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Metal Injection Molding with Hot Runner Systems: A Direct Injection Approach

Oerlikon HRS
Luisa Barbisan

Moldex3D

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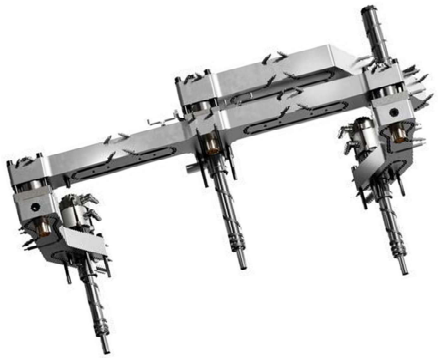
Division Flow Control - Oerlikon HRSflow



Division Flow Control
Oerlikon HRSflow

Polymer Processing Solutions Division

A key enabler for a sustainable polymer processing industry with a focus on manmade fiber plant engineering and flow control equipment solutions.

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Oerlikon HRSflow Know How

360°
PLASTIC INJECTION
KNOW HOW

Division Flow Control - Oerlikon HRSflow

Our Worldwide presence

- 3 production plants (Europe, America, Asia)
- 1035 employees worldwide
- 52 branches worldwide
- 5 CAE calculation pools

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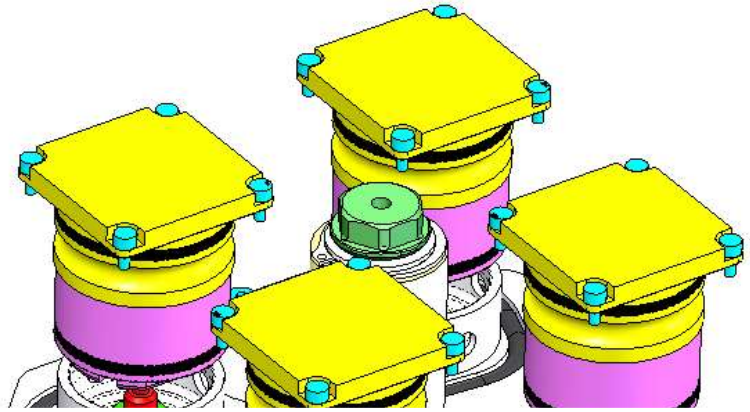
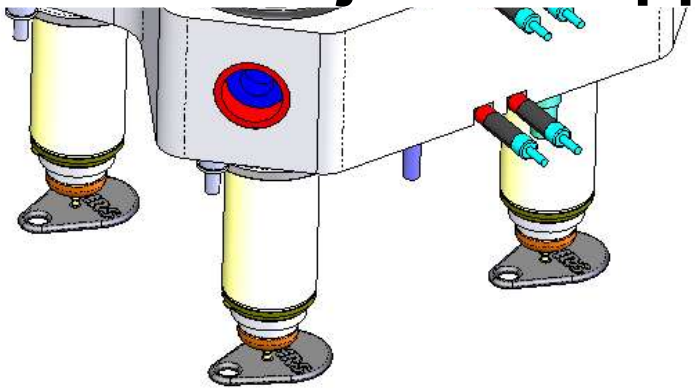


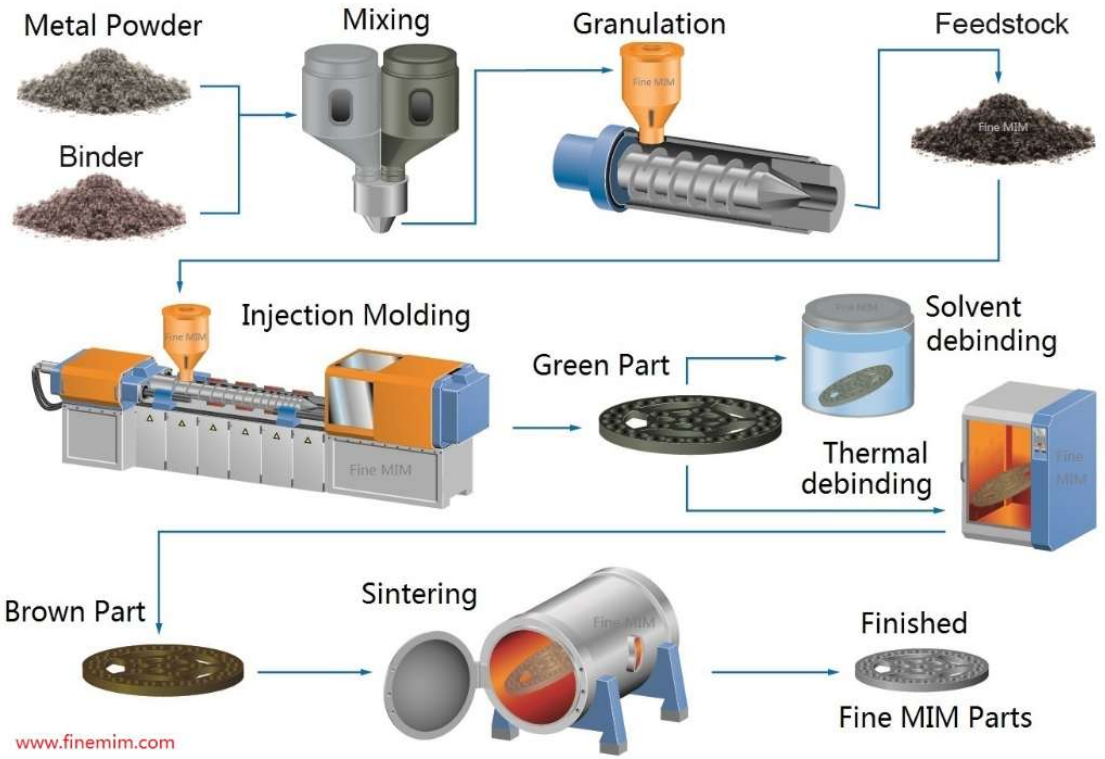
Metal Injection Molding with Hot Runner Systems:

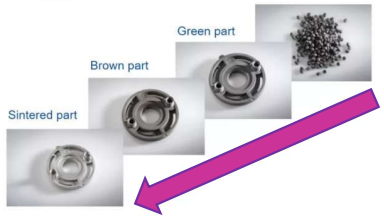
A Direct Injection Approach



Metal Injection Molding

MIM is a process that merges two established technologies: plastic injection molding and powdered metallurgy. It offers a manufacturing capability of producing precise and complex part.

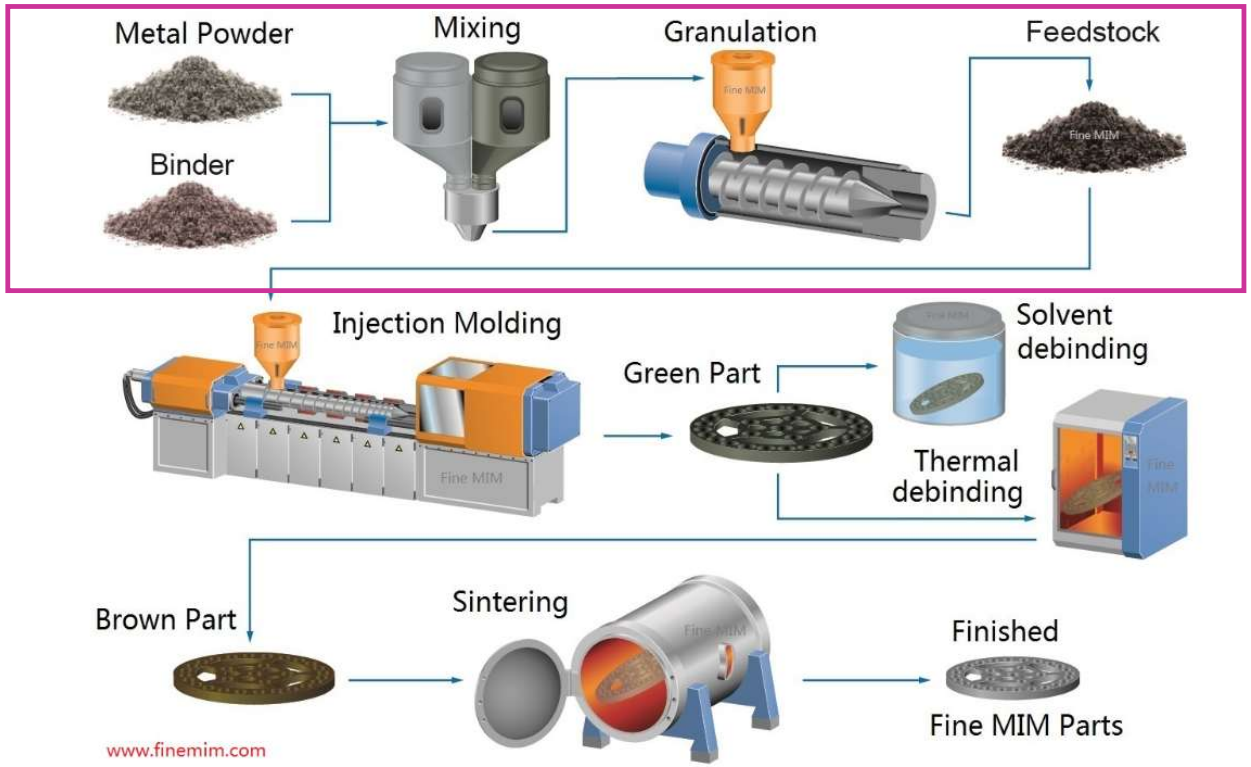


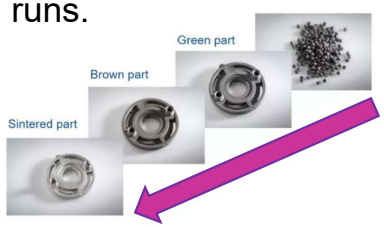


Metal Injection Molding Process

Step 1 - Feedstock: Very fine metal powders are combined with thermoplastic and wax binders in a precise recipe. A proprietary compounding process creates a homogenous pelletized feedstock that can be injection molded just like plastic. This achieves ultra-high density and close tolerances over high-production runs.

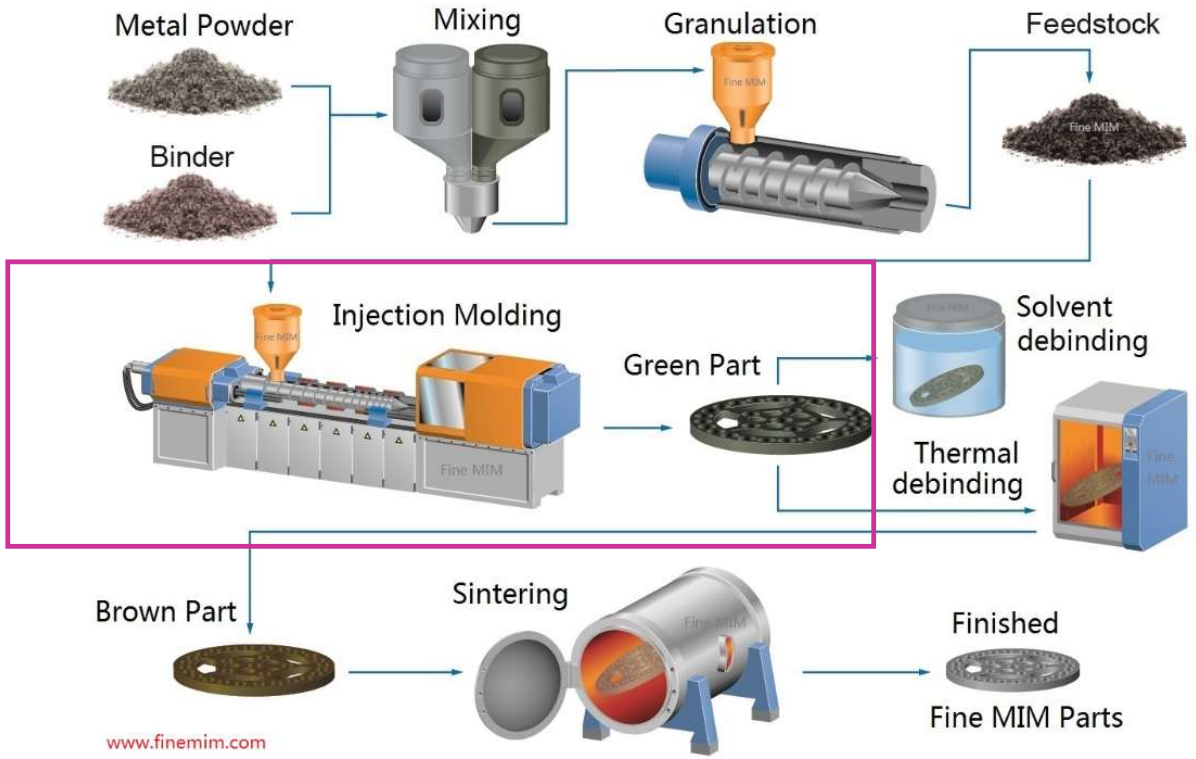
1

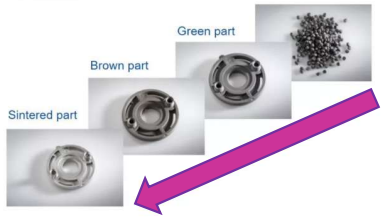




Metal Injection Molding Process

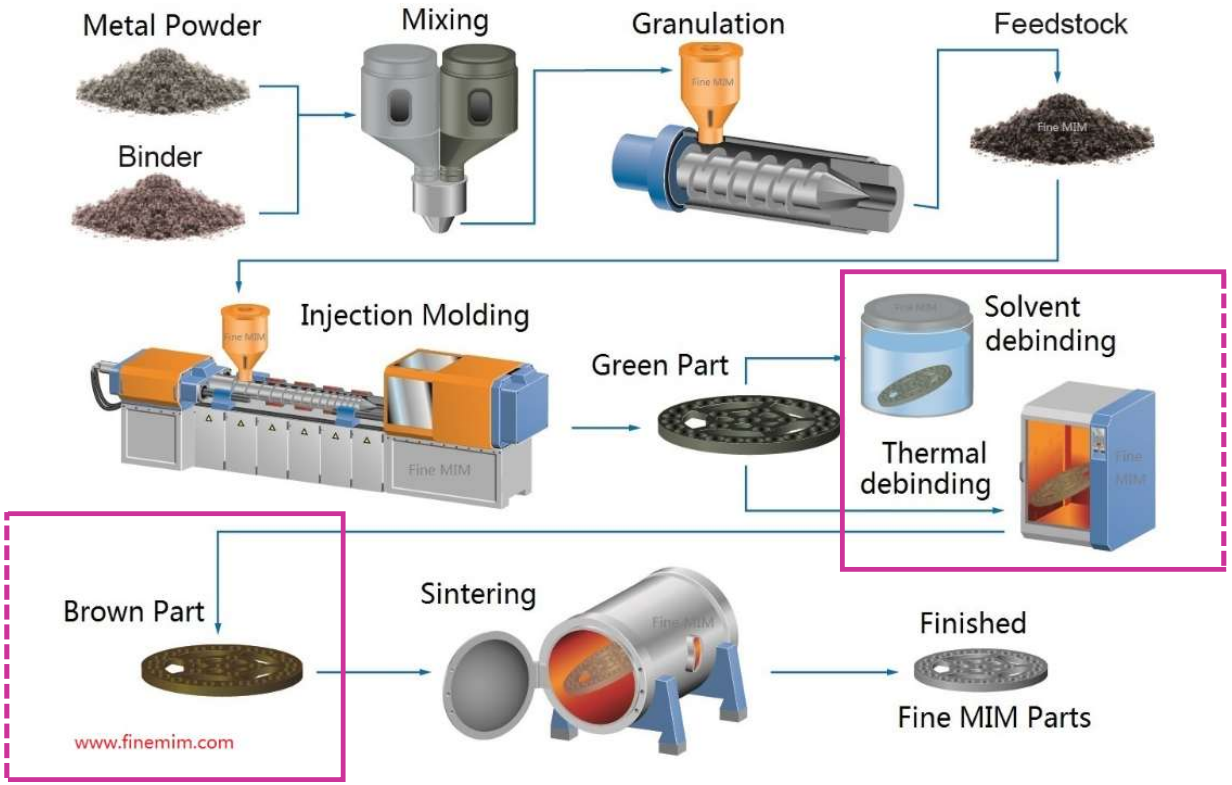
Step 2 – Injection Molding: The feedstock is heated and injected into a mold cavity under high pressure, allowing for extremely complex shapes. Once the component is removed it is known as a "green part."

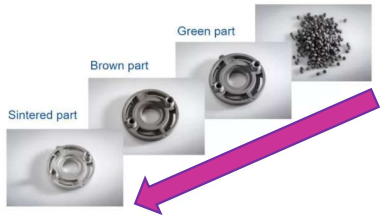




Metal Injection Molding Process

Step 3 - Debinding: the “green part” is then put through a controlled process called debinding that removes the binder and prepares the part for the final step. Once the debinding is complete, the component is referred to as “brown.”

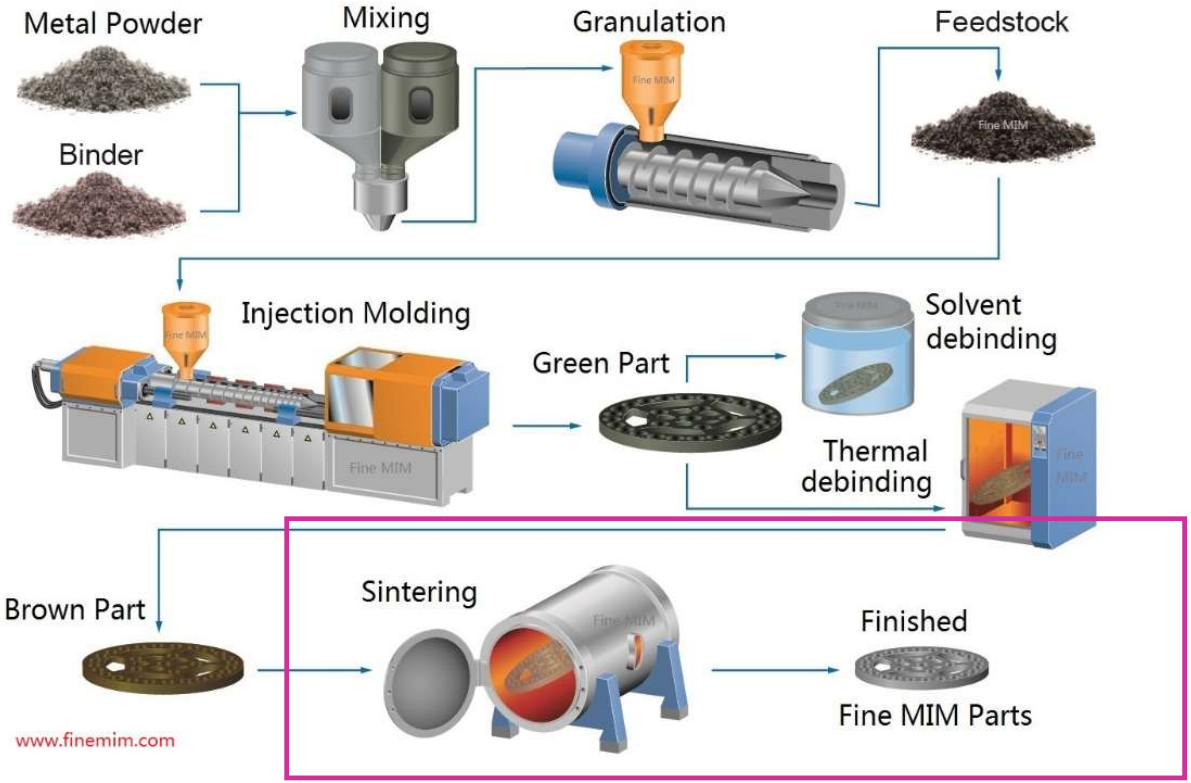


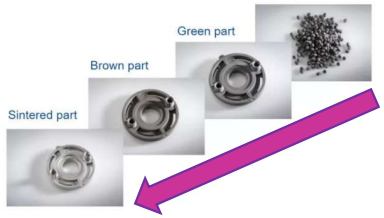


3

Metal Injection Molding Process

Step 4 – Sintering: the “brown” part is held together by a small amount of binder and is still fragile. During sintering temperatures reach near the melting point of the material. Sintering eliminates the remaining binder and gives the part its final density and strength.





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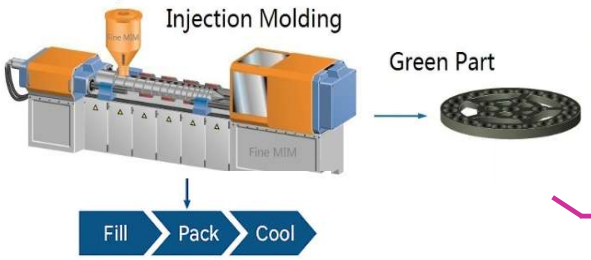
Metal Injection Molding with Moldex 3D



Type	PIM
Grade Name	MIM-002
Producer	BASF
Powder Specific	Alloy
Powder Diameter	0.01 (mm)
Average Concentration	60 (vol%)
Powder Density	7.9 (g/cc)

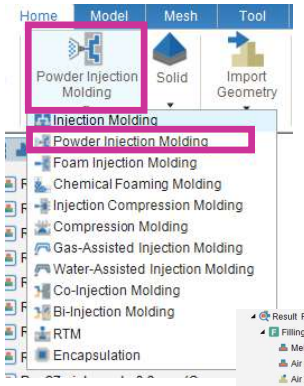
Type	PIM
Grade Name	MIM-002
Producer	BASF
Density	7.9 g/cc
Melt Temperature (Minimum)	180 °C
Melt Temperature (Normal)	190 °C
Melt Temperature (Maximum)	200 °C
Mold Temperature (Minimum)	120 °C
Mold Temperature (Normal)	128 °C
Mold Temperature (Maximum)	130 °C
Ejection Temperature	135 °C
Freeze Temperature	155 °C

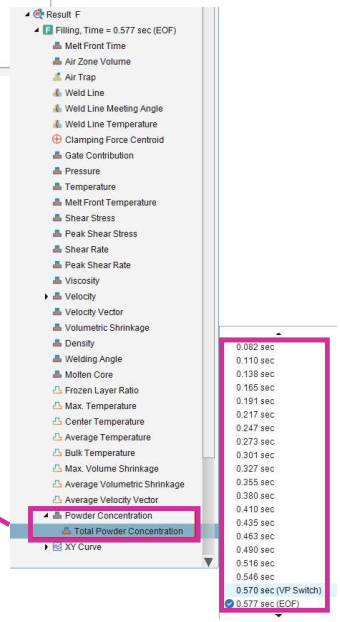
Powder Injection Molding process **Fill + Pack**

Powder Injection Molding module

Material Characterization with **Powder Information**

Total Powder Concentration result: potential surface defect can be predicted in MIM part.





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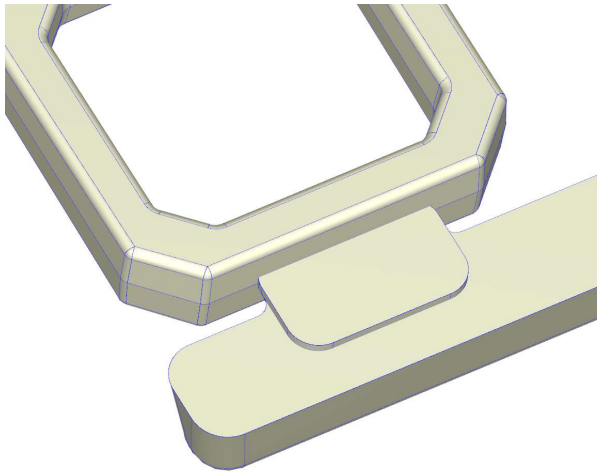
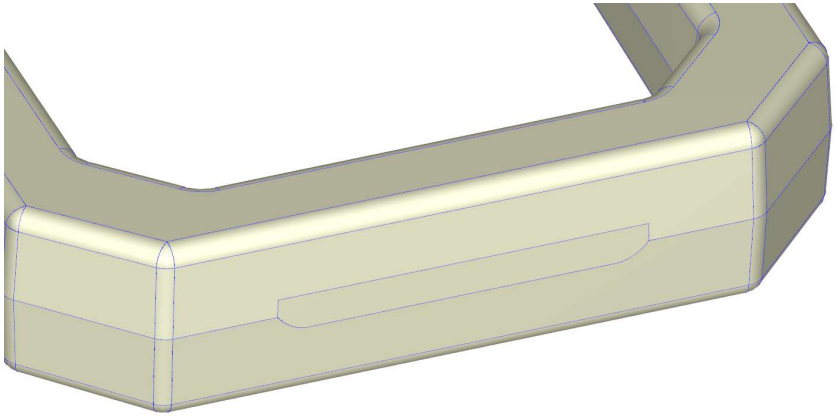
Cold Gate Issue

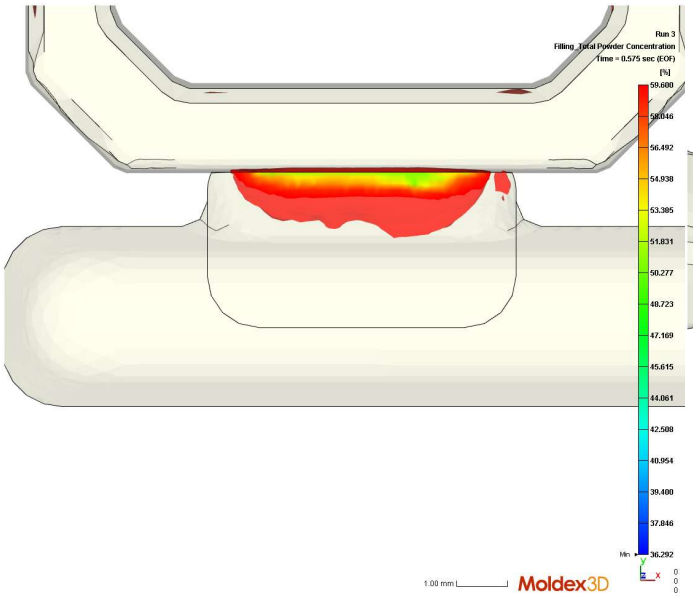
A cold gate defect prompted an investigation into powder concentration

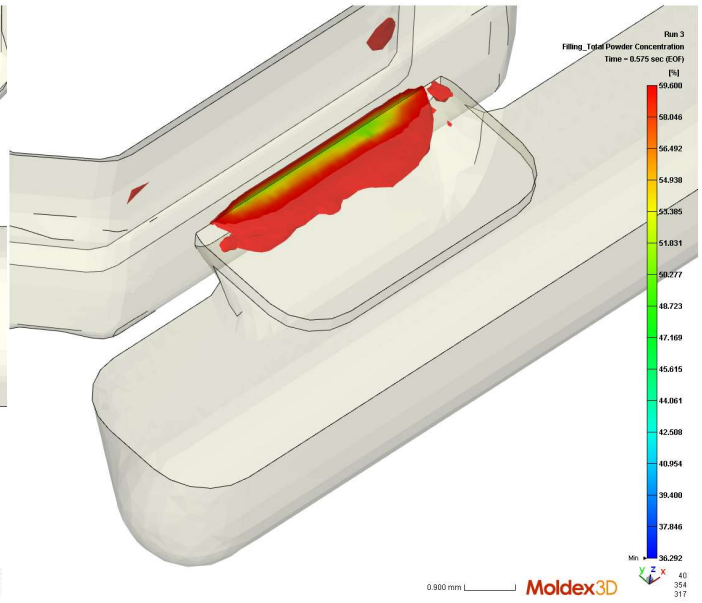


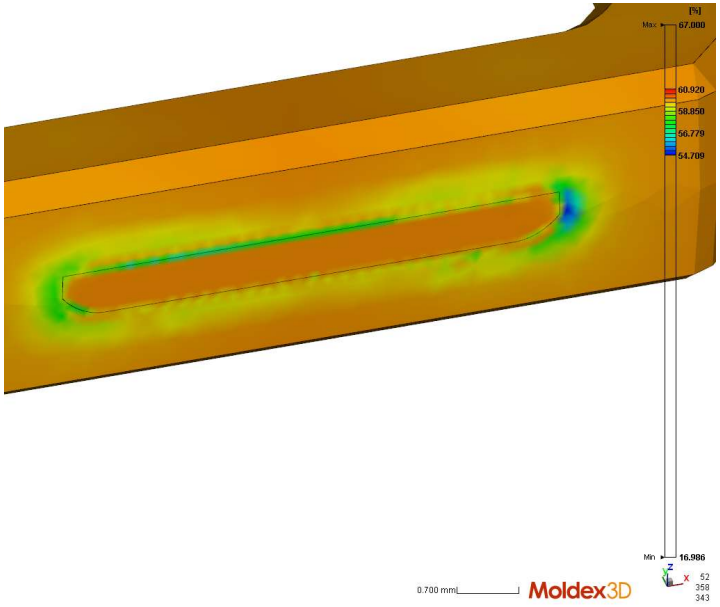


Powder Concentration Analysis

Simulations revealed a black-line phenomenon at the gate area, consistent with what was observed on the molded green part. This issue is linked to powder-binder separation, leading to regions of low powder concentration.







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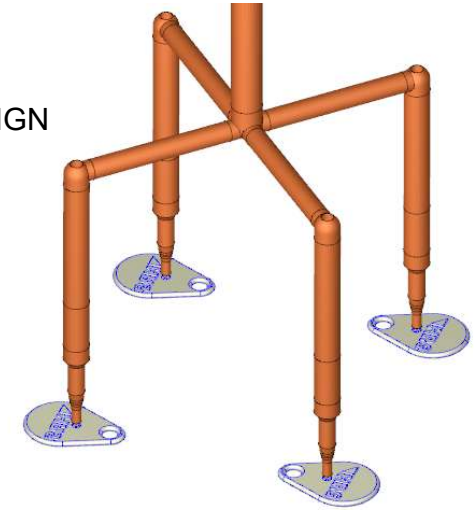
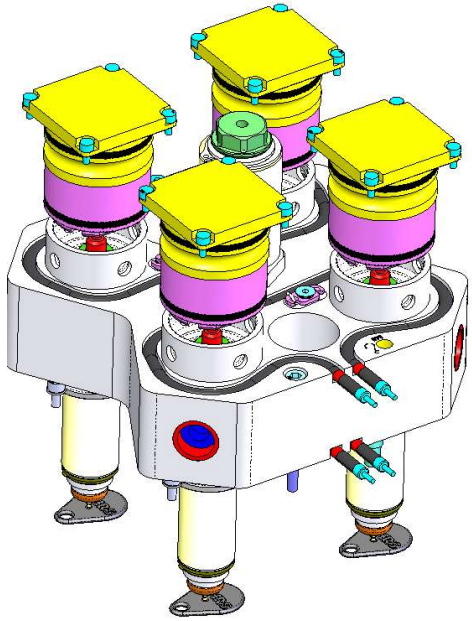
Case Study for Direct Hot Runner Injection

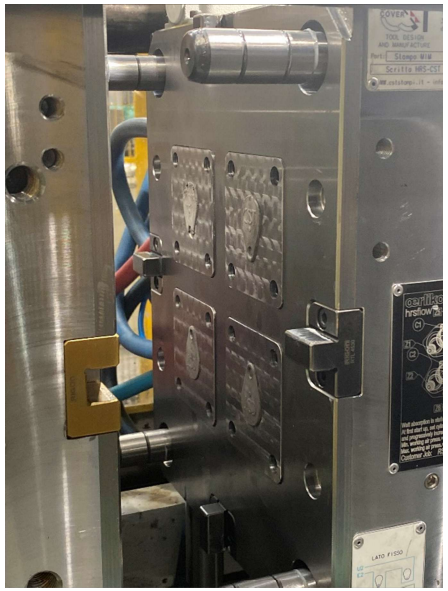
PART DESIGN



MOLDEX 3D SIMULATION



HOT RUNNER SYSTEM PROJECT



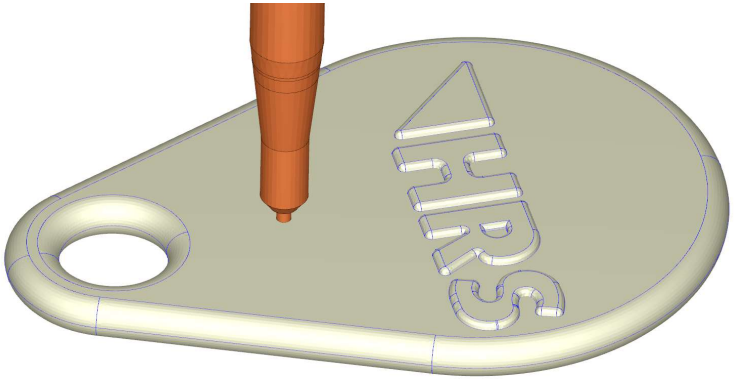
TOOL

GREEN PART

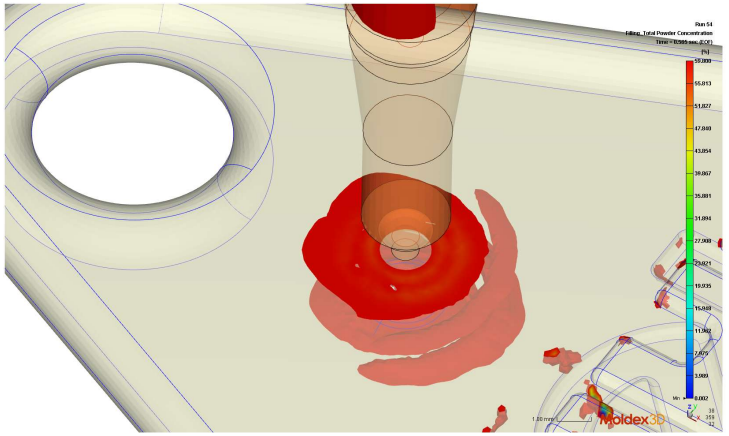
FINISHED PART

Total Powder Concentration on Gate Area

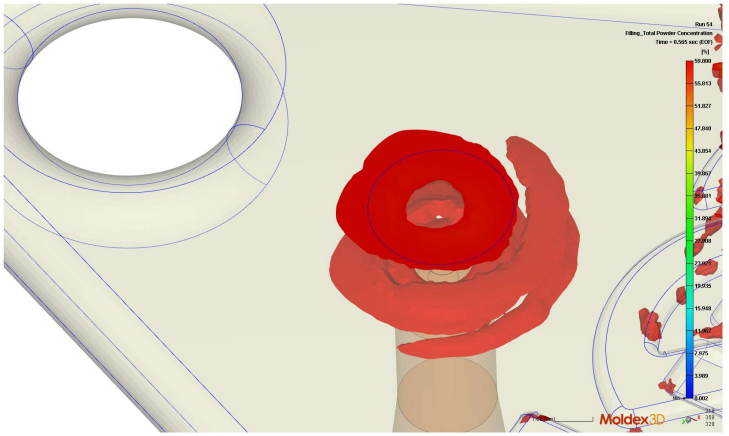
Hot Runner Direct Injection on side A



Side A

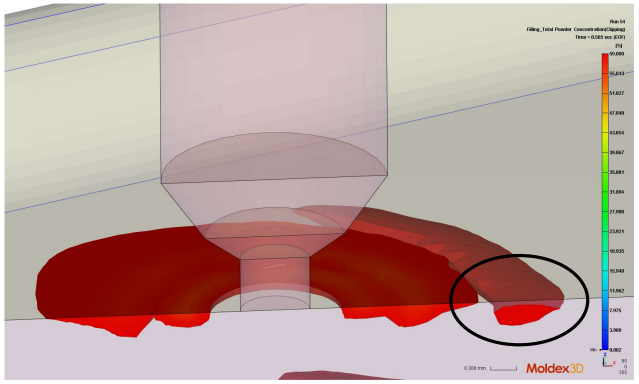


Side B



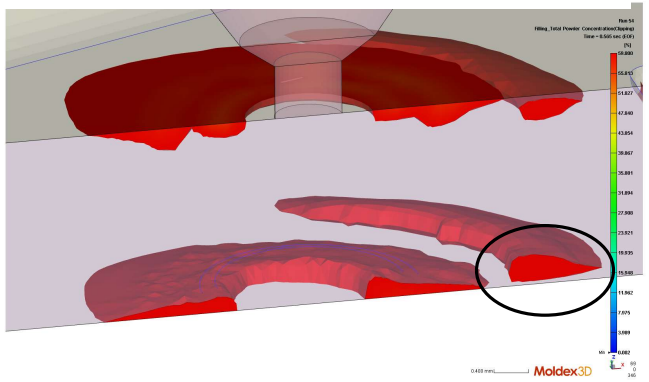
Total Powder Concentration on Gate Area

Side A



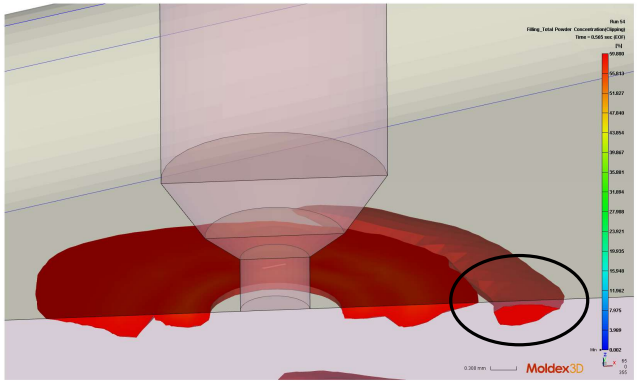
Half-moon marks of lower powder concentration has been noticed under the part skin on both sides.

Side B



Total Powder Concentration on Gate Area

Side A



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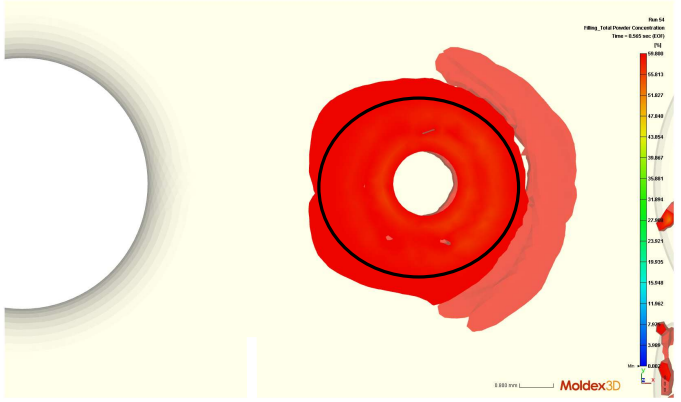
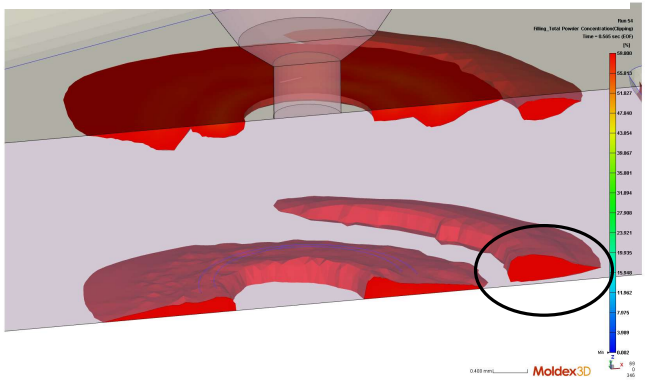
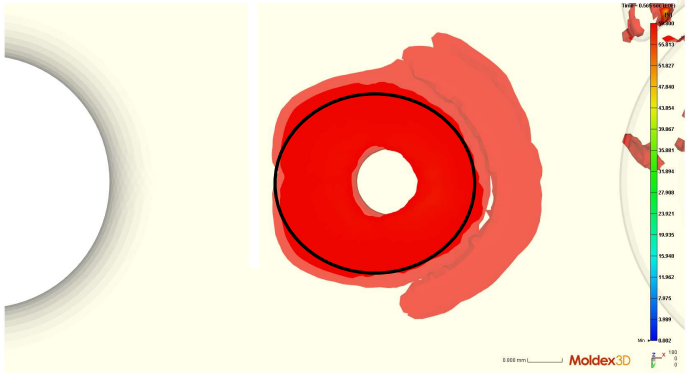


A halo with a lower powder concentration was identified surrounding the injection area on both sides.

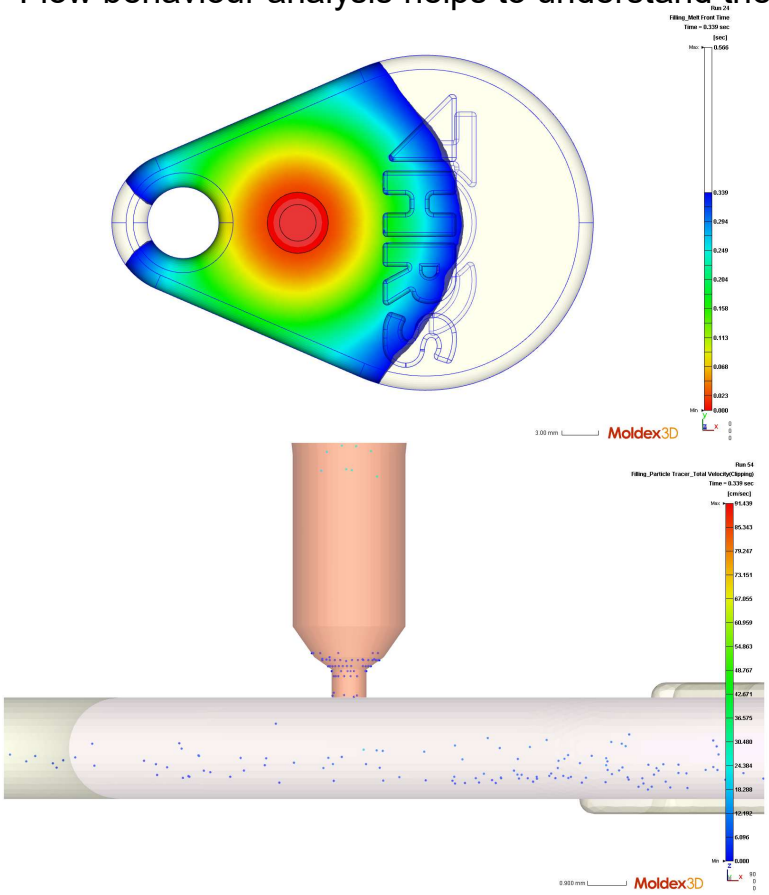
Side B

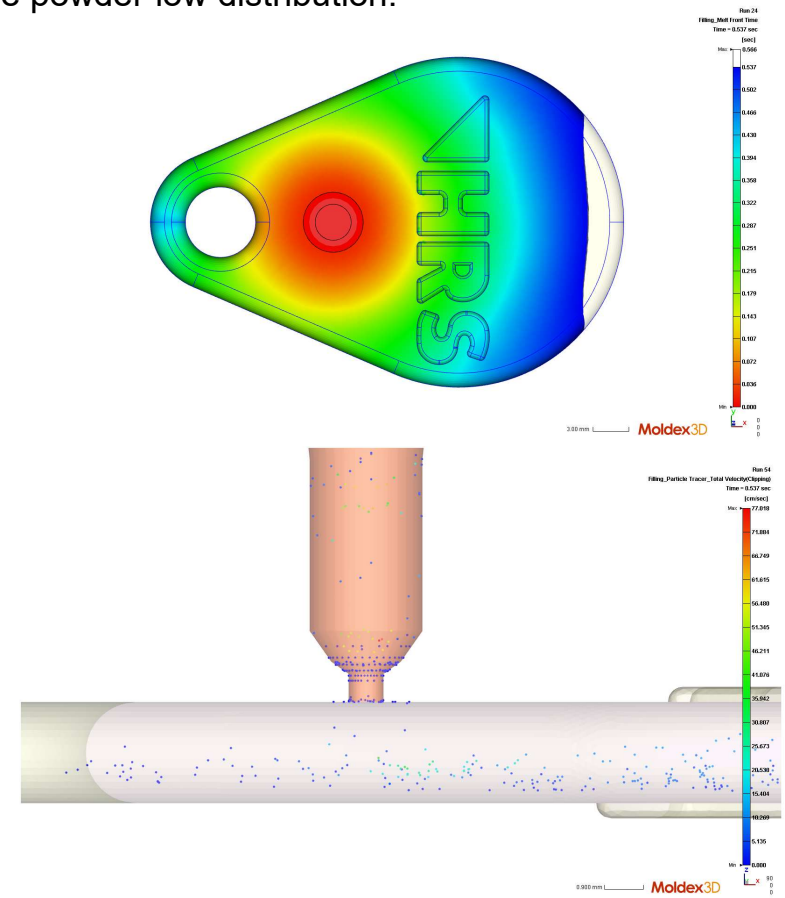




Direct Injection Flow Beaviour at the Hot Runner Gate

Flow behaviour analysis helps to understand the reason of the powder low distribution.





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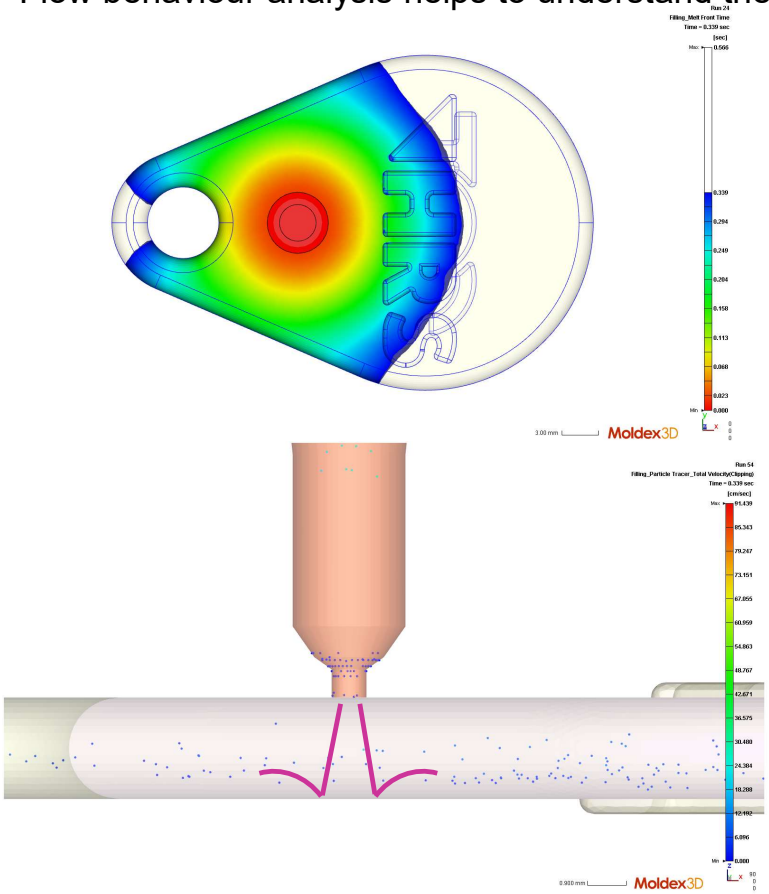

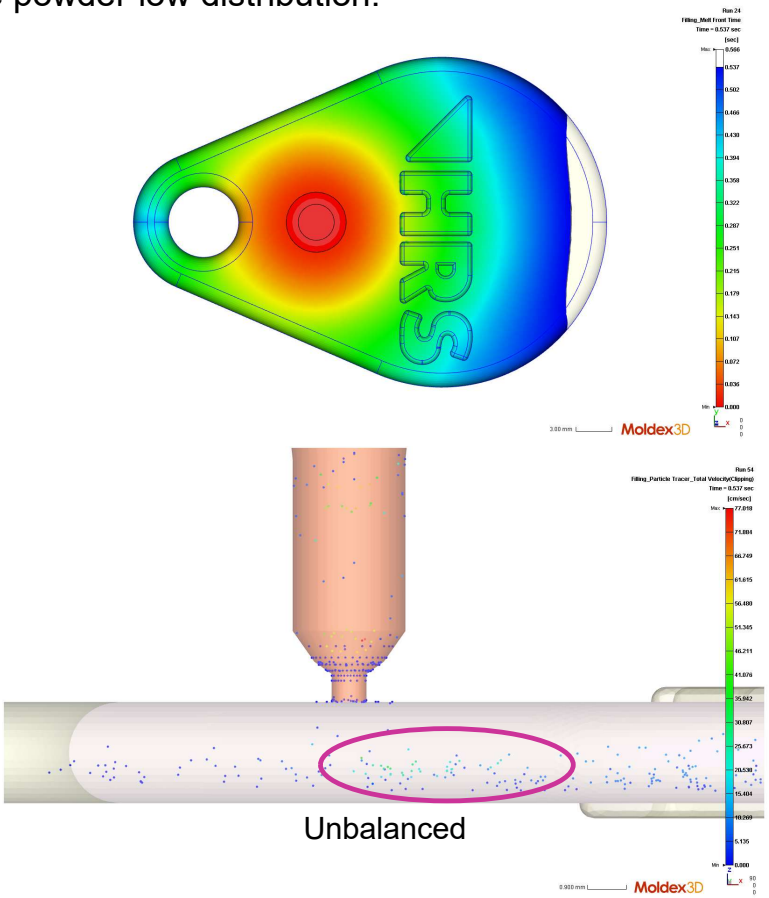

Unbalanced

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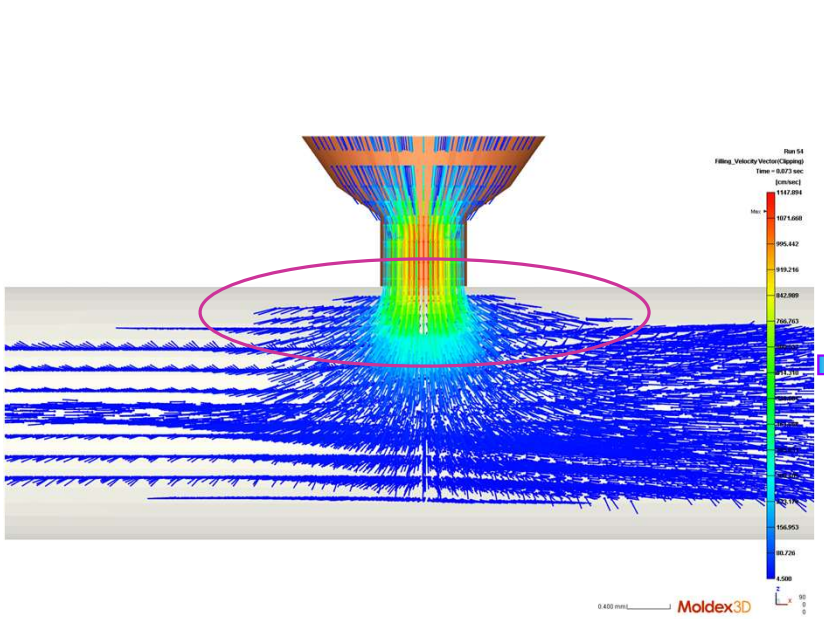
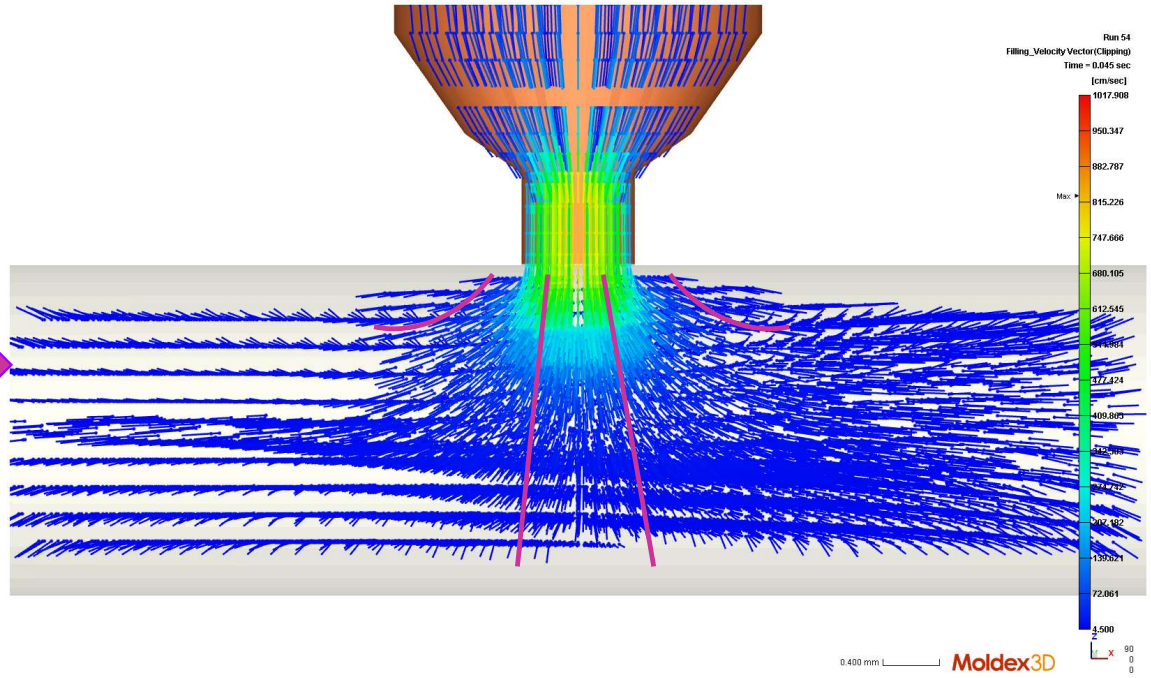
Powder Injection Molding

Direct Injection Flow Beaviour at the Hot Runner Gate





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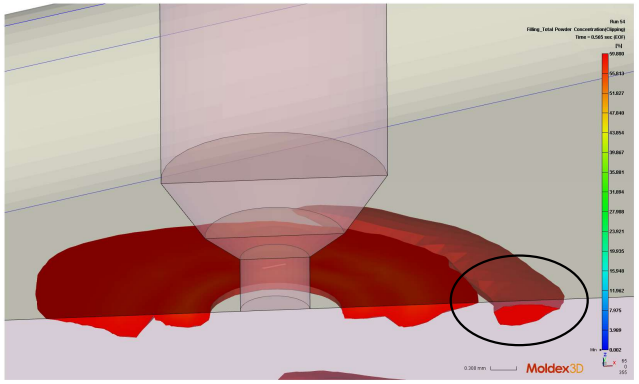
Powder Injection Molding

Direct Injection Surface Optimization

Side A

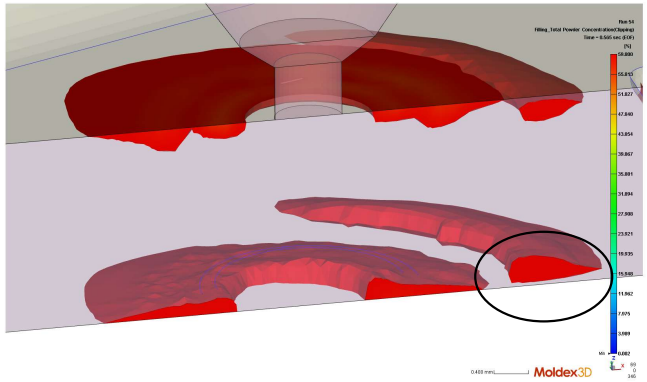
DEFECT



CAUSE

SOLUTION

Side B



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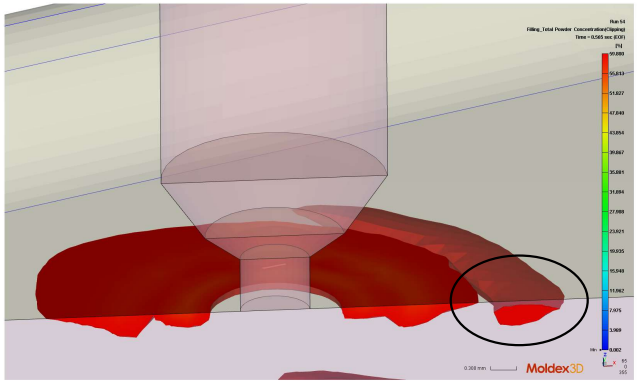
Powder Injection Molding

Direct Injection Surface Optimization

Side A

DEFECT



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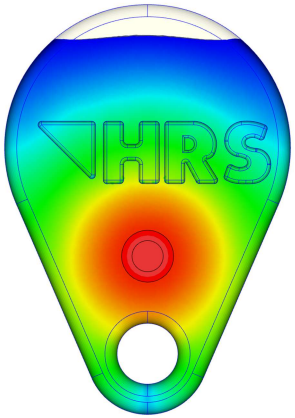
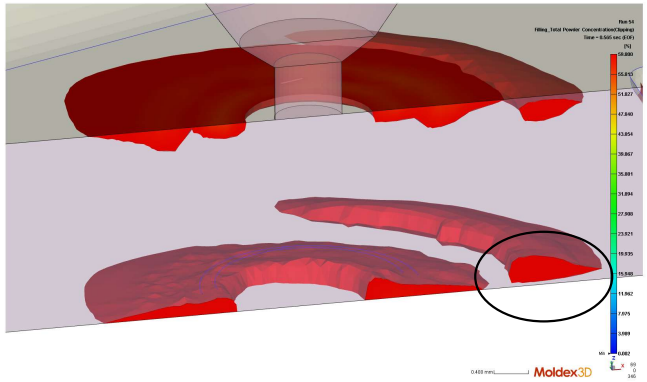


SOLUTION

Side B



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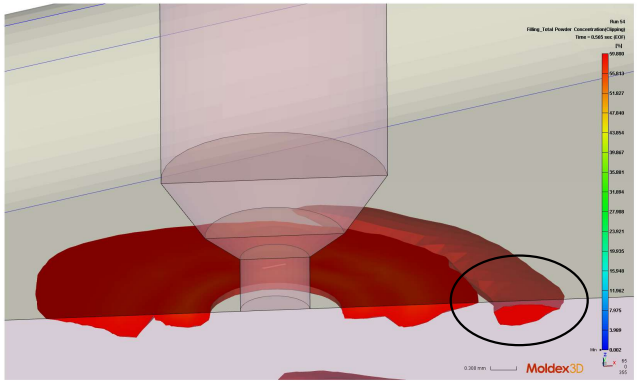
Powder Injection Molding

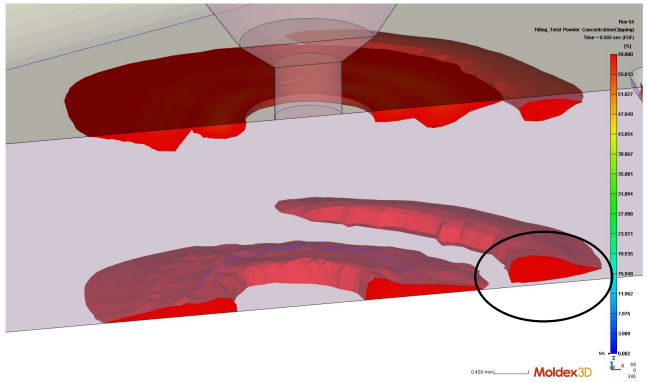
Direct Injection Surface Optimization

Side A

DEFECT



Side B



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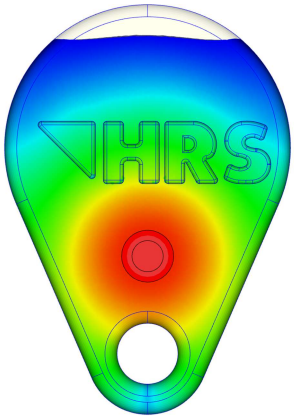
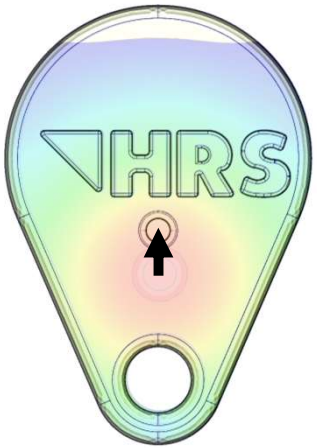


SOLUTION



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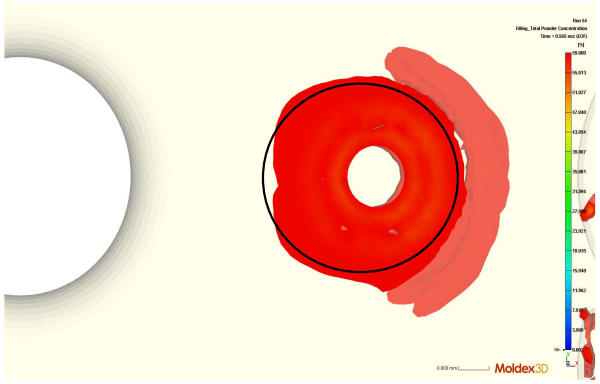
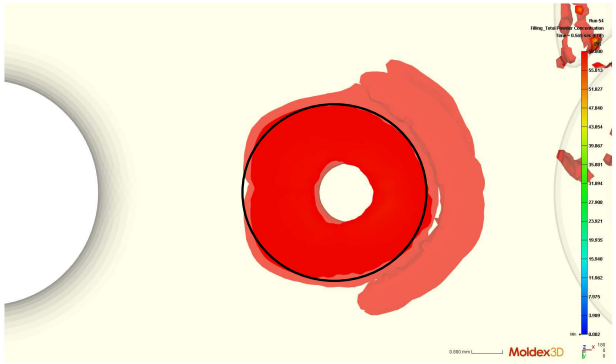
Powder Injection Molding

Direct Injection Surface Optimization

Side A	DEFECT	CAUSE	SOLUTION
			
Side B			
			

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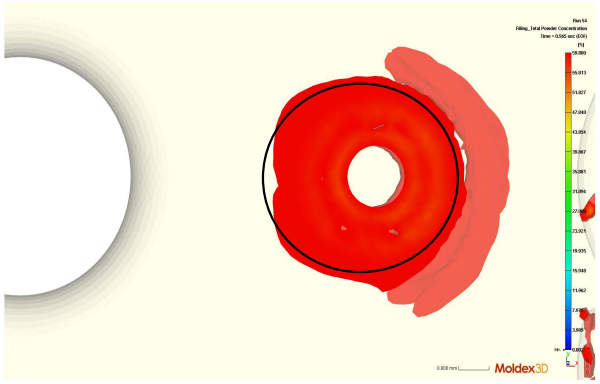
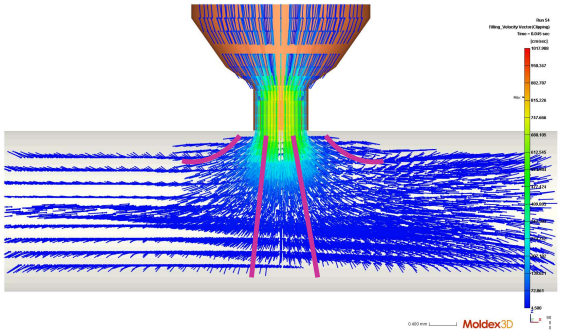
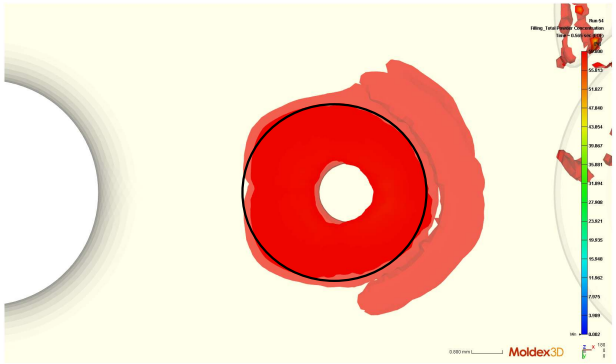
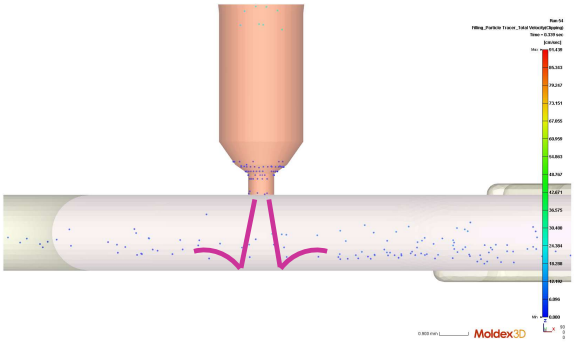
Powder Injection Molding

Direct Injection Surface Optimization

Side A	DEFECT	CAUSE	SOLUTION
			
Side B			
			

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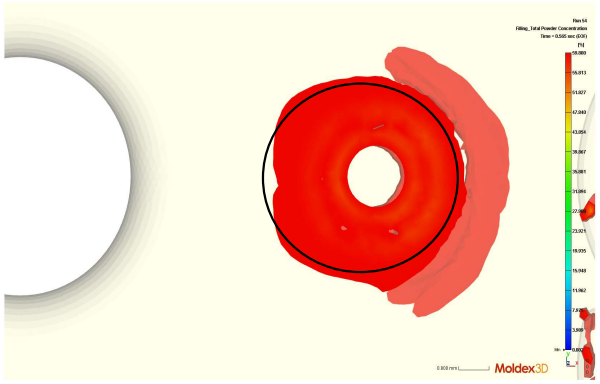
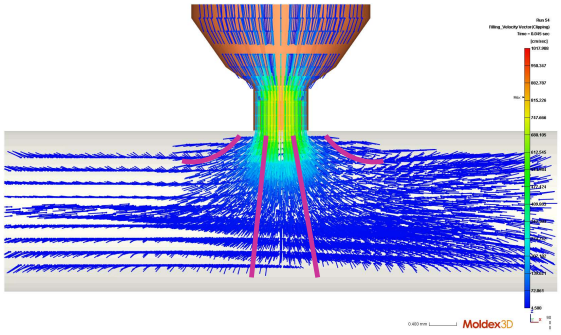
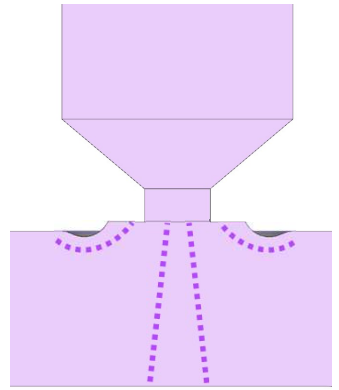
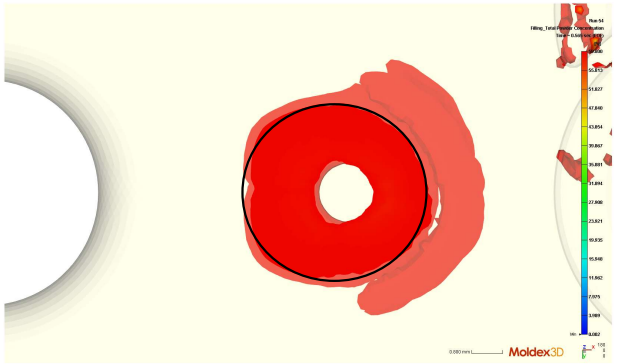
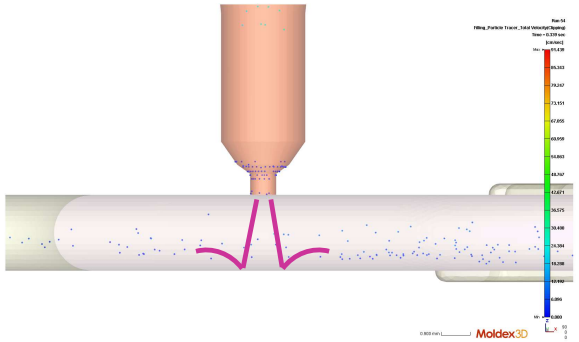
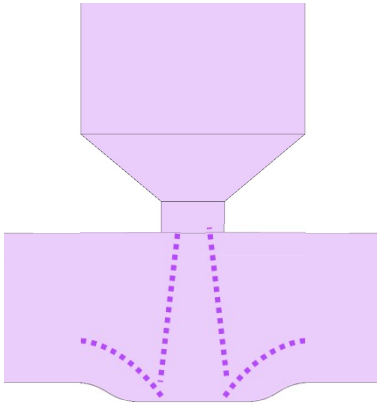
Powder Injection Molding

Direct Injection Surface Optimization

Side A	DEFECT	CAUSE	SOLUTION
			
Side B			
			

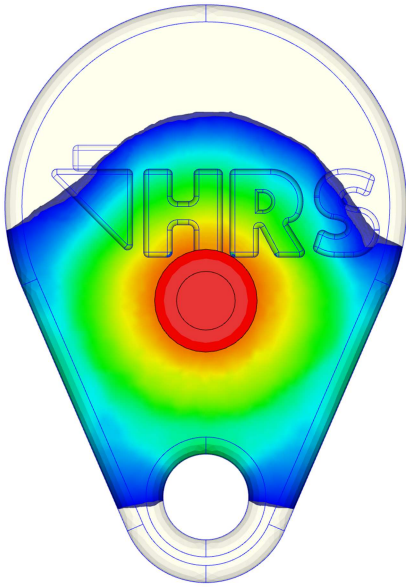
Effect of Optimization: Simulation Results

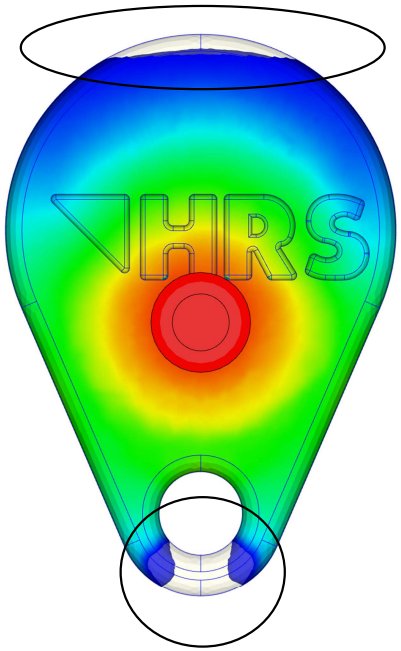
OPTIMIZED DESIGN

Side A

Side B

BALANCE FILLING





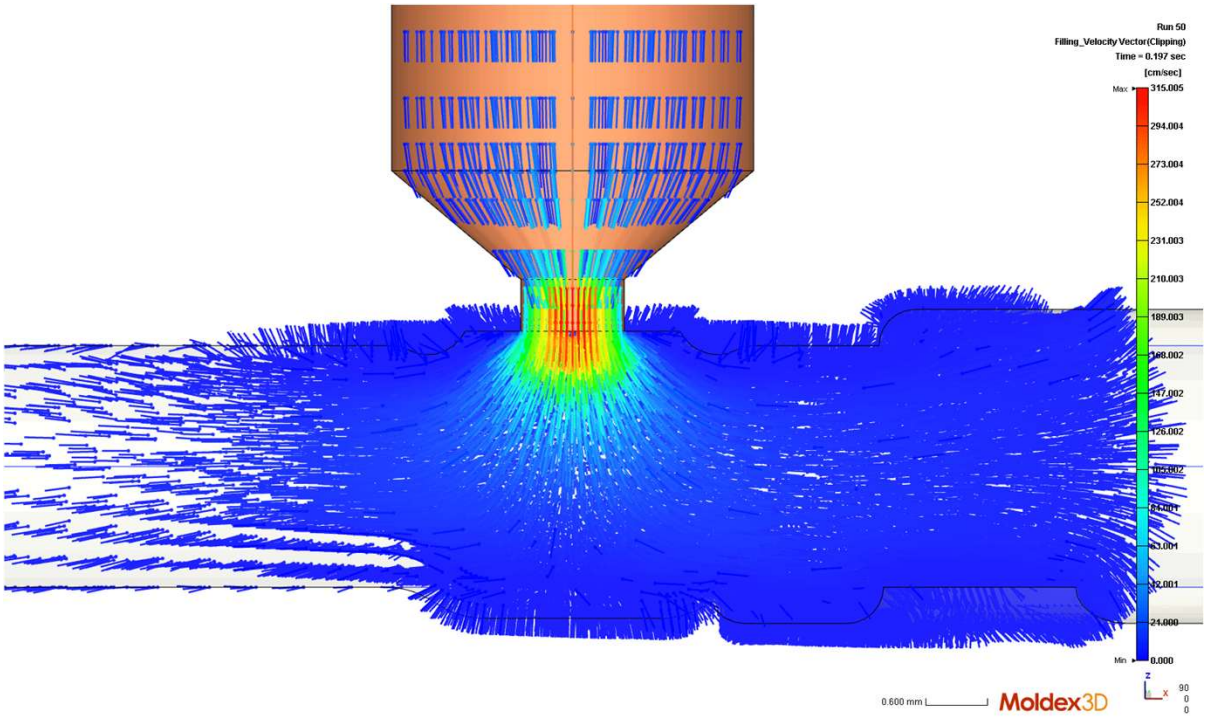
Effect of Optimization: Simulation Results

OPTIMIZED DESIGN

Side A

Side B

UNIFORM FLOW FRONT



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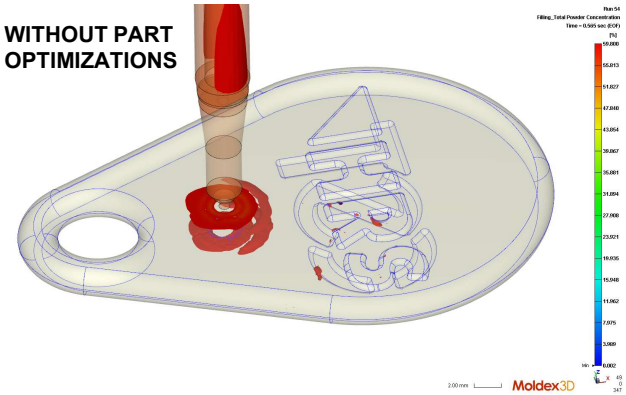
Powder Injection Molding

Effect of Optimization: Simulation Results

WITHOUT PART OPTIMIZATIONS

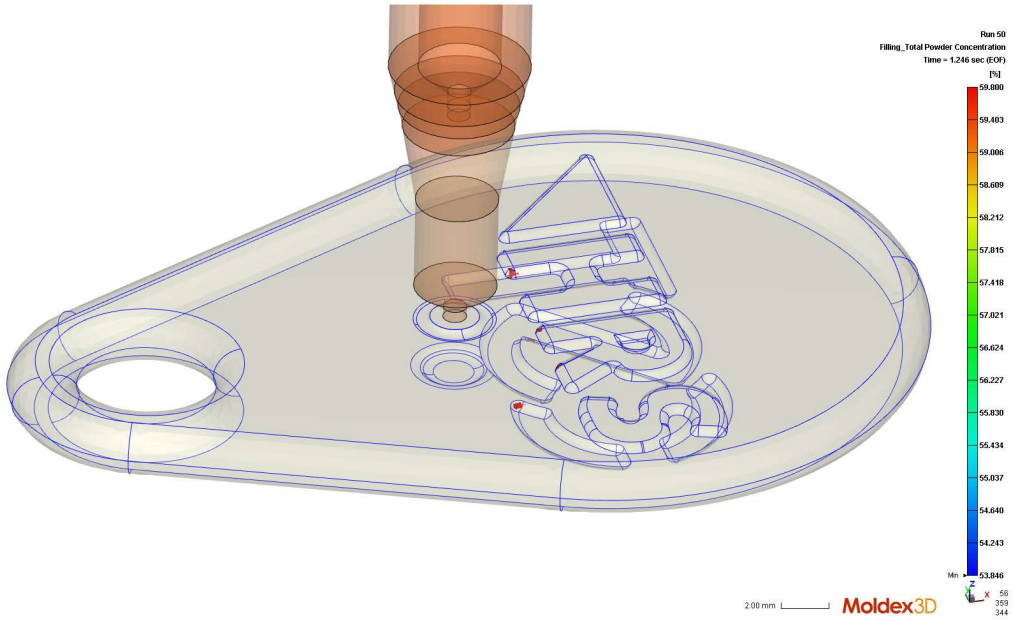


OPTIMIZED DESIGN

Side A

Side B

TOTAL POWDER CONCENTRATION



Simulation results show that geometry optimization reduced the risk of low powder concentration around the gate area on both sides.

From simulation to practice

Side A

OPTIMIZED DESIGN

Side B

GREEN PART: From analysis to implementation, the results confirm that gate design optimization improves the aesthetics of the final part already on the green part.

From simulation to practice

Side A

OPTIMIZED DESIGN

Side B

FINISHED PART: After sintering and polishing, the part maintains good surface aesthetics.

Conclusion

Direct Injection Tips – MIM

1) **Optimized Gate Location**

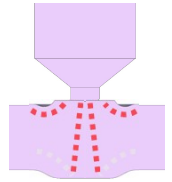
→ Balanced Filling

Conclusion

Direct Injection Tips – MIM

1) **Optimized Gate Location**

→ Balanced Filling



2) **Add a localized thickness increase** on both sides

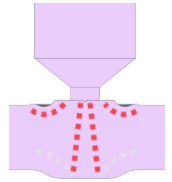
→ Avoid Halo and Low Powder Concentration

Conclusion

Direct Injection Tips – MIM

1) **Optimized Gate Location**

→ Balanced Filling

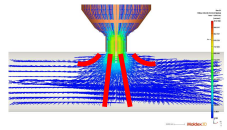


2) **Add a localized thickness increase** on both sides

→ Avoid Halo and Low Powder Concentration

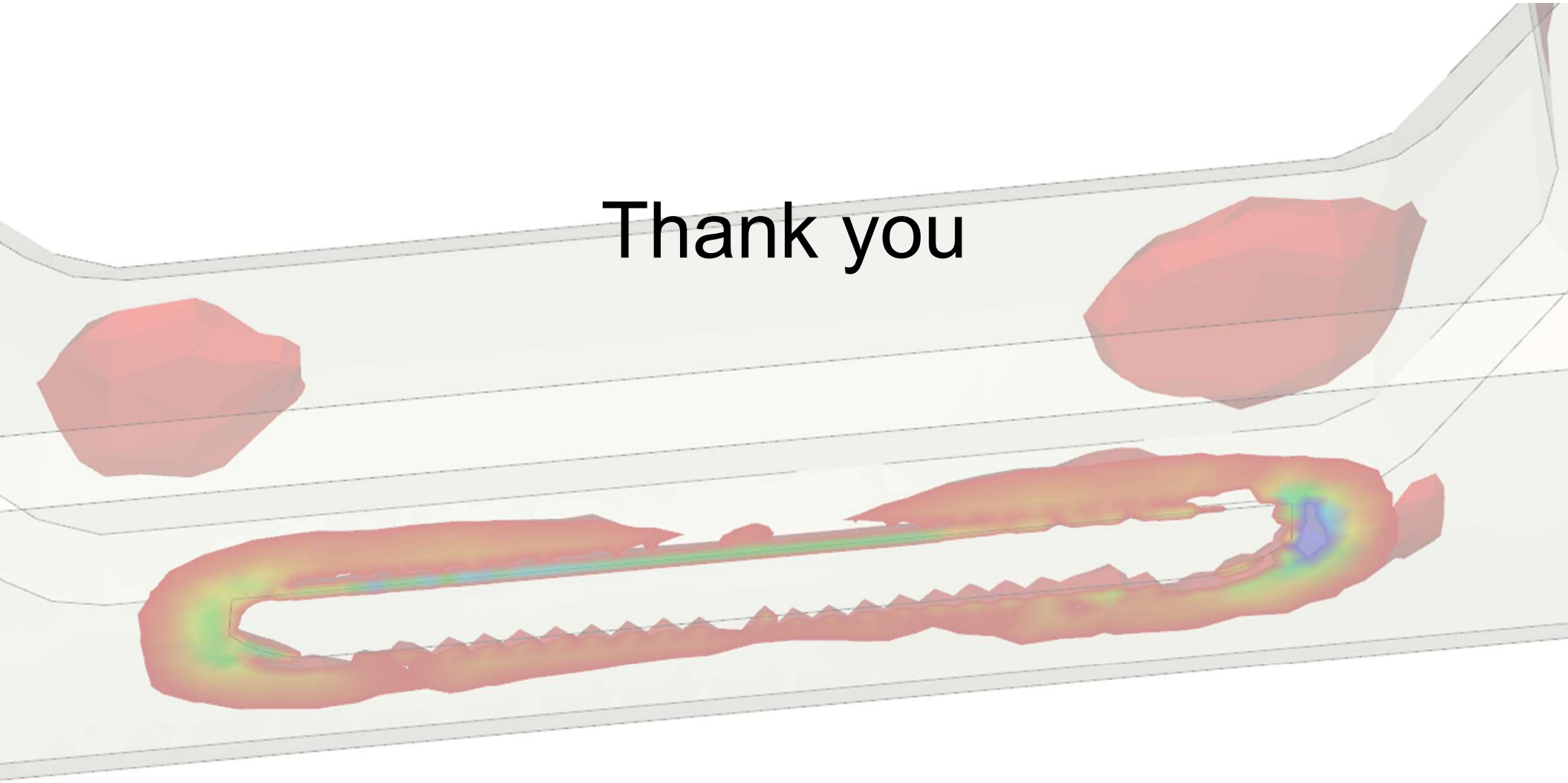
3) **Introduce a circular ring under the gate**

→ Ensure proper material flow



The optimizations are function of gate dimension and thickness of the part.

Thank you



Thank you