Rochester Institute of Technology

MCET 583: Plastics Product Design

Moldflow Simulation Analysis

By

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Introduction

Moldflow is a type of CAD software made to simulate plastic part production. Models can be taken from other 3D modeling programs like Solid Works or Inventor. Once the model is imported, a mesh can be generated and the conditions for the simulation can be adjusted. The simulation will conduct multiple tests for the characteristics and properties during the parts creation. These tests help decide whether the mold will be successful for the desired outcome. By analyzing the simulations, defects in the part can be found before the mold is even made, saving money and time.

Objective

Analyze two similar part designs using three different gate locations. With the information gathered, recommend the best combination of part design and gate location. Using tests from the simulation, summarize findings and explain the chosen combination.

Analysis

Each of these tests show different aspects of the injection process and the outcome of the part. A blue to red gradient is used as a scale for the unit specific to the test. By observing these gradients, flaws can be detected. Fill time shows the movement of the polymer during the injection. With only this test, a general idea of how the part will form can be made. Knit lines are seen by two of the same colors surrounding another (green surrounding yellow and red). These areas will have lower overall properties and in turn be a weak point in the part. When the two flows of the polymer meet, the orientation of the chains is non-uniform creating an area of low mechanical strength as well. Along with knit lines come air traps. If the polymer surrounds a section of the mold with no vent, the air inside will have nowhere to go. Depending on where the mold comes together air traps may not be a problem. Exhausts can be added to the mold around the parting line to let the air evacuate the mold when the polymer fills its position. Sink marks can be predicted by the lack of density in the part. As the process continues more pressure is needed to push the polymer; as the process comes to an end, the polymer being pushed last will have a lower density than the polymer pushed first. With less density, the plastic will shrink on itself creating a sink mark. Warpage is created with a differential of cooling, When a section of the part cools faster than the surroundings, it will pull in on itself creating bends in the geometry.

Discussion

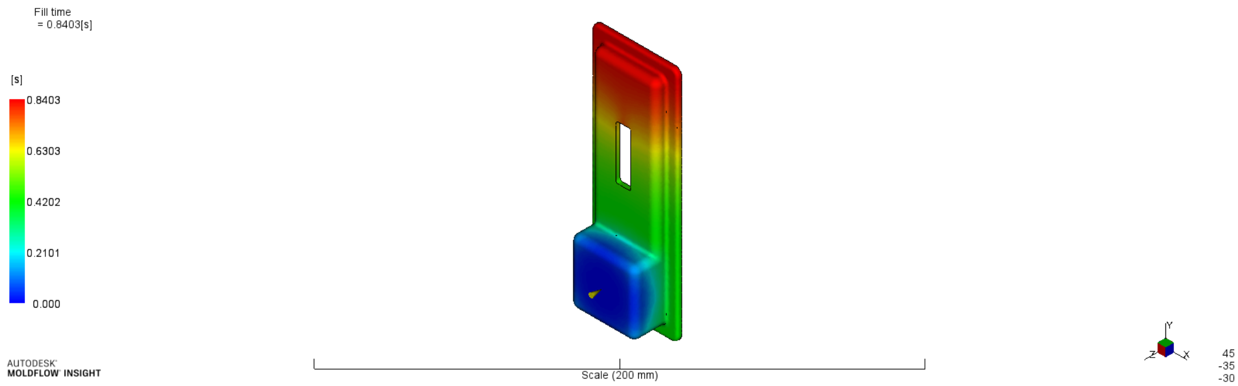
The environment in which the part will be placed plays a large role in the "optimal" gate location and part geometry. The final decision is based upon where the strength of the part is required. For this report, the part will be assumed to have similar forces throughout the structure. The initial 6 tests were done with HDPE and the final test is done with PVC. With that, the best option seems to be part 1 in combination with gate 1. Assuming the mold faces will be on the Z plane, exhausts can be added at the end of the part to release the air within the part. With this choice, the overall properties of this part will be uniform. The smallest knit line is found in the orientation as well. Knit lines in other gate options are larger and span the part. With options 2 or 3, the part has a greater chance of breaking on the knit line. The flow of the polymer can be seen in the path lines test; part 1, gate 1, has a uniform flow up the part creating a strong orientation in the polymer's chains. Part 2, gate 1 suffers when the two flows after the slot come together again. Warpage is always a factor in part creation. With this choice, there will be around 22% warpage near the end of the shot. The warpage on this choice can be mitigated by changing the geometry before the mold is created. The warpage for gate locations 2 and 3 are more central to the part, creating more of a banana effect therefore creating areas of lower mechanical strength in more vital areas. The main structure of the part has a uniform density. If an area with less material is applied with the same forces, there is a greater chance of failure at that point. By reducing the number of low-density areas, sinks in the surface will decrease along with an increase in mechanical strength. While higher pressures are required to use PVC rather than HDPE, other characteristics are still greater than other options. While HDPE will need a maximum of 15.38MPa, PVC will require 62.23MPa. There is a large reduction in warpage between the two polymers, PVC shrinking only around 5%. The choice between part one and part two can be assumed before the simulations even begins. By having a uniform nominal wall, defects decrease while the cooling rate and mechanical properties increase. With thicker areas of the part, polymers lose velocity and will have less orientation inside the part's skin. As seen in most graphs part two had a race-tracking effect around the larger areas creating a weld line and air trap. The path lines show very clearly how the polymer stays to lower pressure areas until required to fill the rest of the part.

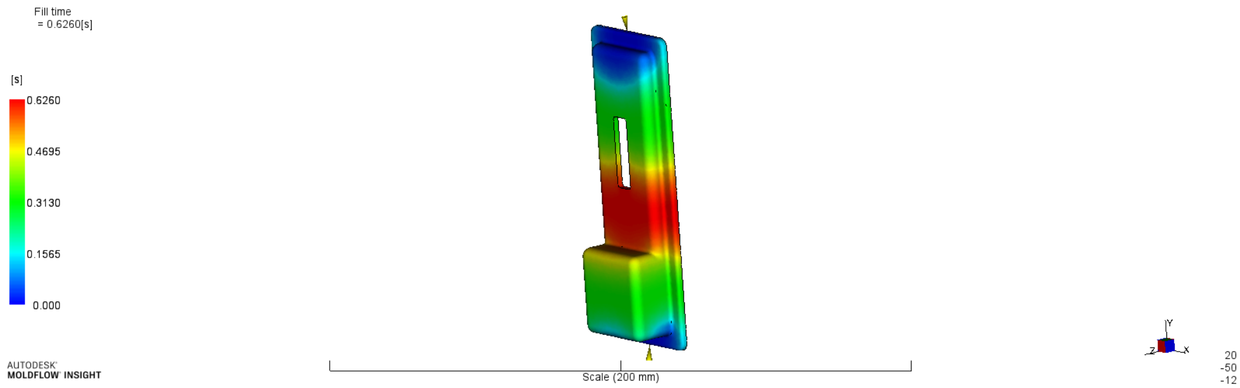
Conclusion

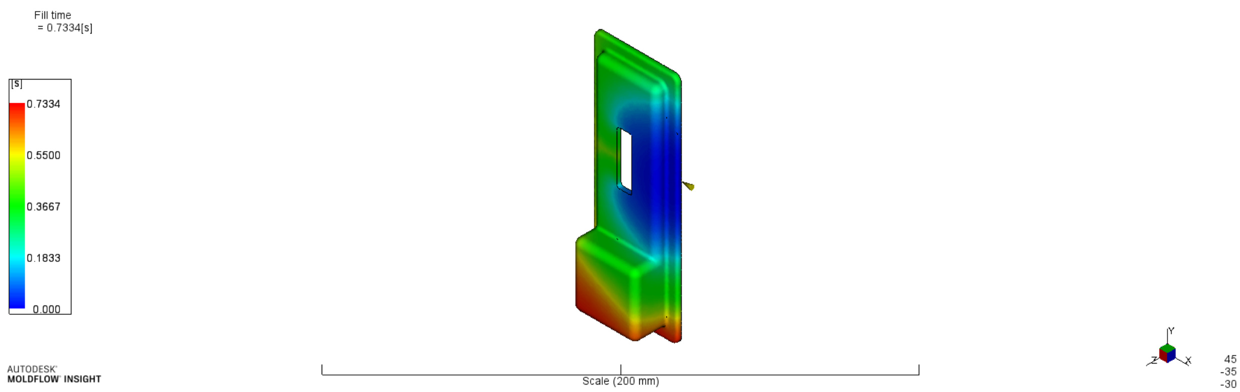
As explained above, by using simulations from Moldflow, part 1 in combination with gate 1 will be the optimum choice. This option provides the most uniform polymer flow through the part, consequently providing uniform properties as well. While imperfections like knit lines and warpage will still be present in the final product, their negative effect in other options will be greater. When a knit line spans the part, that line will most likely be compromised. Warpage in a part will always occur, being able to mitigate the warpage is the challenge. Sink marks can be minimized with a constant flow of polymer into the mold. If the gate location is chosen in a suboptimal spot the polymer may struggle to pack the mold completely. For the decision between part one or two, Moldflow is not required but good support. For a plastic part to have optimal properties and minimal defects, a uniform nominal wall needs to be maintained. By testing a multitude of options and observing their results an idea of how the part will form in the real world can be assembled.

Fill time

Part 1: Uniform Block w/ Blends and Slot







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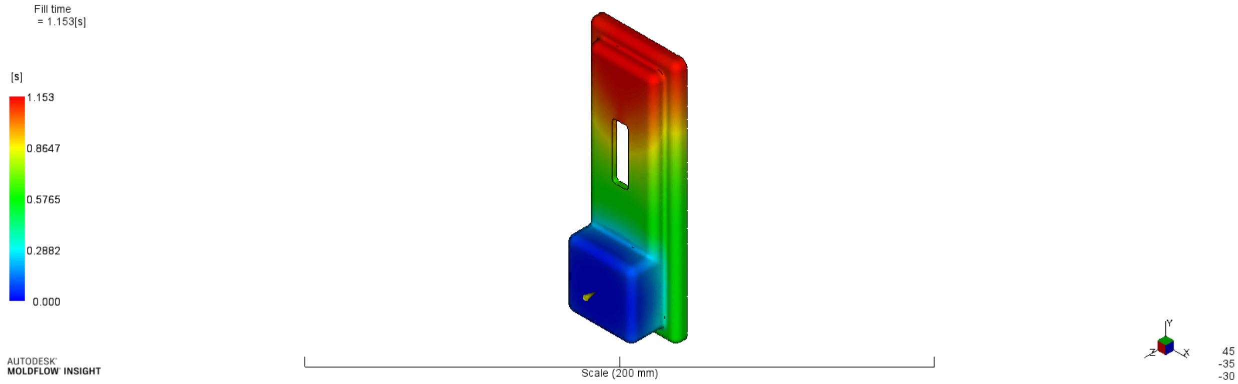
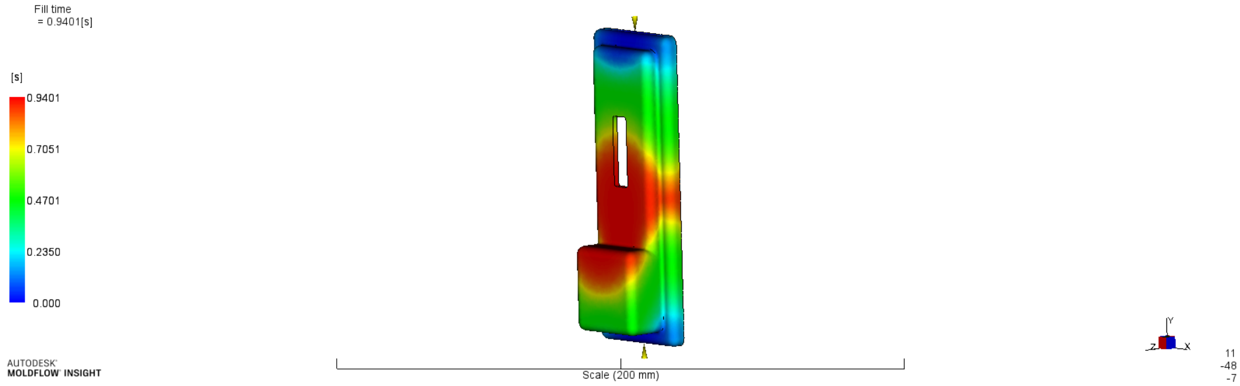
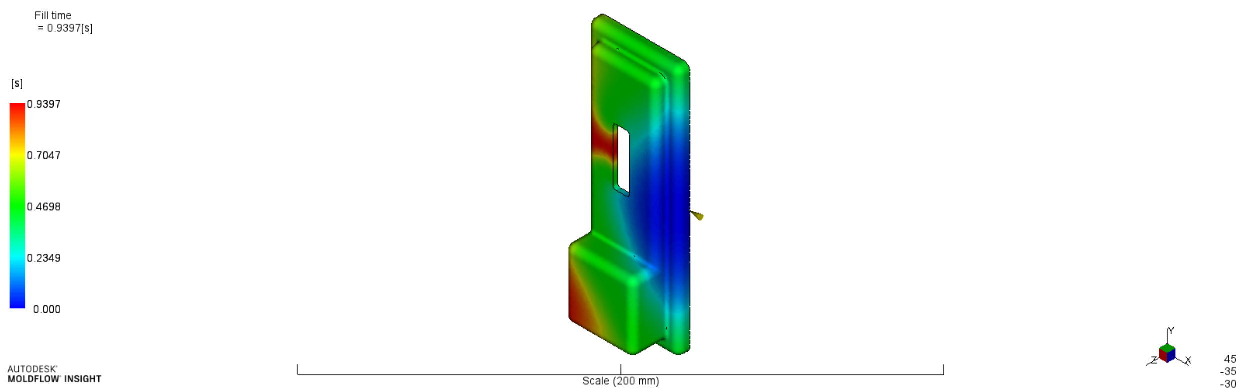
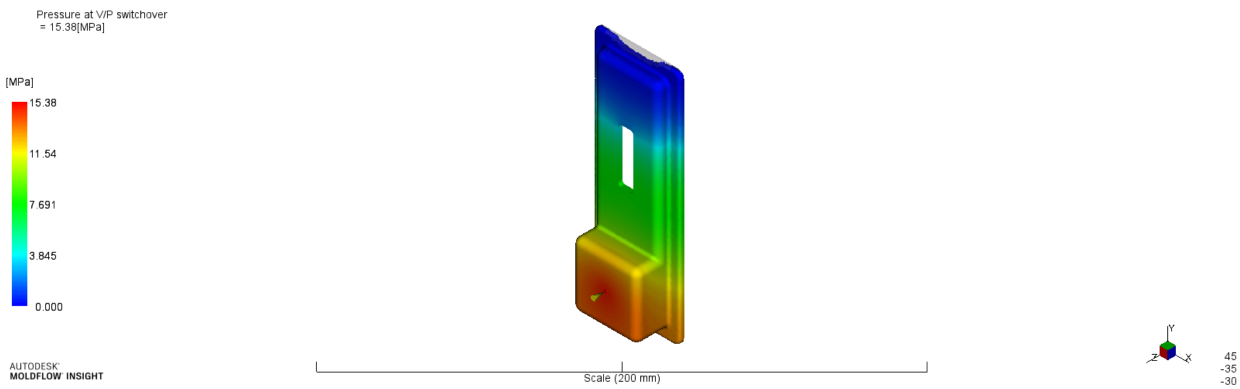


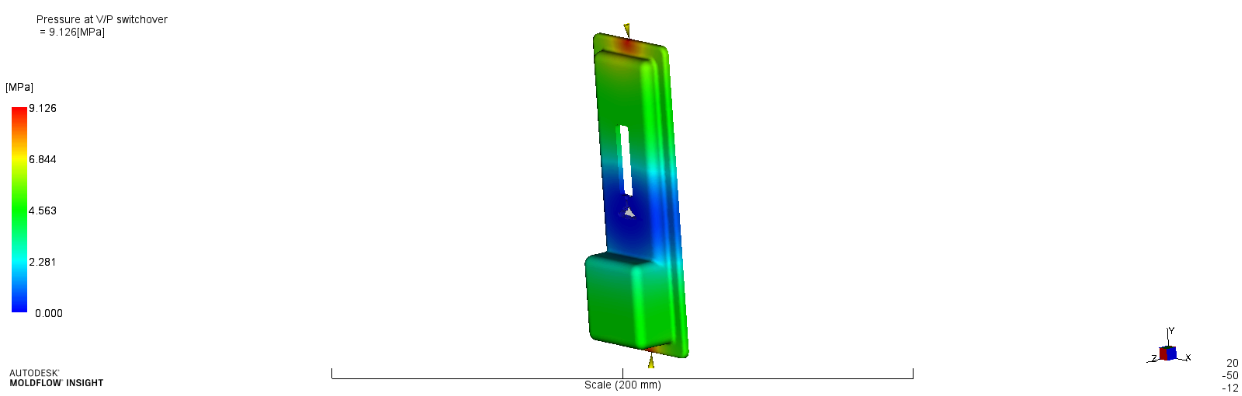


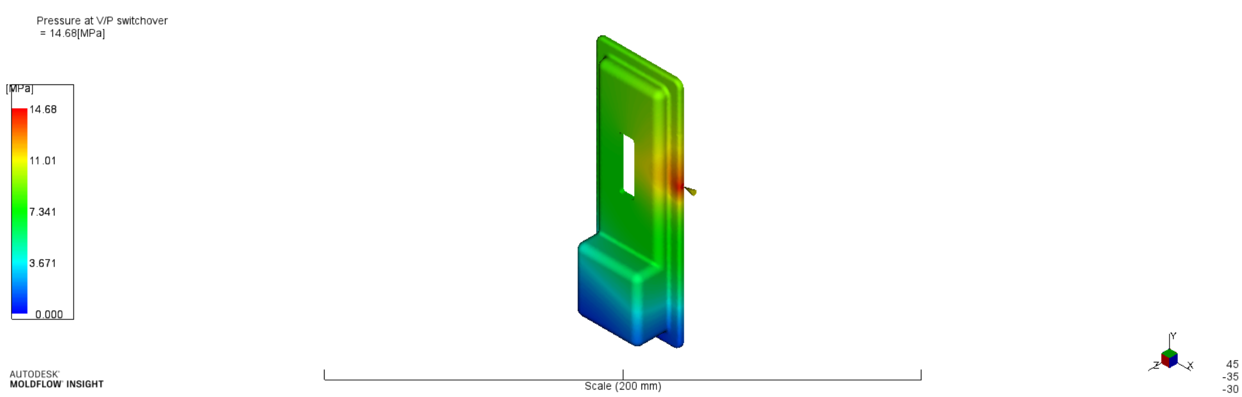


Pressure at V/P switchover

Part 1: Uniform Block w/ Blends and Slot







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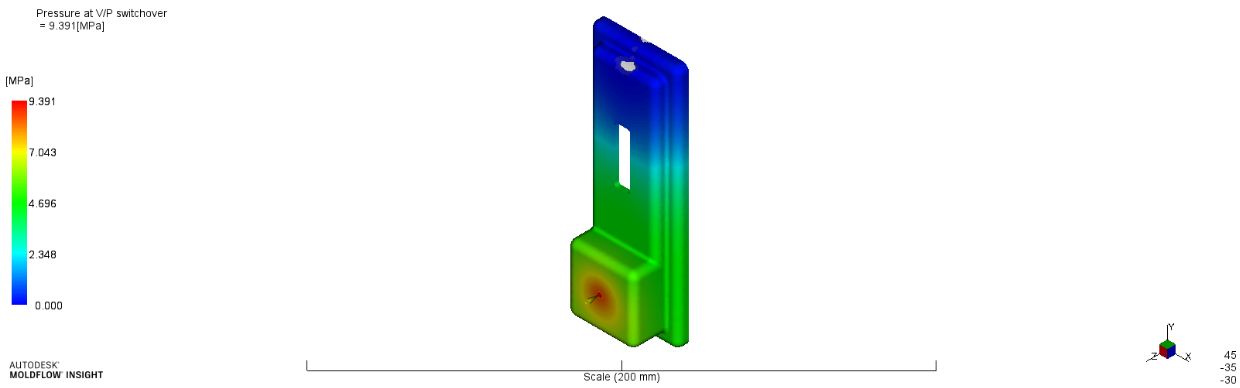
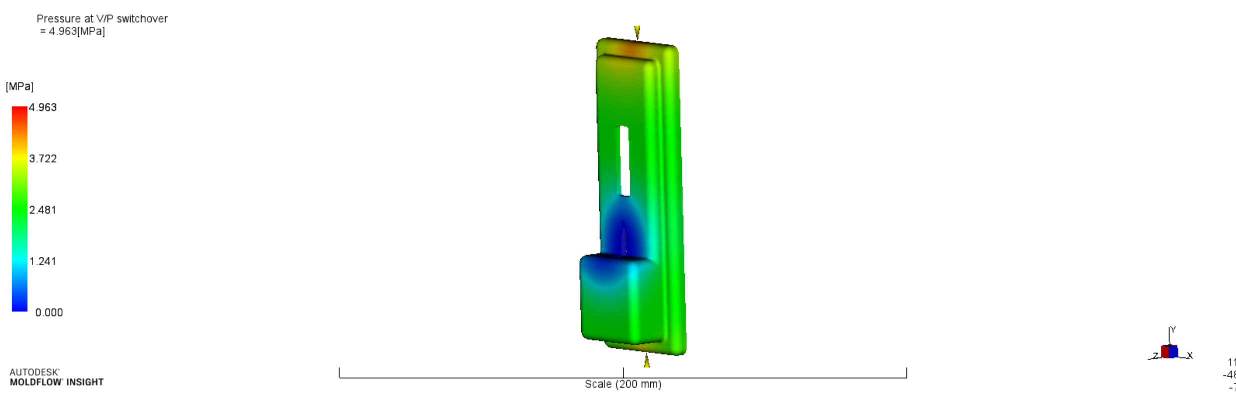
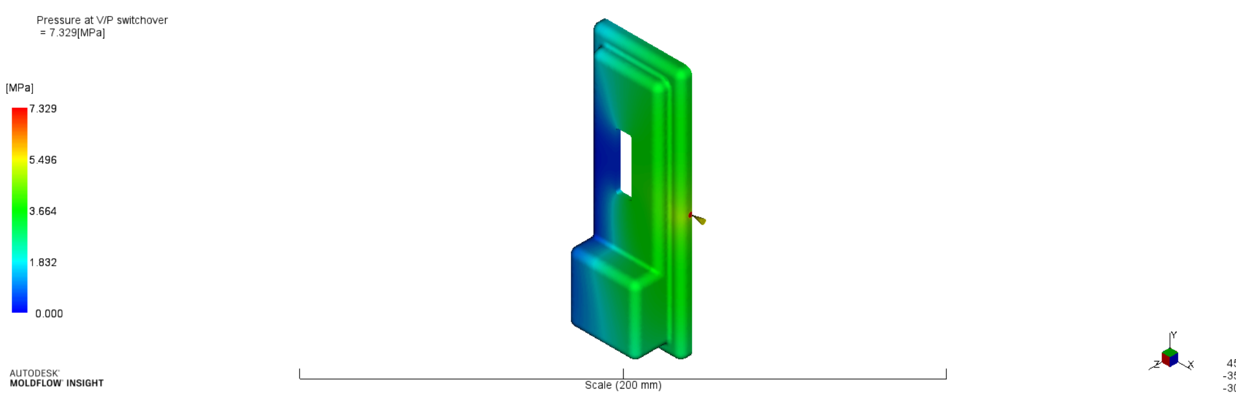
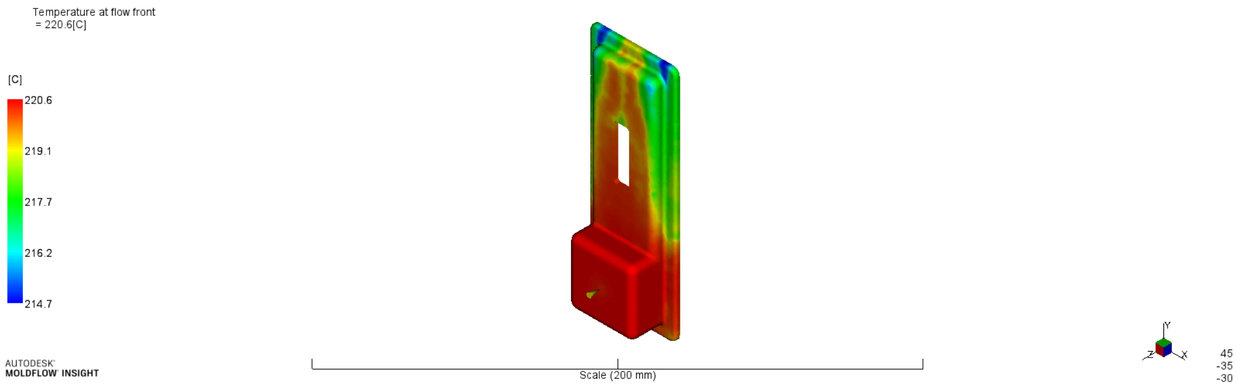


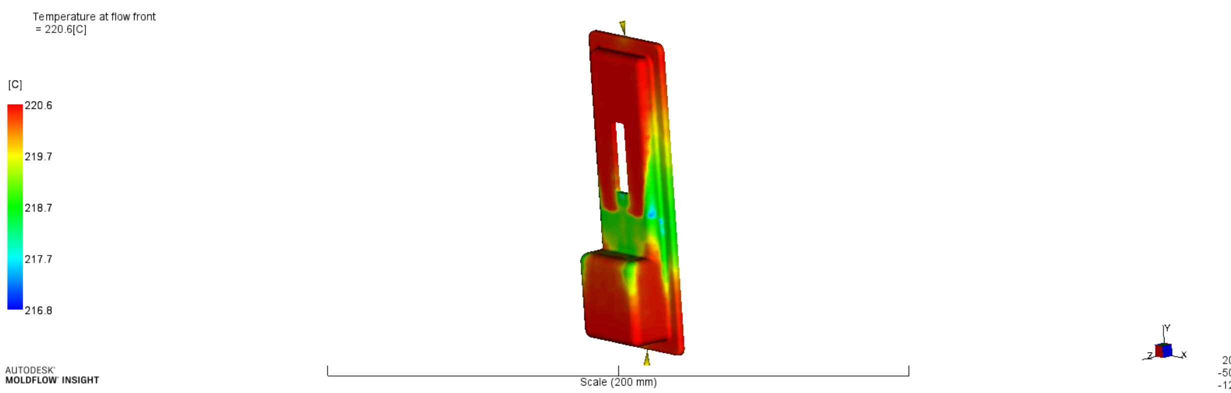


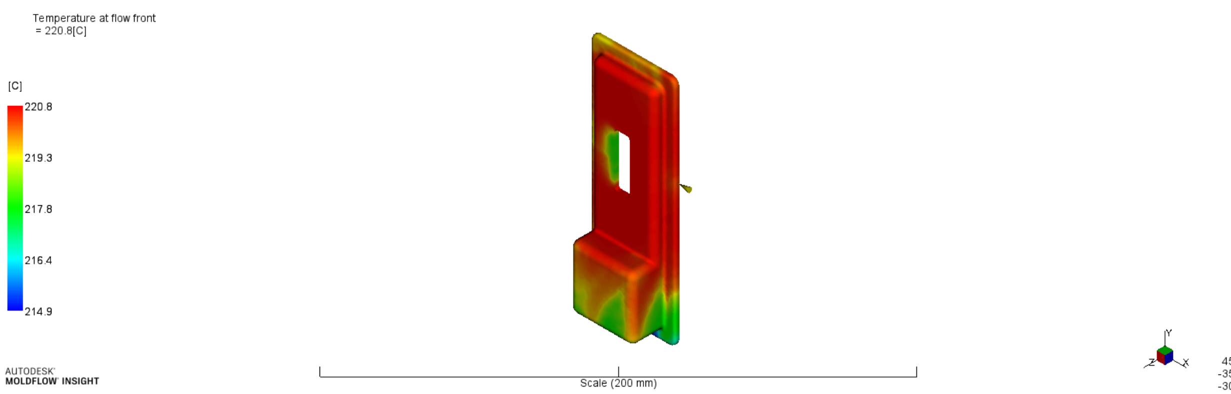


Temperature at flow front

Part 1: Uniform Block w/ Blends and Slot







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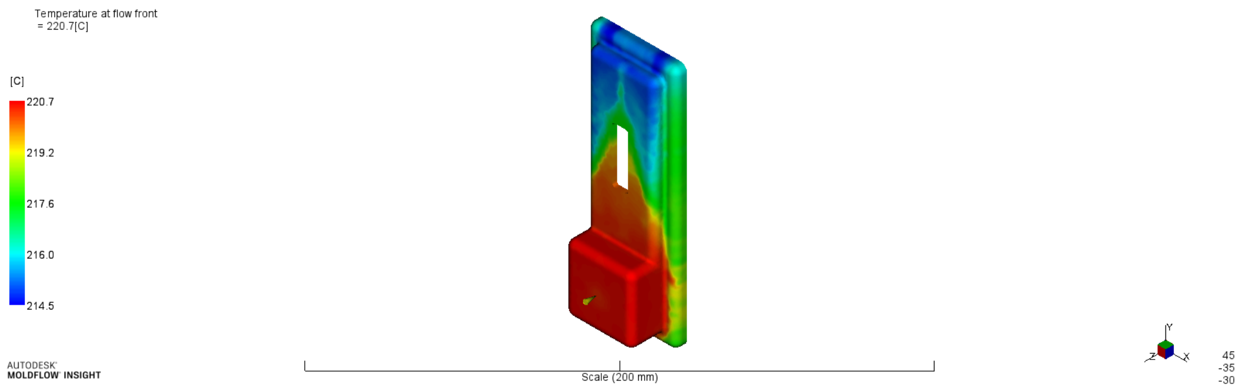
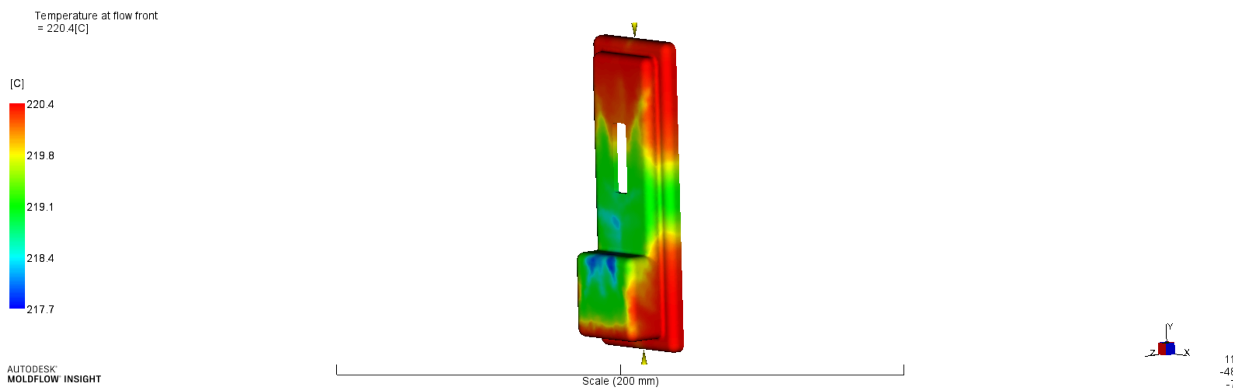
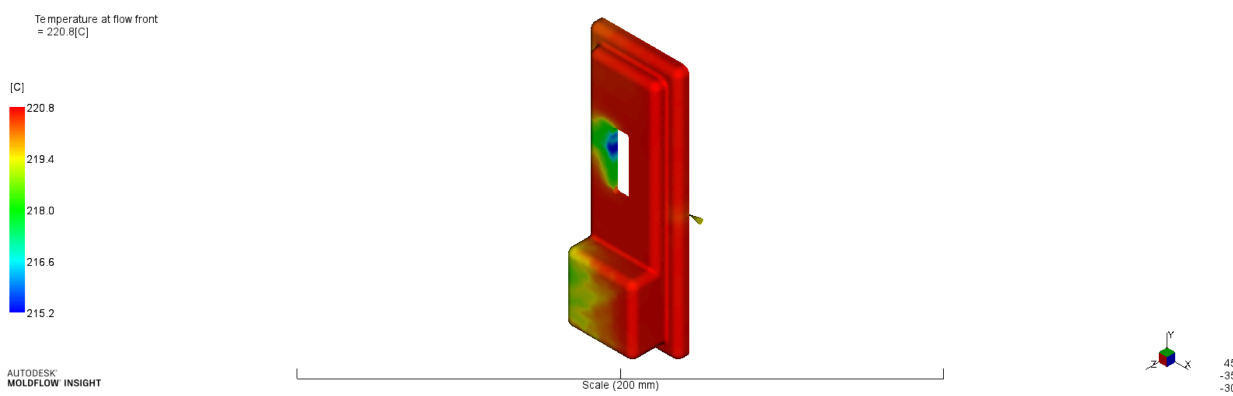
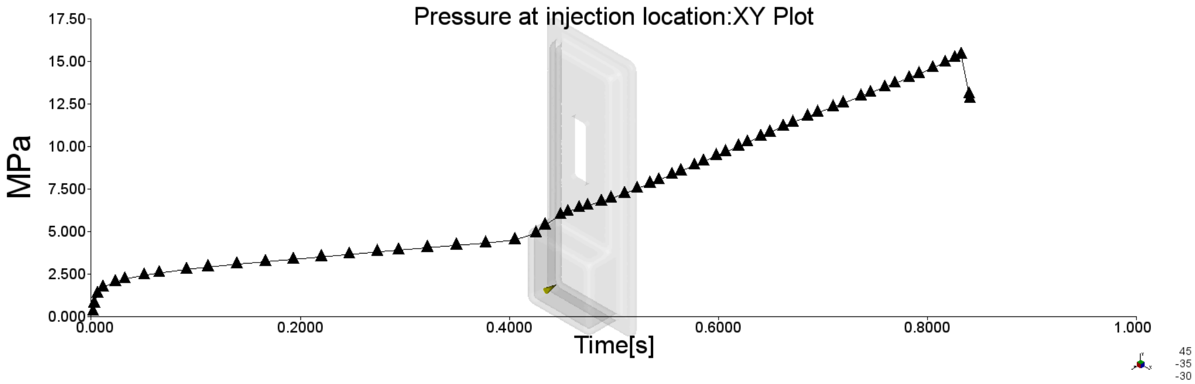


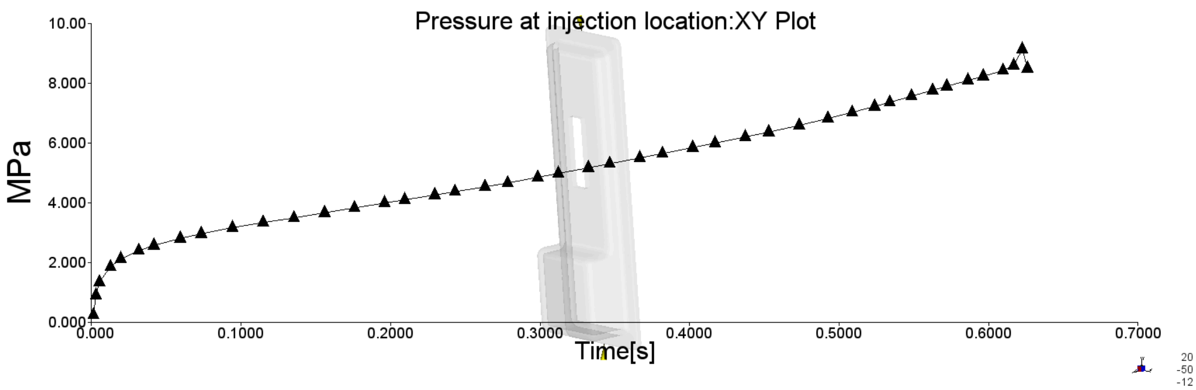


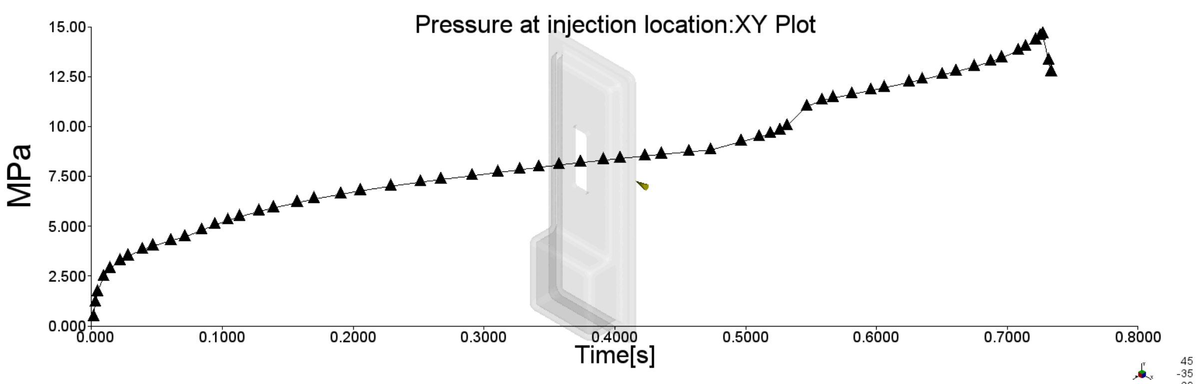


Pressure at injection location XY plot

Part 1: Uniform Block w/ Blends and Slot







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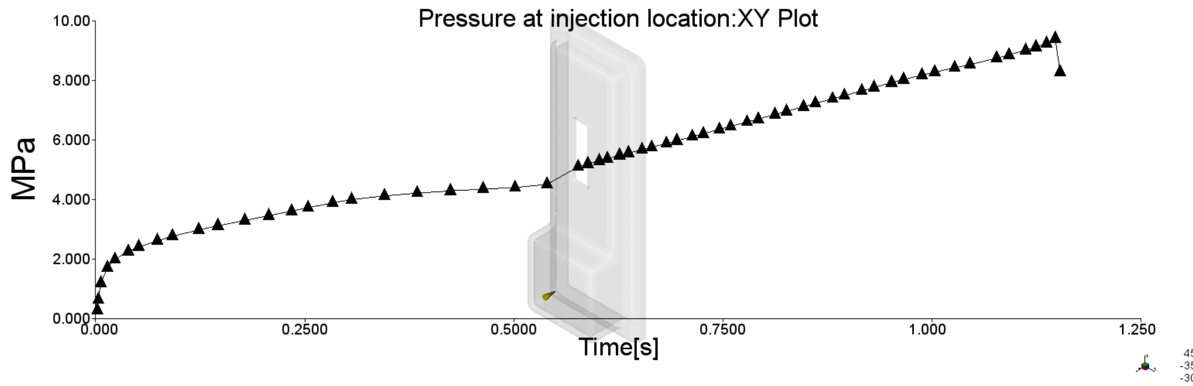
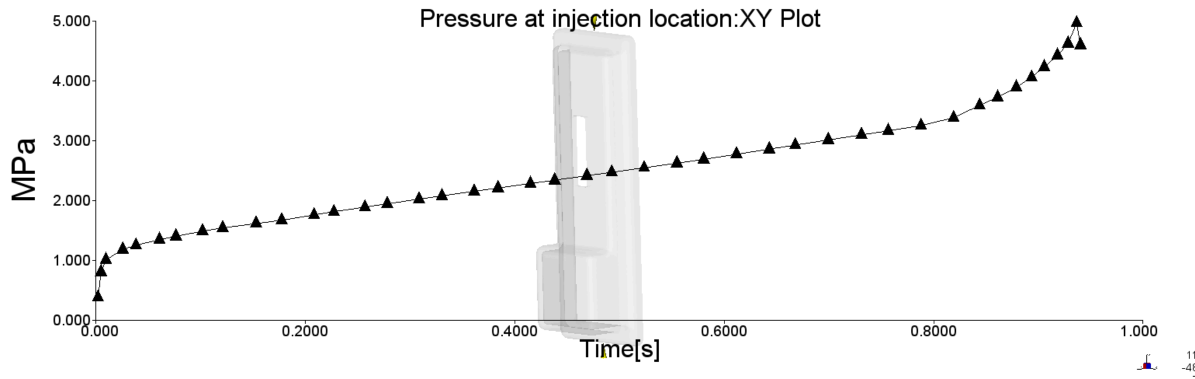
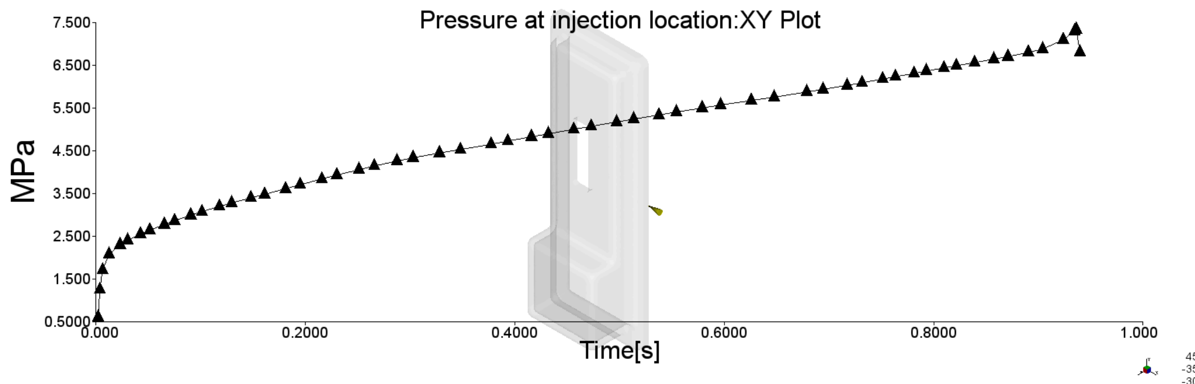
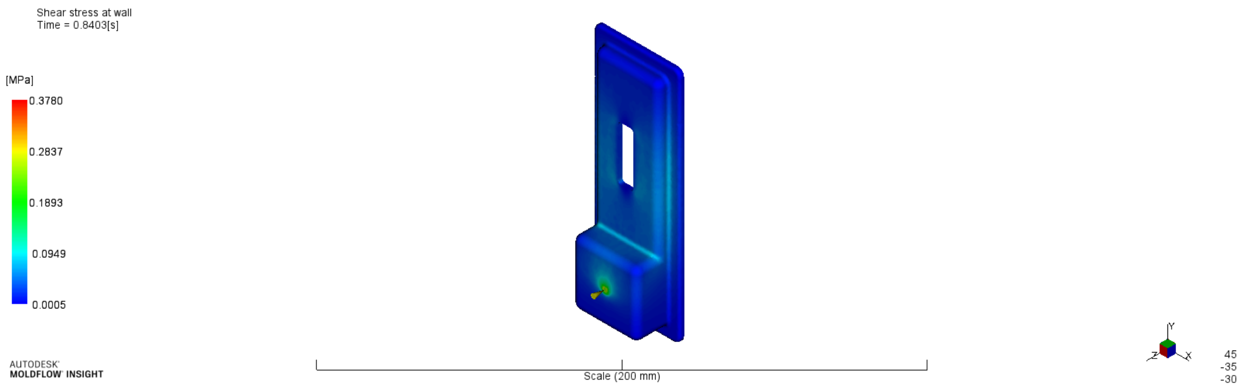
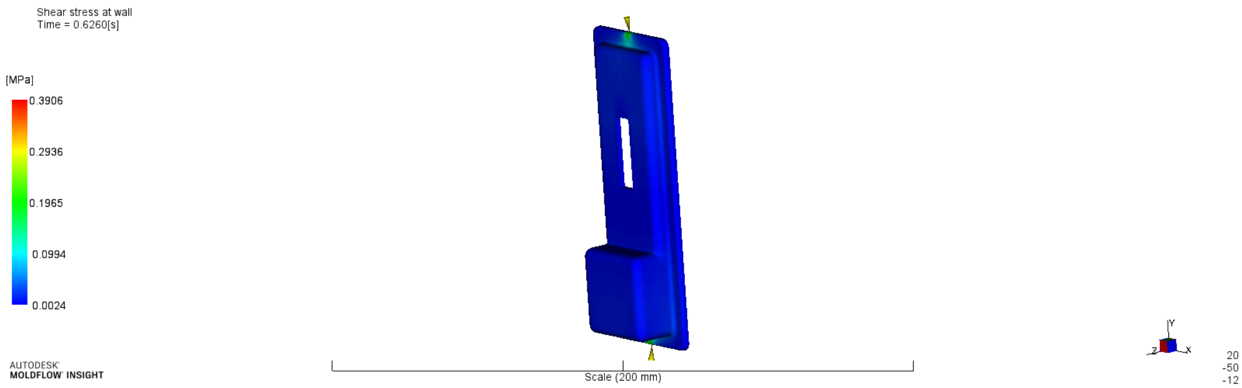


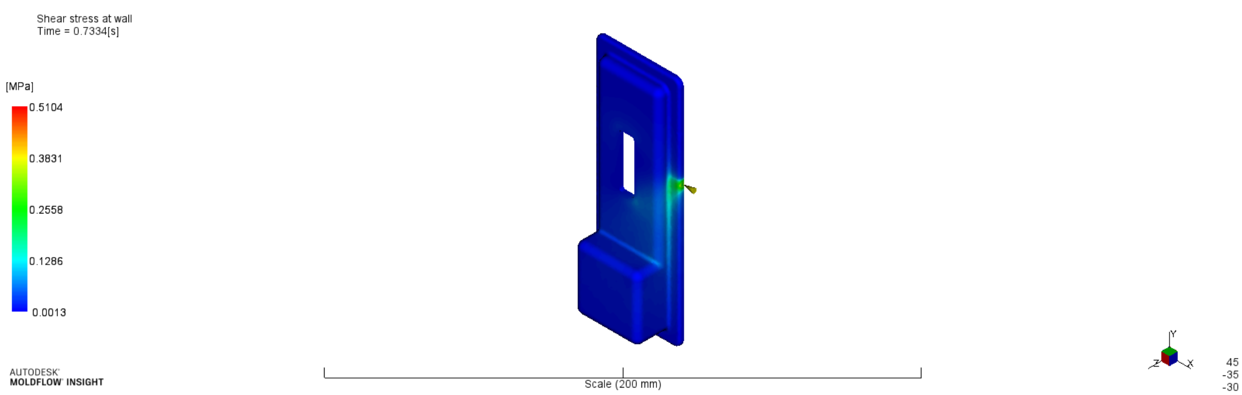




Shear stress at wall







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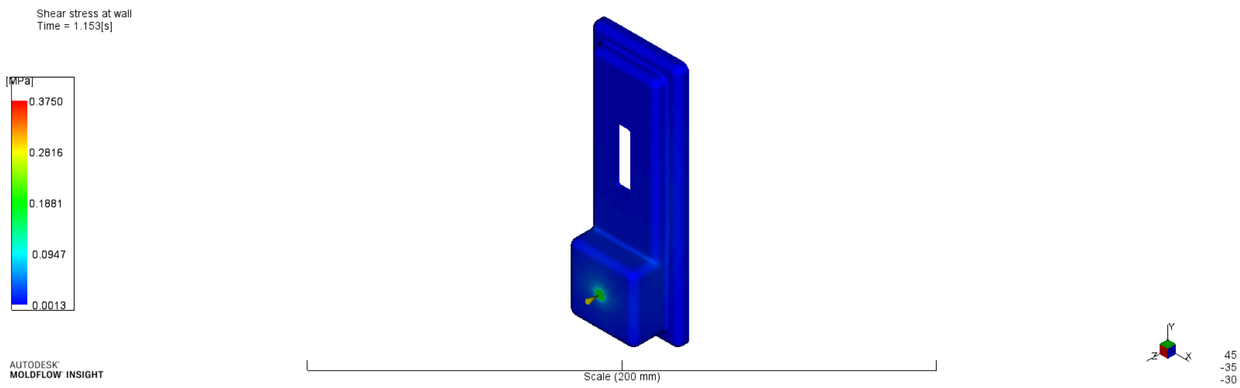

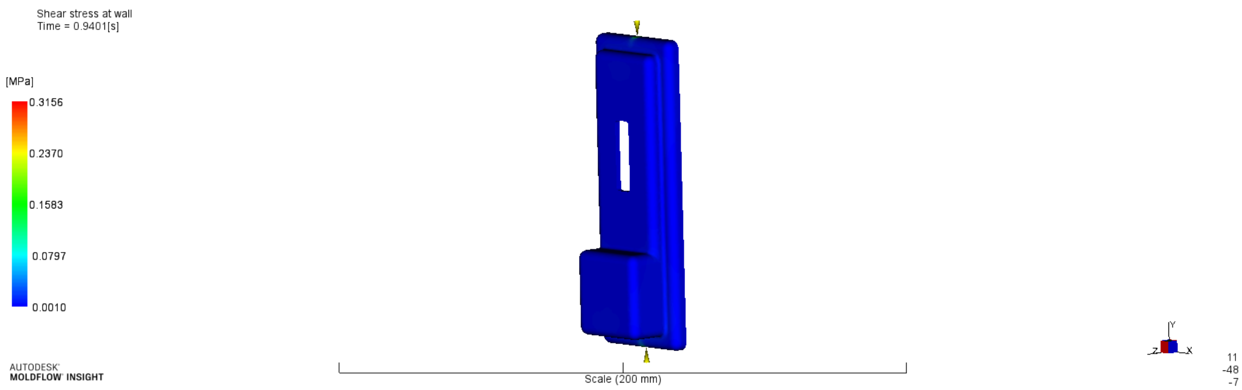

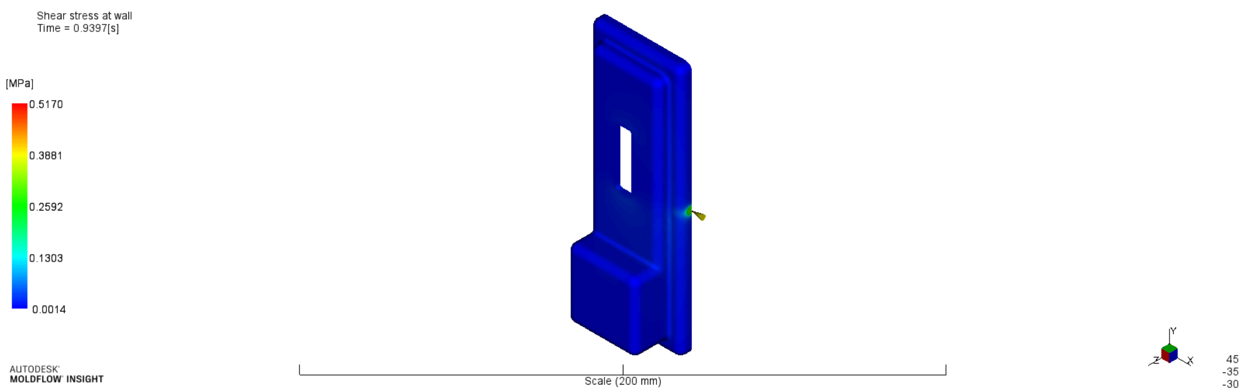

Pressure at end of fill

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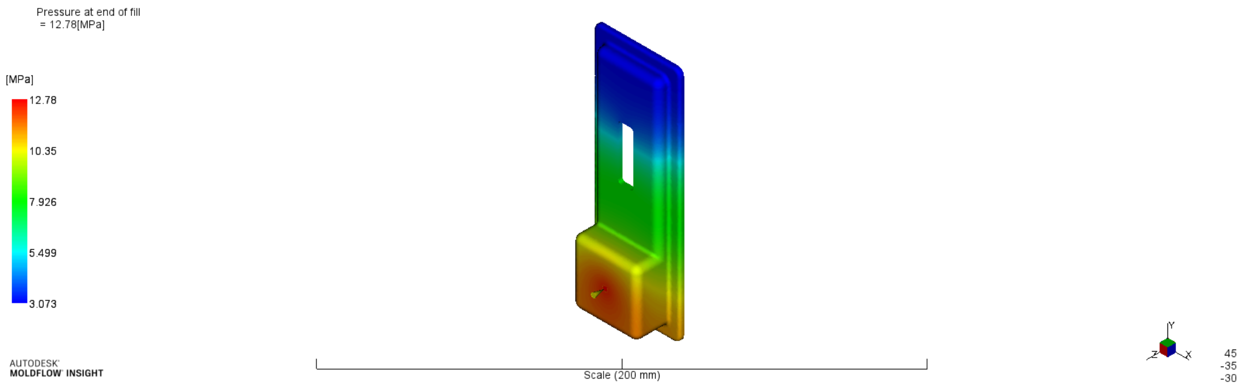

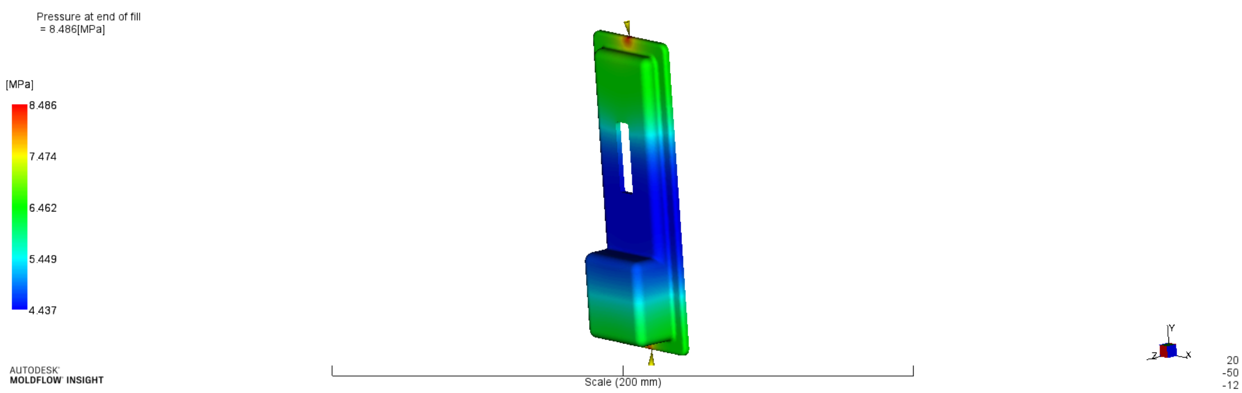

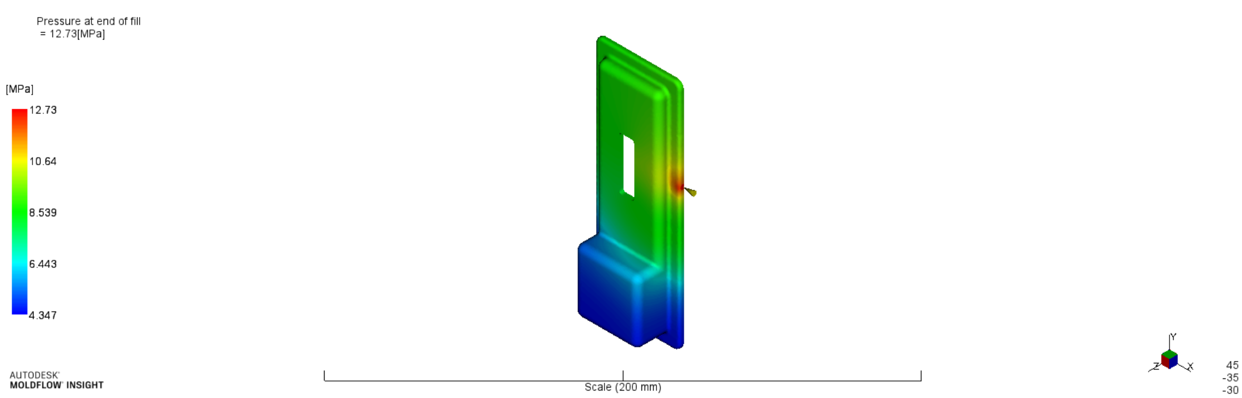

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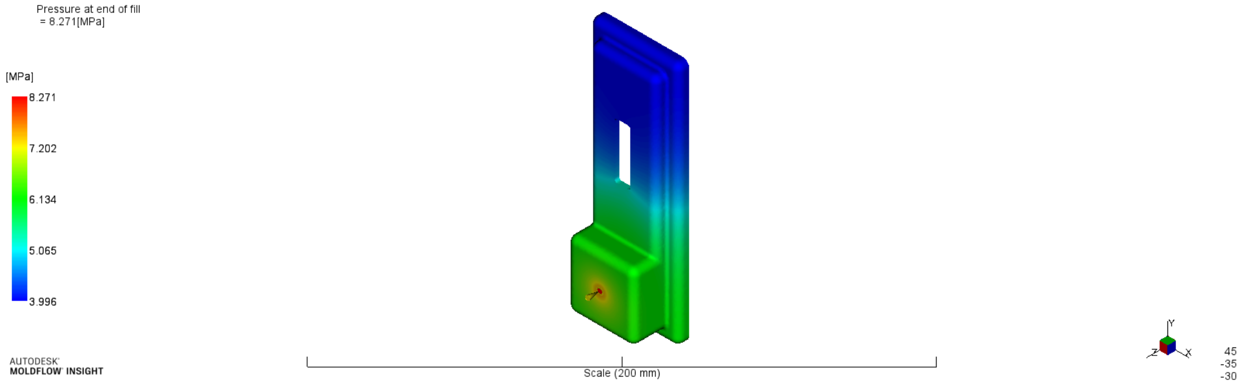
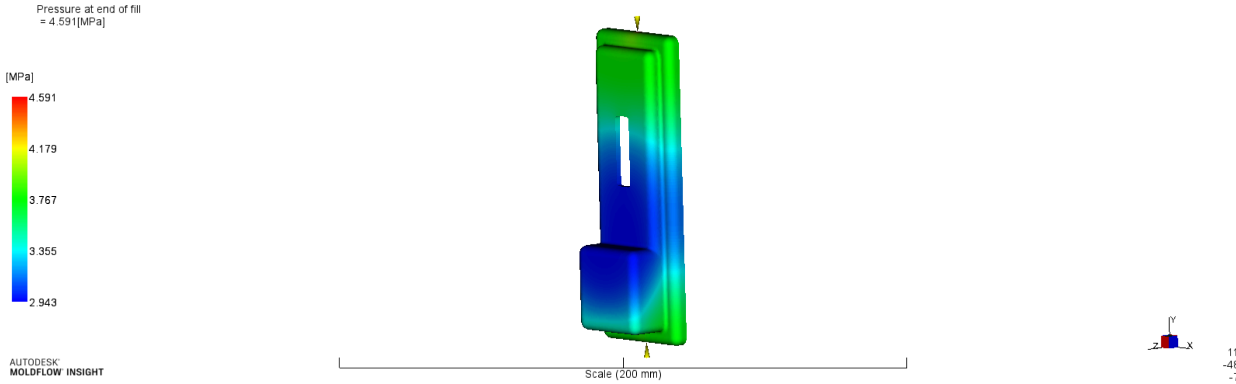
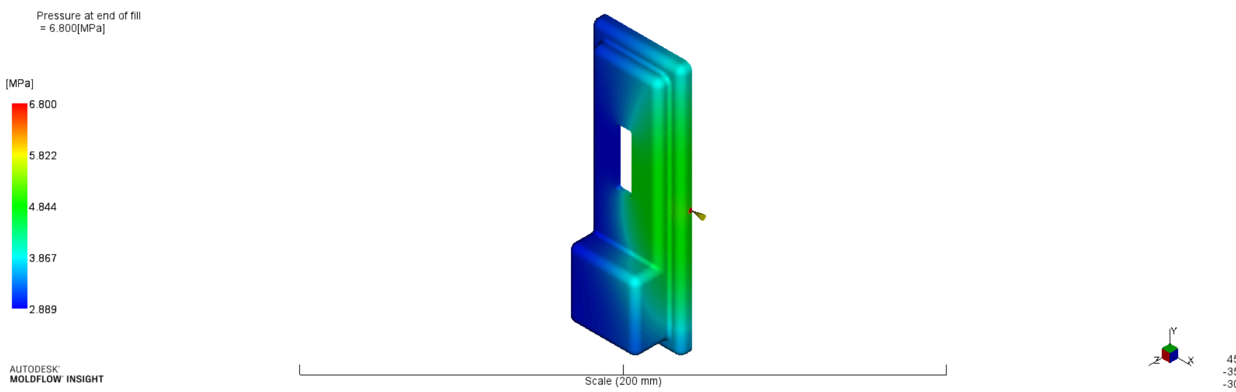
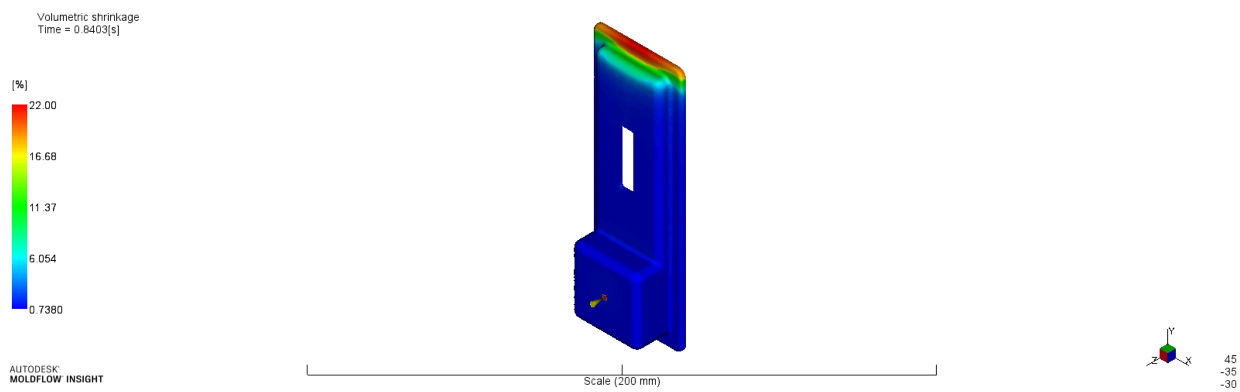


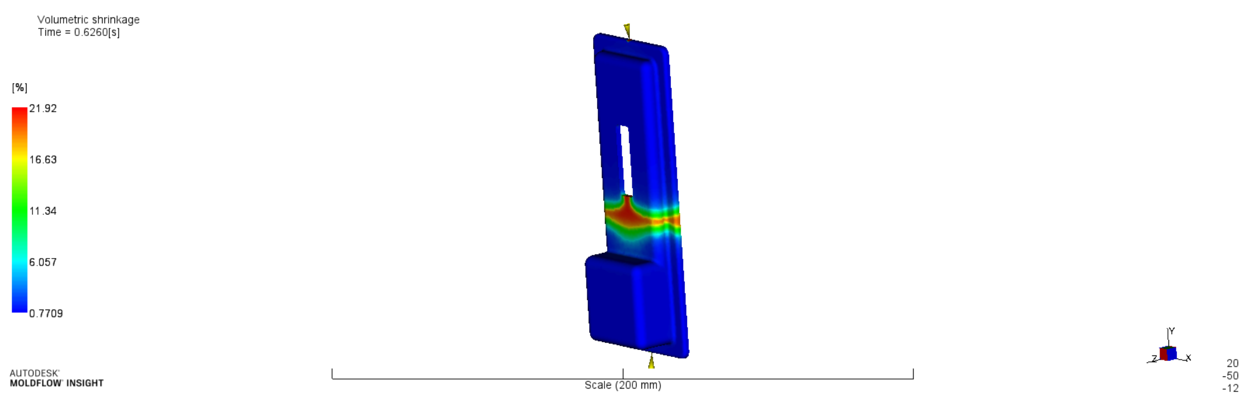


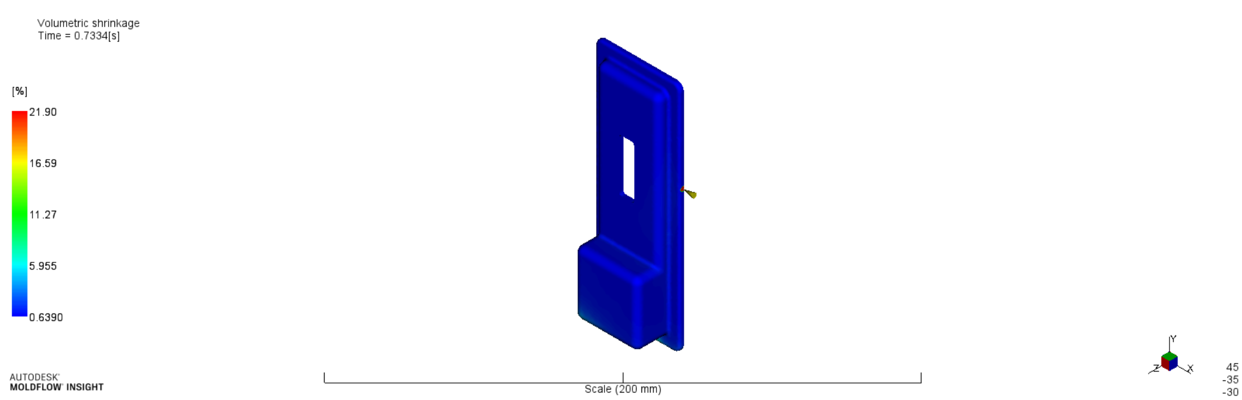


Volumetric shrinkage

Part 1: Uniform Block w/ Blends and Slot







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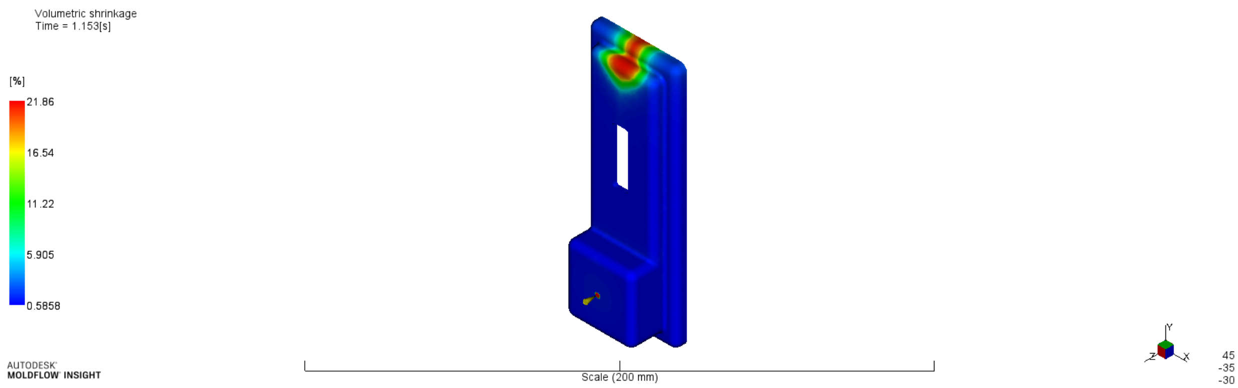
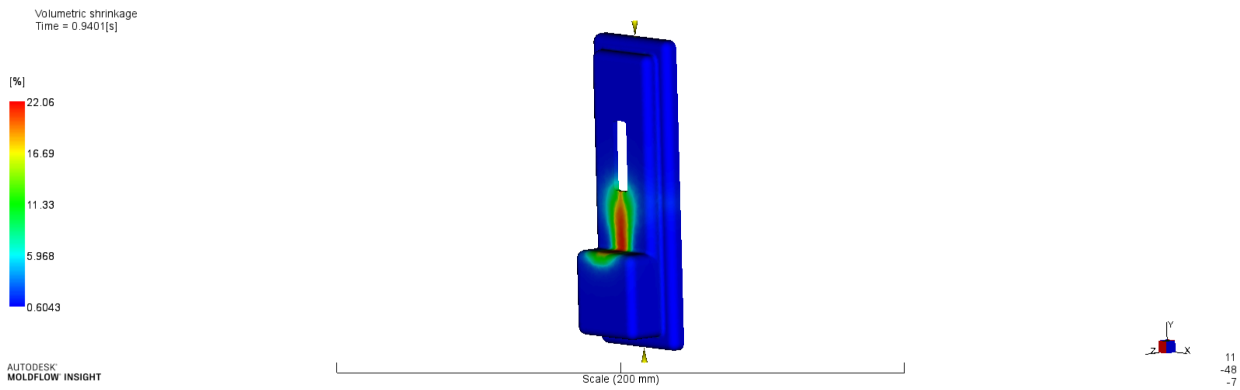
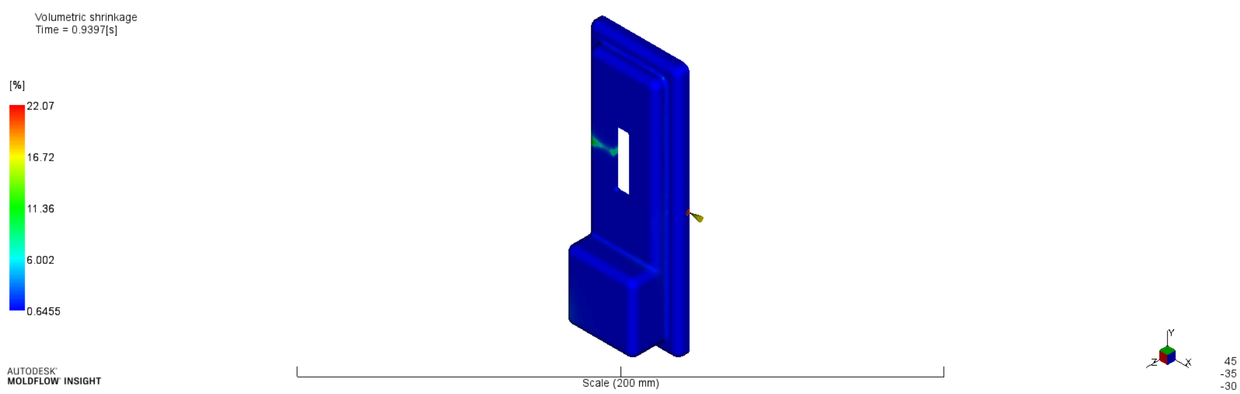
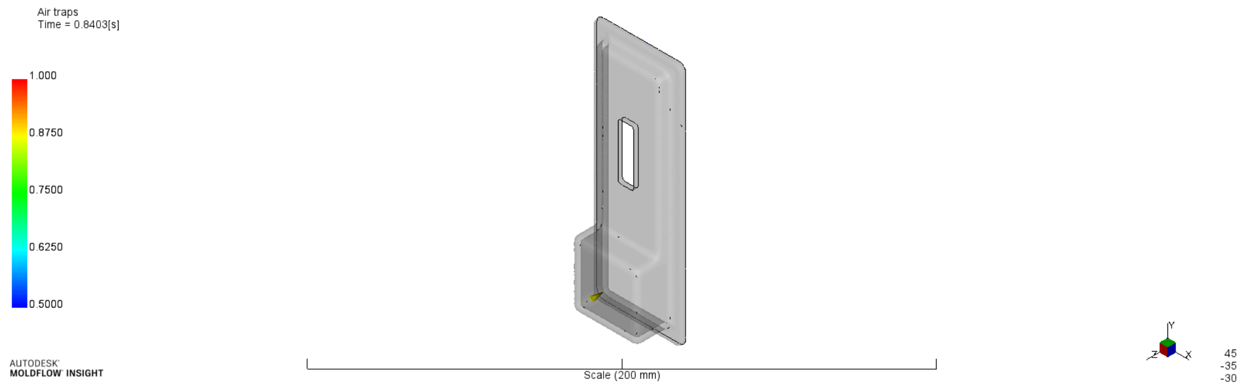


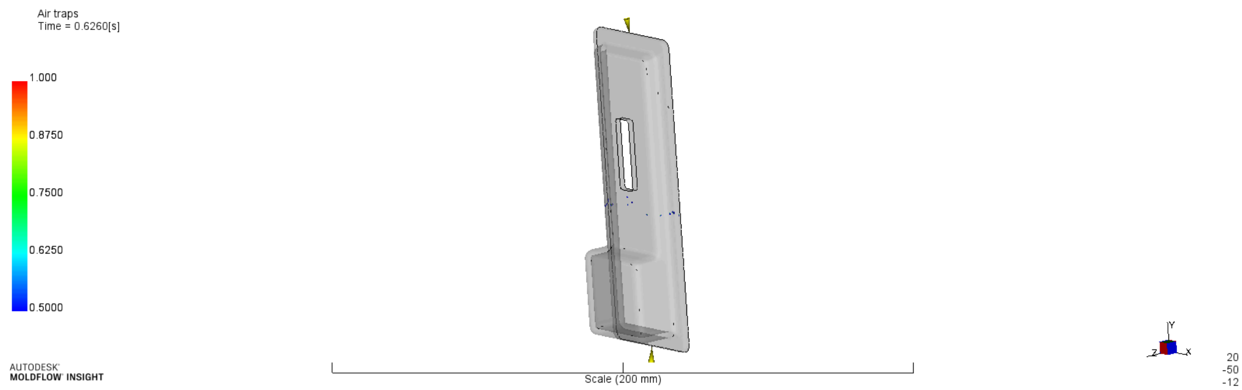


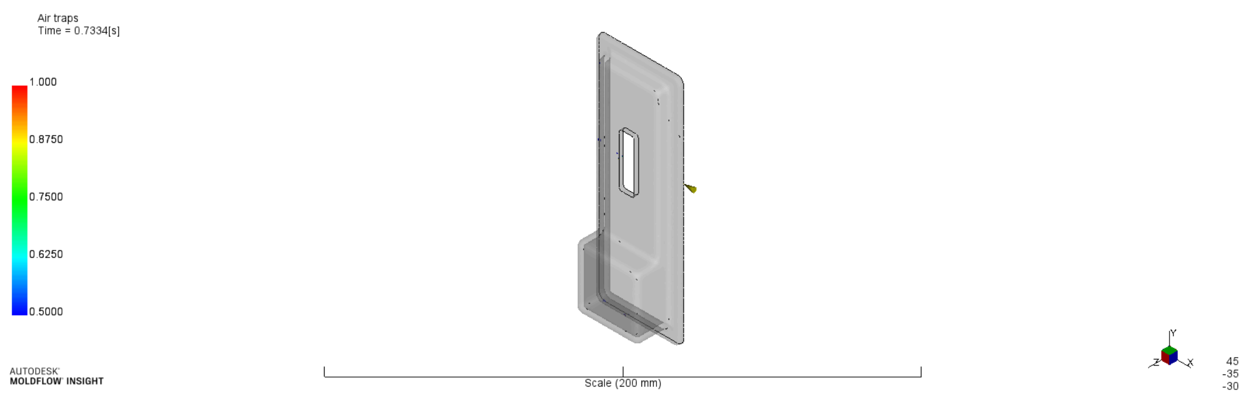


Air traps

Part 1: Uniform Block w/ Blends and Slot







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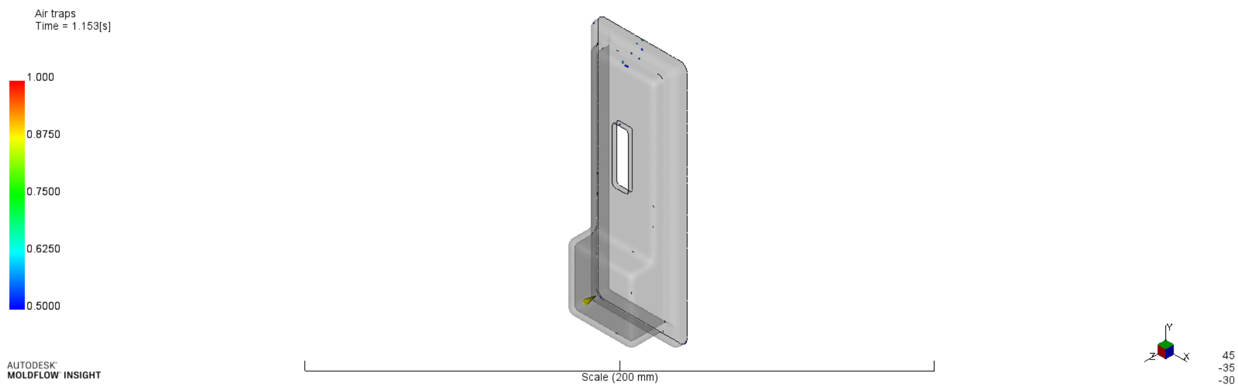
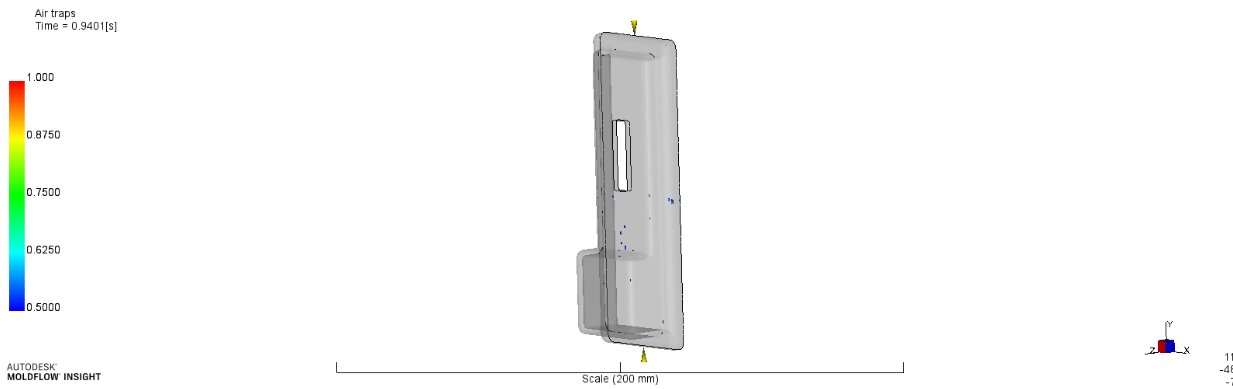
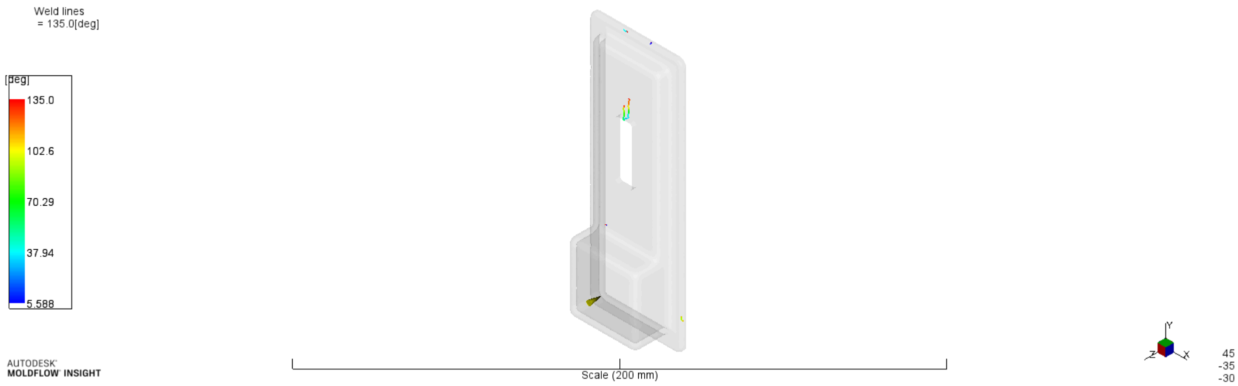
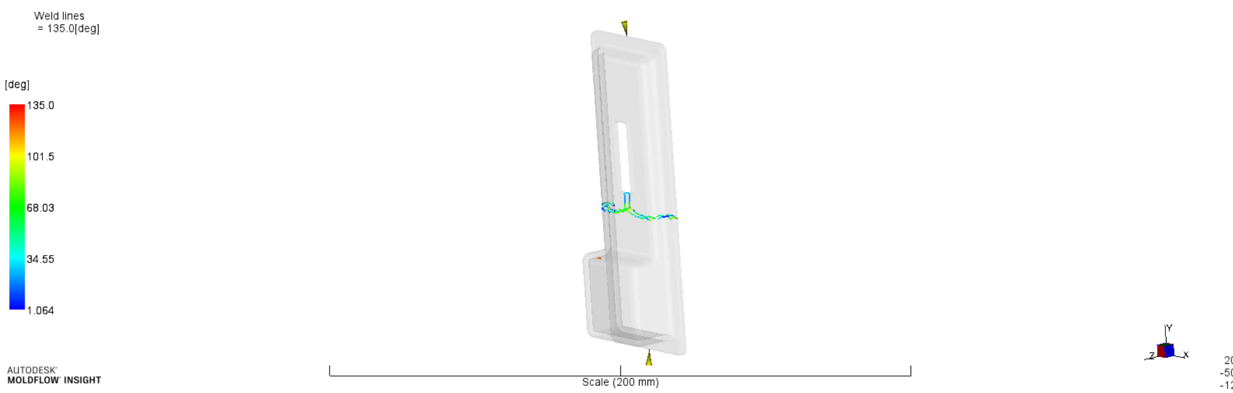


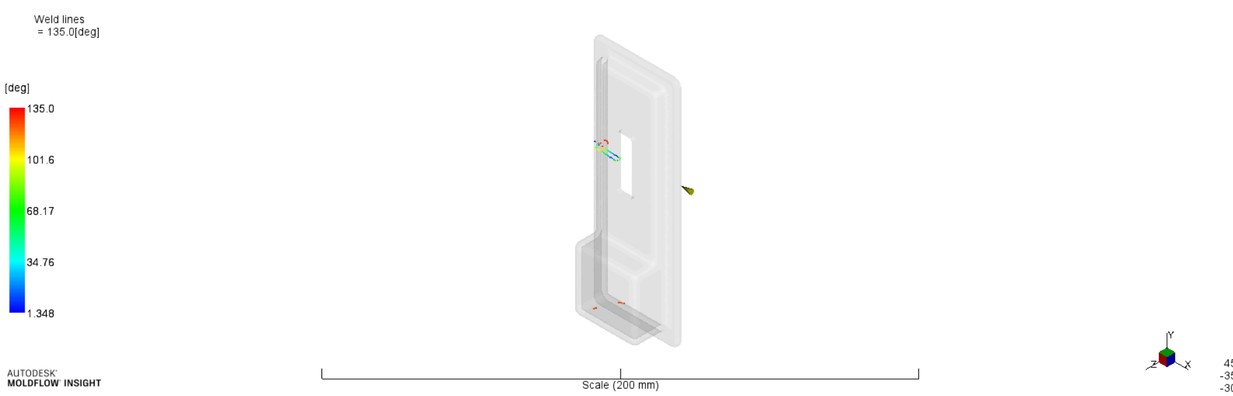


Weld lines

Part 1: Uniform Block w/ Blends and Slot







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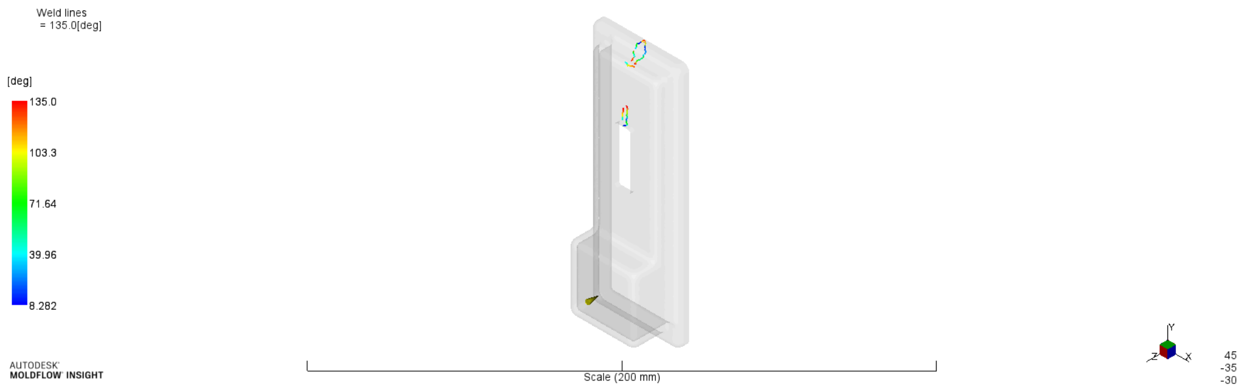
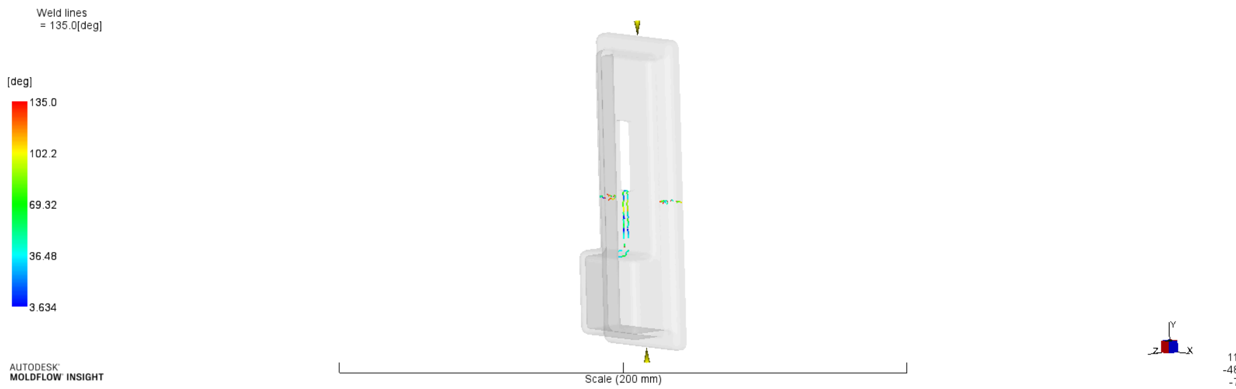
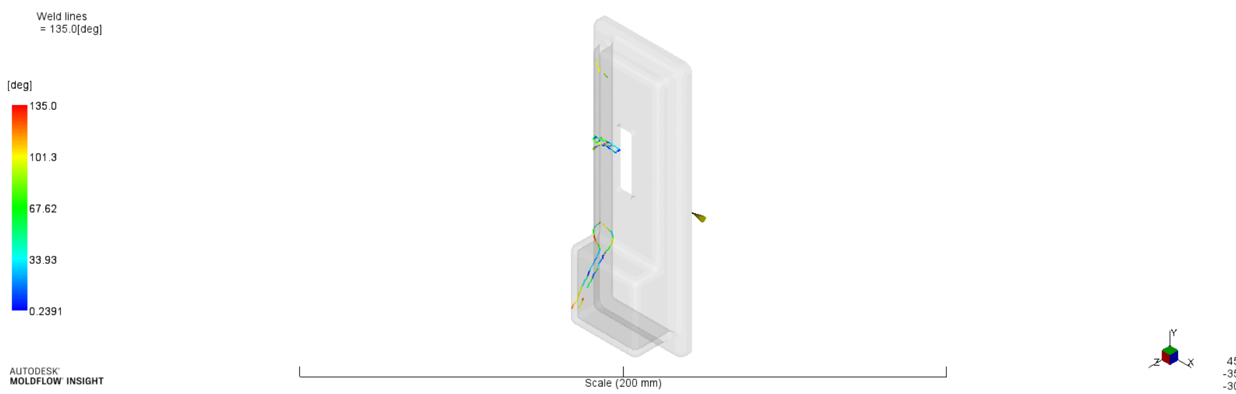
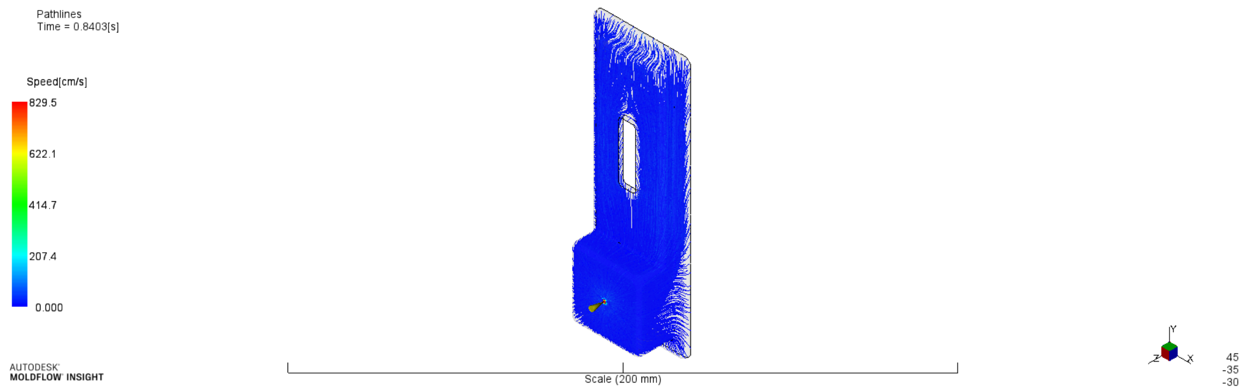


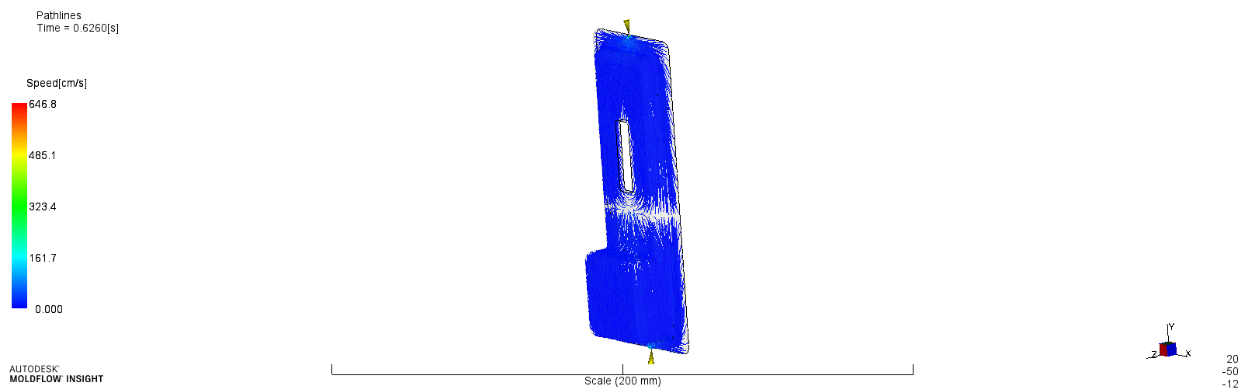


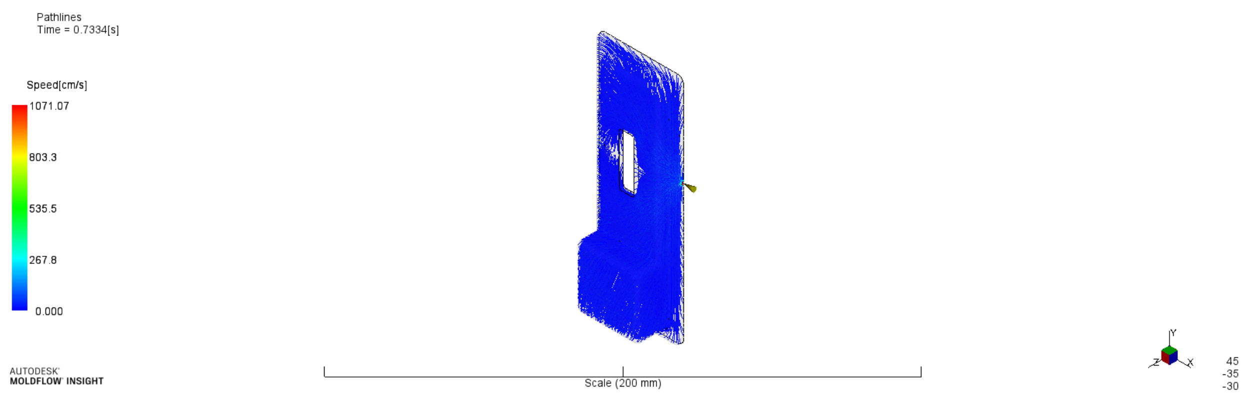


Path lines

Part 1: Uniform Block w/ Blends and Slot







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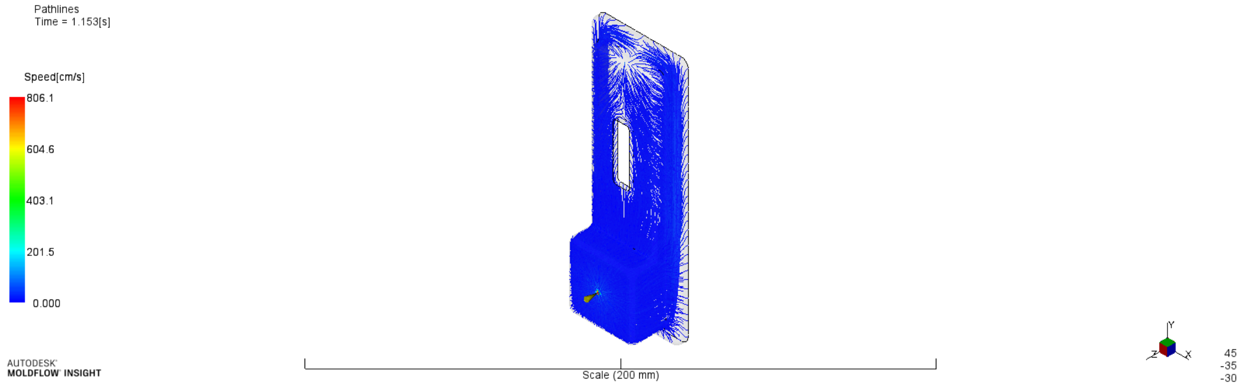
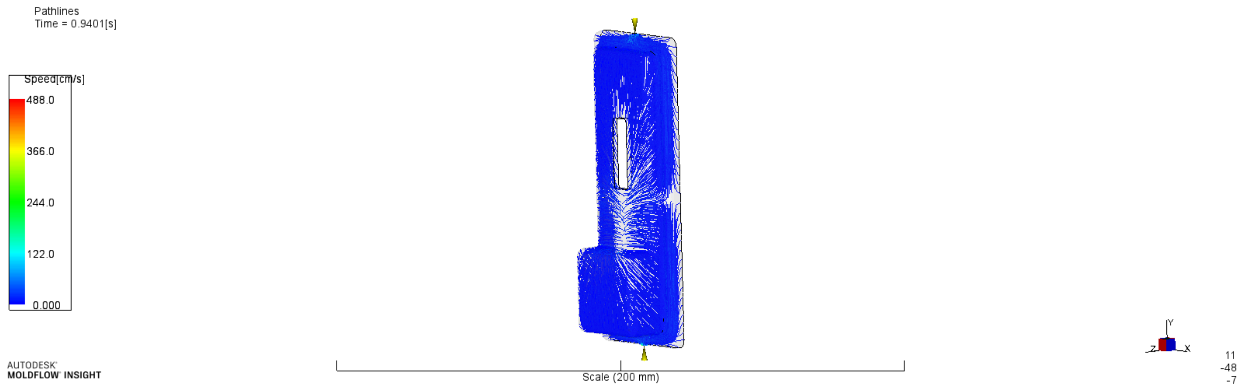
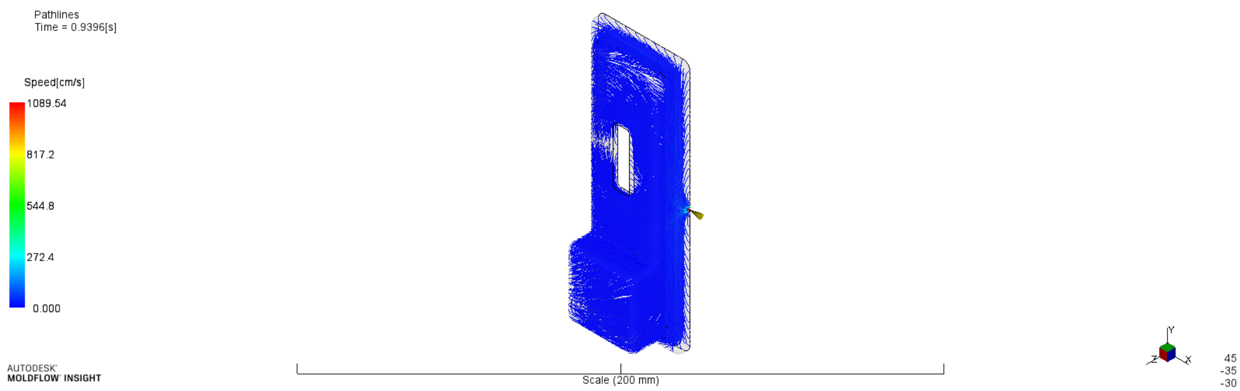
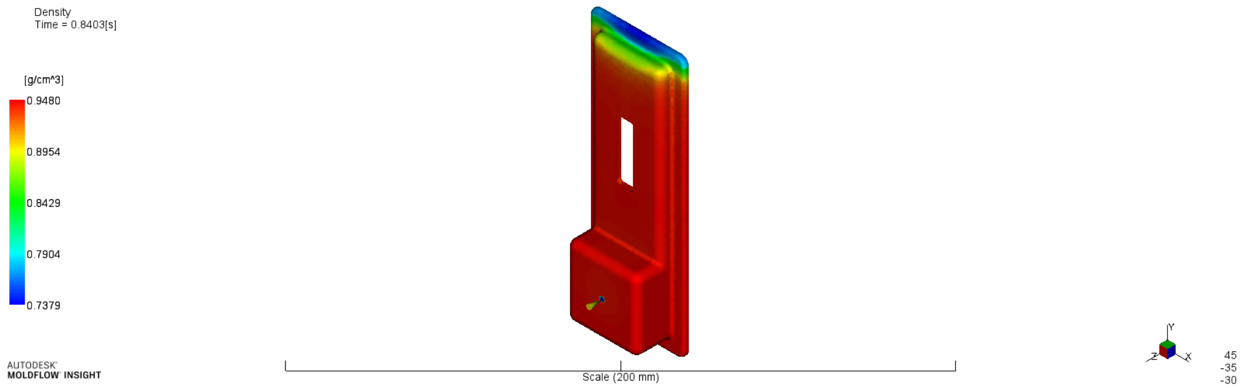


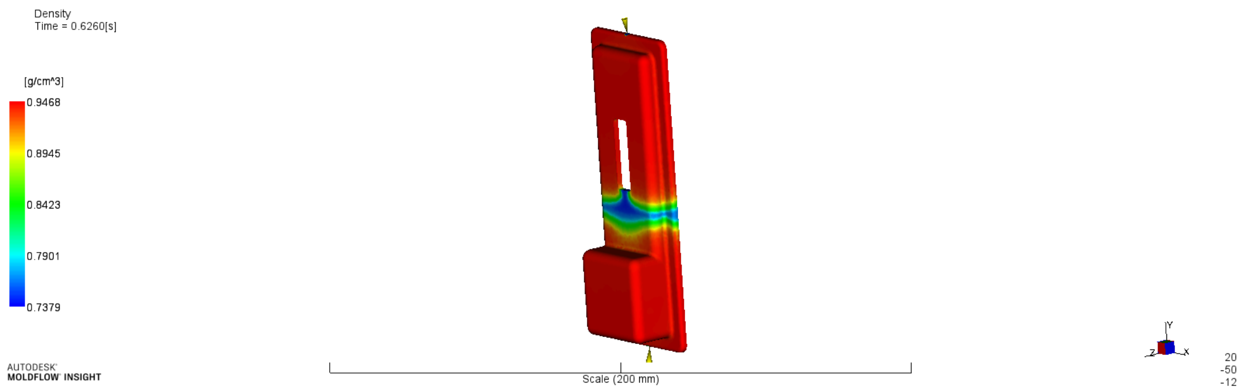


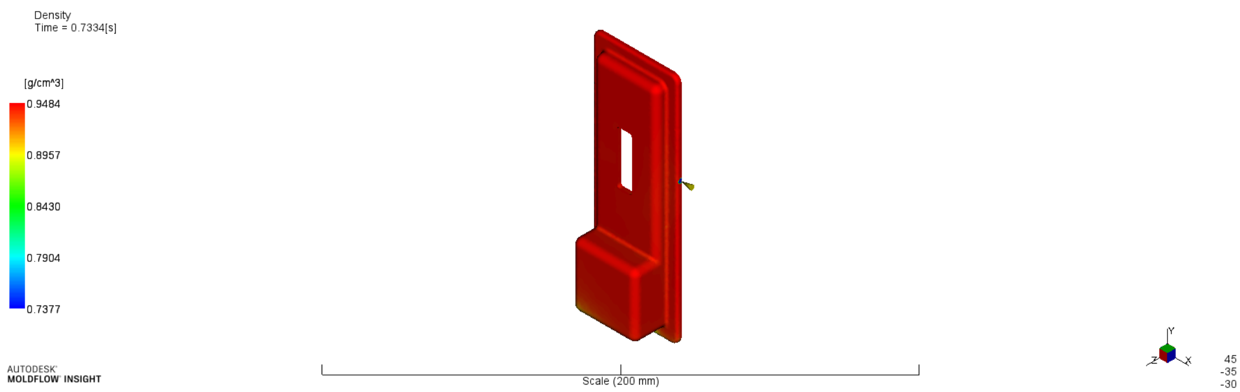


Density

Part 1: Uniform Block w/ Blends and Slot







Part 2: Block Shorter w/ Blends and Slot