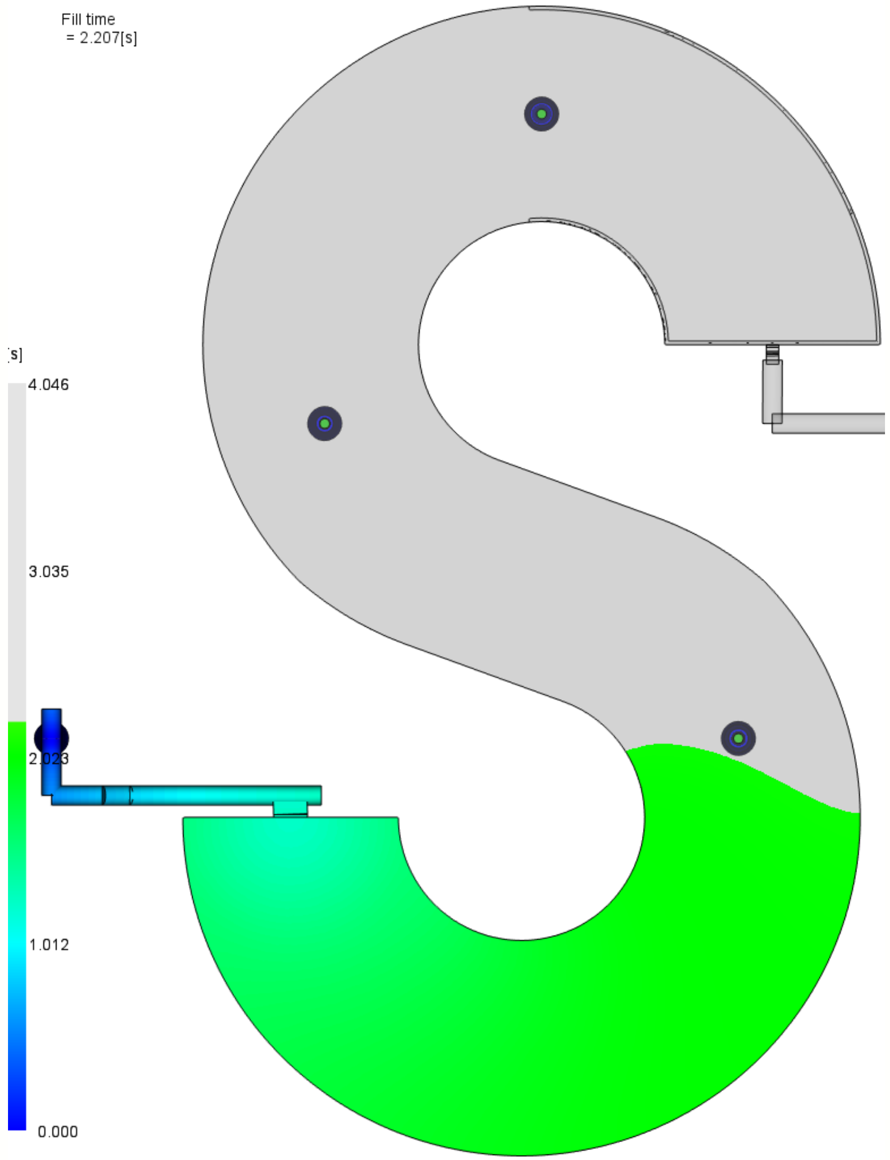


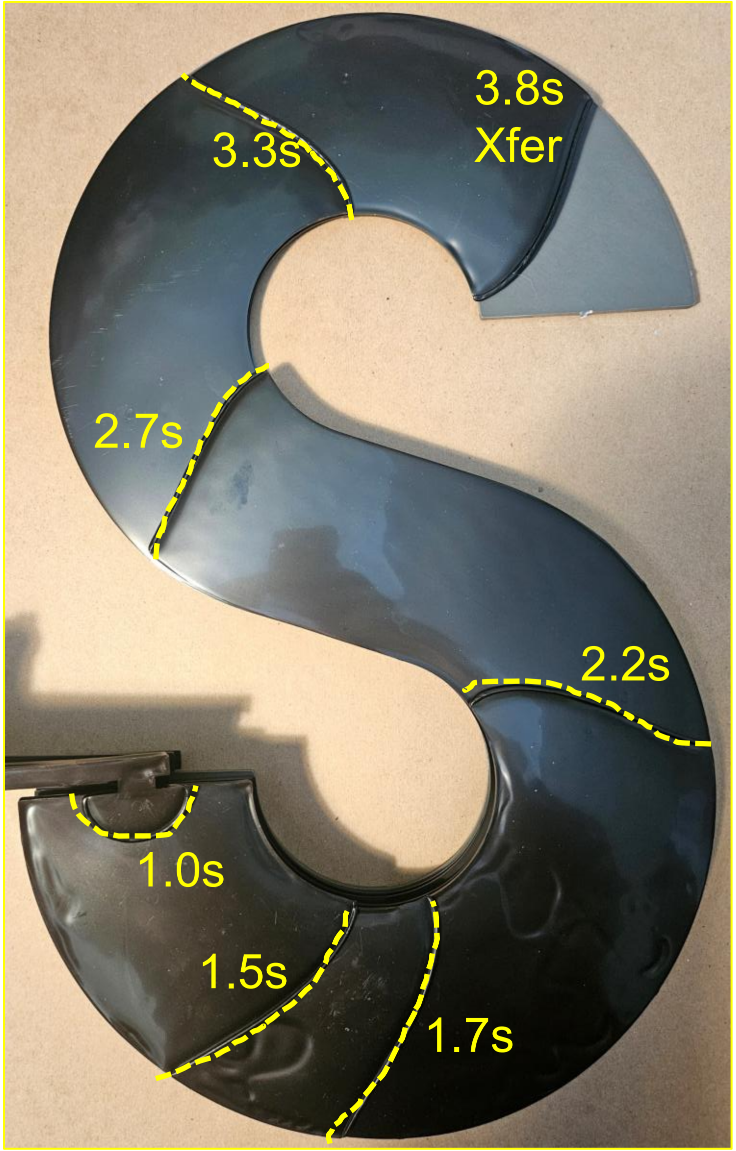
DD: “T2_B0 ADX2149 EG258ms_91_5_32 CFPW”

"B0" Baseline Sequenced vs. Moldflow T2_B0 (DD)

Very Good!

First direct drop flowing.





DD: "T2_B0 ADX2149 EG258ms_91_5_32 CFPW"

"B0" Baseline Sequenced vs. Moldflow T2_B0 (DD)

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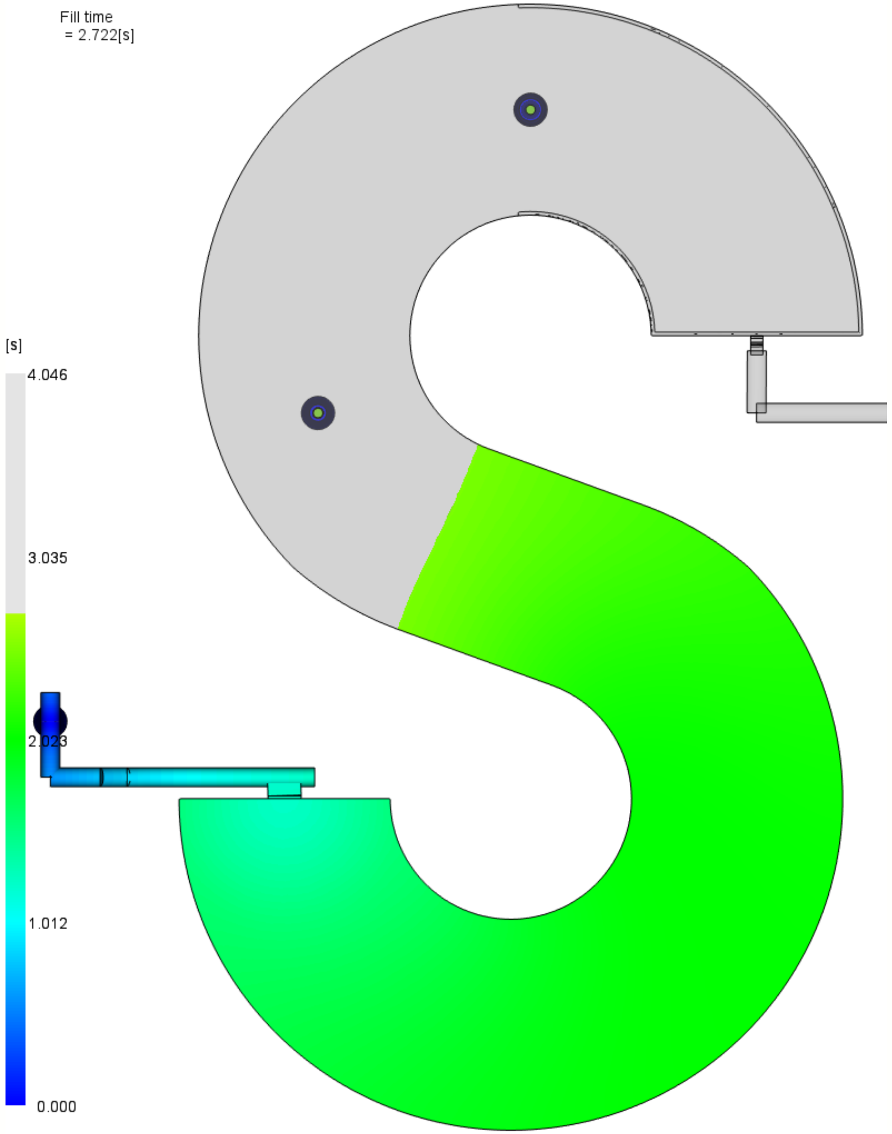
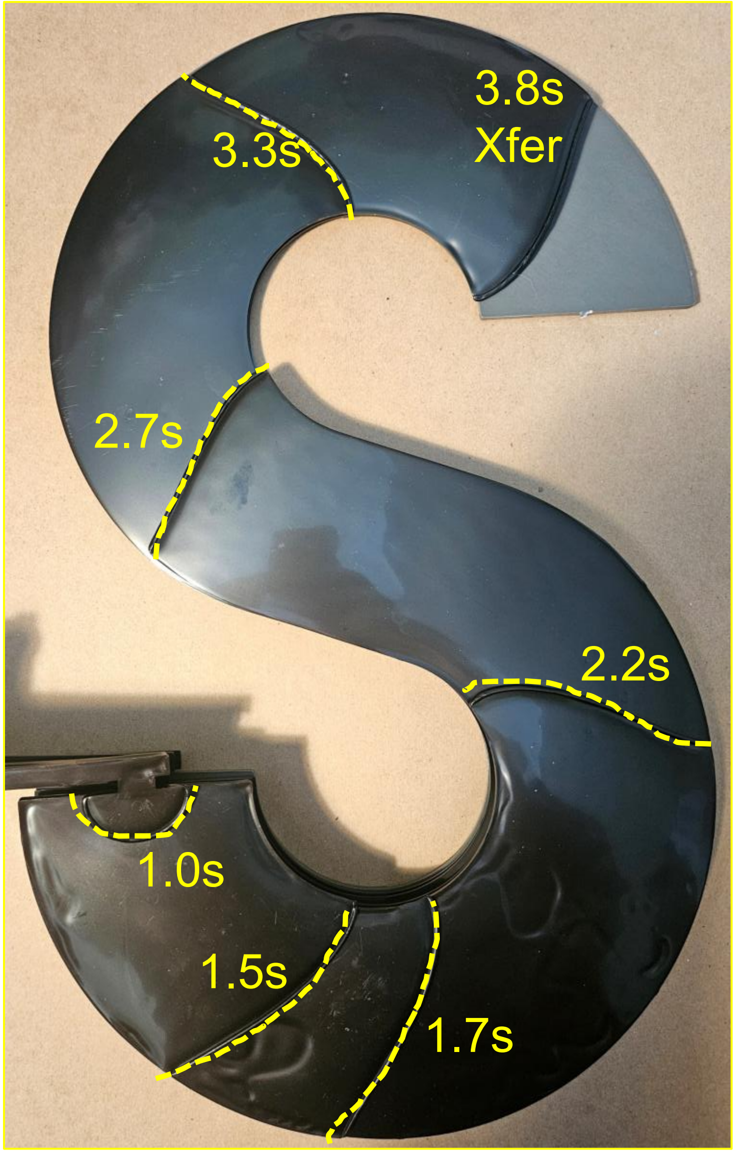
Very Good!

Second direct drop flowing.



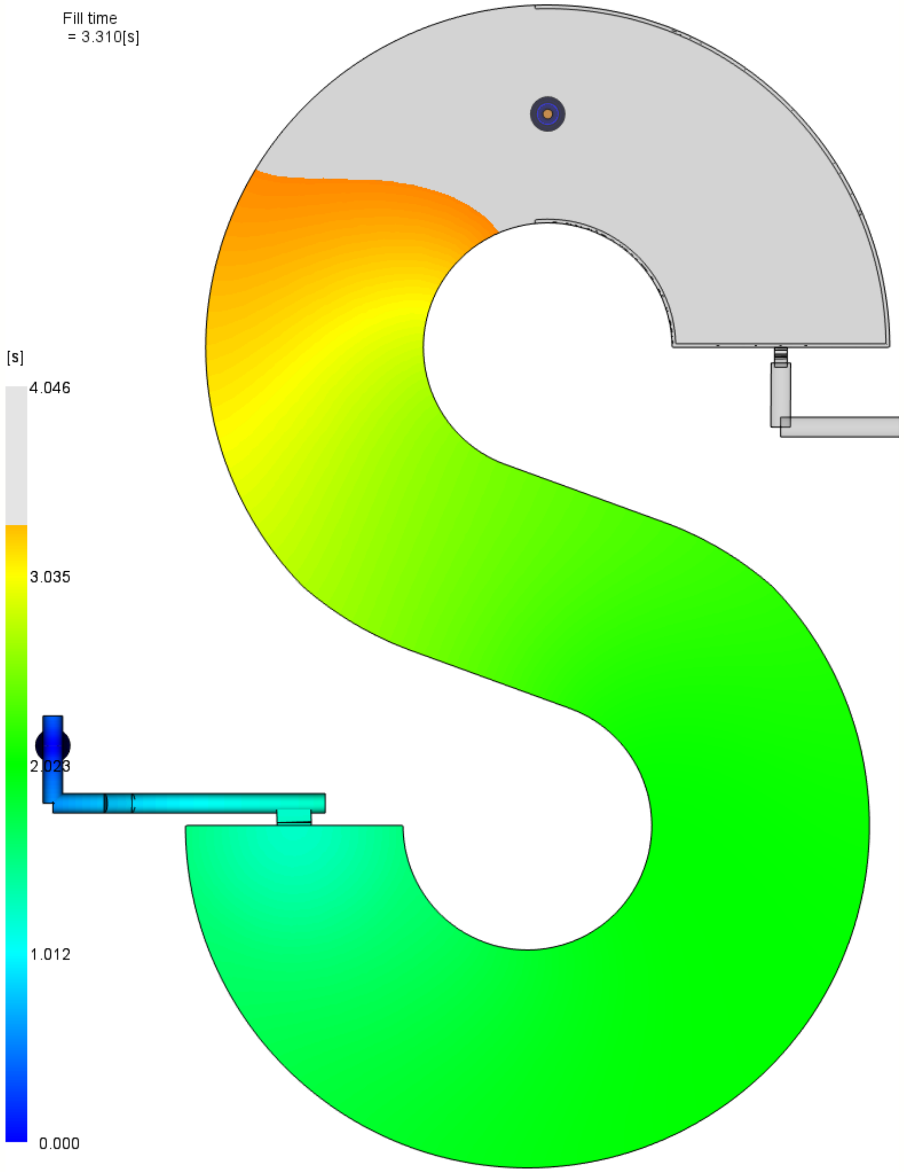


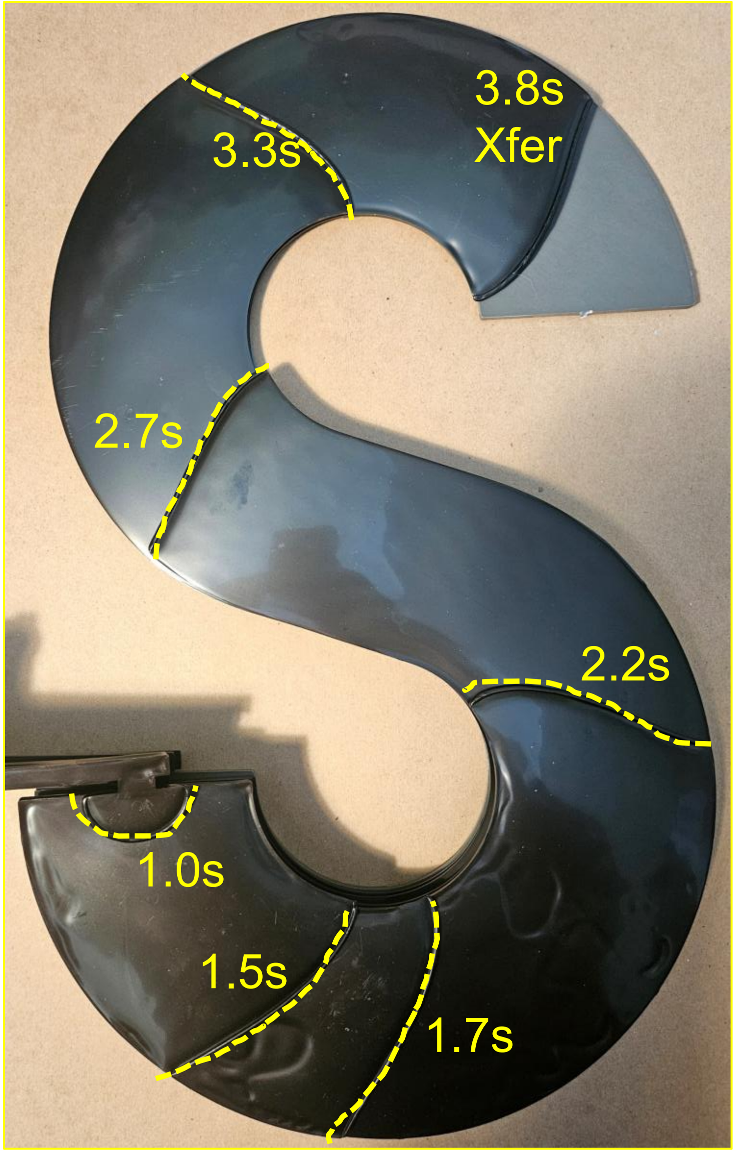
DD: "T2_B0 ADX2149 EG258ms_91_5_32 CFPW"

"B0" Baseline Sequenced vs. Moldflow T2_B0 (DD)

Very Good!

Moldflow a tiny bit behind.





DD: "T2_B0 ADX2149 EG258ms_91_5_32 CFPW"

“B0” Baseline Sequenced vs. Moldflow T2_B0 (DD)

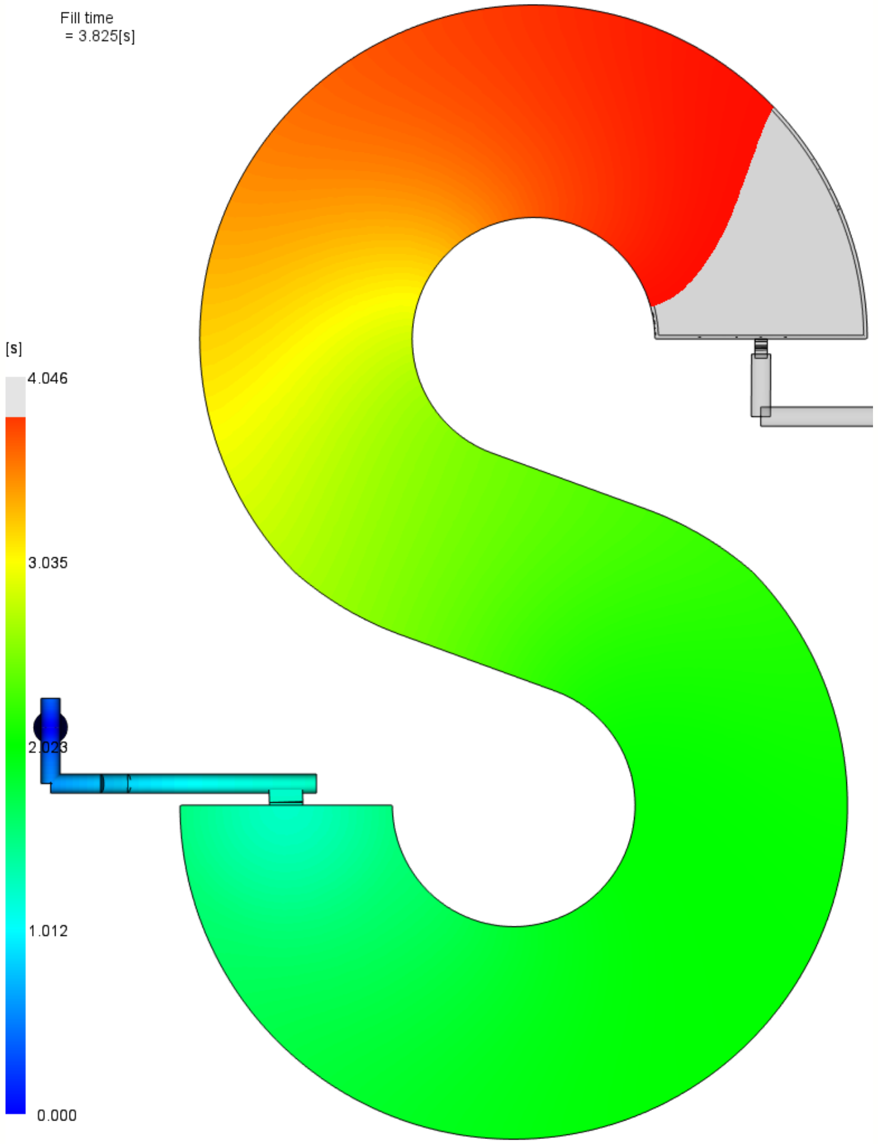
Very Good!

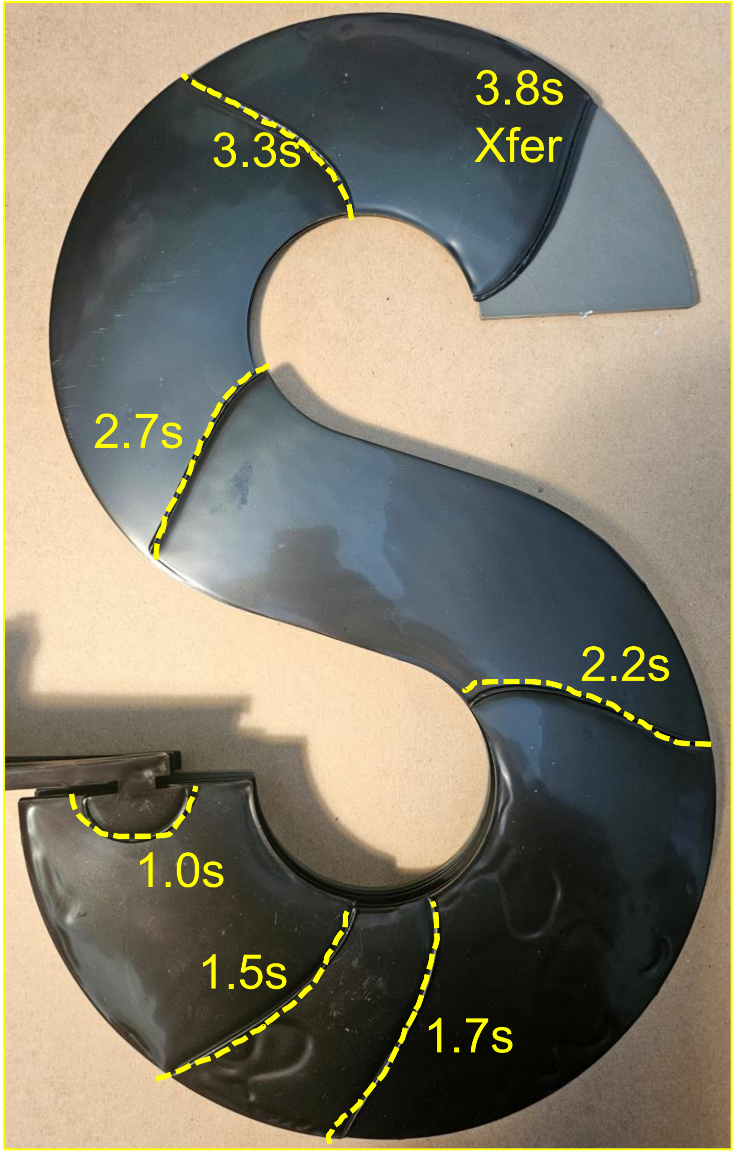
All direct drops opened.

Transfer time and position unchanged.

Success!

(…using a fudge factor.)

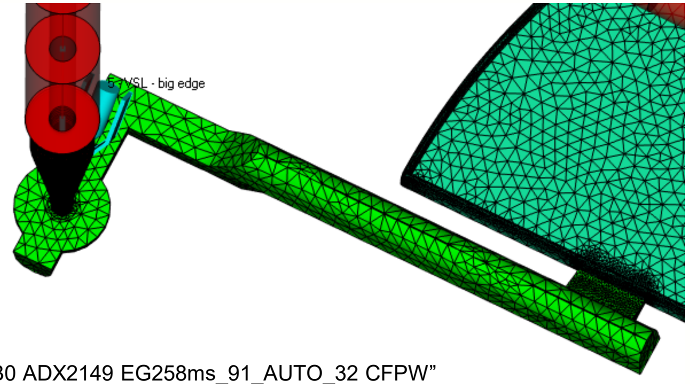


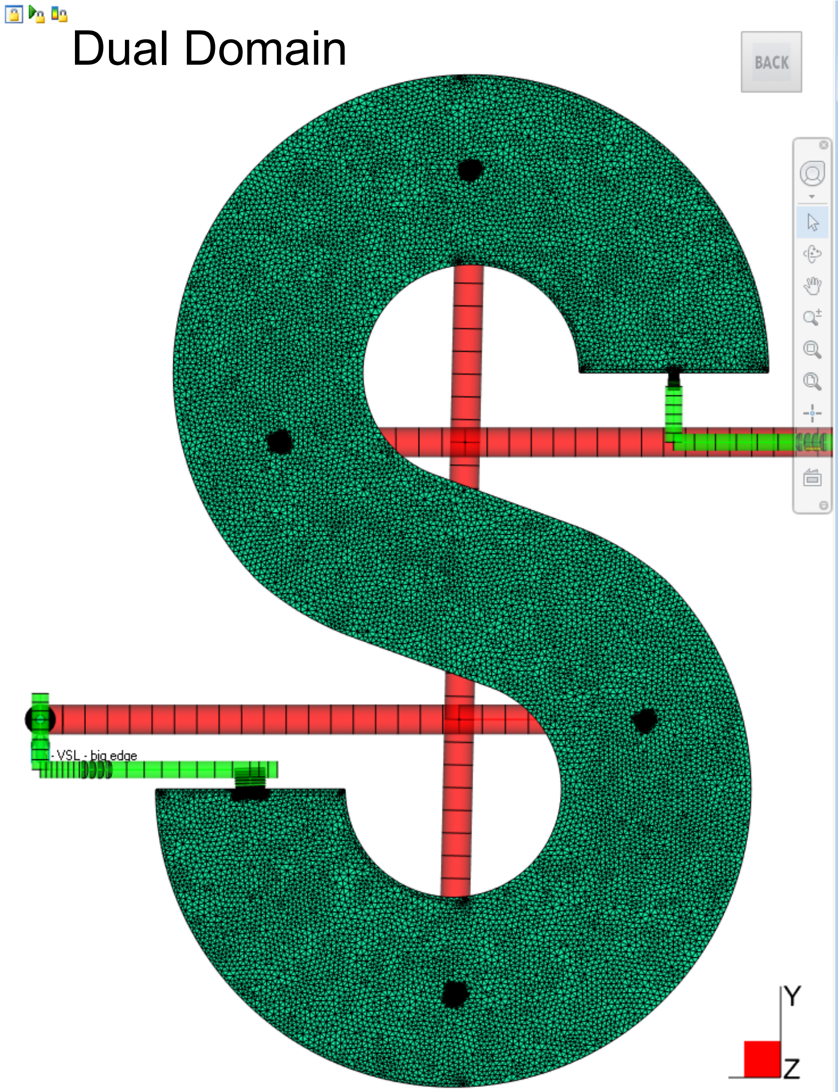


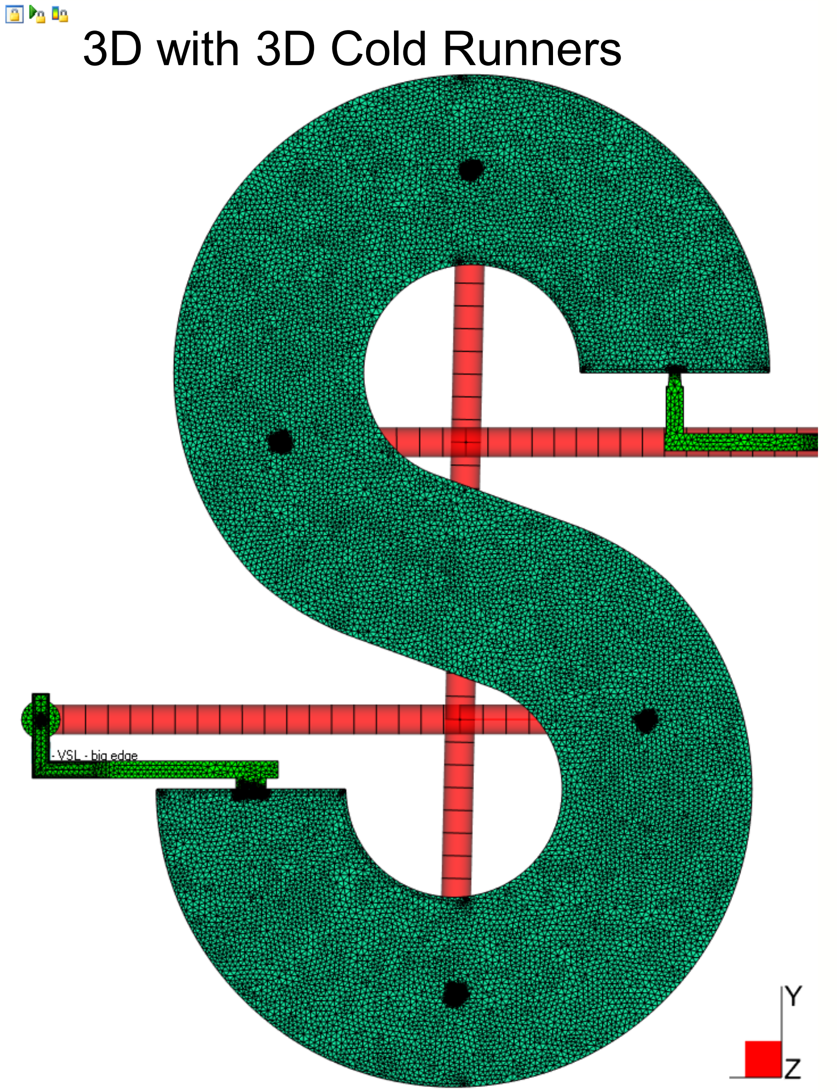
DD: “T2_B0 ADX2149 EG258ms_91_5_32”

What About a 3D Mesh?

- “But, but, but… **3D mesh**!!” you hear a voice cry out!
- For those CPU-crushing, 3D-mesh loving, tetra-touting, polyhedral-pushing champions out there!
- How about a default 10-layer 3D mesh with 3D cold runners!

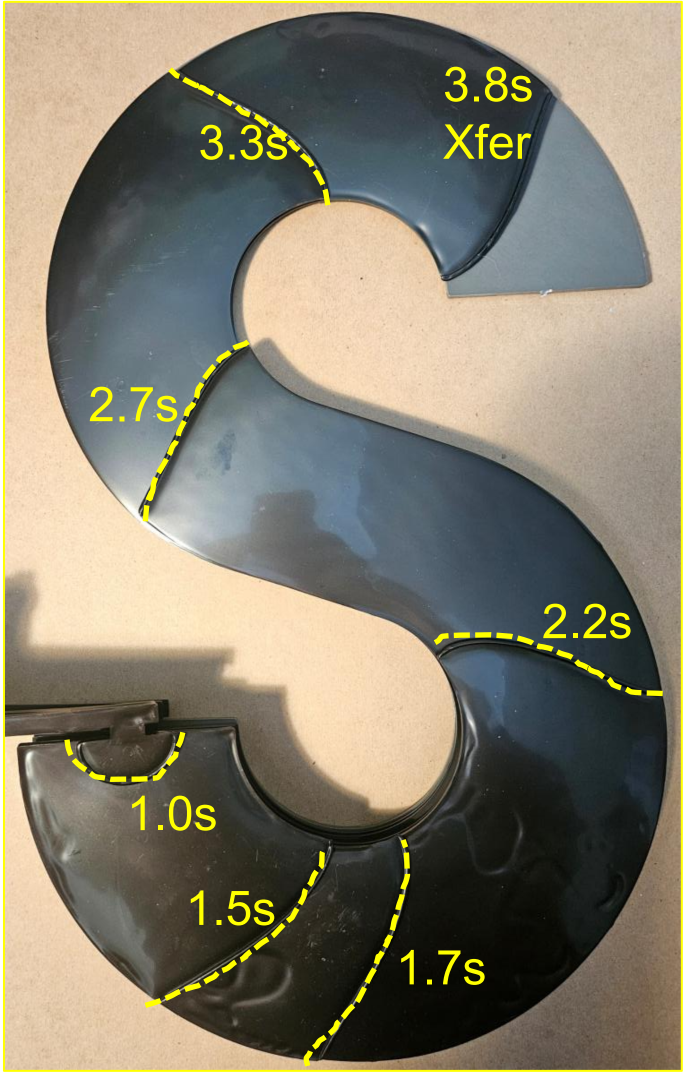


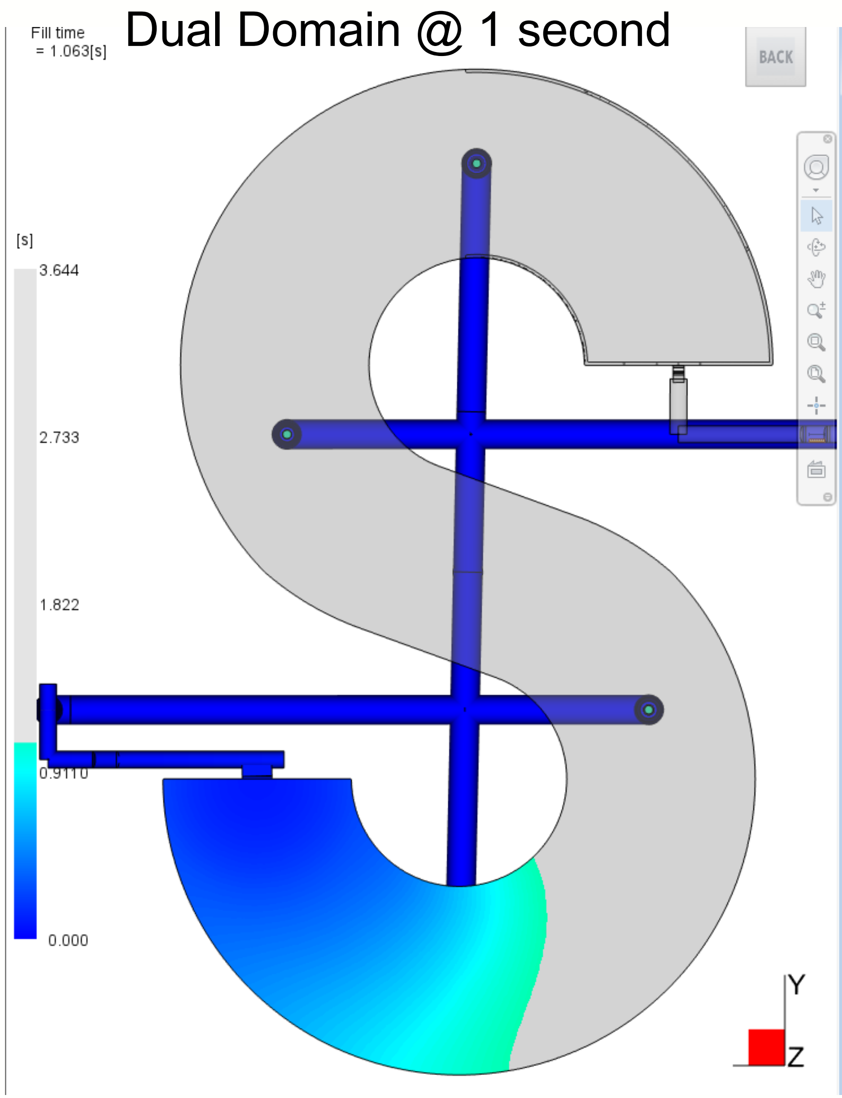


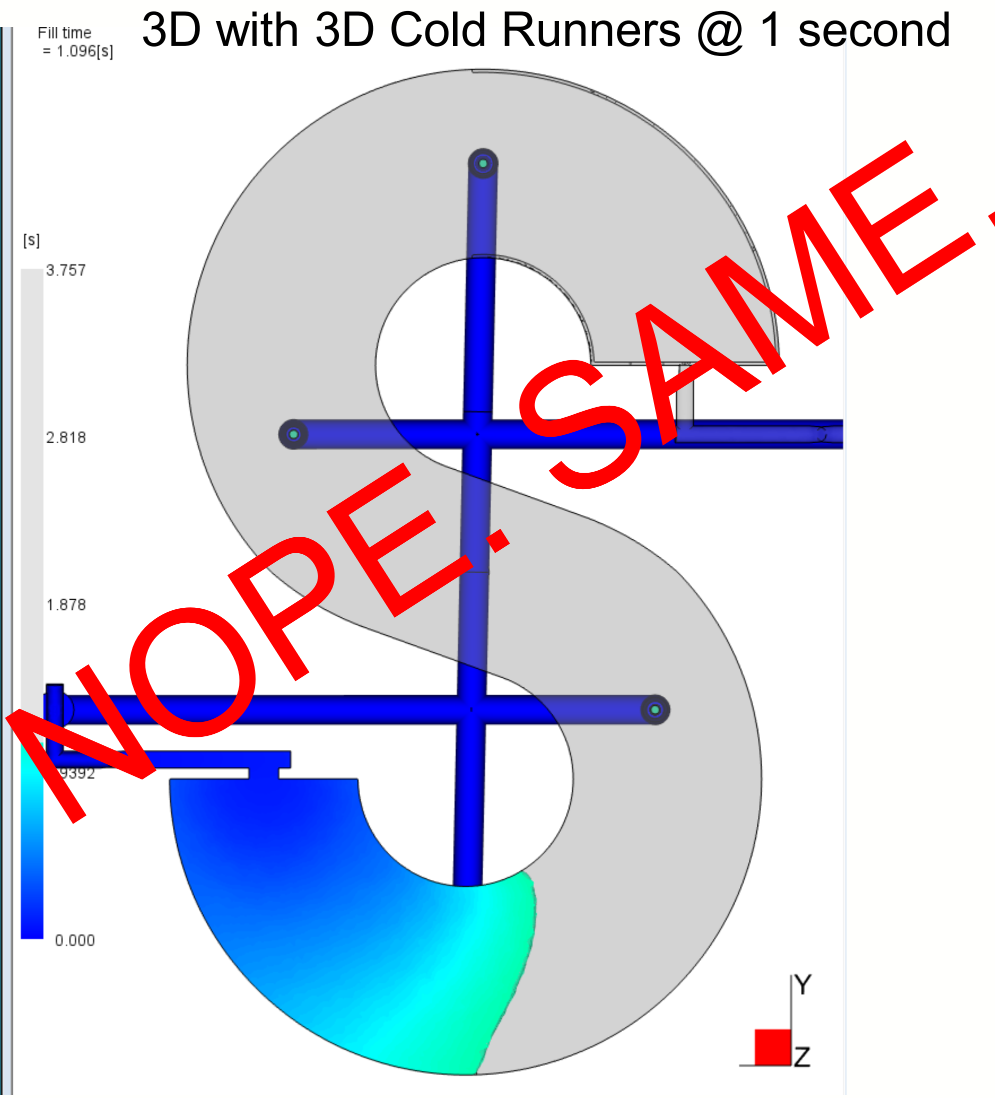


DD: “T2_B0 ADX2149 EG258ms_91_AUTO_32 CFPW”
3D: “T2_B0 ADX2149 EG258ms_91_AUTO_34 3D_runners CFPW”

What About a 3D Mesh? At 1.0 seconds...







DD: “T2_B0 ADX2149 EG258ms_91_AUTO_32 CFPW”
3D: “T2_B0 ADX2149 EG258ms_91_AUTO_34 3D_runners CFPW”

Why do we Care?

- In many situations and applications, none of this matters. Yes, Moldflow shows the initial fill reaching the cavity faster than reality.

- As analysts, we should be aware of it. Understanding the necessary assumptions of the software is critical to provide meaningful results and explaining them to our customer.

- Situations when this MAY matter:
  1. When you have a customer that really, REALLY insists that everything in the moldflow matches reality 100% no matter what, and you have already exhaustively explained that “Moldflow is an engineering tool” and “all CAE software has to make assumptions,” yet all of that has fallen on deaf ears.
  2. In some sequentially valve gated applications. If you are using a moldflow to set up the process at the press, it is important that someone at the press understands that fill rates may be different between software and the mold-press system at the start of injection.

In Conclusion

- Moldflow is an engineering tool. It counts on injection molding engineers to run the analysis, interpret the results, and use the analysis in a meaningful way.

- Computer Aided Engineering (CAE) tools make assumptions so that they can do their jobs. Reality is more complex. The injection unit is no exception.

- It is important to understand what is happening in the moldflow, and why.

- This exercise was overkill. And arguably a fudge factor. We only go to this level of benchmarking accuracy for very specific scenarios. **This sort of thing should NEVER appear in anyone's "Moldflow requirements."**

(Dramatic Pause)

Unrelated & Undesirable Anomalies in Moldflow

Synventive molding solutions
A business of BARNES GROUP INC

- Mold inserts and core deflection with very small deflections and very small constraints (<0.1mm). Software struggles. (Eye dropper cap)
- Large part inserts and warpage (when the insert is near-same size as the molded plastic). Warpage prediction goes right out the window. Literally. There are some maybe-work-arounds out there, but… is anyone going do a validation study to confirm the accuracy of ANY of it? (Oven door, fascia skins, S-mold)
- Injection-compression. Part weight fluctuates up-down-up-down during compression when it should not. Makes identifying process conditions tricky. Might have been fixed in 2026? (big donut, septic parts)
- Gas-Assist. Moldflow does not like apply packing pressure and gas pressure at the same time. It will run, but it will do strange things in the analysis, which can impact your warpage. (door panels, MF test plaque)
- Flow Rate, Beams result in 3D. If you have a job where you are running sequenced filling with drops into cold runners, check the output Flow Rate, Beams. It might have a sign (+/-) error. Does not appear to impact shear or flow outside of the janky beam elements.
- Running with MS Onedrive (temp file swaps & cloud). Has it been fixed? Will it be addressed?
- Not a bug… but SHEAR in Moldflow. Everyone needs to quit blaming shear! Shear is NOT the enemy! Shear is probably NOT to blame for 80% of the defects it gets blamed for! Shear is what helps injection molding do it’s magic! Stay tuned: Another deep dive presentation is in the works!

Thank you