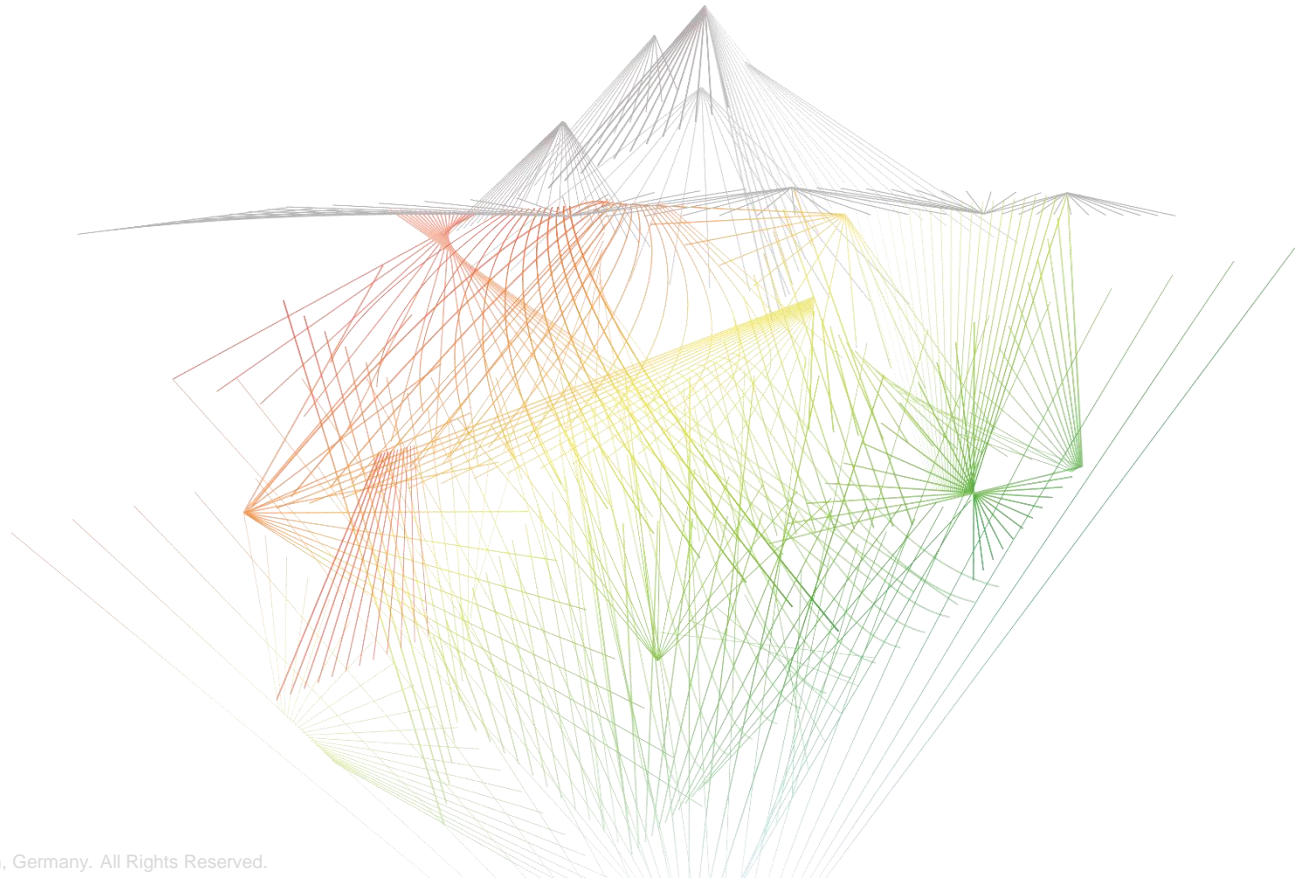




# MAPP 2023 – Understanding Mold Stresses

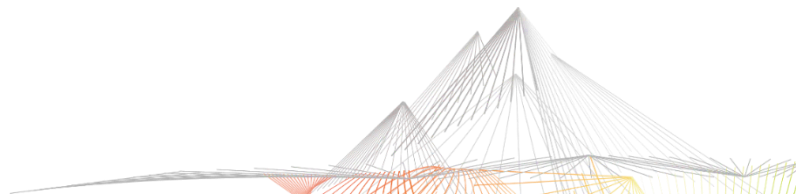




MAPP 2023

# Agenda

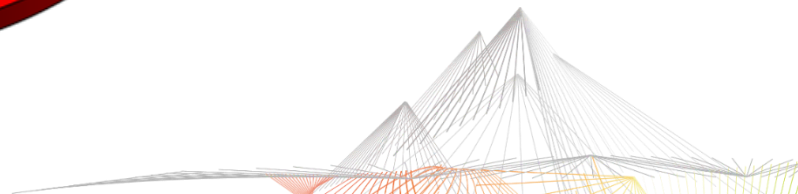
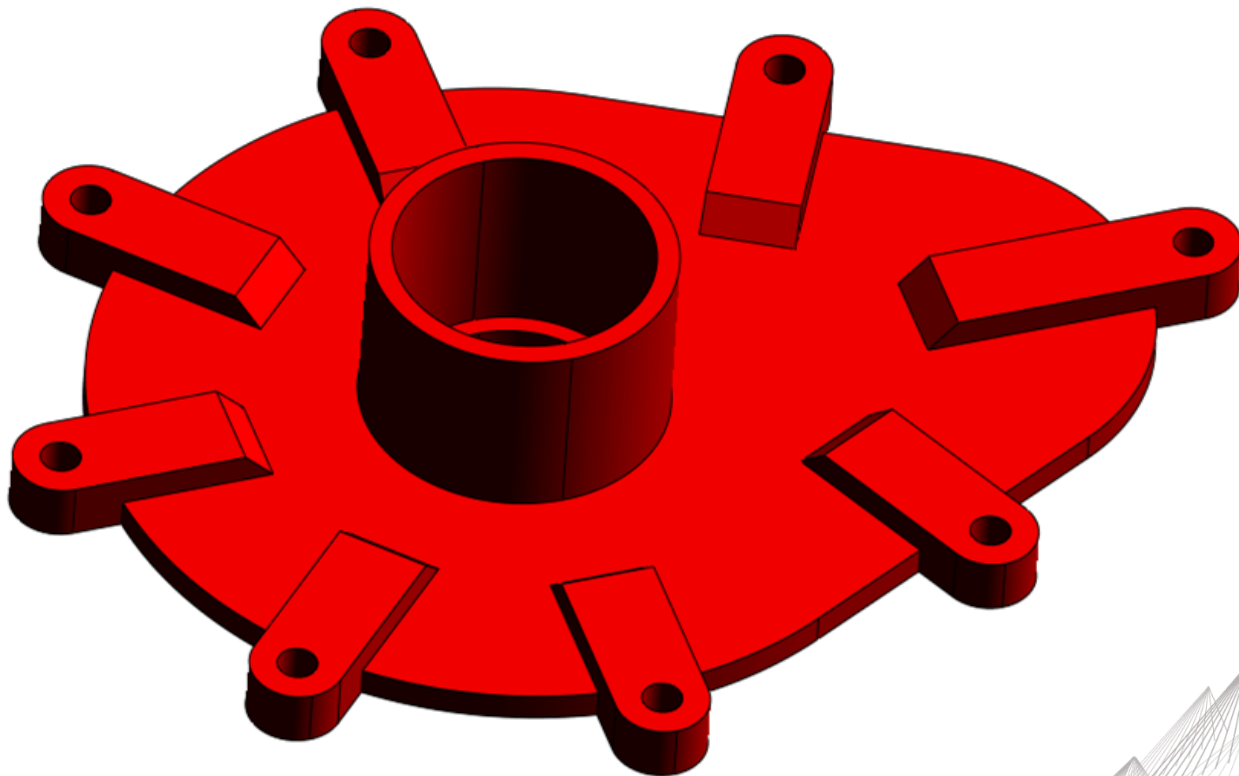
- Overview of the project and goals
- Process parameters and corresponding results
- Discuss Mold Design considerations
- Final Conclusions





MAPP 2023

# Project Overview

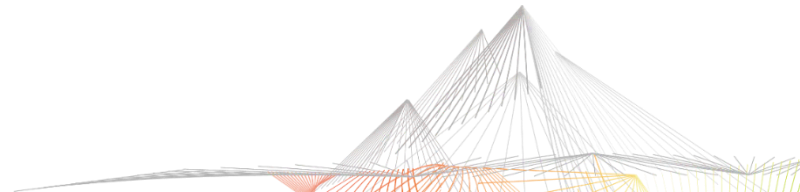
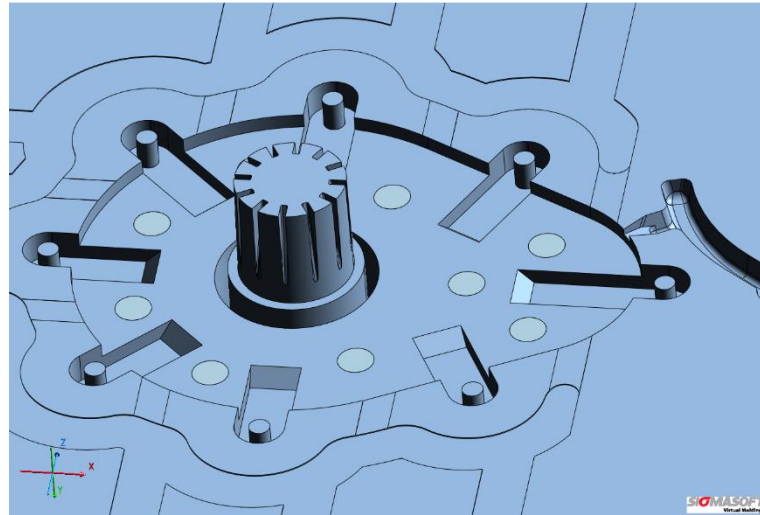




MAPP 2023

# Project Overview

There are a couple of areas of concern within the mold design

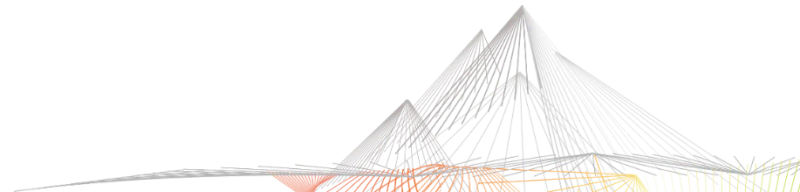
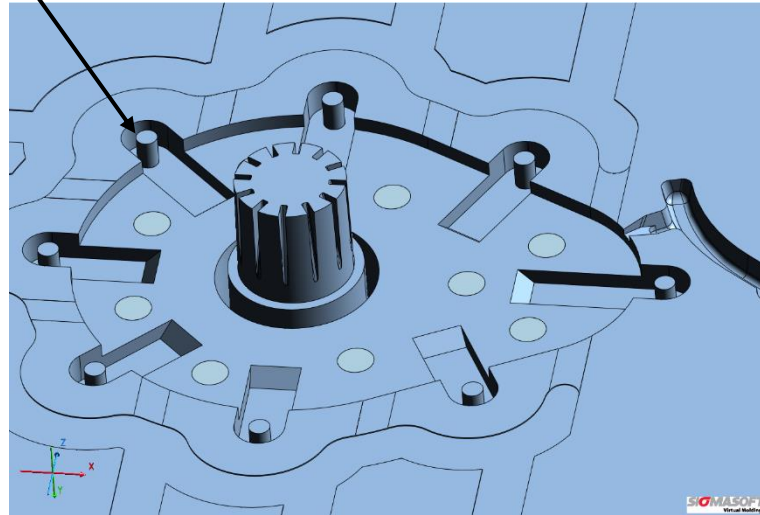




MAPP 2023

# Wear and Tear

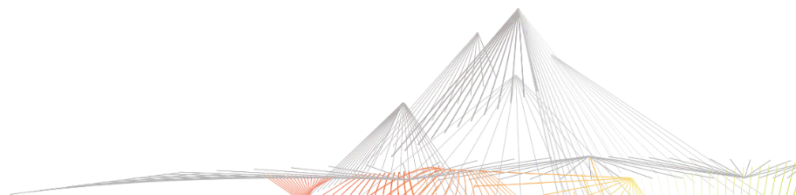
Concerned that the core pins wear and tear over time





# What could increase core pin bending and stress?

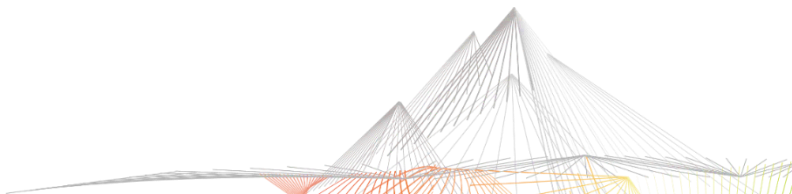
- ❑ Temperature of the core pins
- ❑ Pressure differential on the pins during filling and packing
- ❑ To a lesser extent, temperature of the part





# Process Parameters

- └ PPA
- └ Polymer Temperature – 617F
- └ Mold Temperature – 284F
- └ Fill Time – 0.3 seconds
- └ Packing Pressure – 15,900 psi
- └ Cooling Time – 10 seconds

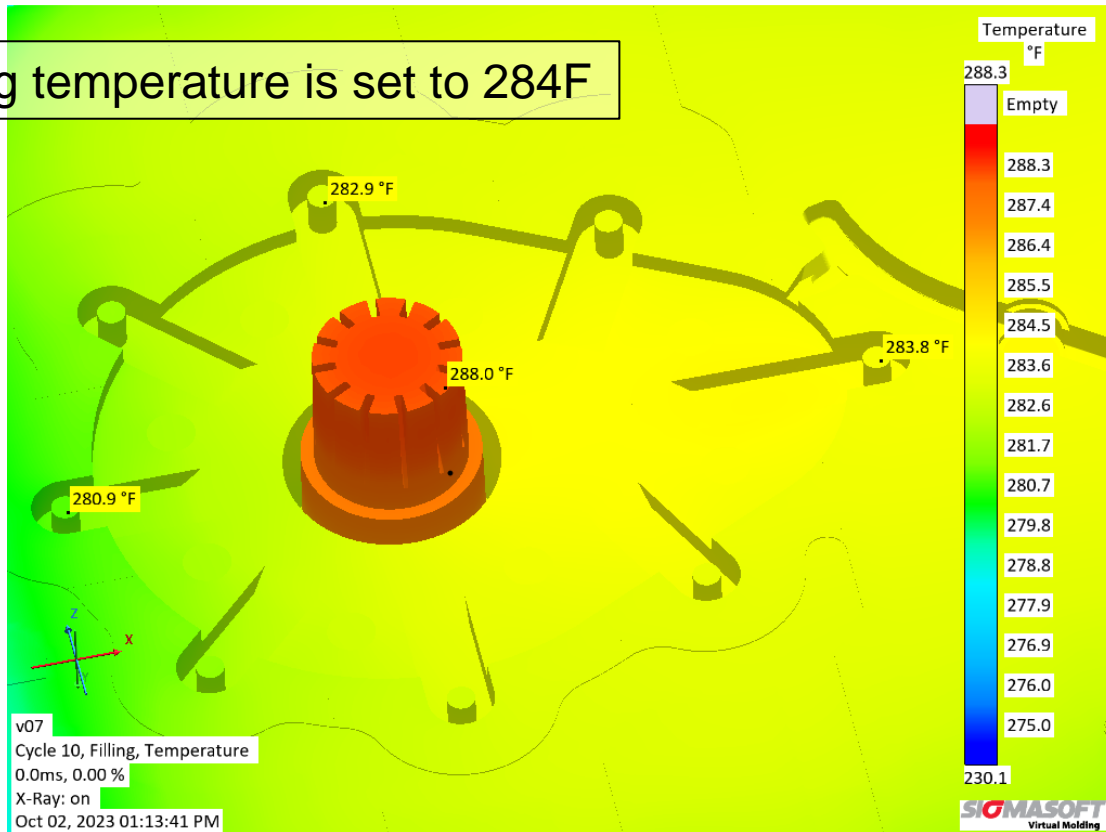




MAPP 2023

# Mold Temperature

Operating temperature is set to 284F







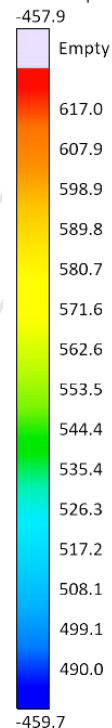
MAPP 2023

# Filling Pattern



v07\_d3  
Cycle 1, Filling, Temperature  
0.0ms, 0.00 %  
X-Ray: on  
Sep 19, 2023 01:45:19 PM

Temperature  
°F



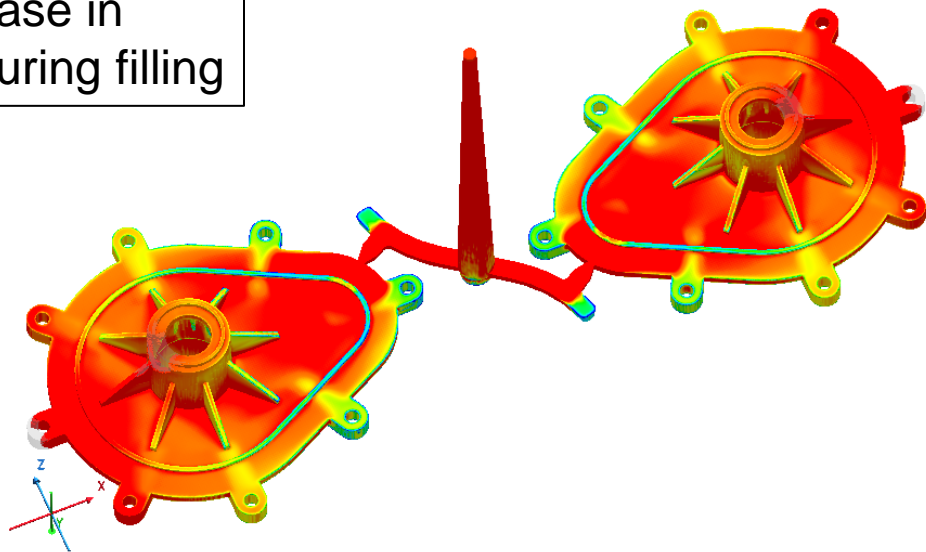
**SIGMASOFT**  
Virtual Molding



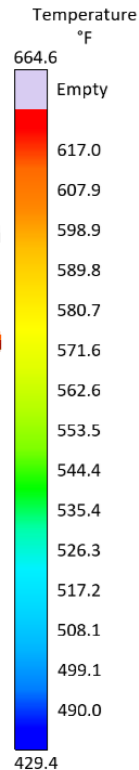
MAPP 2023

# Filling Temperature

50F increase in  
temperature during filling



v07\_d3  
Cycle 1, Filling, Temperature  
742.6ms, 99.01 %  
X-Ray: on  
Sep 19, 2023 02:56:21 PM



**SIGMASOFT**  
Virtual Molding

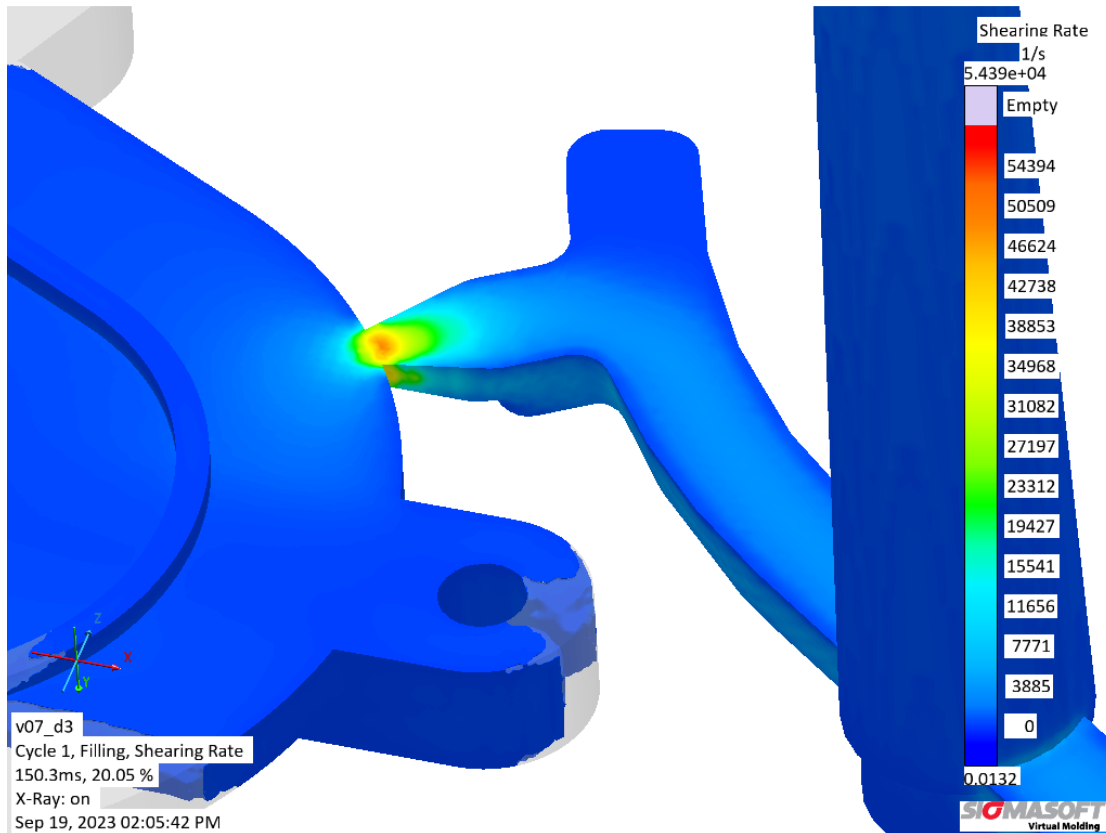


MAPP 2023

# Shear Rate

The Shear Rate is 54,400 1/s

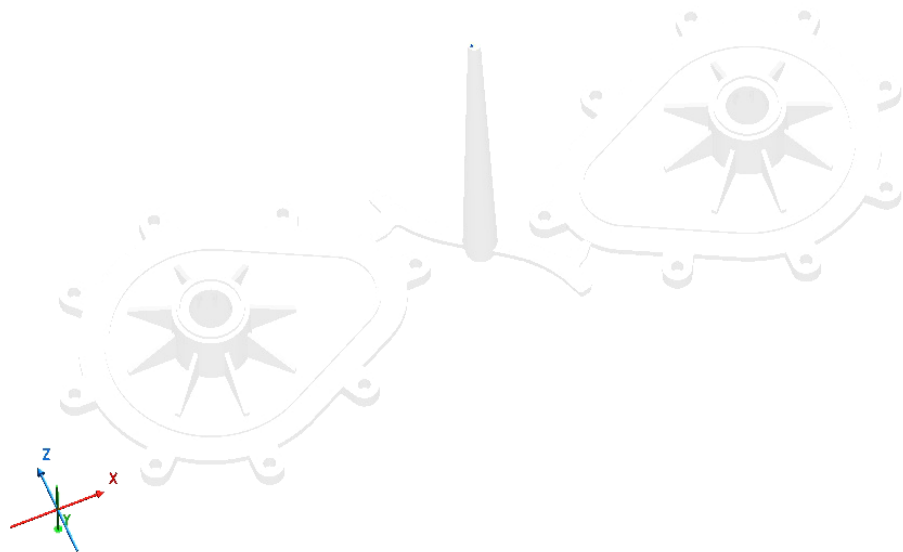
Shear rate value corresponds to the temperature increase



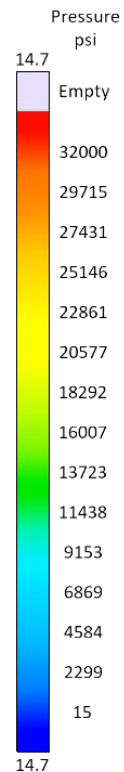


MAPP 2023

# Filling Pattern



v02  
Cycle 1, Filling, Pressure  
0.0ms, 0.00 %  
X-Ray: on  
Sep 30, 2023 09:03:26 AM



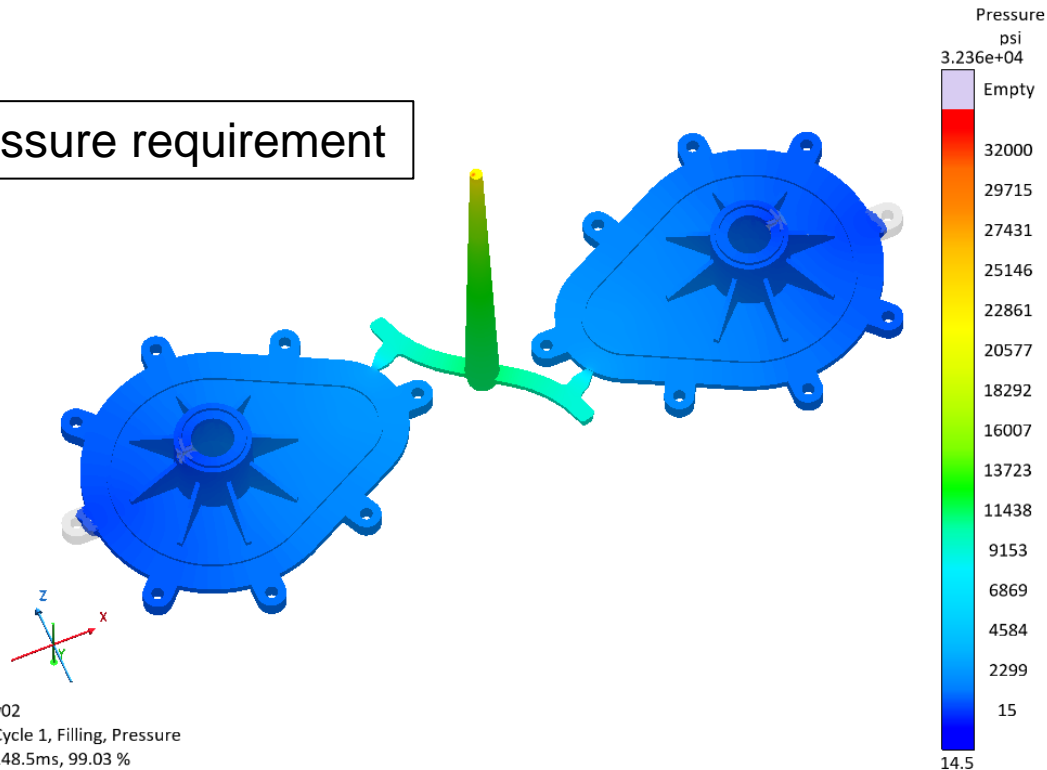
**SIGMASOFT**  
Virtual Molding



MAPP 2023

# Filling Pressure

32,000 psi pressure requirement

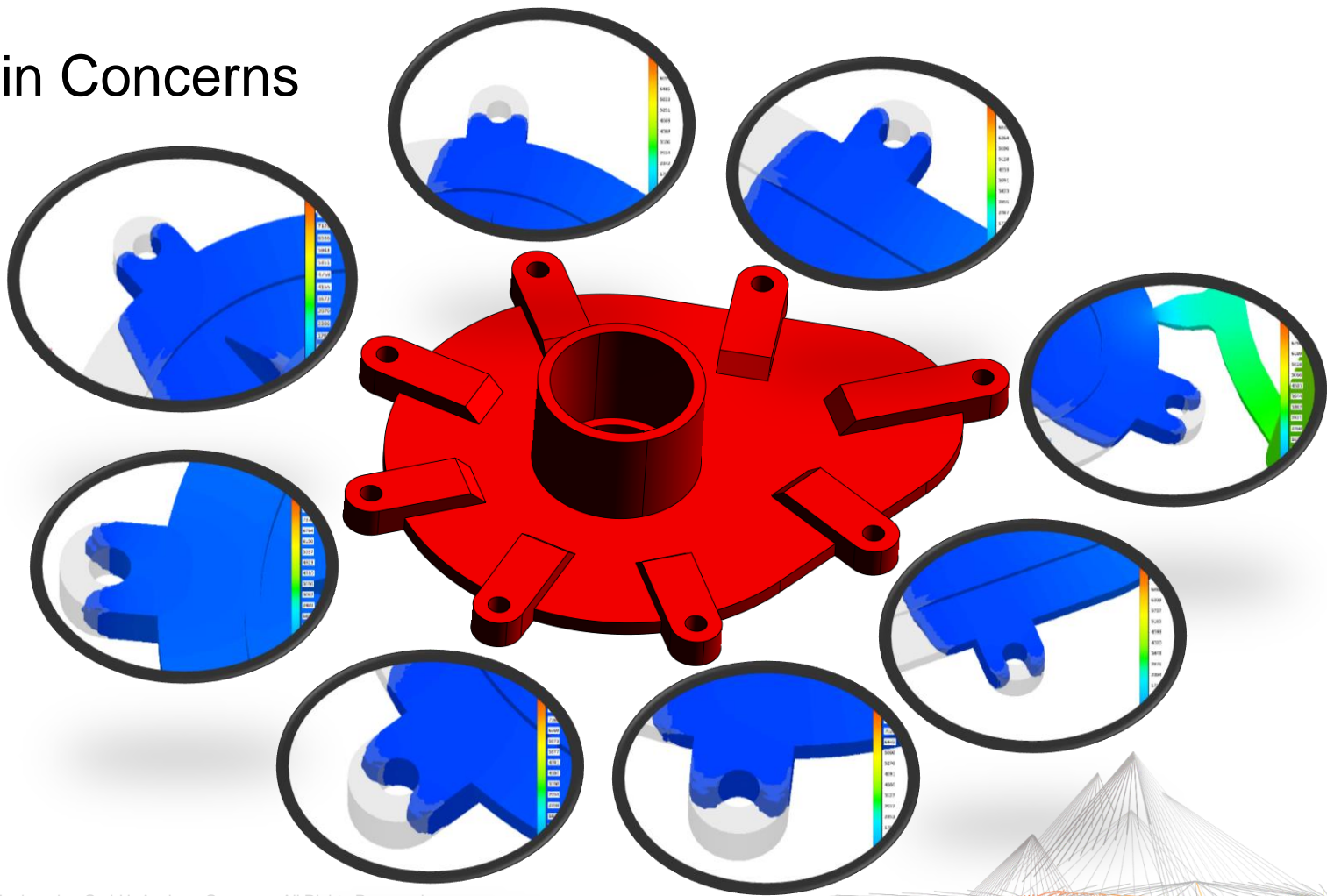


SIGMASOFT  
Virtual Molding



MAPP 2023

# Core Pin Concerns

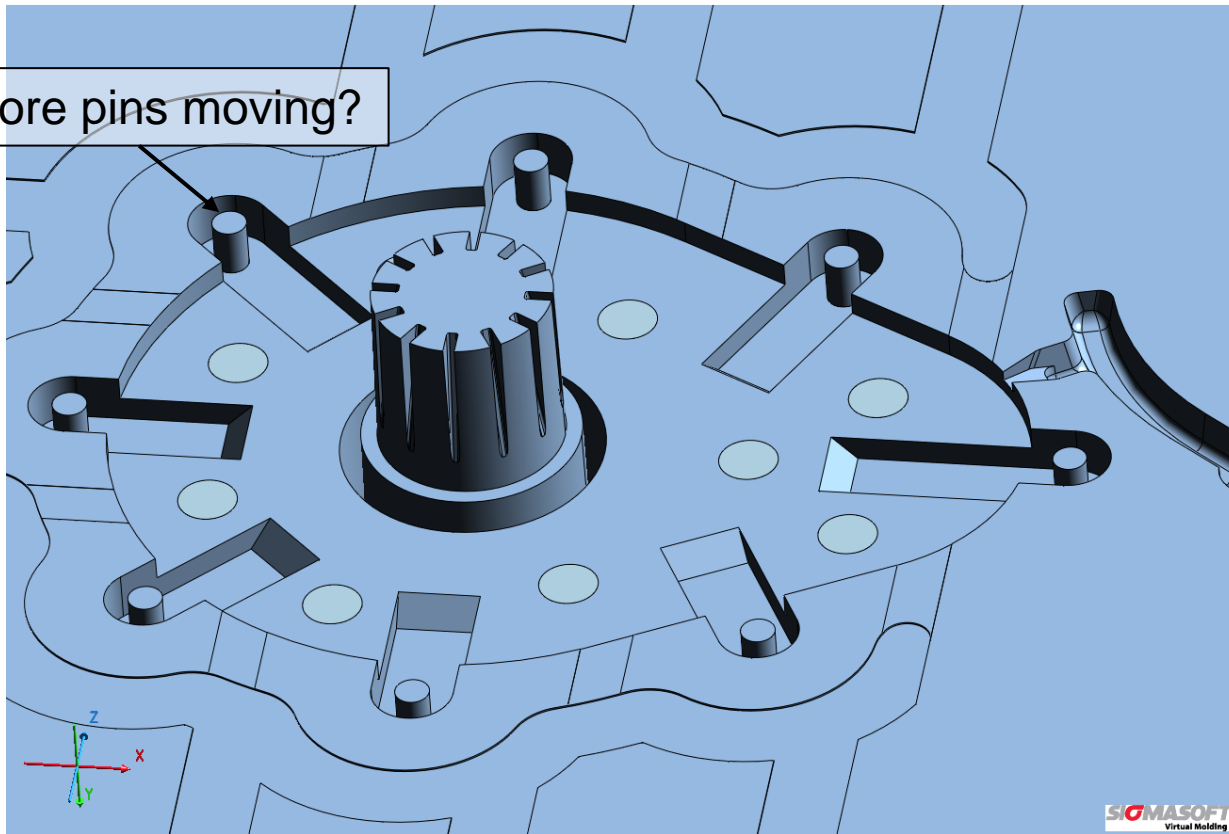




MAPP 2023

# Stresses in the Core Pins

Are the core pins moving?

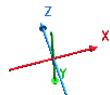




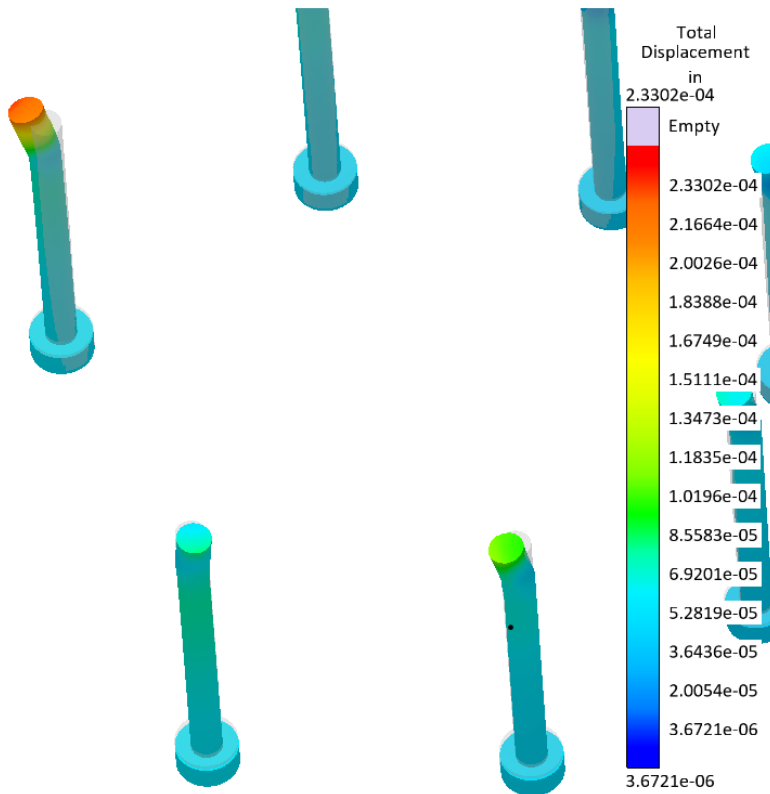
MAPP 2023

# Deformation in the Core Pins

Core pins  
move in the  
direction that  
the flow hits it



v06  
Cycle 1, Cooling, Total Displacement  
1.913s, 20.00 %  
X-Ray: off  
Sep 18, 2023 12:32:03 AM



SIGMASOFT  
Virtual Molding

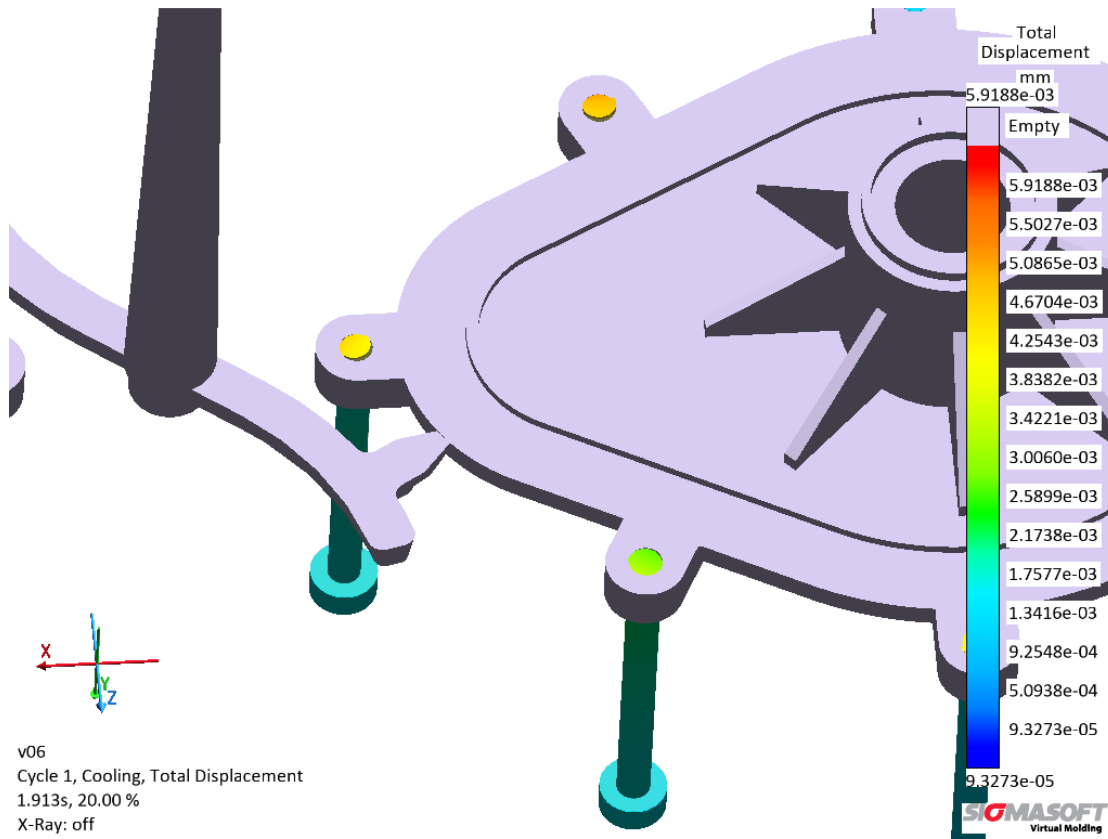




MAPP 2023

# How does this movement influence part quality?

Shift the placement of the holes and cause assembly issues



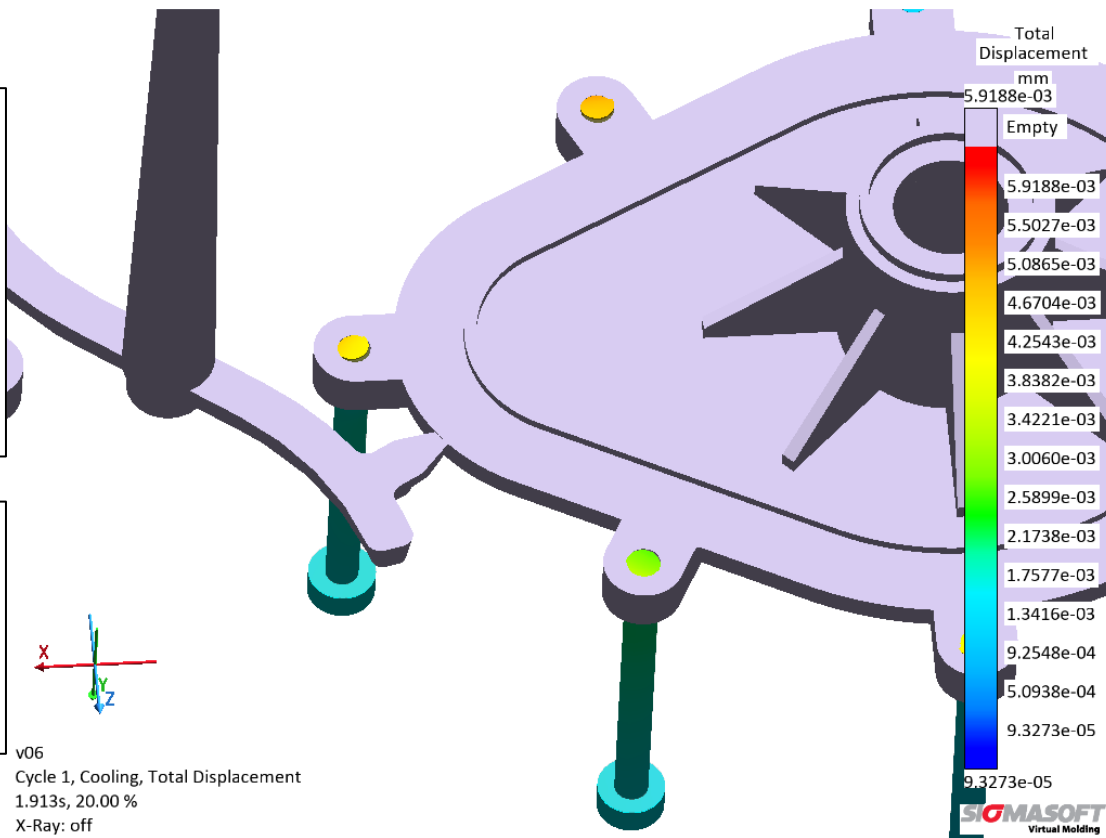


MAPP 2023

# How does this movement influence part quality?

Create differences in wall thickness which can impact cooling time

Differences in cooling can lead to warpage

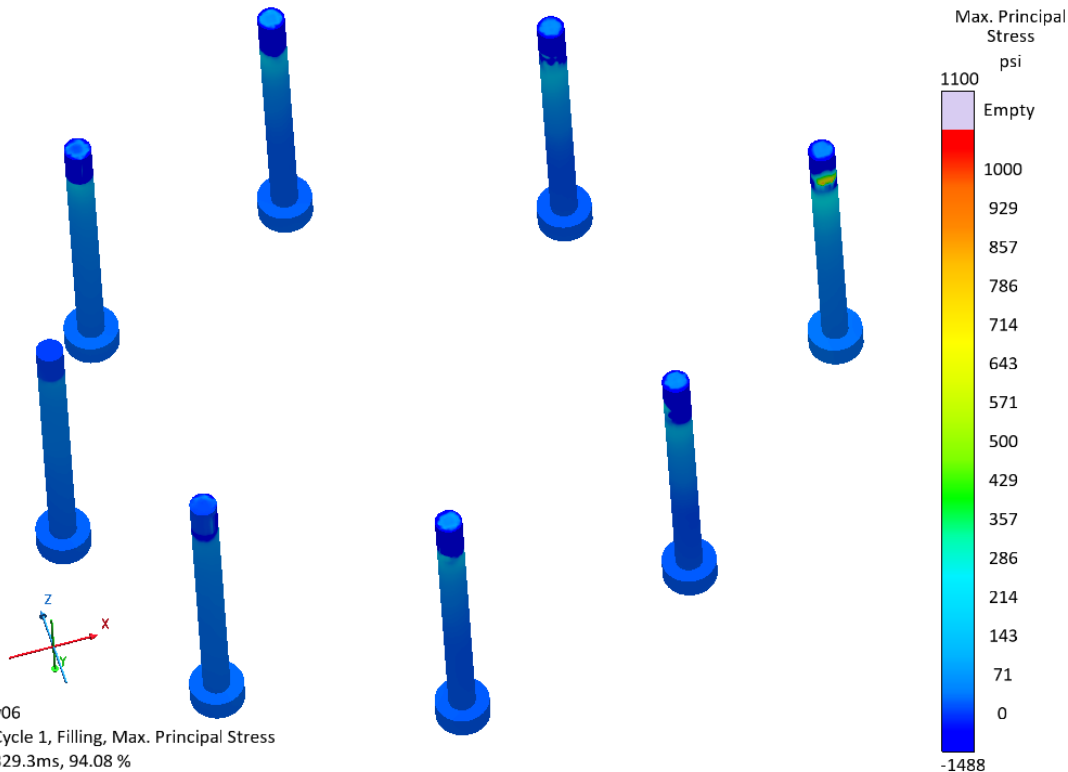




MAPP 2023

# Stresses in the Core Pins during Filling

The highest stresses are located just above where the core pin touches the core block



v06

Cycle 1, Filling, Max. Principal Stress

329.3ms, 94.08 %

X-Ray: on

Sep 17, 2023 10:57:00 PM

SIGMASOFT  
Virtual Molding

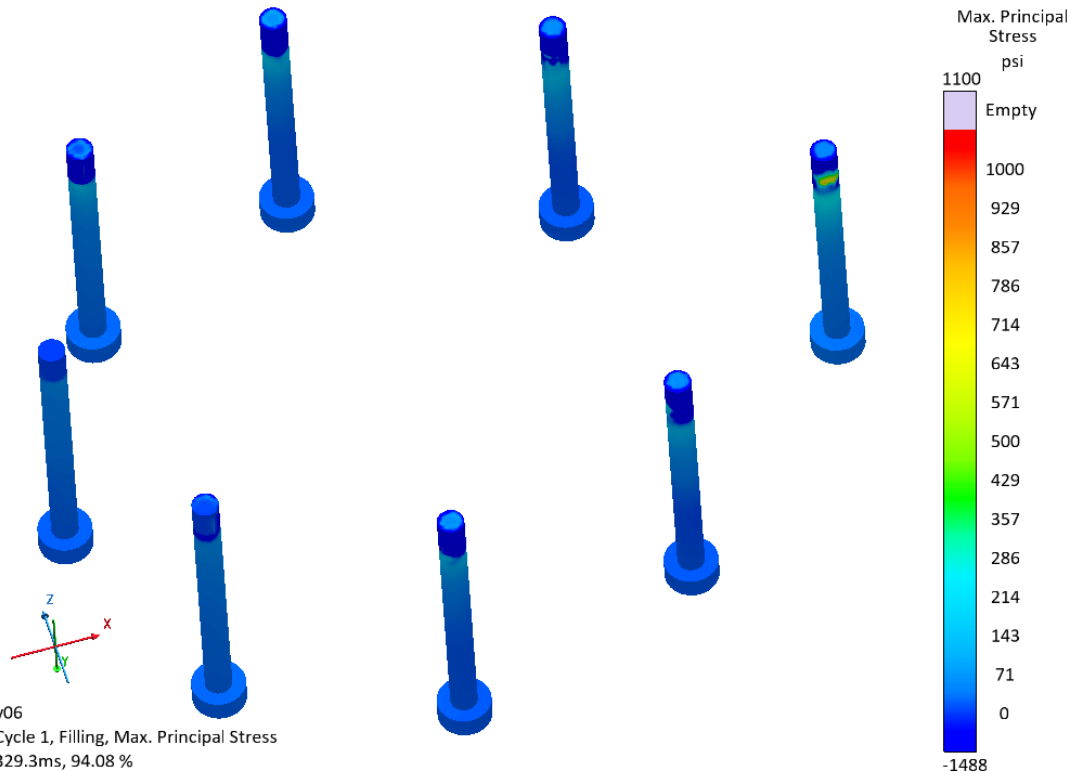




MAPP 2023

# Stresses in the Core Pins during Filling

Stresses are not high enough to break the pins



v06  
Cycle 1, Filling, Max. Principal Stress  
329.3ms, 94.08 %  
X-Ray: on  
Sep 17, 2023 10:57:00 PM

**SIGMASOFT**  
Virtual Molding

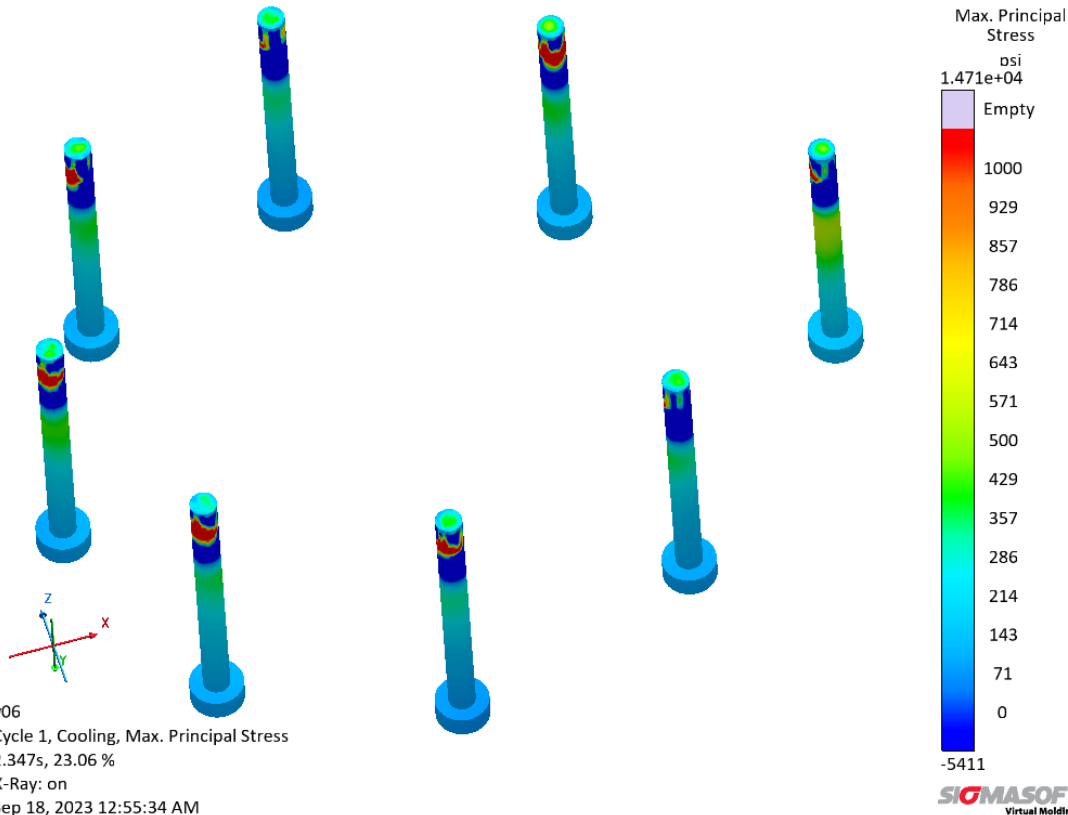


MAPP 2023

# Stresses in the Core Pins during Packing

Stress increases during packing

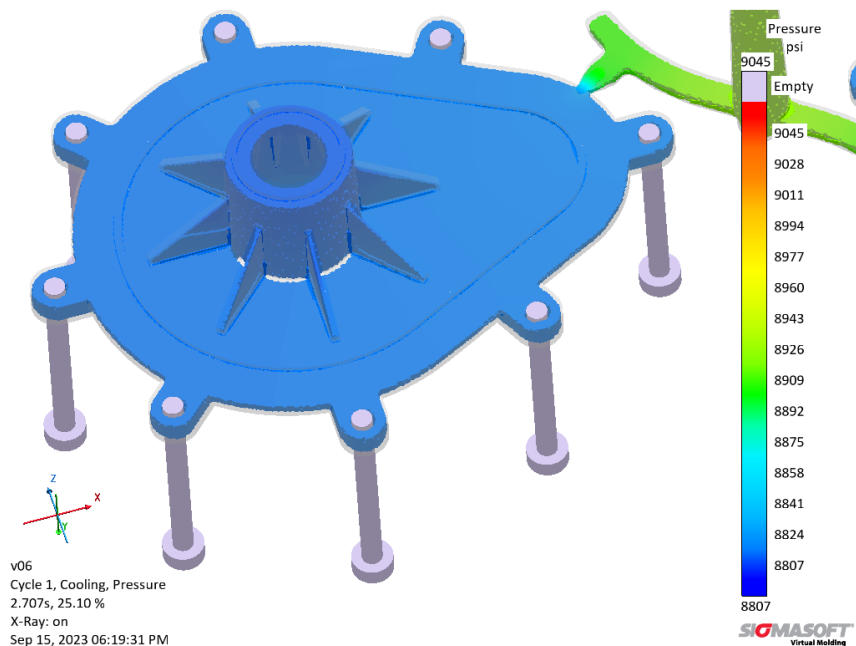
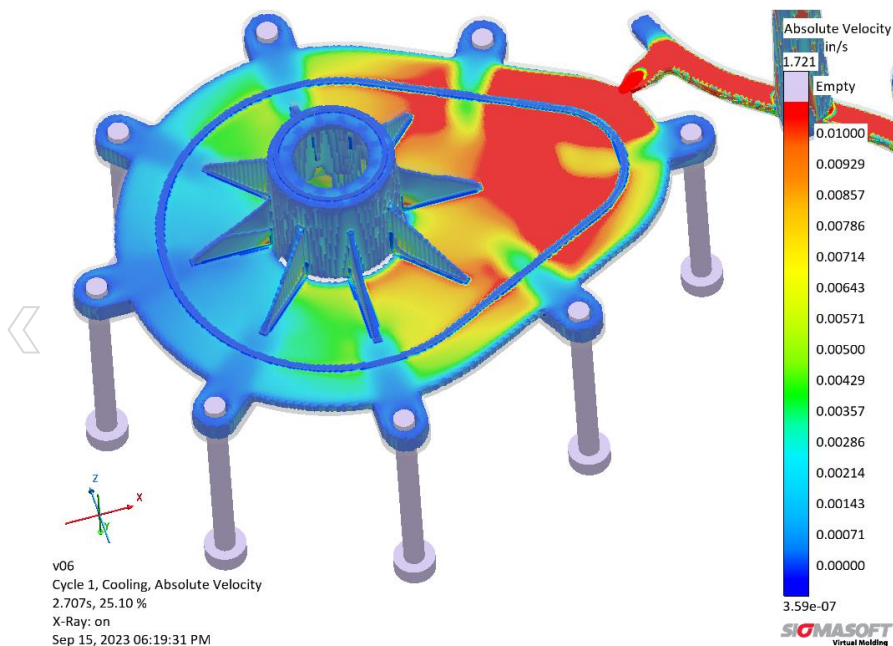
Stresses are not high enough to break the pins





MAPP 2023

# Why is the force higher during Packing?

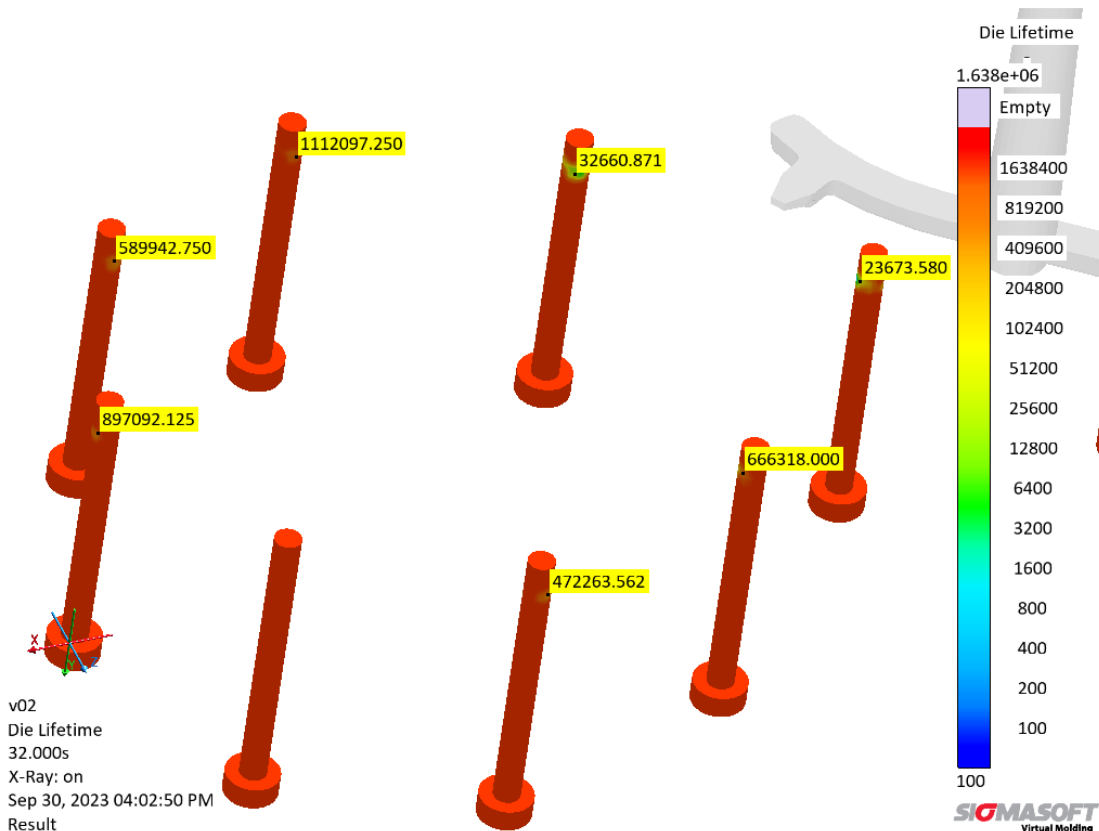




MAPP 2023

# Wear and Tear

How the mold runs would determine how often the cores would need to be replaced

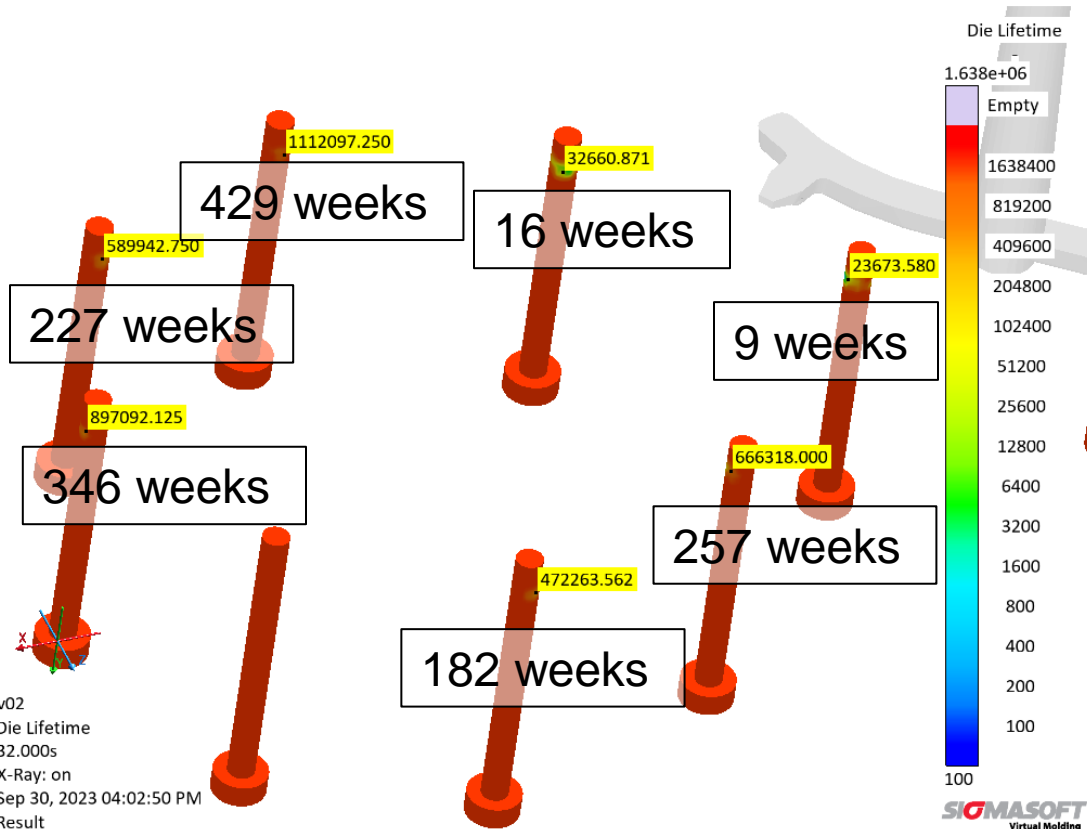




MAPP 2023

# Wear and Tear

Assuming the tool runs 12 hours a day and 6 days a week







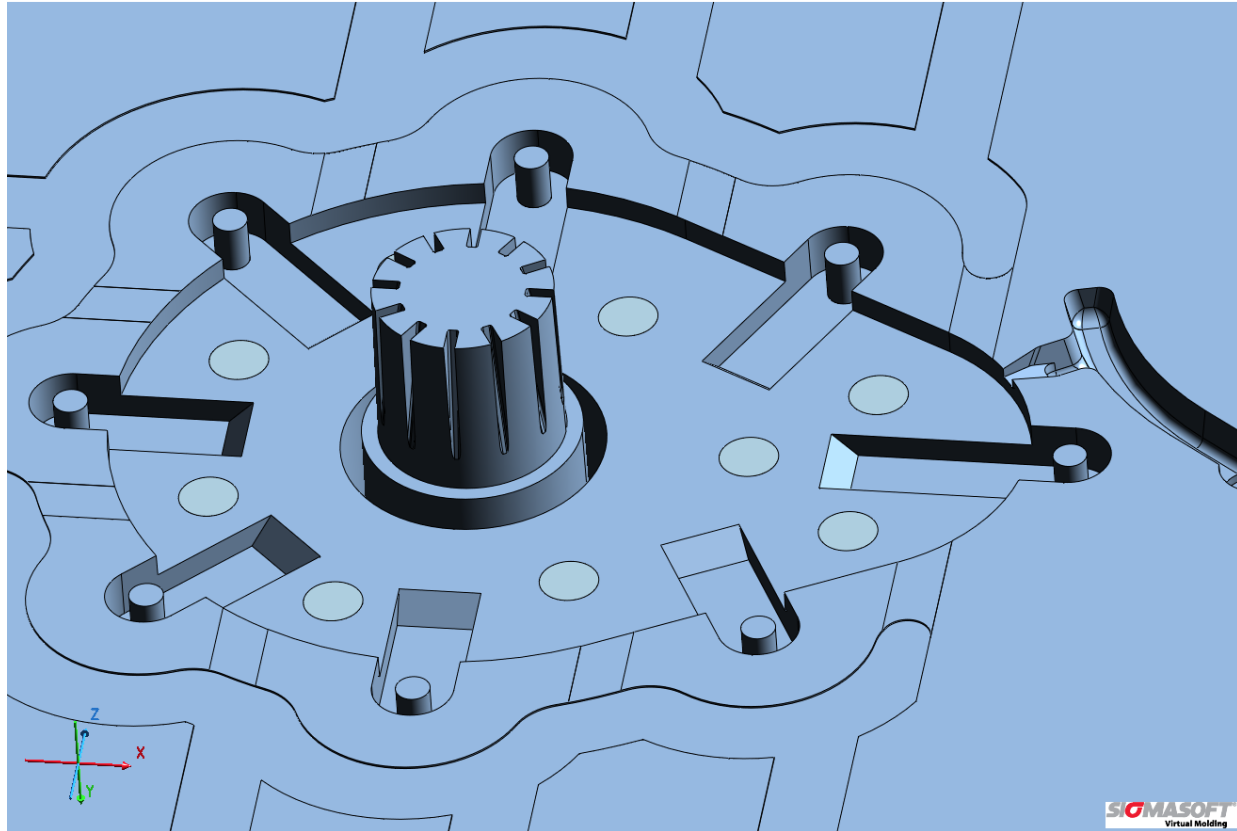
MAPP 2023

# Does our Process influence the Wear and Tear?

Filling Time  
between 0.25  
to 2 seconds

Part  
Temperature  
between 590F  
to 644F

Mold  
Temperature  
between 248F  
to 320F



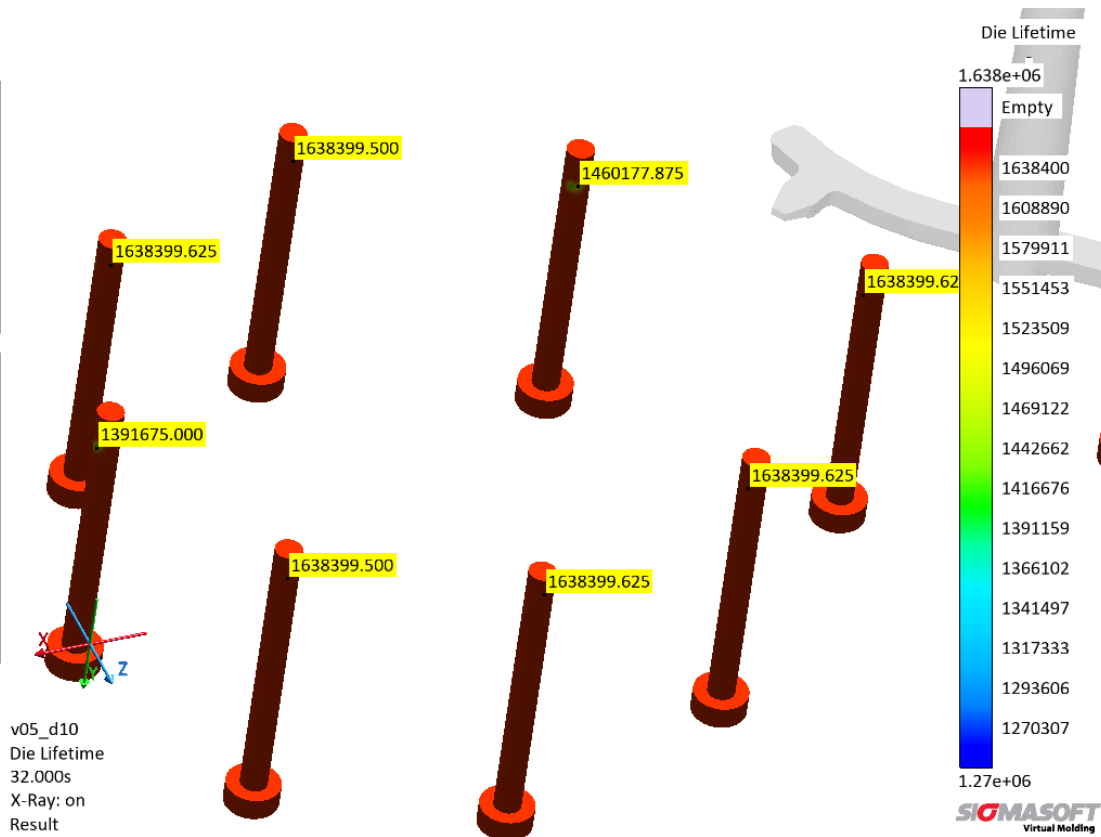


MAPP 2023

# Does our Process influence the Wear and Tear?

Running a fill  
time slower  
than 0.5  
seconds

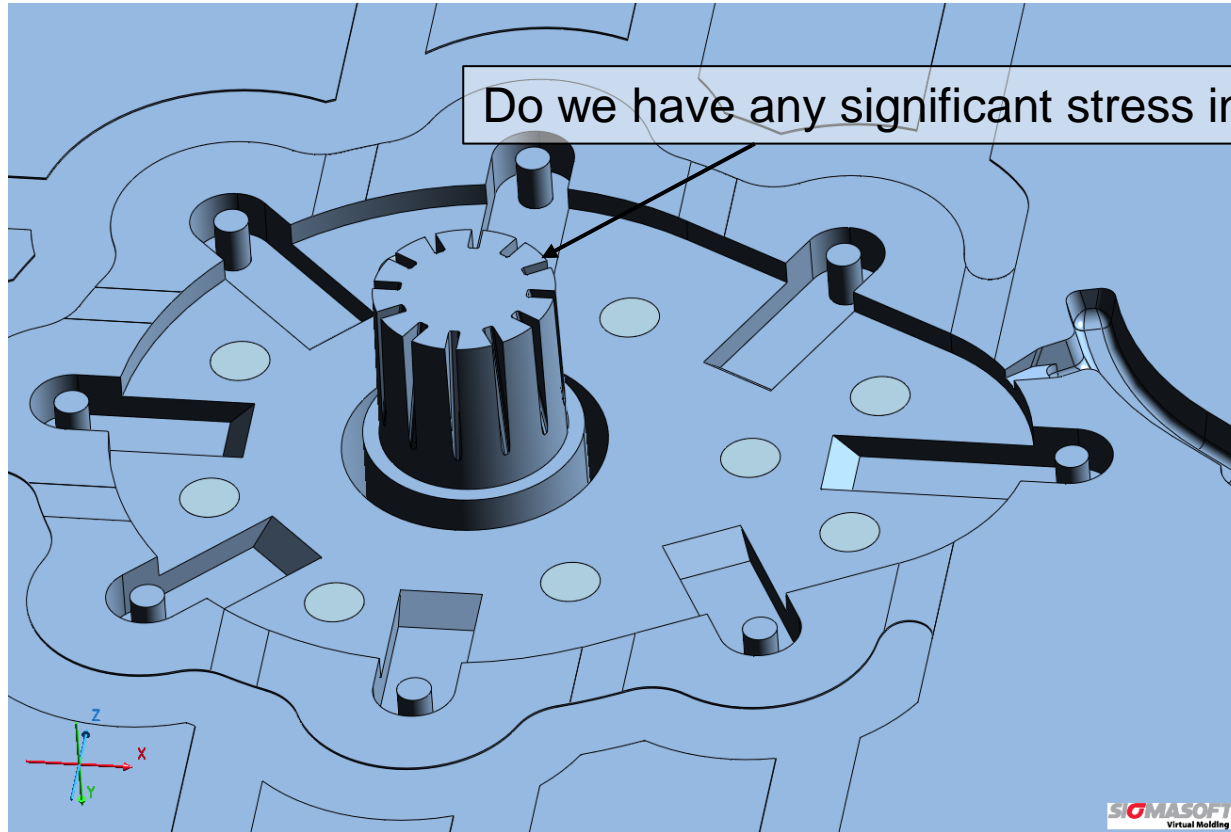
However,  
short shots  
start to  
happen above  
1.5 seconds





MAPP 2023

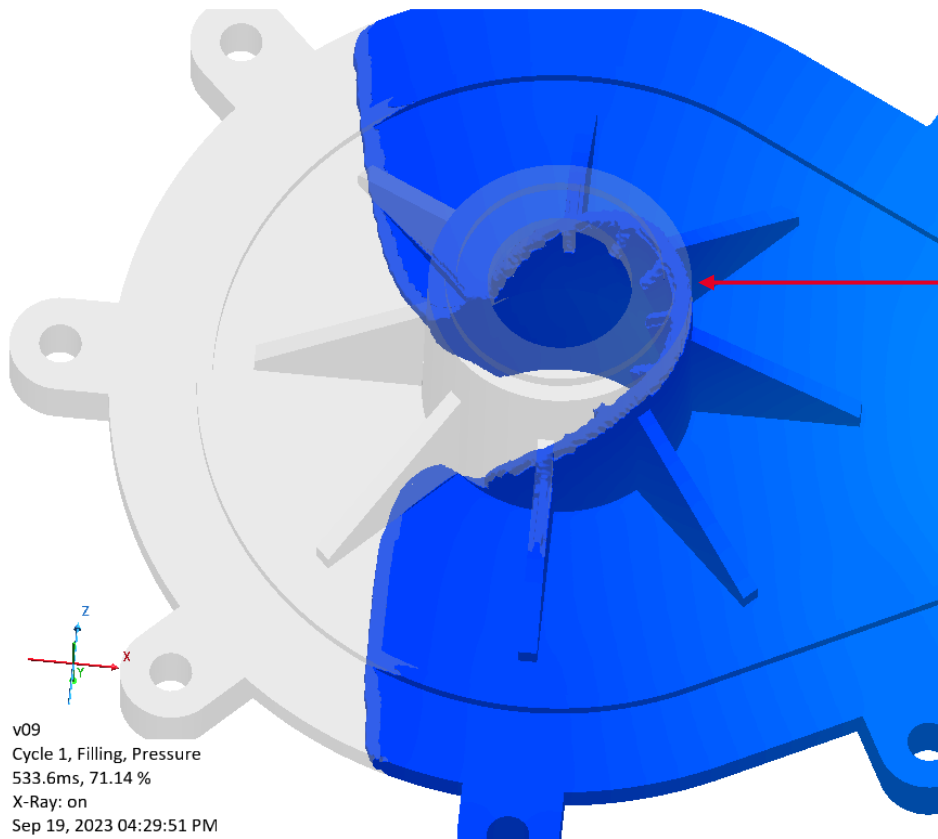
## Next Area of concern





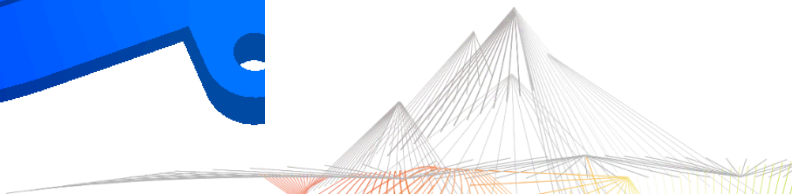
MAPP 2023

# Filling Pattern



Melt is pushing on the core without any resistance from the other side

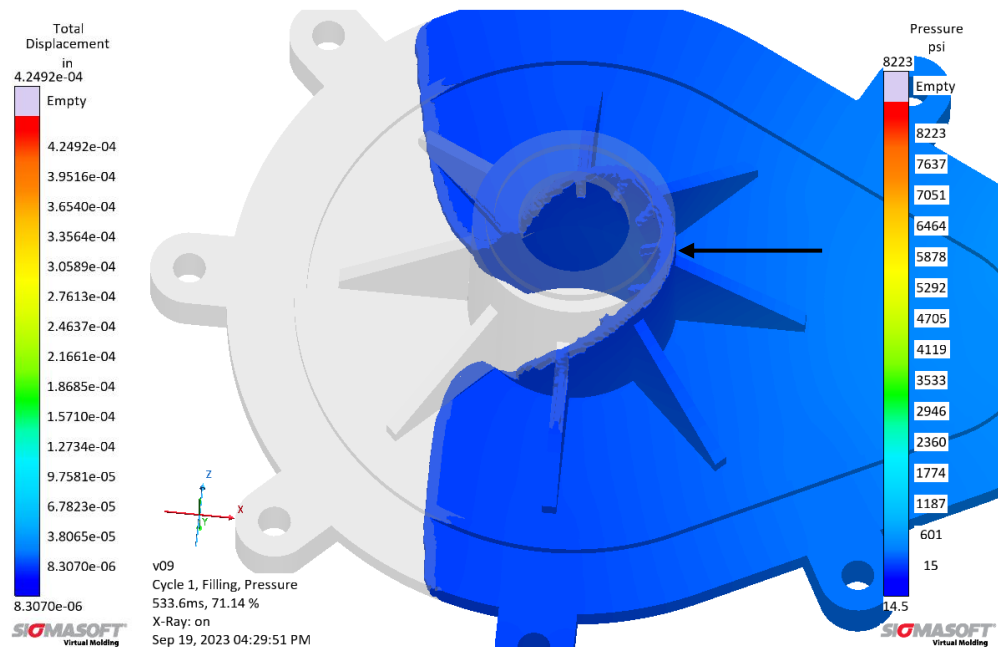
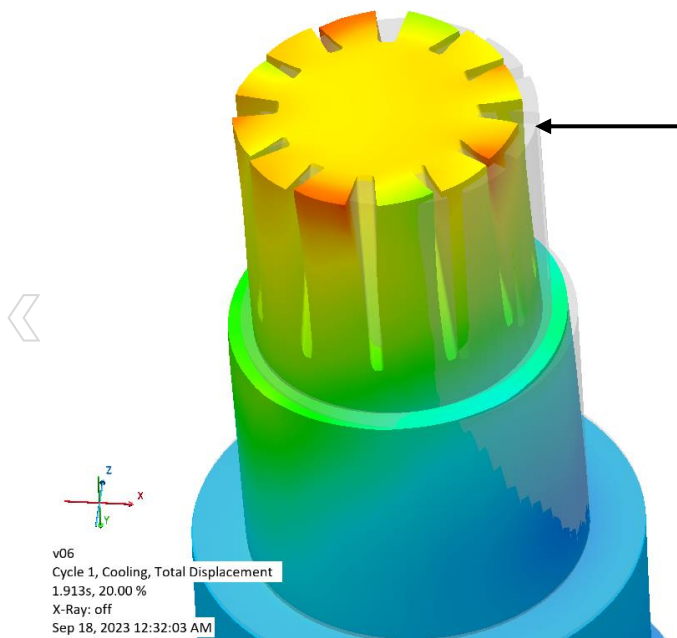
v09  
Cycle 1, Filling, Pressure  
533.6ms, 71.14 %  
X-Ray: on  
Sep 19, 2023 04:29:51 PM





MAPP 2023

# Pressure influence on the core movement





MAPP 2023

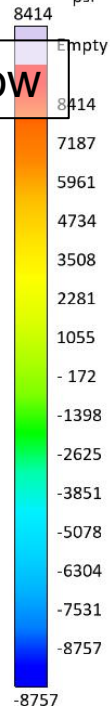
# Wear and Tear

Highest stress in the direction of flow



v06  
Cycle 1, Cooling, Max. Principal Stress  
1.913s, 20.00 %  
X-Ray: off  
Sep 18, 2023 12:32:12 AM

Max. Principal  
Stress  
psi



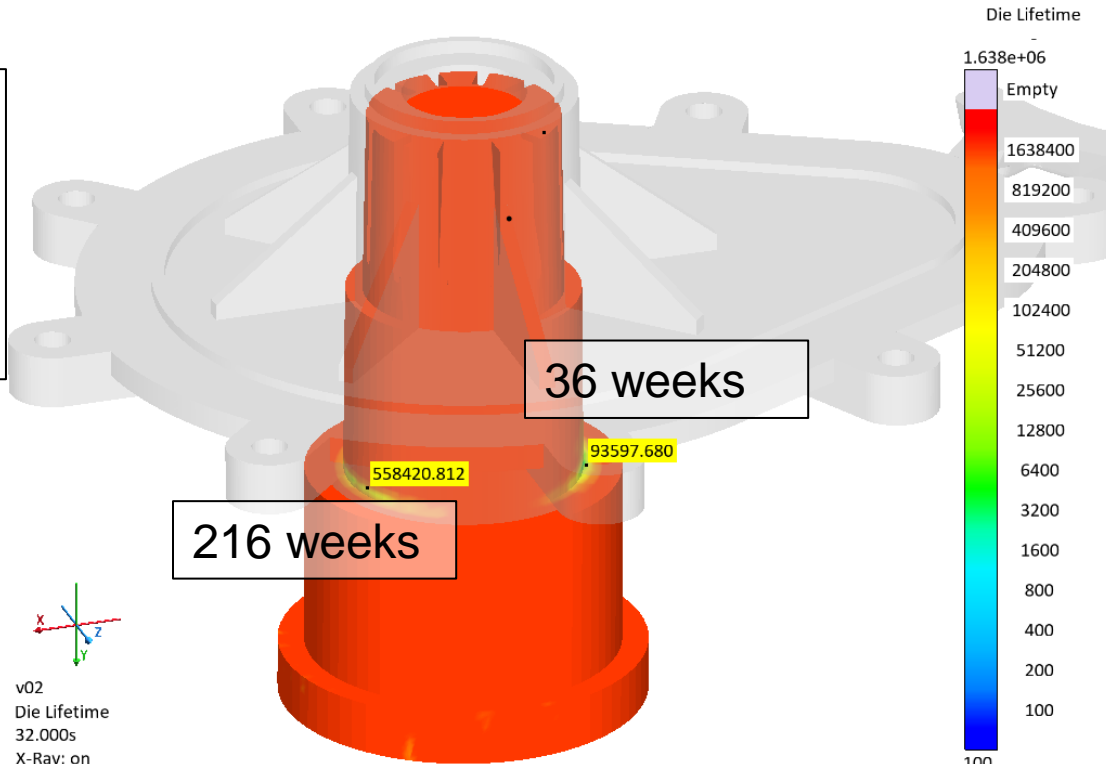
SIGMASOFT  
Virtual Molding



MAPP 2023

# Wear and Tear

Assuming the tool runs 12 hours a day and 6 days a week



v02  
Die Lifetime  
32.000s  
X-Ray: on  
Sep 30, 2023 04:02:50 PM  
Result

SIGMASOFT  
Virtual Molding

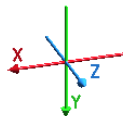
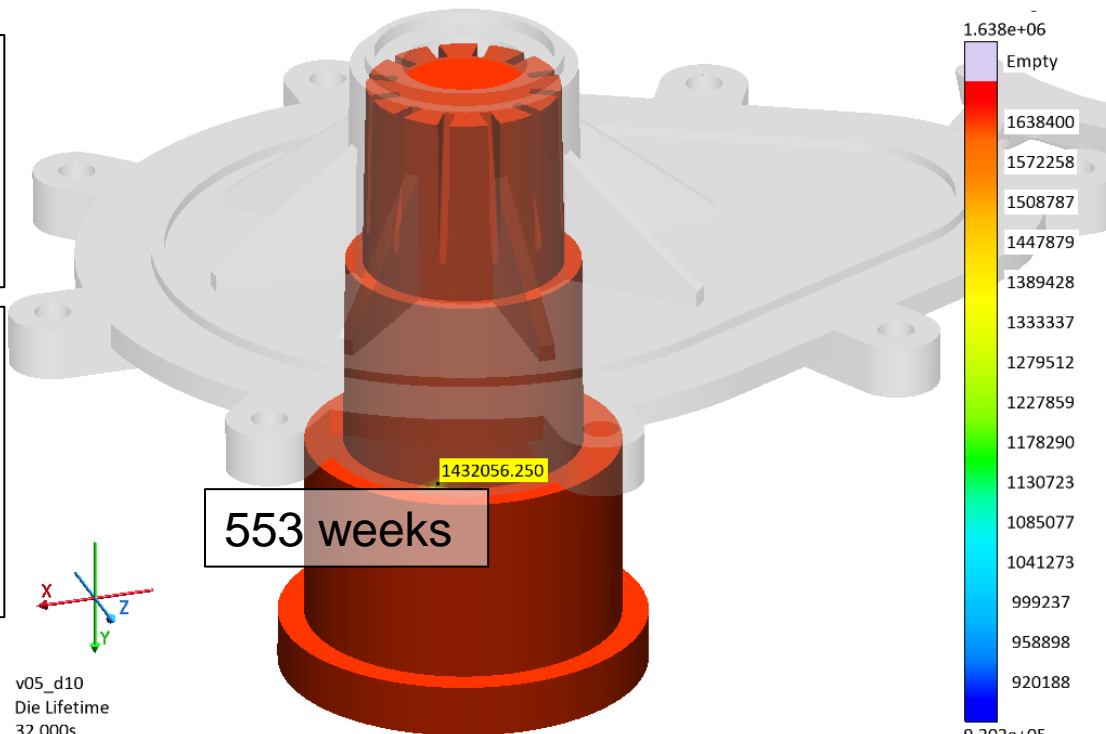


MAPP 2023

# Does our Process influence the Wear and Tear?

Running a fill  
time slower  
than 0.5  
seconds

However,  
short shots  
start to  
happen at  
1.75 seconds



v05\_d10  
Die Lifetime  
32.000s  
X-Ray: on  
Result

SIGMASOFT  
Virtual Molding





# New Process Parameters

## Previous

- Polymer Temperature – 617F
- Mold Temperature – 284F
- Fill Time – 0.3 seconds
- Packing Pressure – 15,900 psi
- Cooling Time – 10 seconds

## New

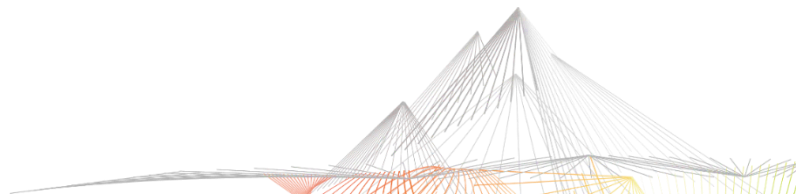
- Polymer Temperature – 590F
- Mold Temperature – 284F
- Fill Time – 0.5 seconds
- Packing Pressure – 14,700 psi
- Cooling Time – 10 seconds





# Review the final parameters to check other issues

- └ Filling
- └ Packing
- └ Cooling
- └ Shrinkage & Warpage

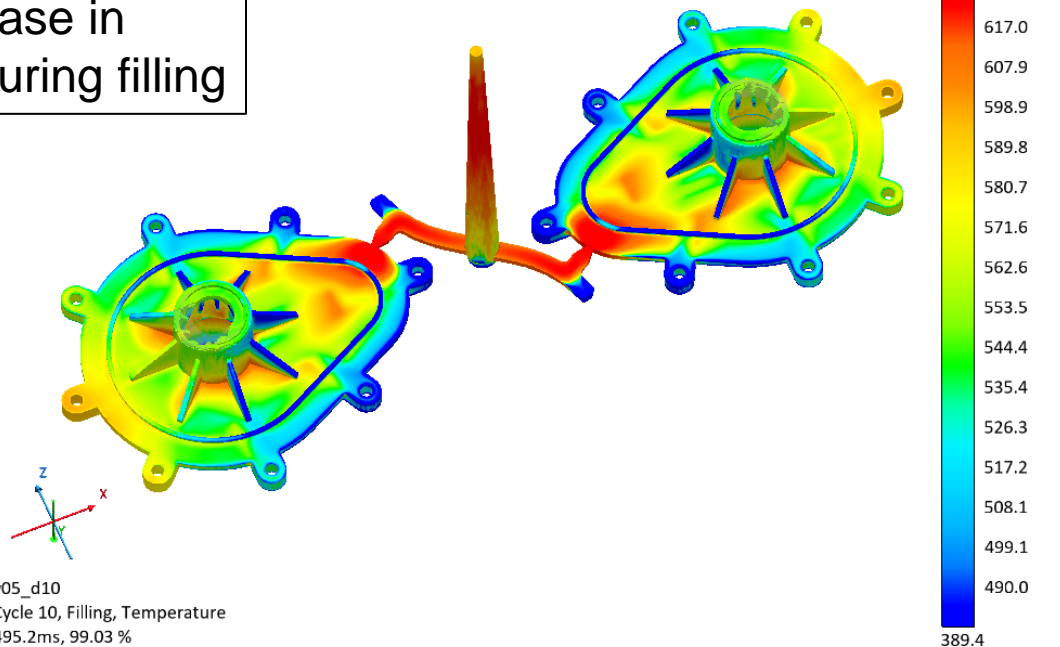




MAPP 2023

# Filling Temperature

15F increase in  
temperature during filling



v05\_d10  
Cycle 10, Filling, Temperature  
495.2ms, 99.03 %  
X-Ray: on  
Oct 01, 2023 09:22:47 AM

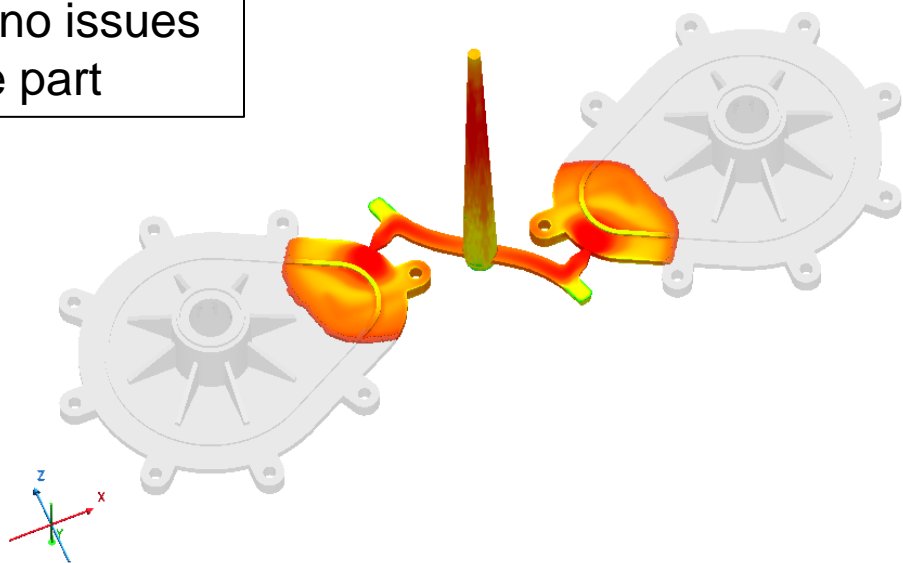
**SIGMASOFT**  
Virtual Molding



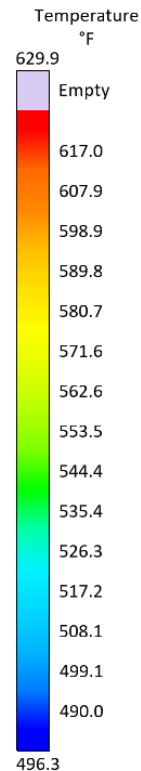
MAPP 2023

# Investigating the areas cooling down quickly

Should have no issues  
filling the part



v05\_d10  
Cycle 10, Filling, Temperature  
110.7ms, 22.13 %  
X-Ray: on  
Oct 01, 2023 08:49:43 AM



**SIGMASOFT**  
Virtual Molding

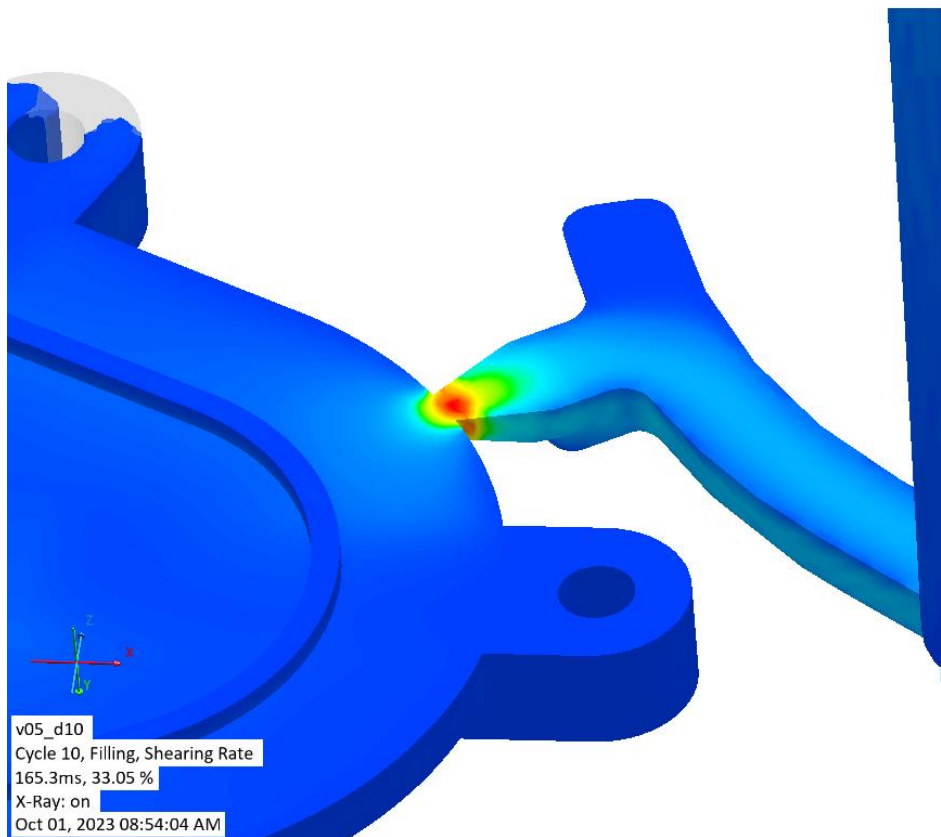


MAPP 2023

# Shear Rate

The Shear Rate is 45,000 1/s

Shear rate value corresponds to the temperature increase

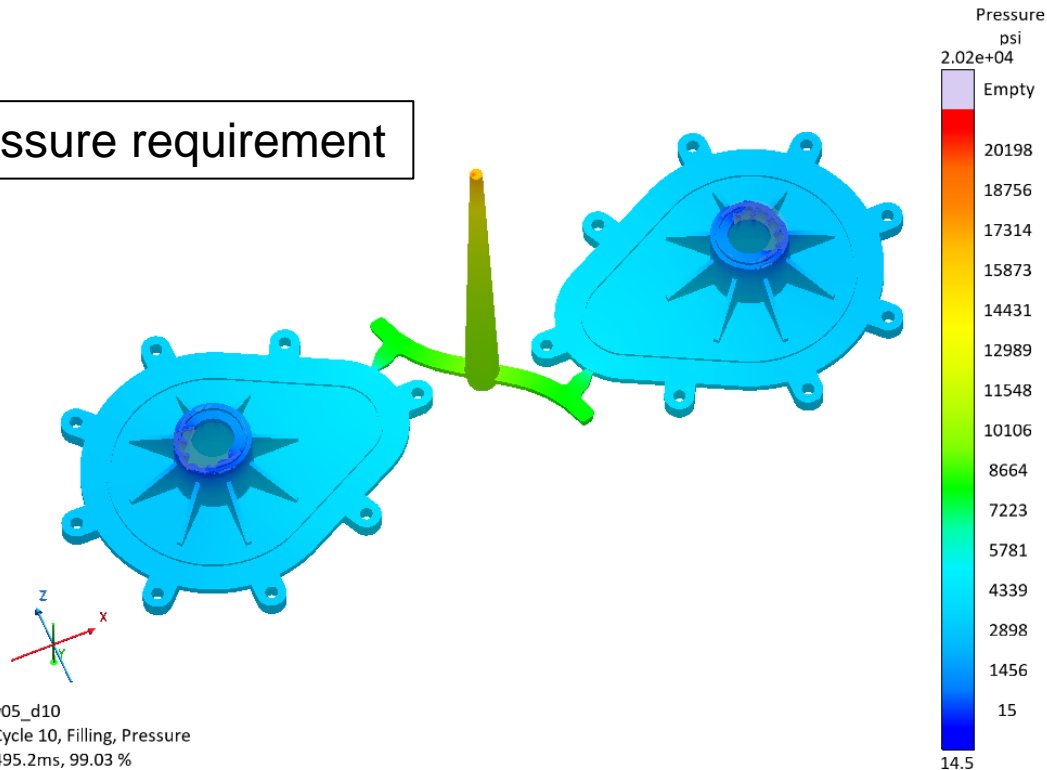




MAPP 2023

# Filling Pressure

20,200 psi pressure requirement



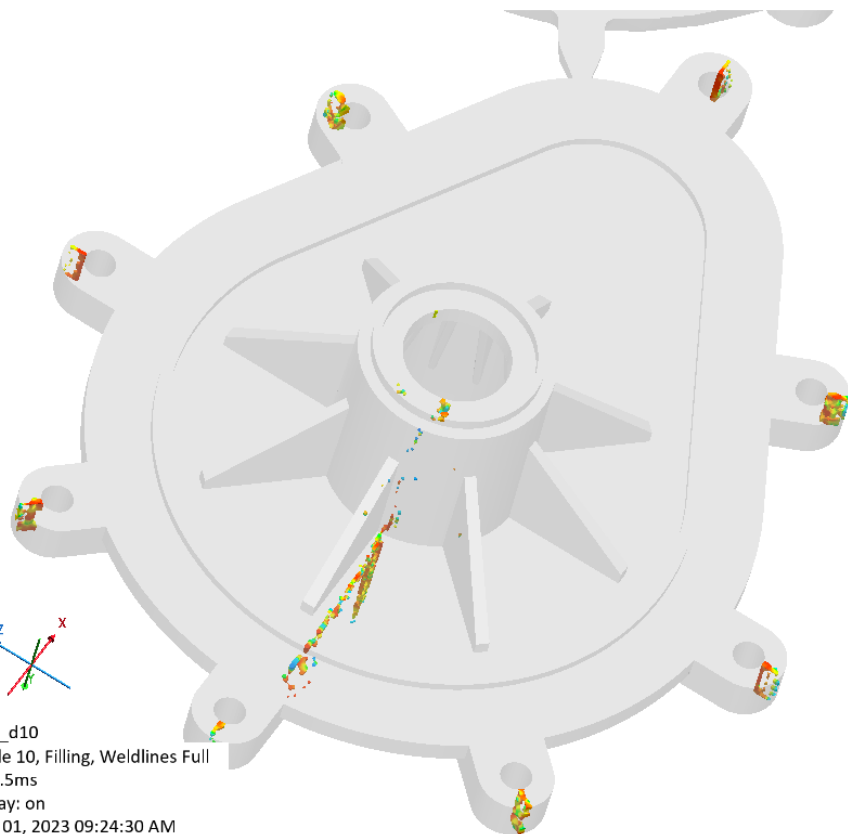
v05\_d10  
Cycle 10, Filling, Pressure  
495.2ms, 99.03 %  
X-Ray: on  
Oct 01, 2023 09:22:46 AM

SIGMASOFT  
Virtual Molding



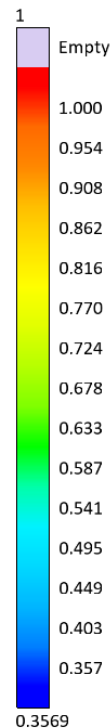
MAPP 2023

# Weldline Locations



v05\_d10  
Cycle 10, Filling, Weldlines Full  
501.5ms  
X-Ray: on  
Oct 01, 2023 09:24:30 AM

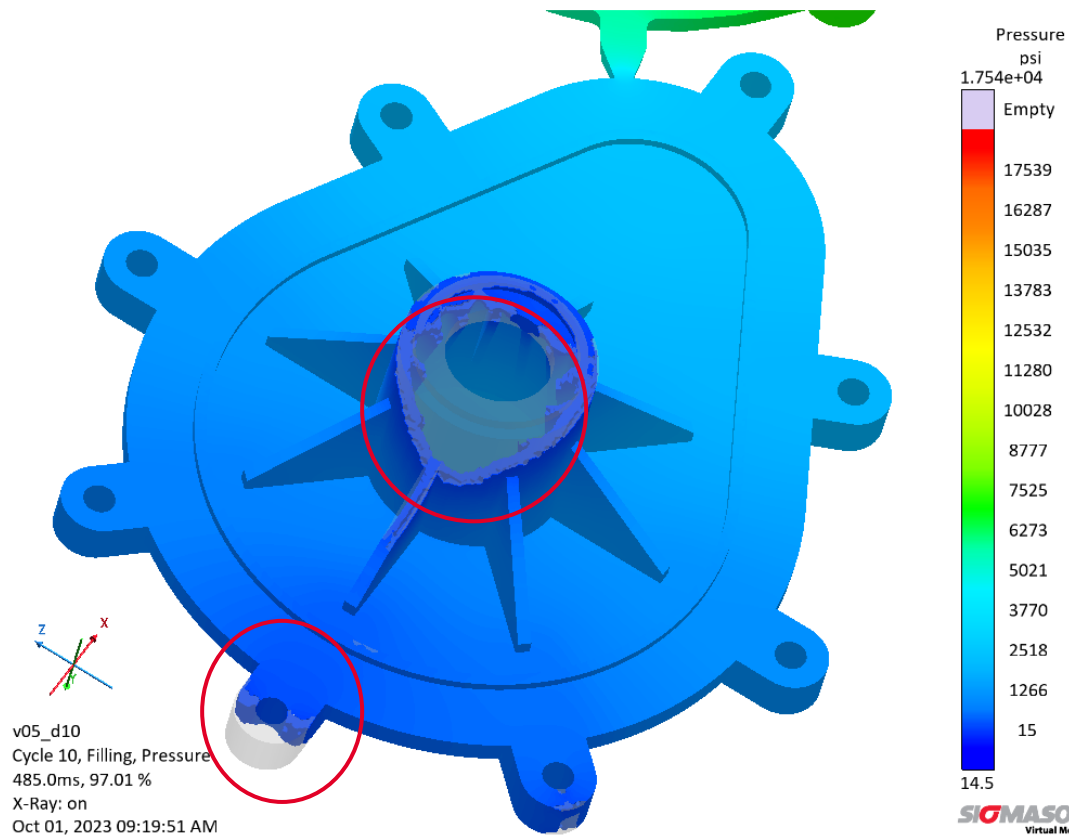
Weldlines Full



SIGMASOFT  
Virtual Molding



# Air Entrapment

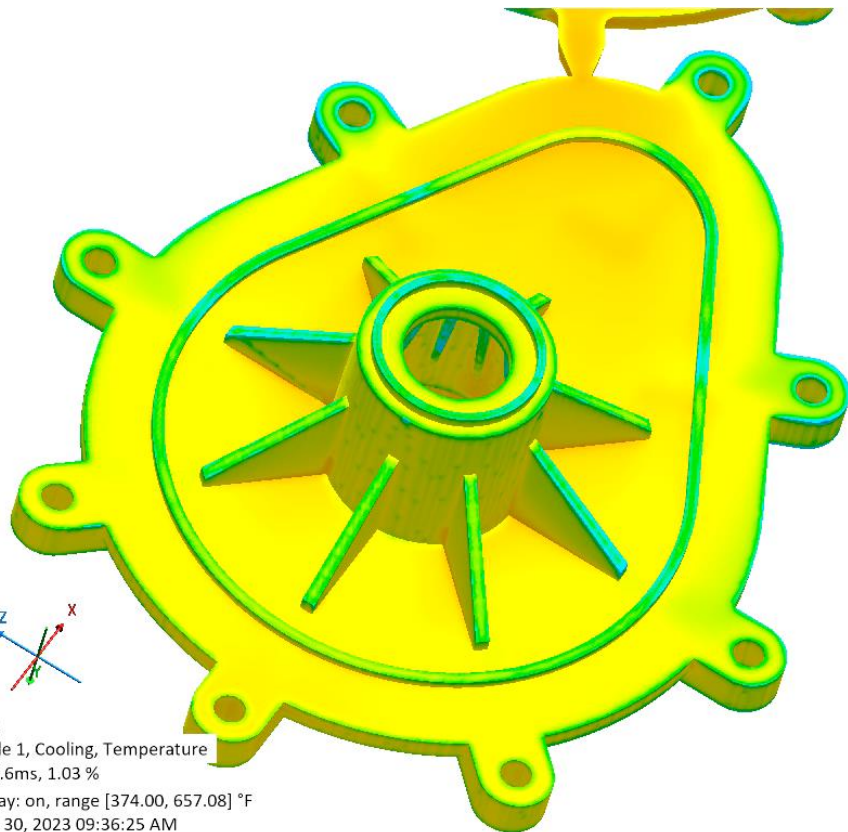




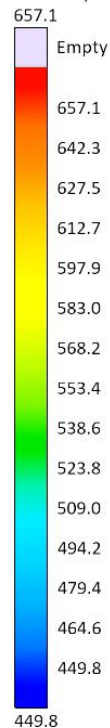


MAPP 2023

# Cooling Pattern



Temperature  
°F



v02  
Cycle 1, Cooling, Temperature  
236.6ms, 1.03 %  
X-Ray: on, range [374.00, 657.08] °F  
Sep 30, 2023 09:36:25 AM

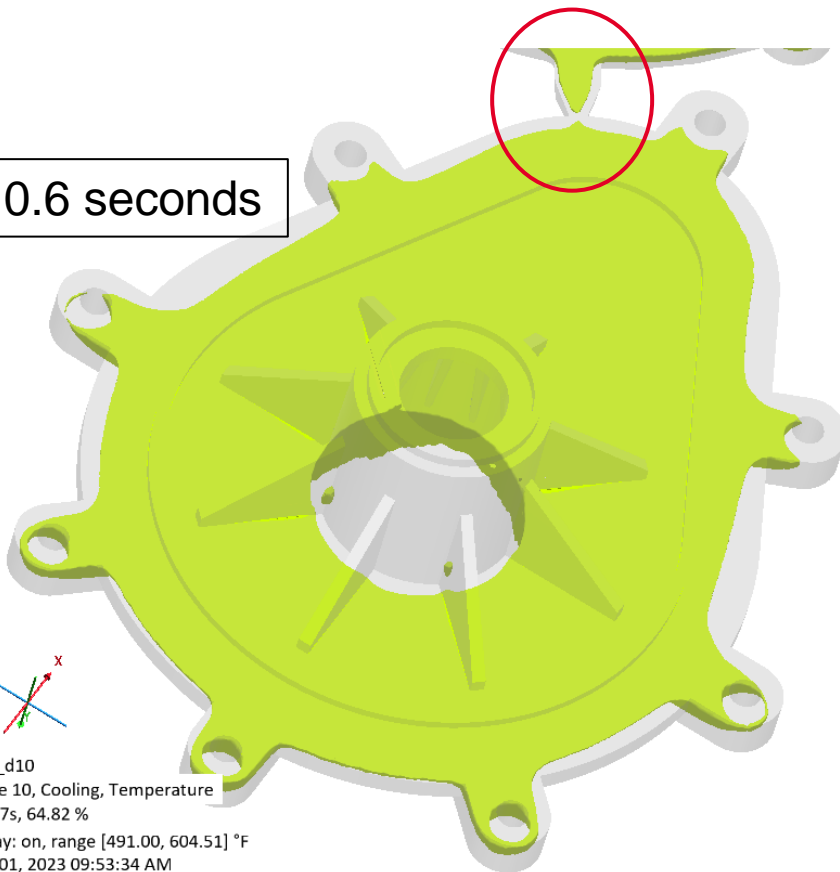
**SIGMASOFT**  
Virtual Molding



MAPP 2023

# Gate Freeze

Gate Freeze at 0.6 seconds



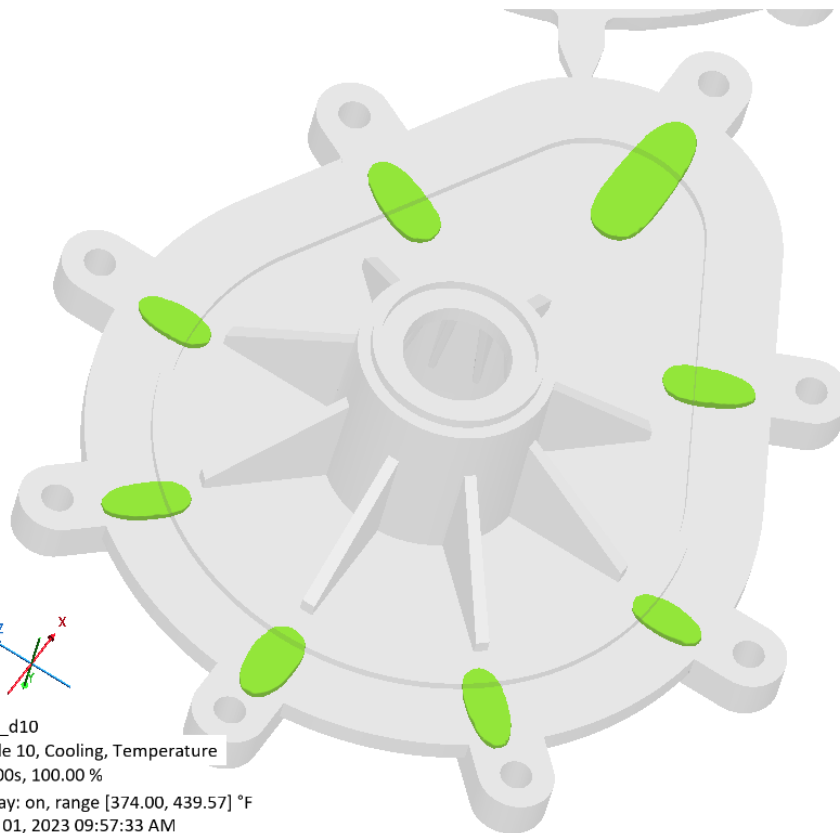
All molten material will continue to cool down without any packing pressure

v05\_d10  
Cycle 10, Cooling, Temperature  
1.137s, 64.82 %  
X-Ray: on, range [491.00, 604.51] °F  
Oct 01, 2023 09:53:34 AM

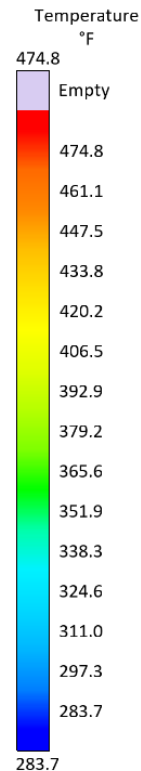


MAPP 2023

# Last Areas to Cool



v05\_d10  
Cycle 10, Cooling, Temperature  
5.000s, 100.00 %  
X-Ray: on, range [374.00, 439.57] °F  
Oct 01, 2023 09:57:33 AM

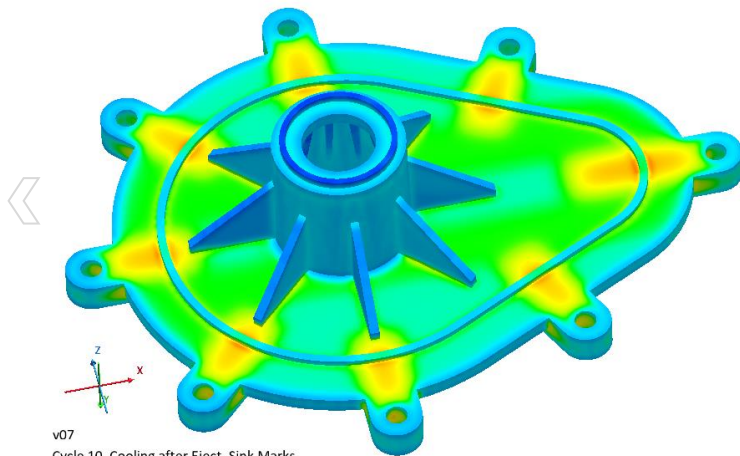


**SIGMASOFT**  
Virtual Molding

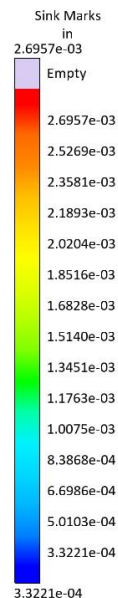


MAPP 2023

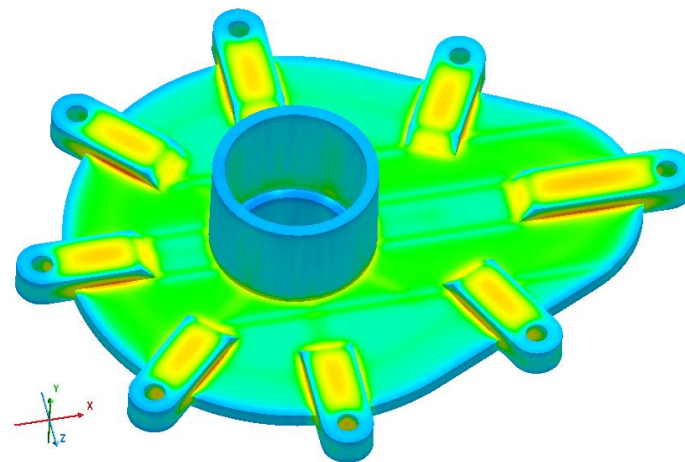
# Sink Marks



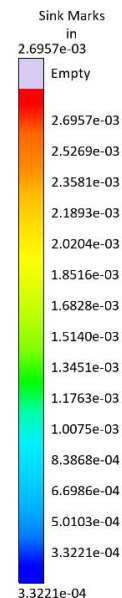
v07  
Cycle 10, Cooling after Eject, Sink Marks  
1h 0min 12s  
X-Ray: on  
Oct 02, 2023 02:04:03 PM



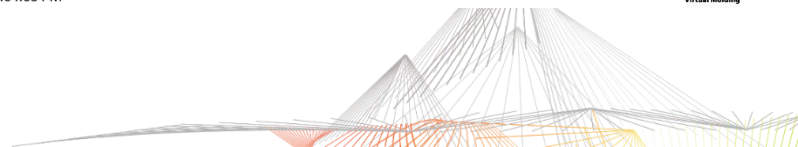
SIGMASOFT  
Virtual Molding



v07  
Cycle 10, Cooling after Eject, Sink Marks  
1h 0min 12s  
X-Ray: on  
Oct 02, 2023 02:04:03 PM



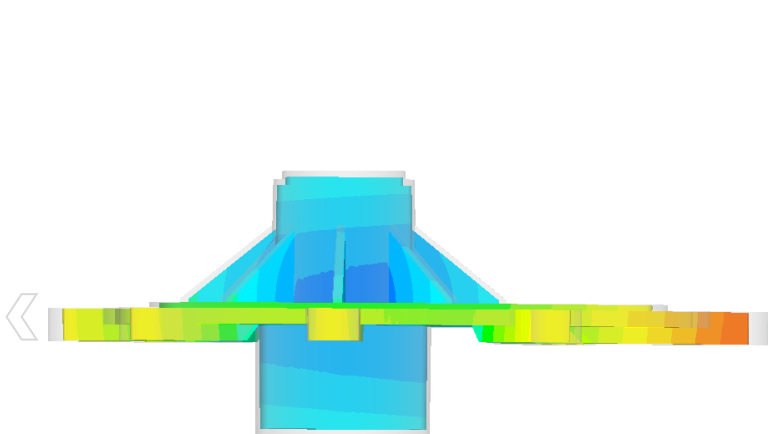
SIGMASOFT  
Virtual Molding



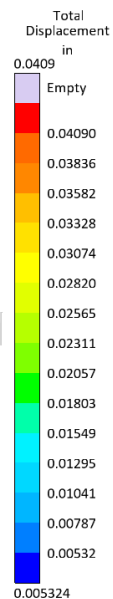


MAPP 2023

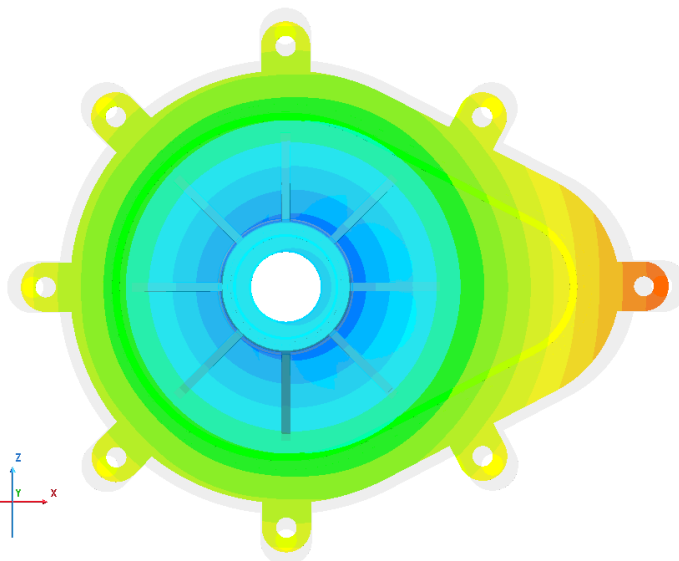
# Shrinkage & Warpage



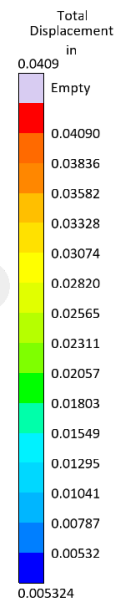
v10  
Cycle 1, Cooling after Eject, Total Displacement  
Ambient, 100.00 %  
X-Ray: off  
Sep 21, 2023 07:50:44 AM



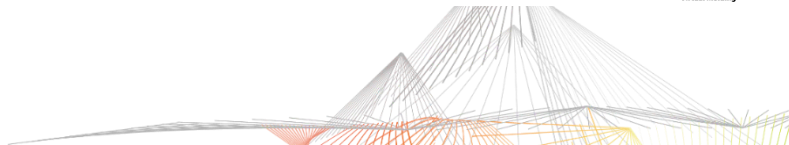
SIGMASOFT  
Virtual Molding



v10  
Cycle 1, Cooling after Eject, Total Displacement  
Ambient, 100.00 %  
X-Ray: off  
Sep 21, 2023 07:50:44 AM



SIGMASOFT  
Virtual Molding

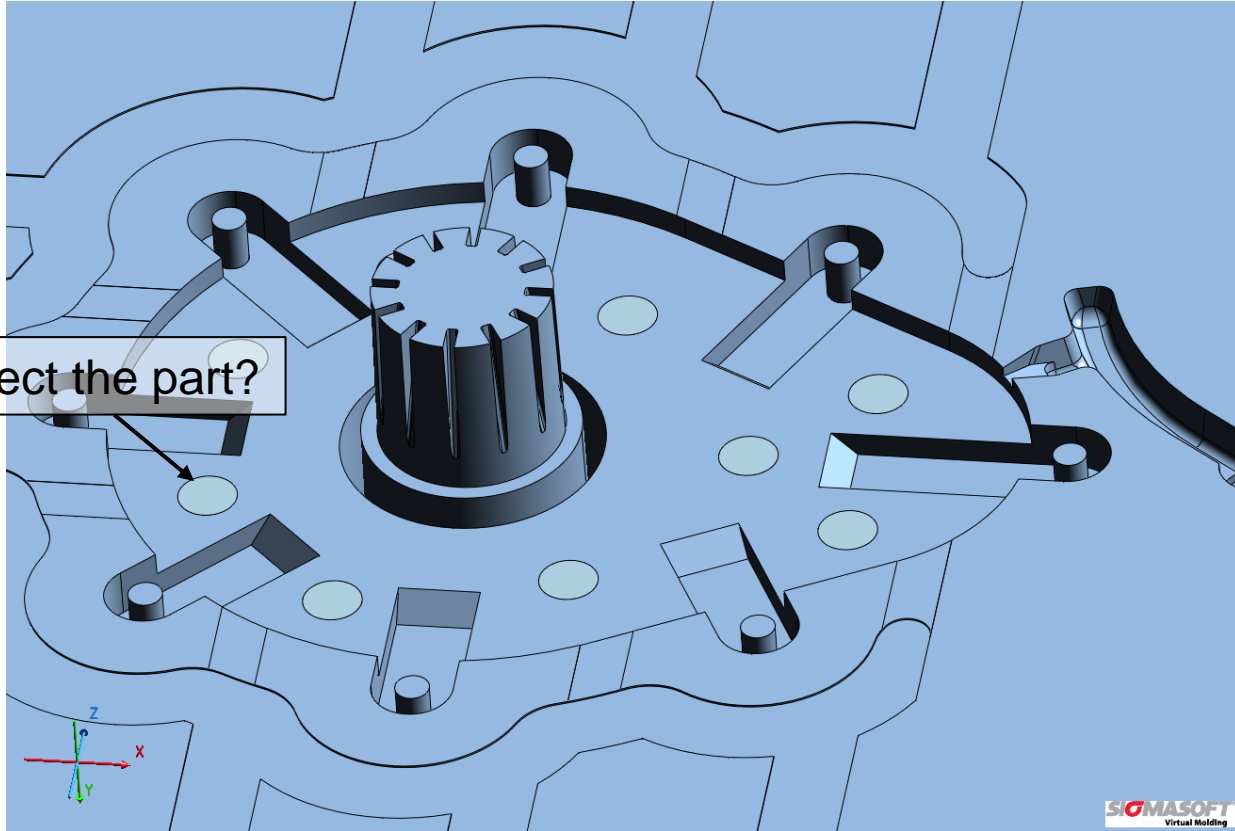




MAPP 2023

# While we are investigating the mold design...

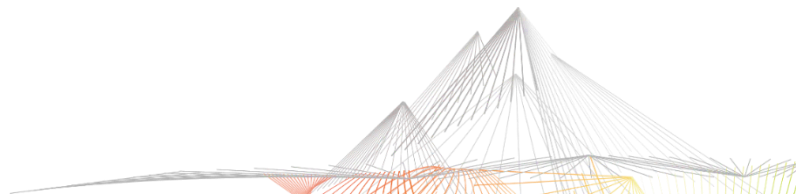
Can we eject the part?





# What could increase part bending and stress during ejection?

- ❑ Temperature of the part
- ❑ Speed of the ejection system
- ❑ Position of the ejector pins



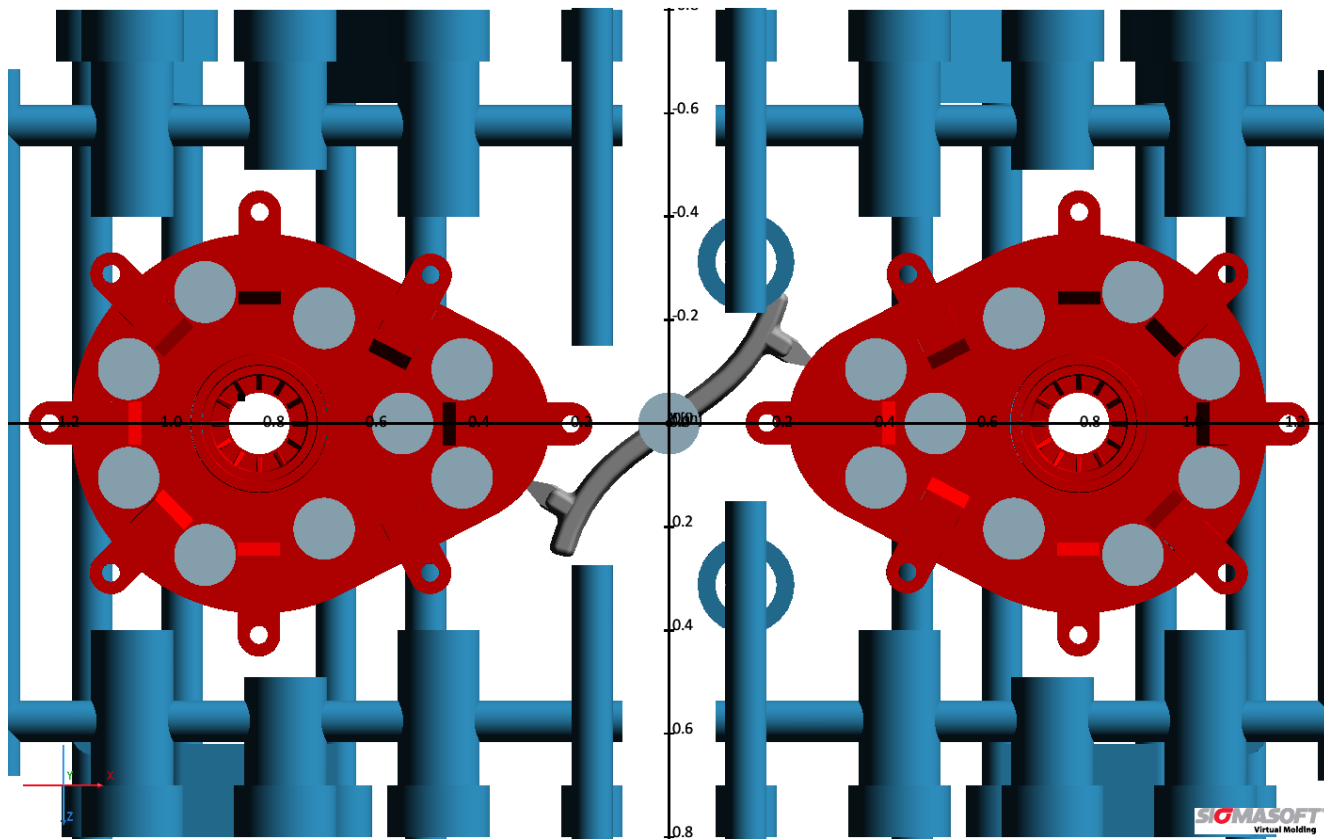


MAPP 2023

# Relationship between Cooling Lines and Ejector Pins

They can't occupy  
the same space

Have to find a  
balance



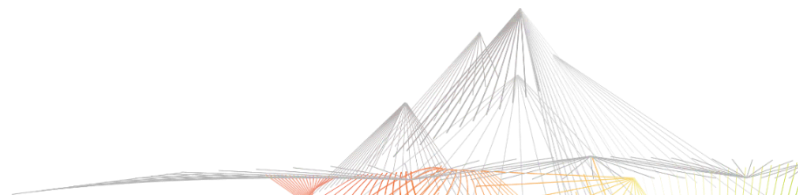




MAPP 2023

# Part Material Review

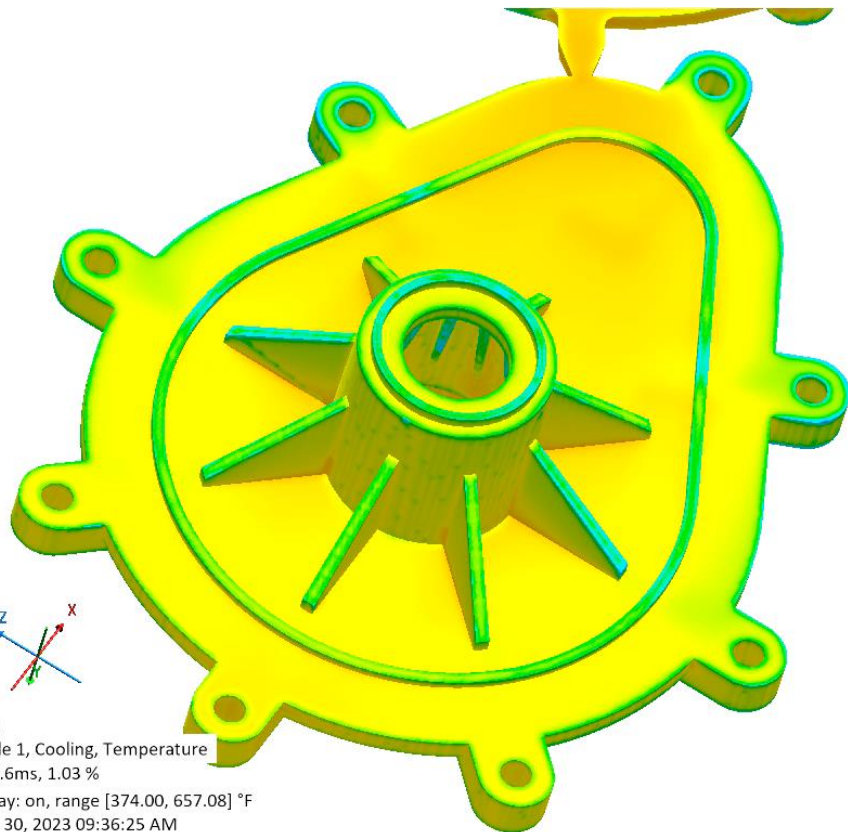
MECHANICAL	Dry	Conditioned	Unit	Test Method
Tensile Modulus	2700	2800	MPa	ISO 527-1
Tensile Stress (Break)	11,600 psi	80.0	MPa	ISO 527-2
Tensile Strain (Break)	3.0	4.0	%	ISO 527-2



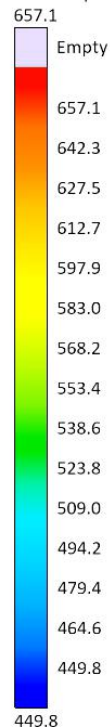


MAPP 2023

# Cooling Pattern



Temperature  
°F



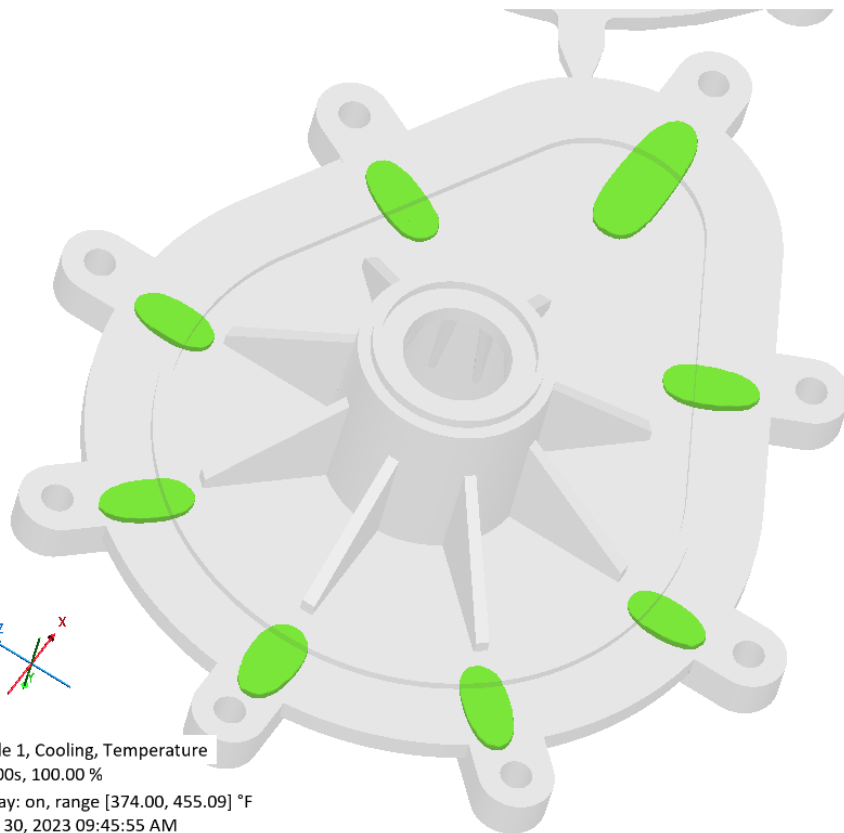
v02  
Cycle 1, Cooling, Temperature  
236.6ms, 1.03 %  
X-Ray: on, range [374.00, 657.08] °F  
Sep 30, 2023 09:36:25 AM

**SIGMASOFT**  
Virtual Molding



MAPP 2023

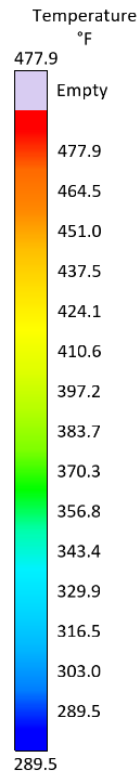
# Last Areas to Cool



v02

Cycle 1, Cooling, Temperature  
5.000s, 100.00 %

X-Ray: on, range [374.00, 455.09] °F  
Sep 30, 2023 09:45:55 AM

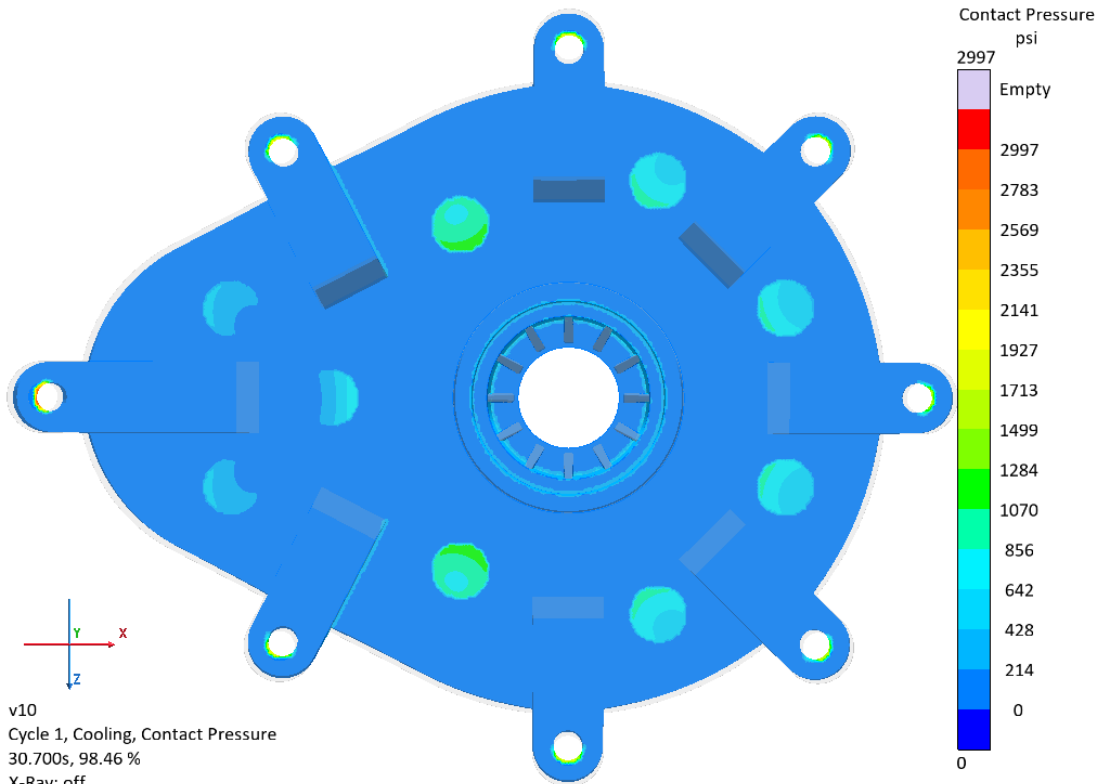


**SIGMASOFT**  
Virtual Molding



MAPP 2023

# Contact Pressure Applied by the Ejector Pins



v10  
Cycle 1, Cooling, Contact Pressure  
30.700s, 98.46 %  
X-Ray: off  
Sep 20, 2023 10:37:49 PM

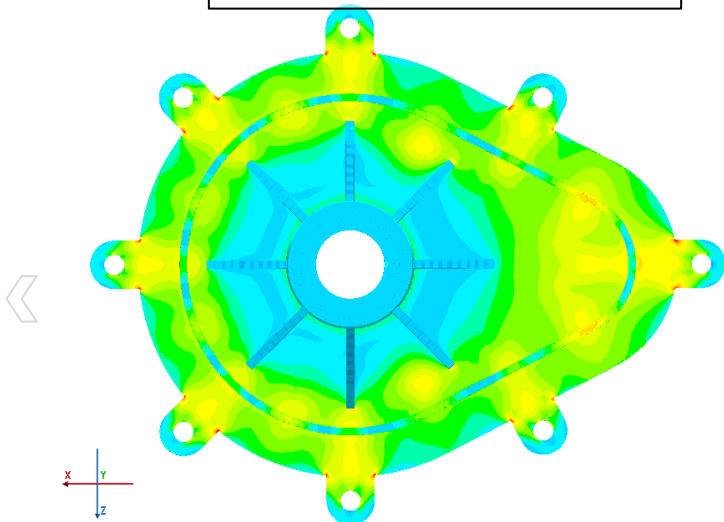
SIGMASOFT  
Virtual Molding



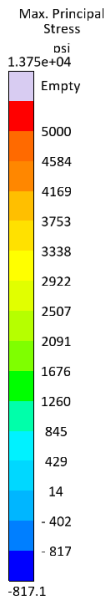
MAPP 2023

# Principle Stresses in the Part

Opposite of Ejection

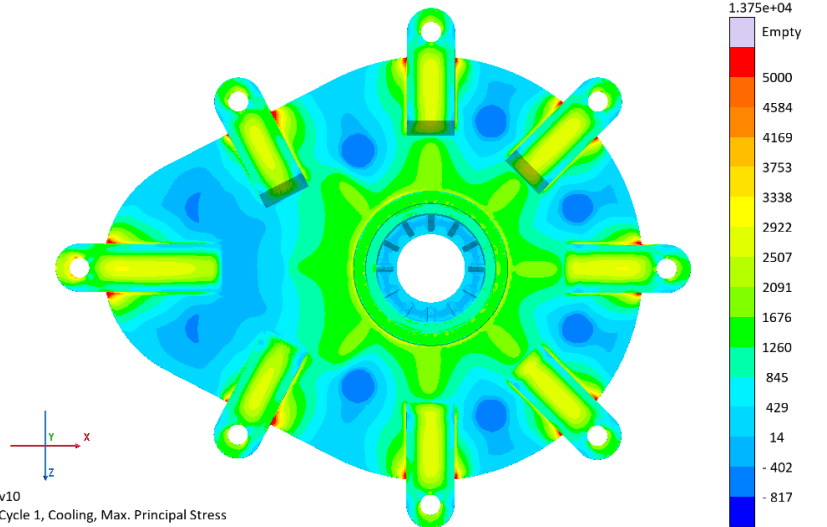


v10  
Cycle 1, Cooling, Max. Principal Stress  
30.950s, 98.58 %  
X-Ray: off  
Sep 21, 2023 12:33:26 AM

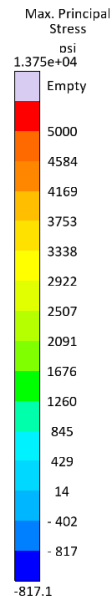


SIGMA SOFT  
Virtual Molding

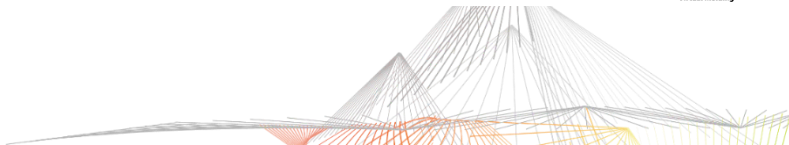
Ejection side



v10  
Cycle 1, Cooling, Max. Principal Stress  
30.950s, 98.58 %  
X-Ray: off  
Sep 21, 2023 12:33:26 AM



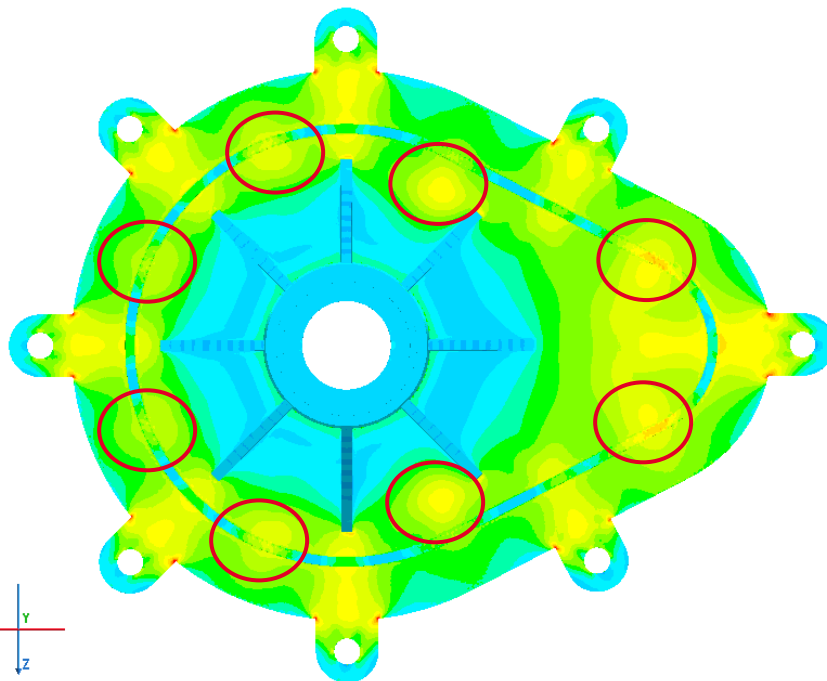
SIGMA SOFT  
Virtual Molding





MAPP 2023

# Do we notice any issues?



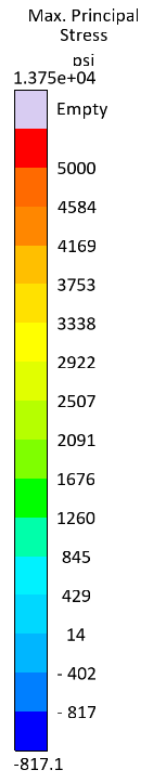
v10

Cycle 1, Cooling, Max. Principal Stress

30.950s, 98.58 %

X-Ray: off

Sep 21, 2023 12:33:26 AM

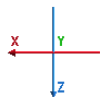
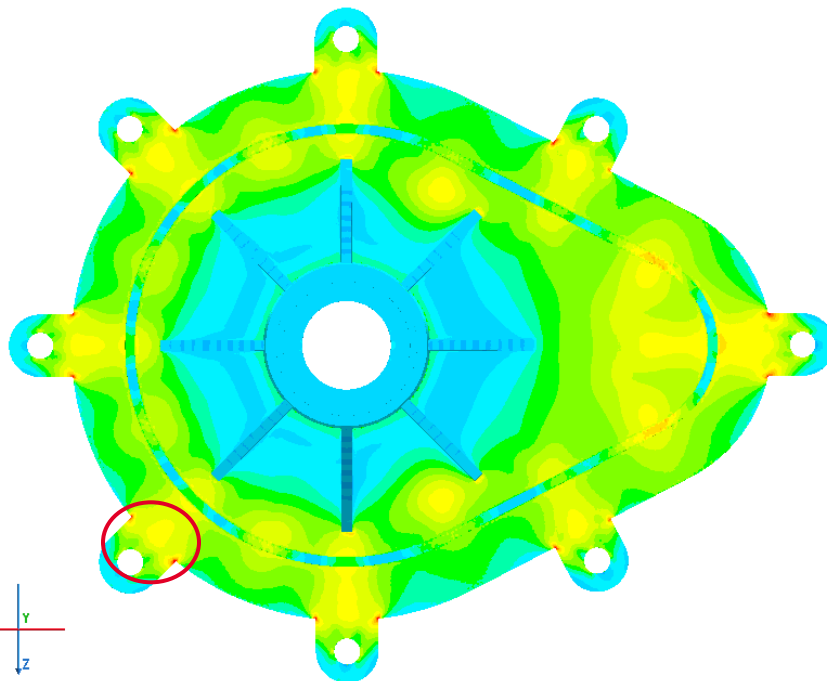


**SIGMASOFT**  
Virtual Molding

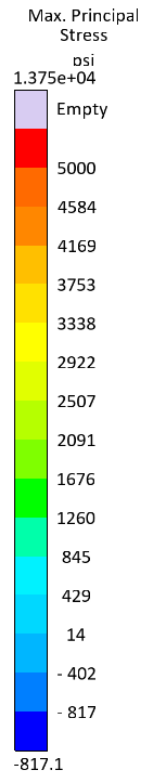


MAPP 2023

# Do we notice any issues?



v10  
Cycle 1, Cooling, Max. Principal Stress  
30.950s, 98.58 %  
X-Ray: off  
Sep 21, 2023 12:33:26 AM



SIGMASOFT  
Virtual Molding



# Final Conclusions

- Reducing the filling time to 0.5-1.5 seconds helped to reduce the stress on the mold and extend the life of the mold components
- Ejector Pins placement and speed is sufficient

