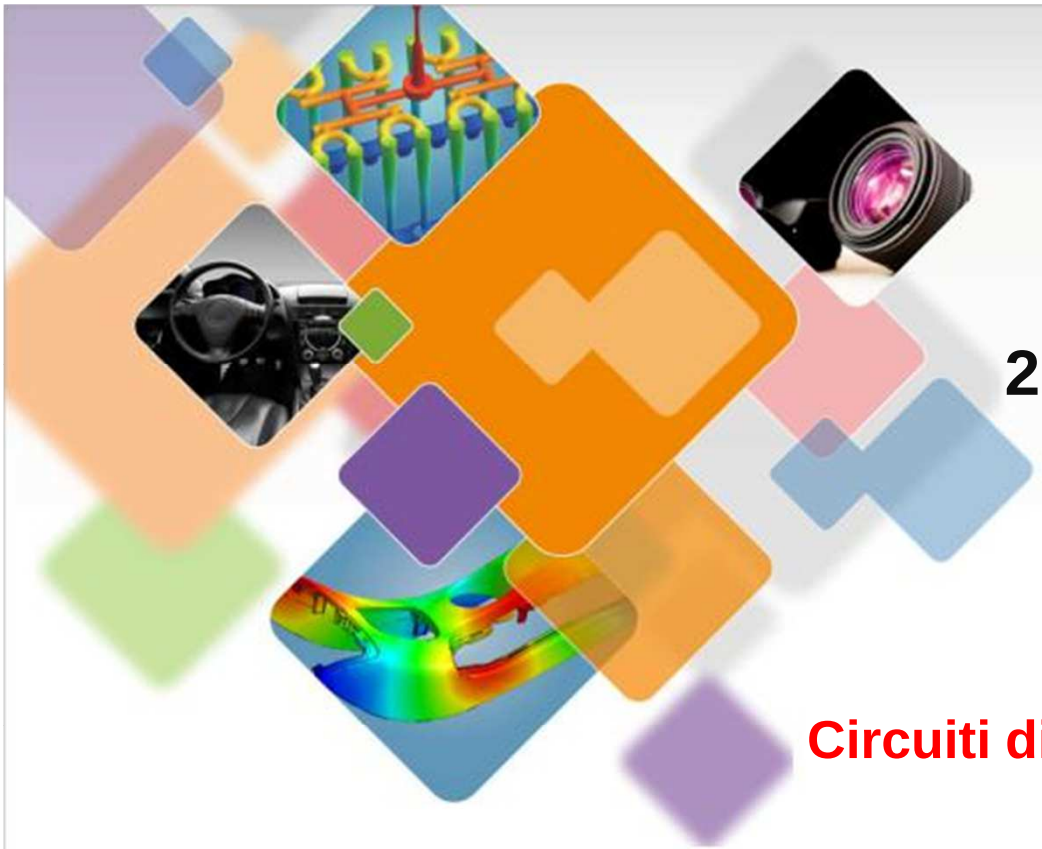

Moldex3D
MOLDING INNOVATION

2015 Molding Innovation Day

CCD e CCS

Circuiti di raffreddamento conformati

Stefano Canali – Moldex3D

10 Luglio 2015
POINT Polo per Innovazione Tecnologica
Dalmine Bergamo

Moldex3D Italia srl
Corso Promessi Sposi 23/D -
23900 Lecco (LC)
www.moldex3d.com

Contents

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Introduction

Outline of Cooling

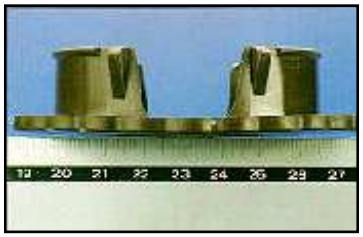
- What are the common problems caused by cooling?
- What is the purpose of minimizing process cycle time?
- What is the critical considerations when designing the cooling system?
- What is the Advantages of Moldex3D Cool?

What Are the Common Problems Caused by Cooling?

- Common problems in polymer molding
  - Sink mark
  - Warpage
  - Long cycle time

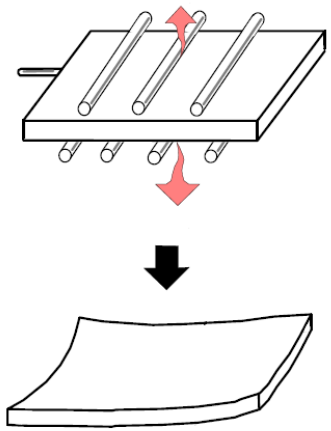
Sink mark

- Warpage caused by non-uniform volume shrinkage due to:
  - Packing pressure difference
  - Mold temperature difference
  - Fiber orientation

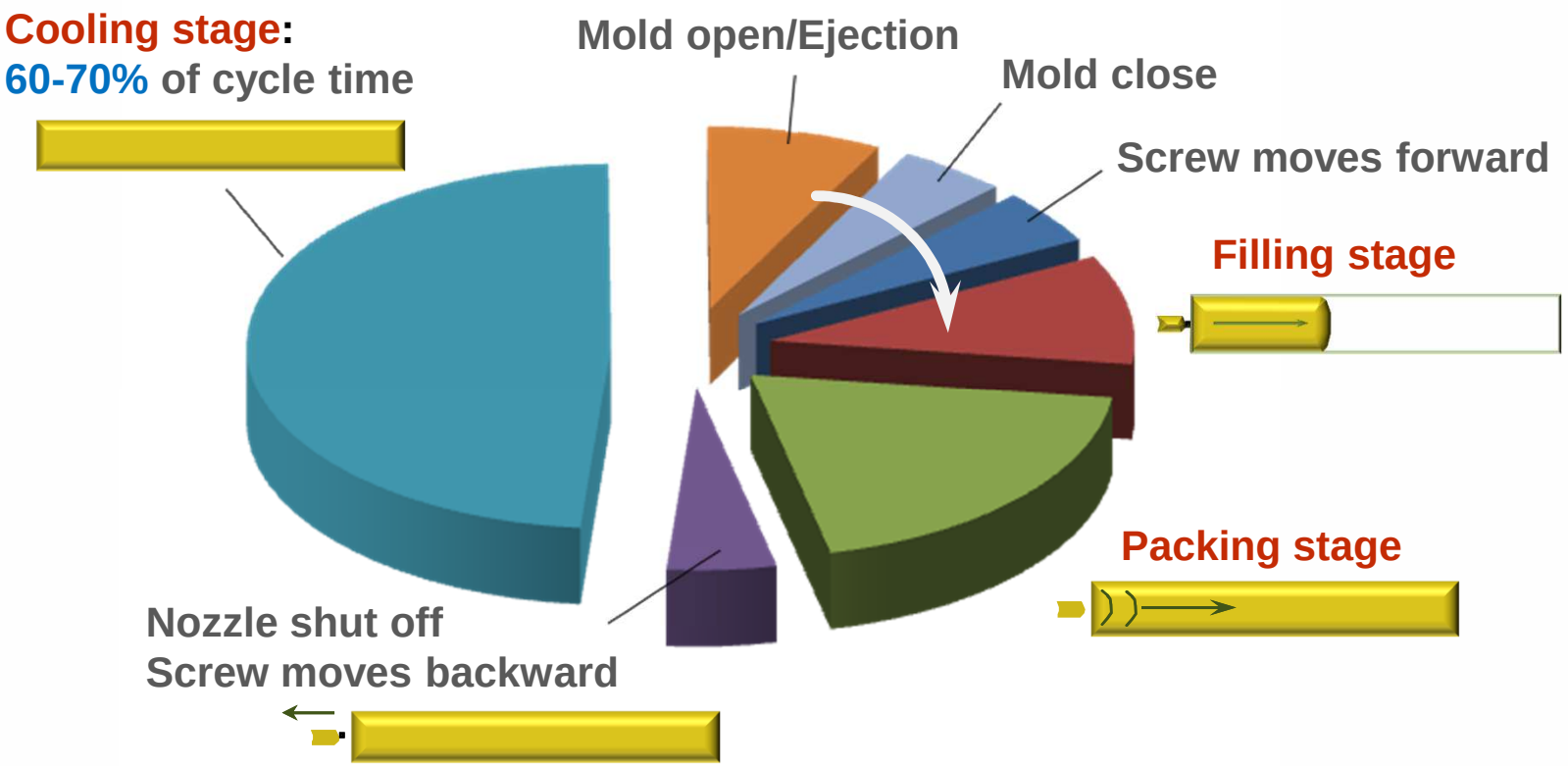


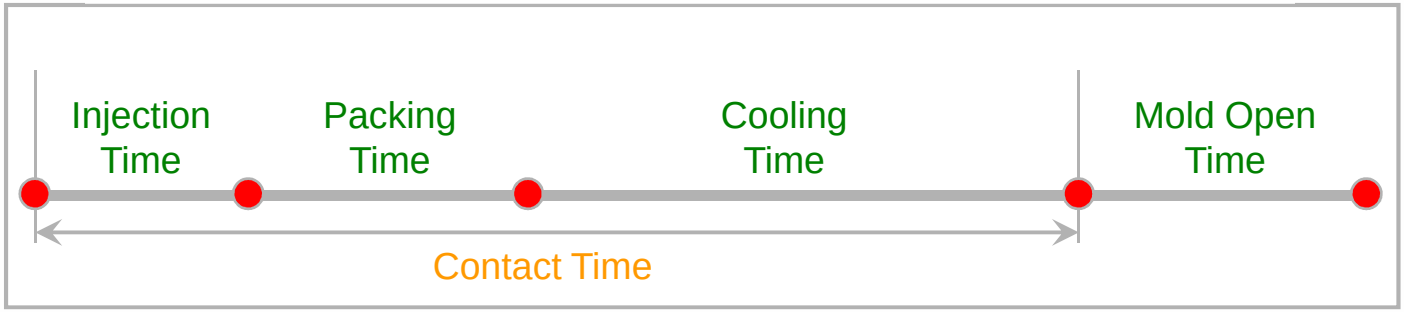
Warpage

- Proper cooling design can help minimize mold temperature difference and warpage



Cooling Time in Injection Molding Cycle





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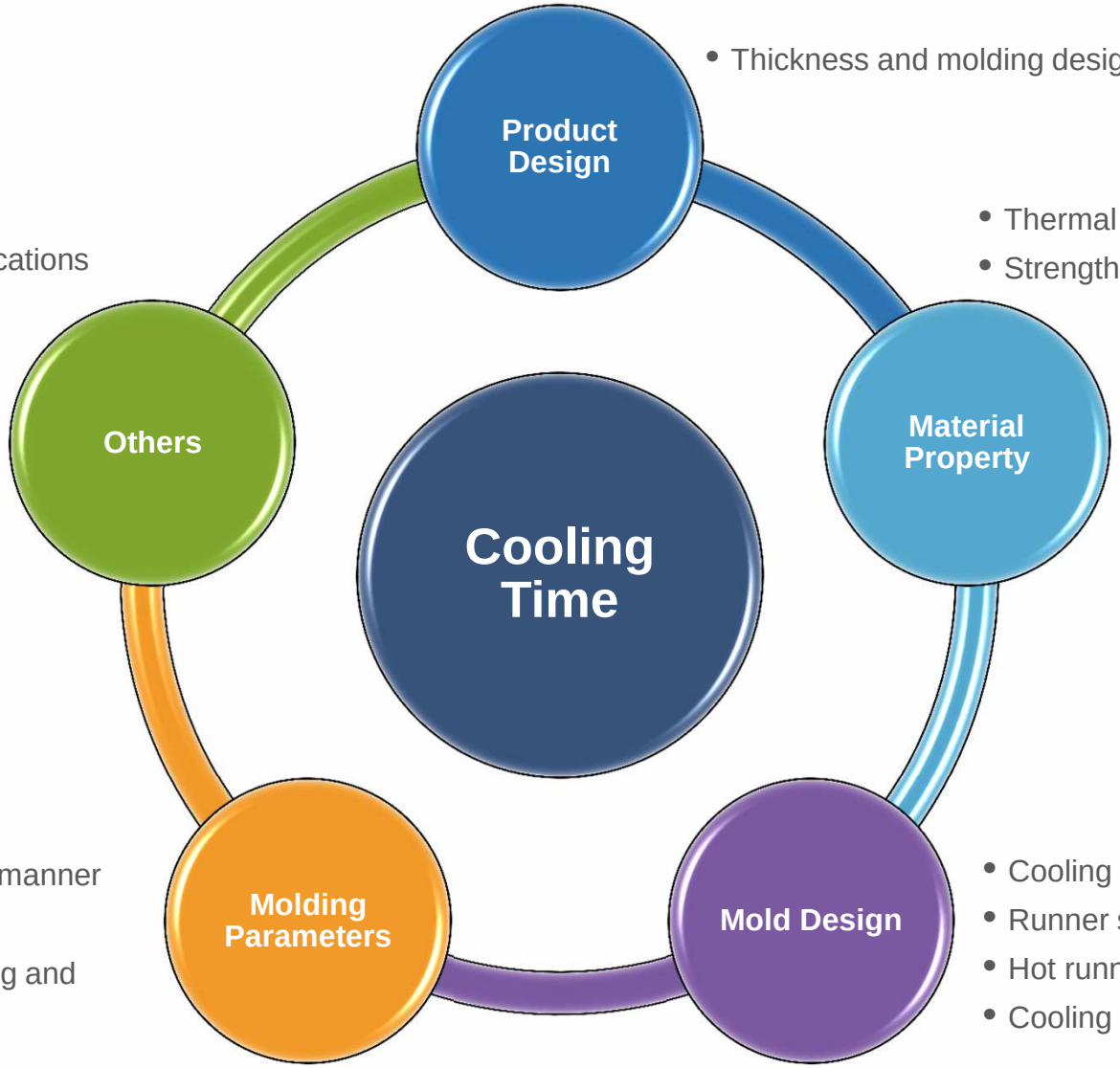
Factors that Affect Cooling Time



- Thickness and molding design

- Thermal properties of material
- Strength material

- Cooling channels design
- Runner systems optimization
- Hot runner applications
- Cooling components

- Temperature control
- Waterway cascading manner
- Mold temperature
- Ejection, mold opening and closing

- Special process applications

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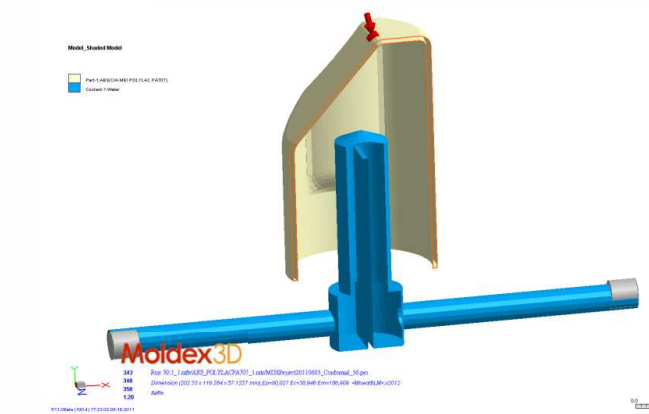
What is the Advantages of Moldex3D Cool

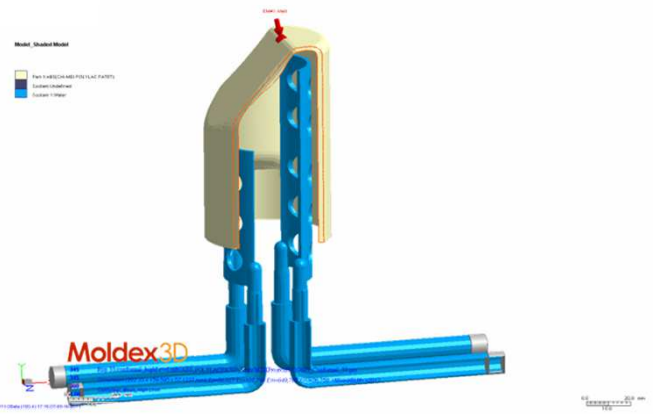
> Moldex3D Cool can help to:

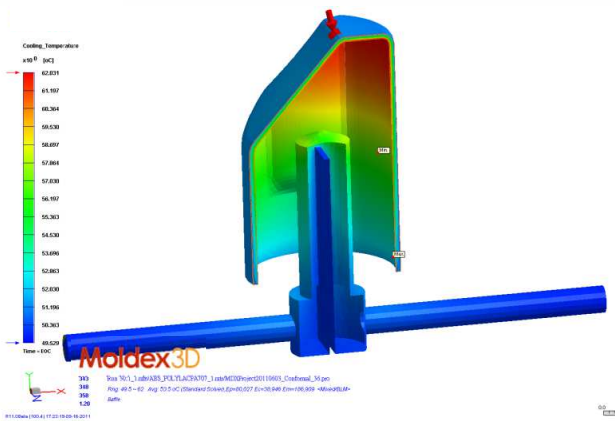
- Validate your cooling design
  - **Which design best fit your need?**
- Predict required cooling time
  - **How much cooling time was saved?**
- Simulate the mold/part temperature distribution at any instance in 3D
  - **Help to find out the hot spots**
- Evaluate the cooling effect on product defects
  - **Such as warpage, sink mark improvement**

Validate and Optimize Your Cooling Design

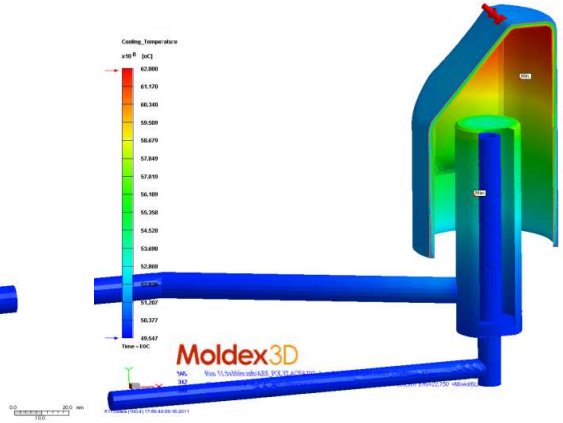
> Part temperature uniformity improved by using conformal cooling design







Baffle



Bubbler

Conformal Cooling

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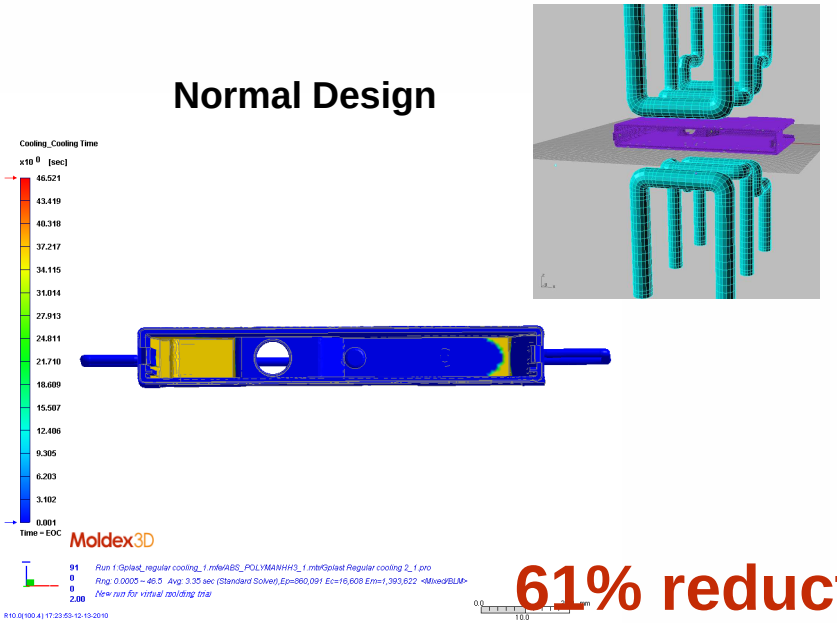
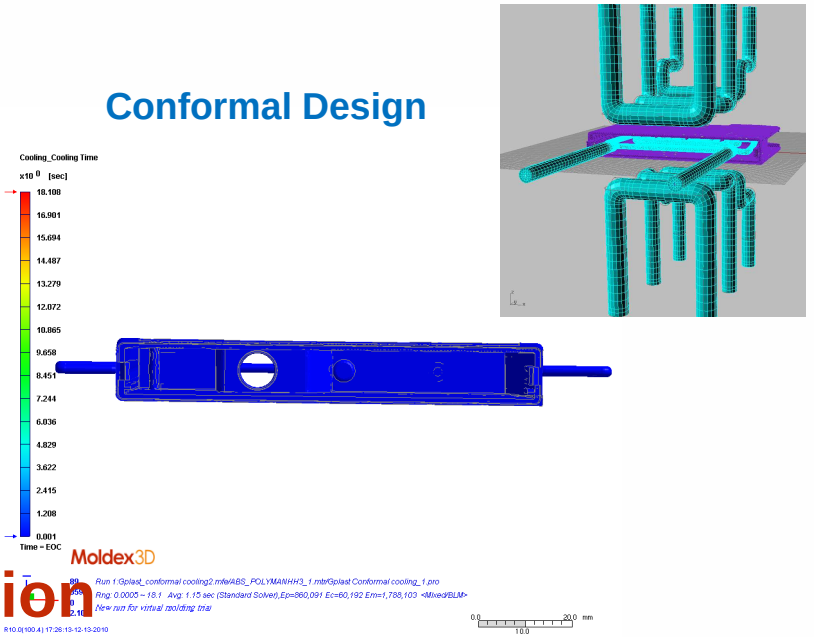
Cooling Time Reduction by Cooling System Design

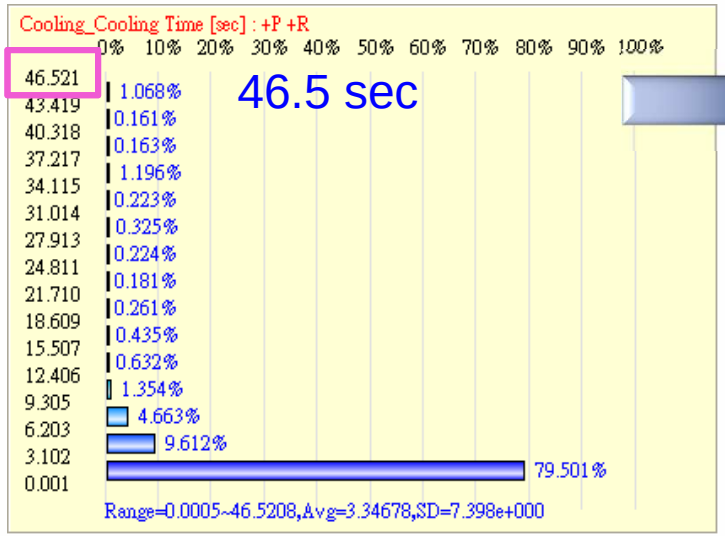
Normal Design

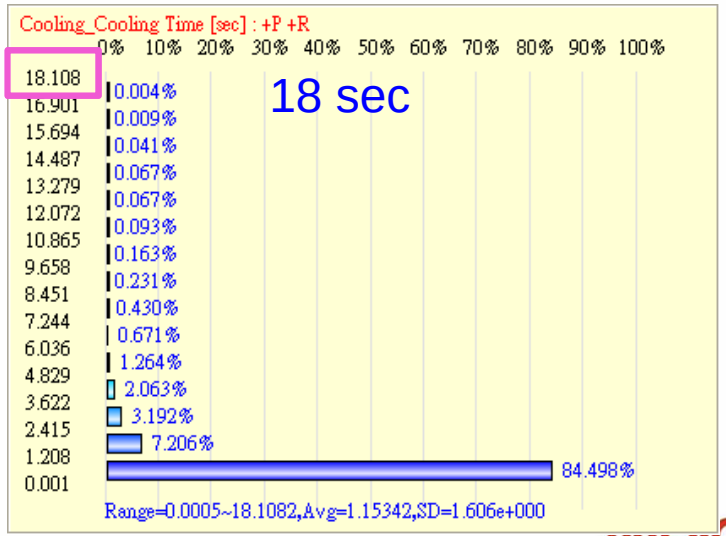


Conformal Design



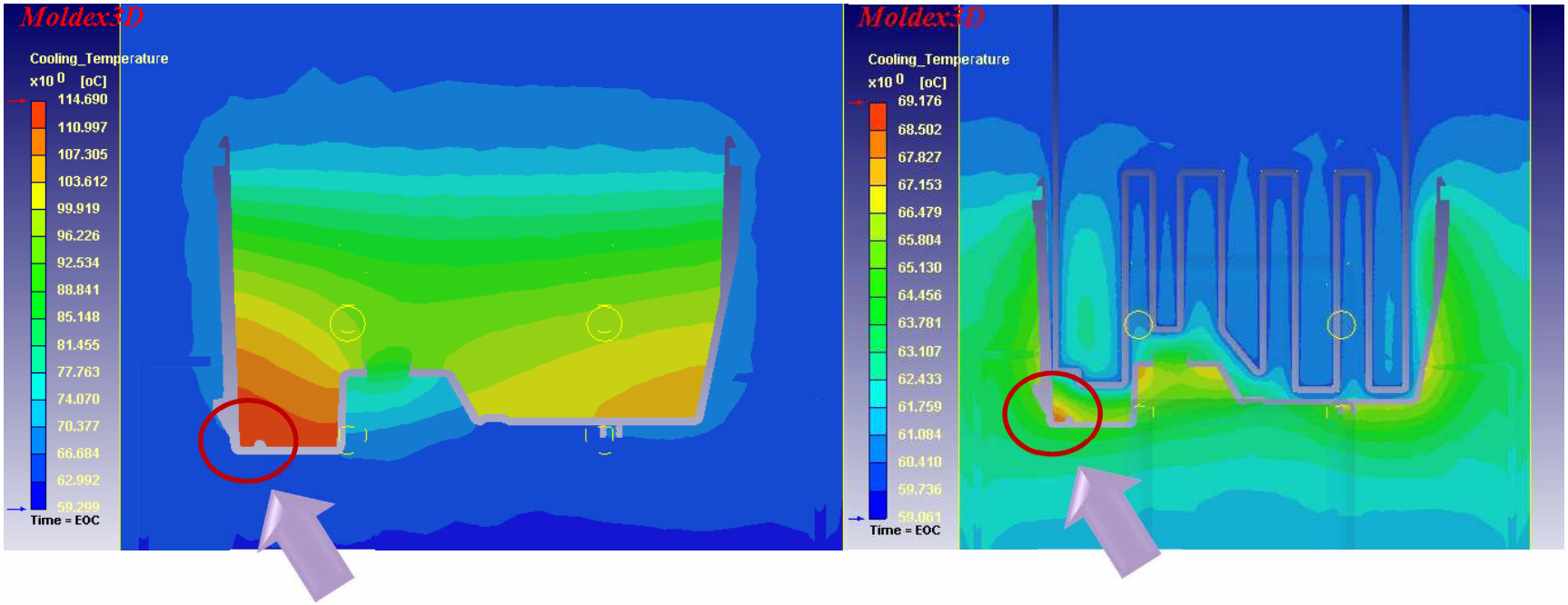
61% reduction





3D Temperature Result Display

> Mold/Part temperature can be displayed in 3D at any cross section. Users can find out heat spots and revise their design easily.



Conventional Design: 114.7˚C

Conformal Design: 69.2˚C

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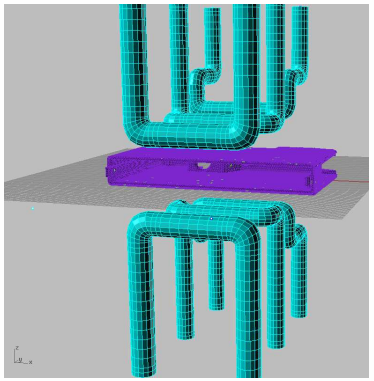
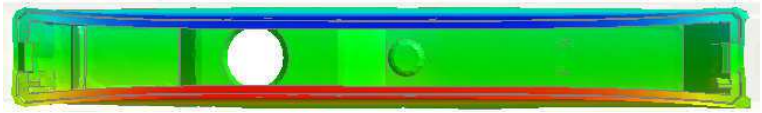
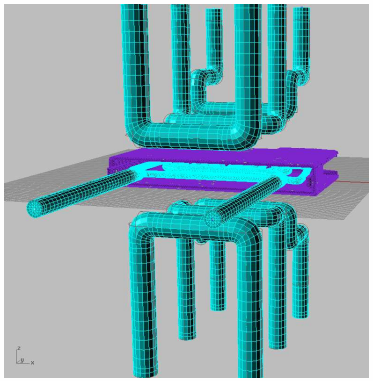
Warpage Reduction by Conformal Design

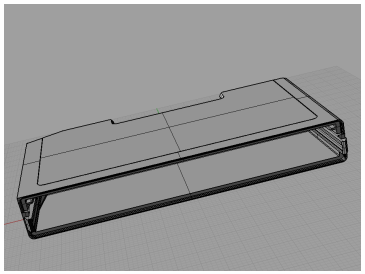
Normal Design

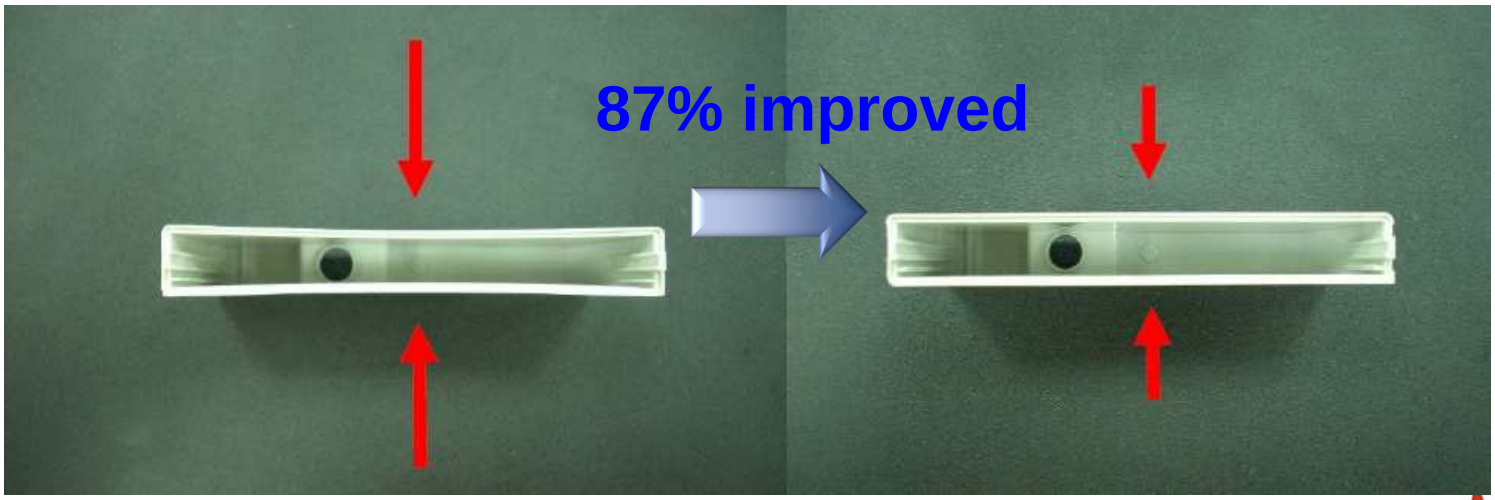




Conformal Design







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Advanced Cooling Analysis

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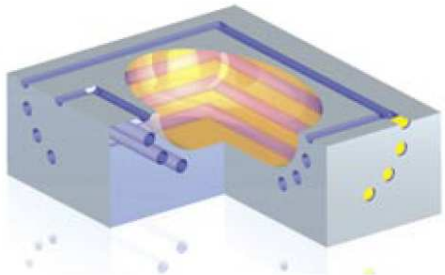
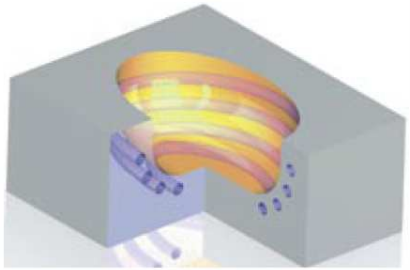
Normal and Conformal Cooling

- Cooling channel types:
  - Conventional: Cooling channel manufactured by traditional method
  - Conformal: Cooling channel design based on product contour

- Why we use conformal cooling?
  - To increase cooling efficiency. With conformal cooling, cooling rate difference can be minimized through the whole part
  - To reduce cycle time and cost
  - To have better product quality



Conventional

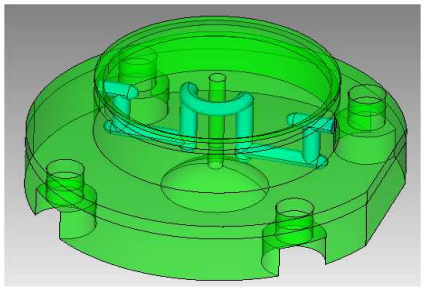


Conformal

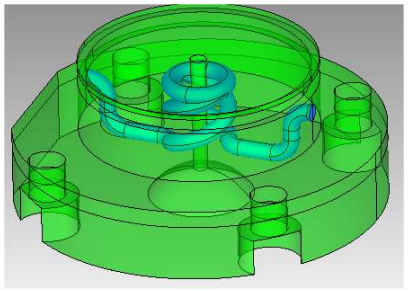
Source: EOS whitepaper, Siegfried Mayer (EOS GmbH)

Channel Pressure Drop Analysis

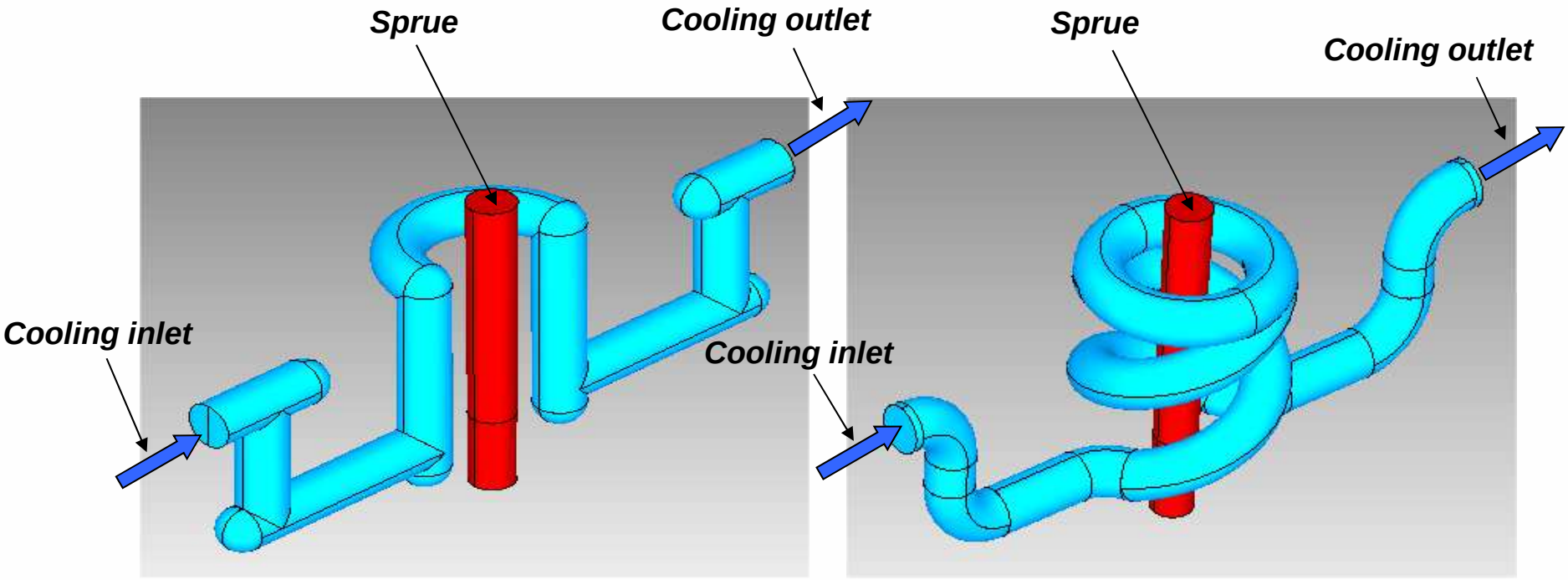
> Compare pressure drop from two different channel designs



Vacuum Brazing



DMLS



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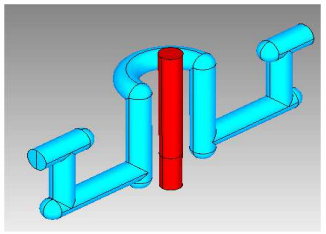
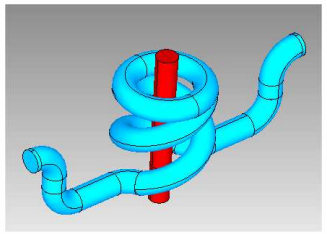
Pressure Drop Effects on Different Channel Designs



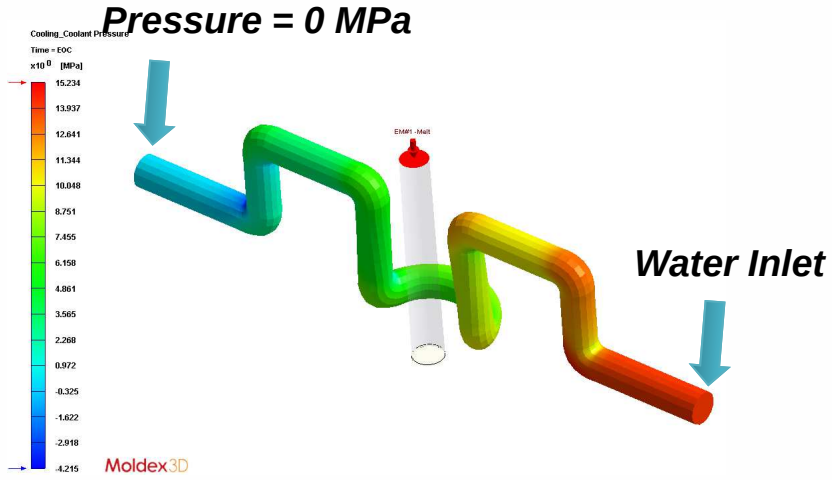


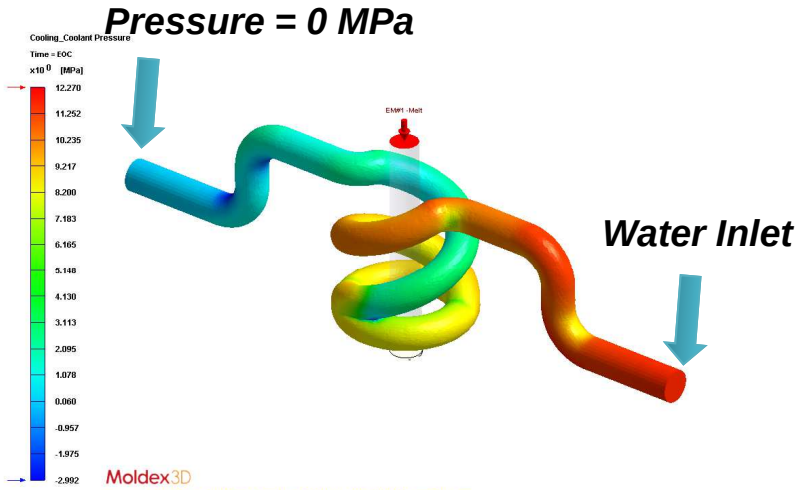
> Design A (Vacuum Brazing)

Pressure drop = 15.234 MPa

> Design B (DMLS)

Pressure drop = 12.27 MPa





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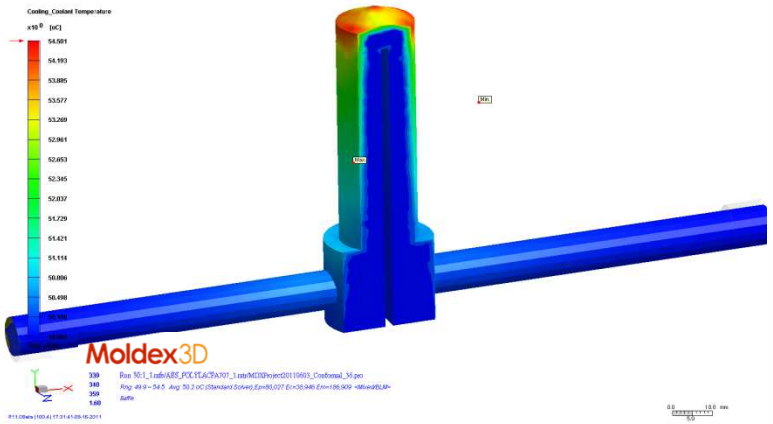
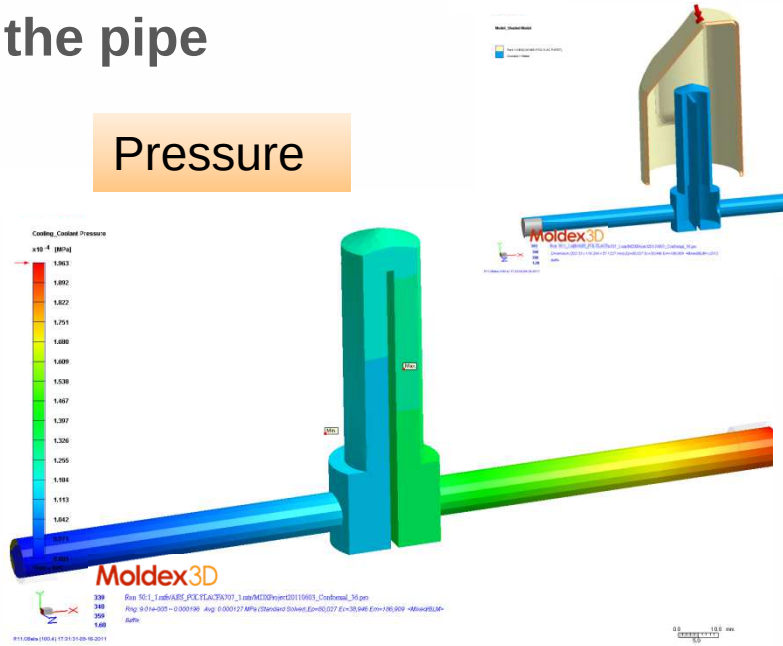
Results of Cooling Effect Analysis in 3D

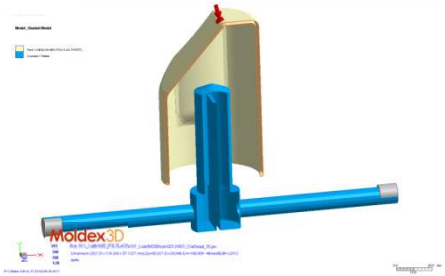
> Estimate properties inside the pipe

Temperature

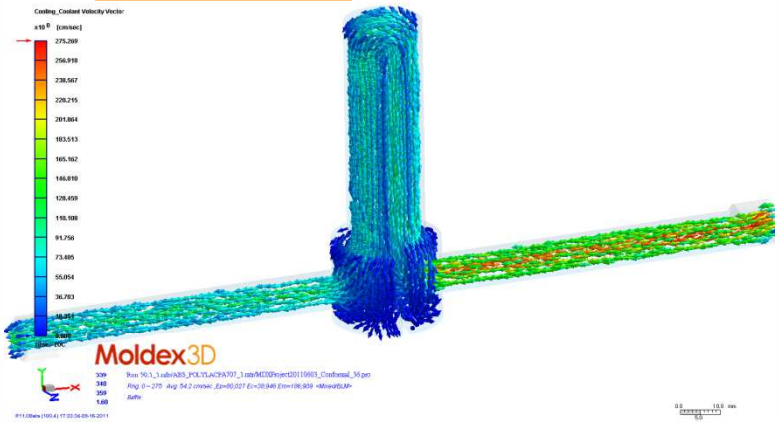


Pressure

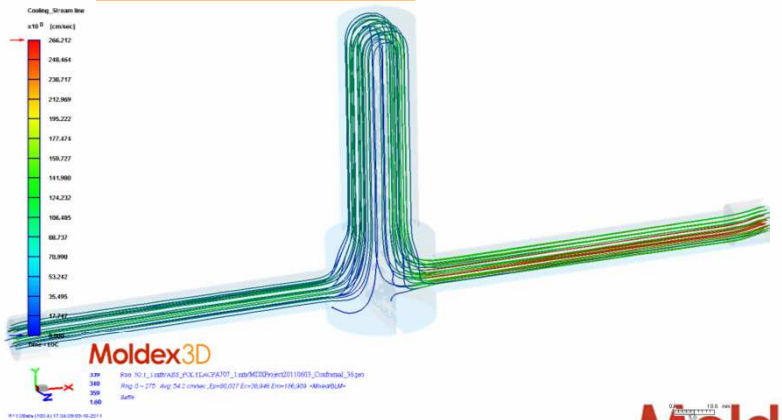




Velocity



Streamline



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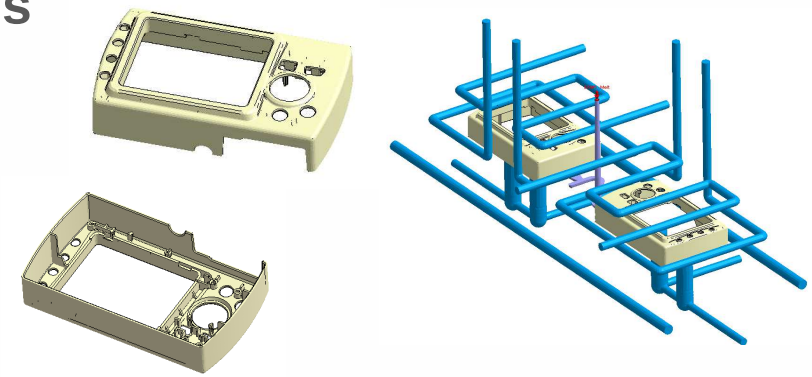
Moldex3D Can Consider Surface Roughness Effects

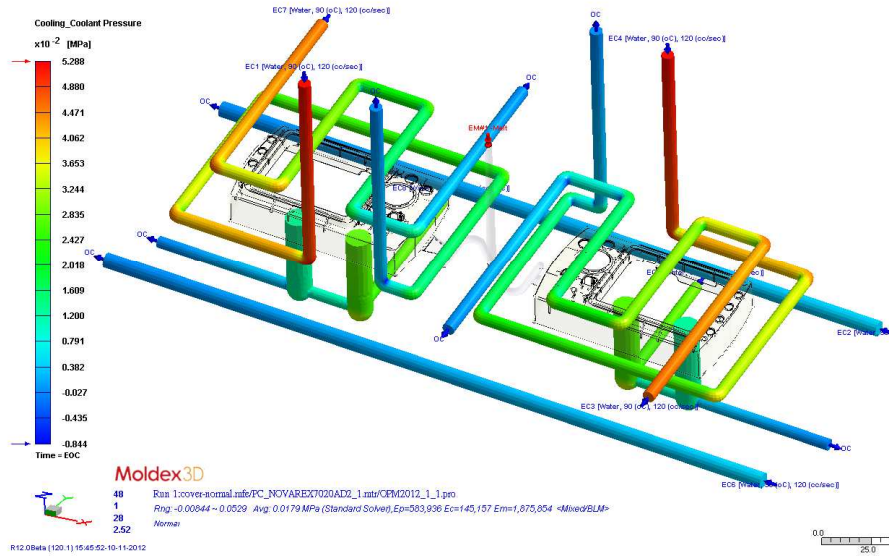
> Higher pipe surface roughness leads larger pressure drop

Benefit

– The results can help predict potential pipe problems

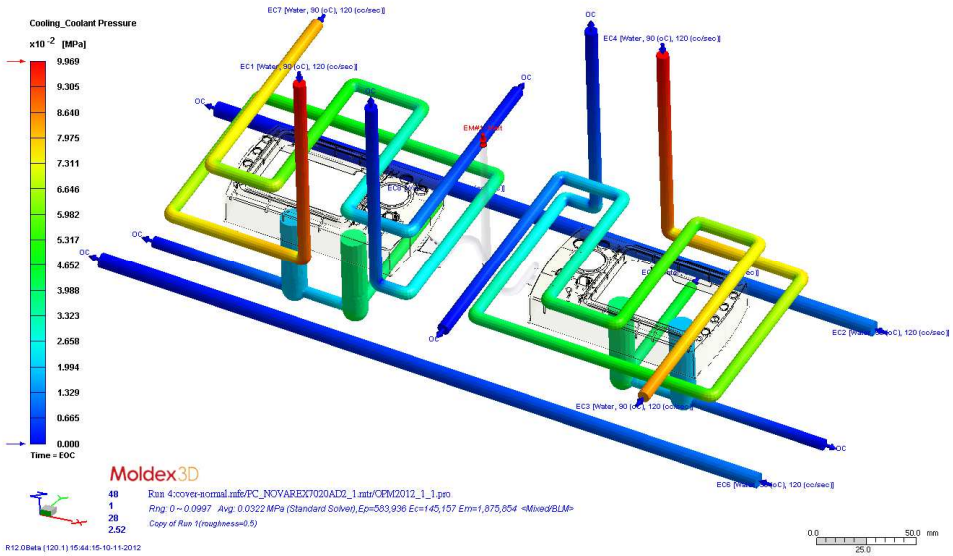


Max. Pressure: 0.0529 MPa



Ra = 0.02 mm

Max. Pressure: 0.0997 MPa



Ra = 0.5 mm

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Moldex3D Cooling System Preprocess Function

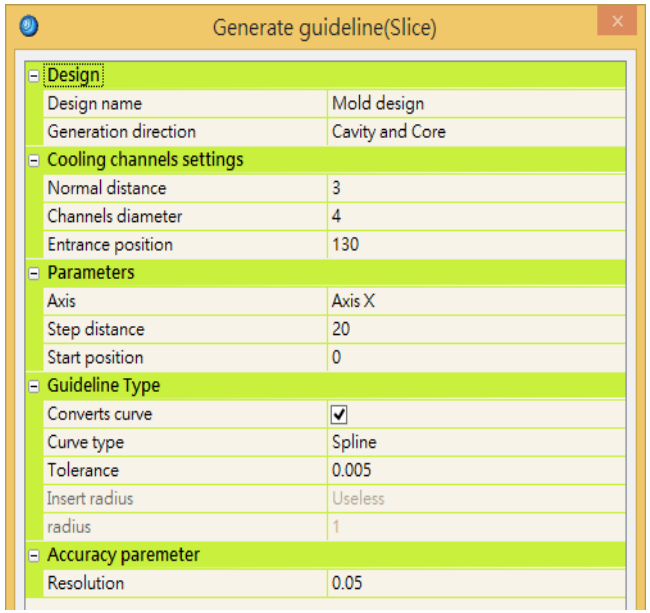
Cooling Channel Designer (CCD) Integration:

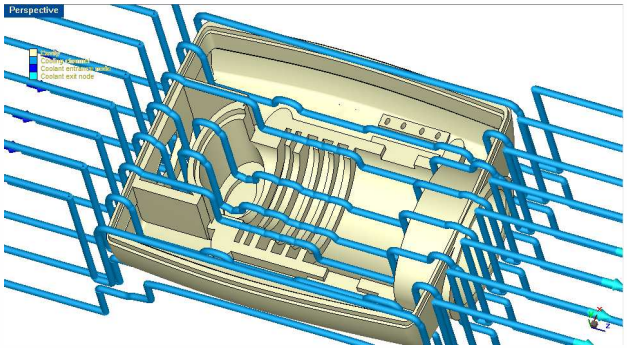
> Provides the function to arrange cooling channel layout with the part surface

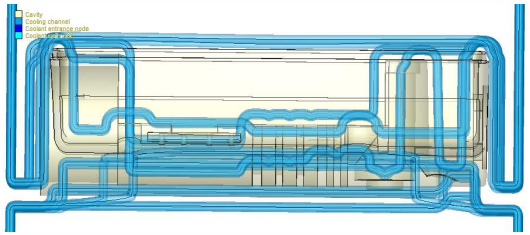
> Options to define channel working axis, distance to part surface, coolant entrance location….etc.

Benefit

– An efficiency approach to design cooling channel layout







Note: Detail information please refer to CCD (Cooling Channel Designer) Module developed by Moldex3D & OPM

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Moldex3D Cool Functions

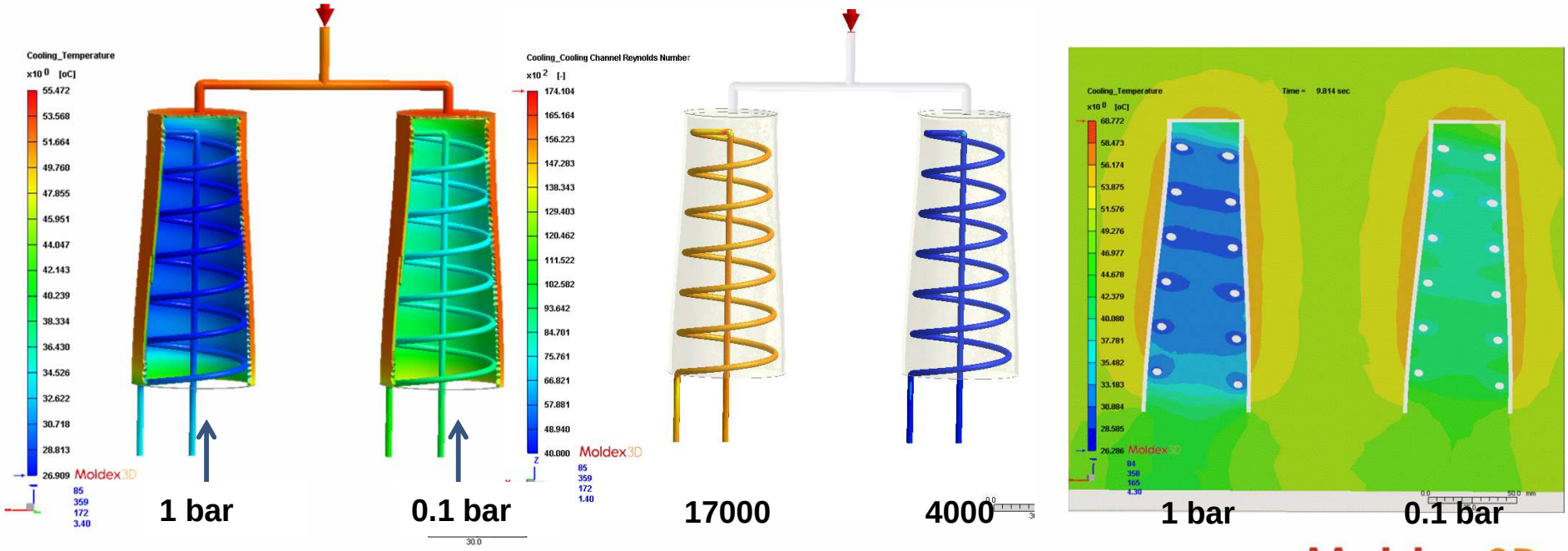
Supports 3D cooling channel simulation by eDesign mesh

Provides Reynolds number prediction (for Solid only)

Benefit

- **Used to help predict similar flow patterns in different fluid flow situations**

Reynolds Number



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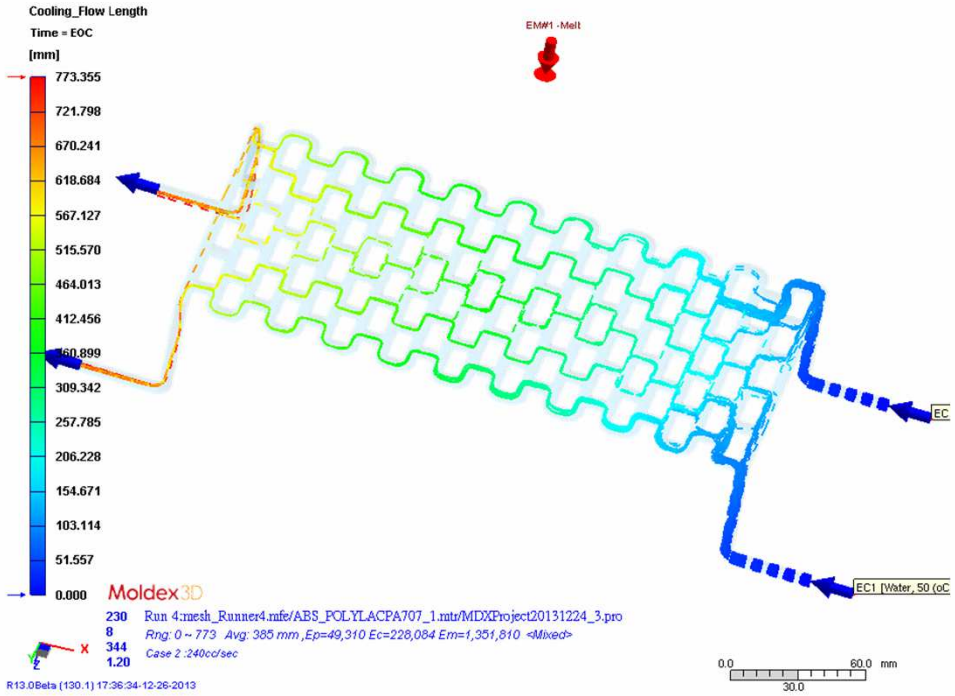
Moldex3D Cool Functions

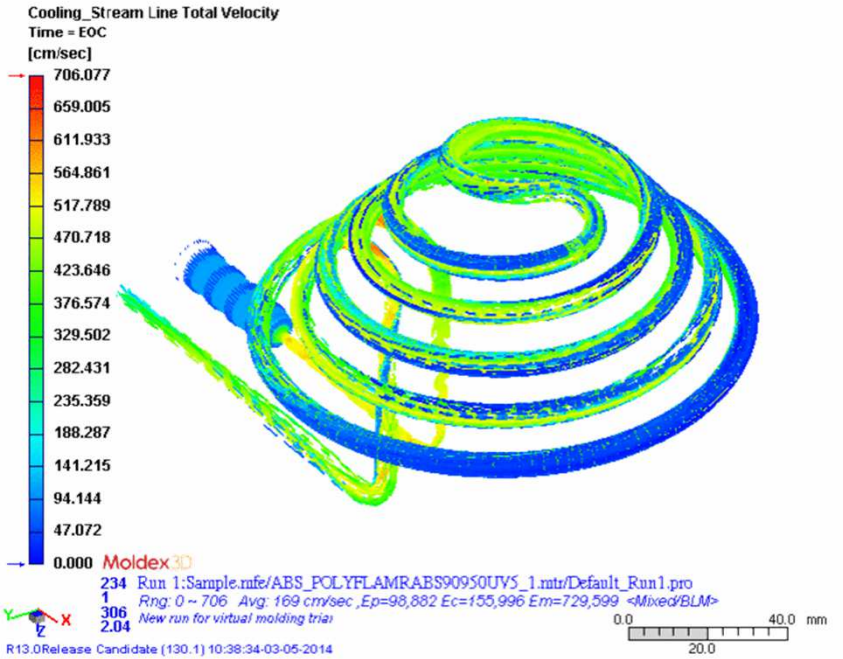
Multiple Coolant Inlet/Outlet Design Simulation

> Supports the cooling channel analysis of complex cooling design, including multi-inlet and multi-outlet design

Benefit

– For any complex cooling system design can be analyzed and visualize coolant streamline and flow filed in cooling channels





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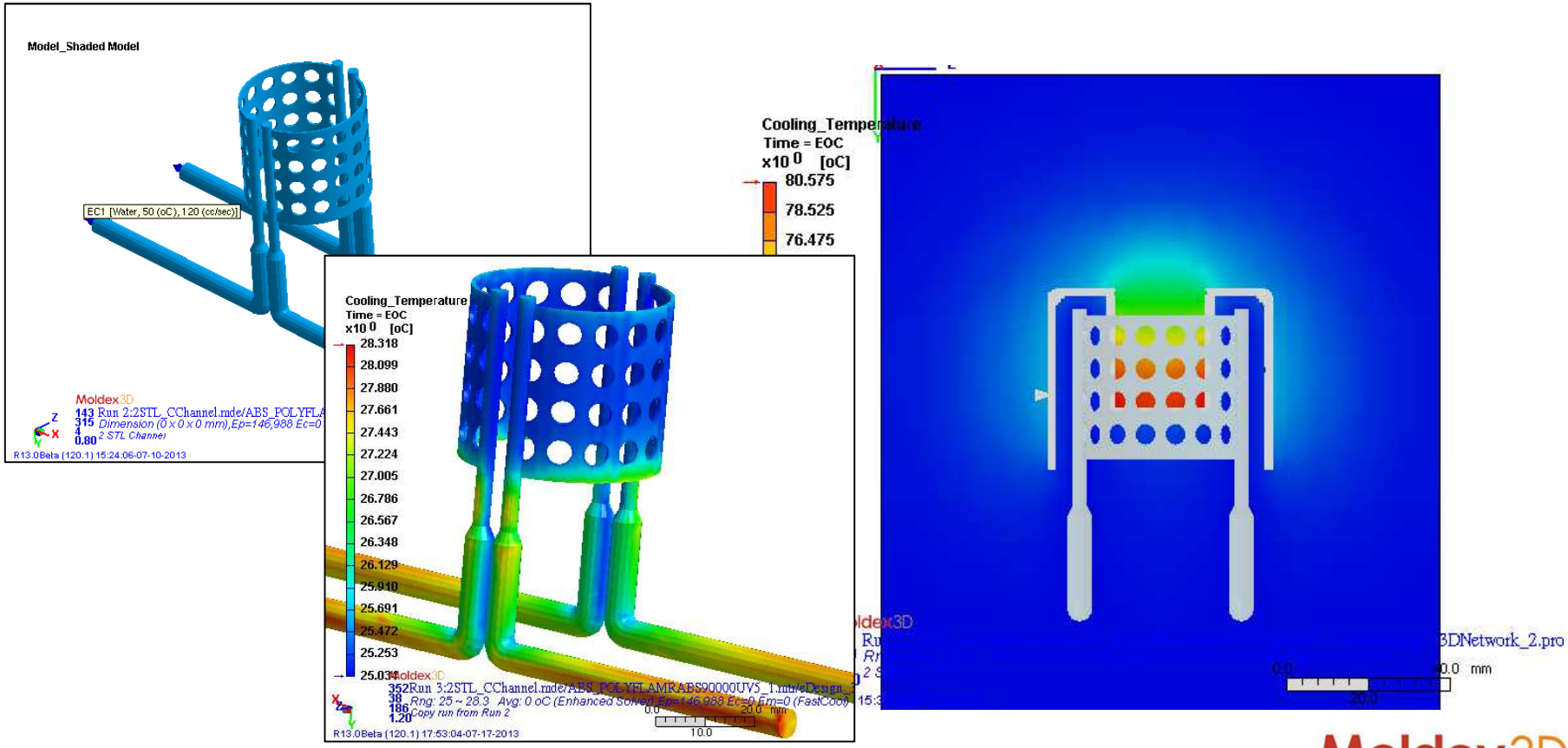
Moldex3D Cool Functions

3D Cooling Channel Simulation

eDesign Shell Solid

Benefit

- More easy-to-run 3D coolant flow analysis for designer level simulation



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Case study

- Carriage Model
- Cup Model

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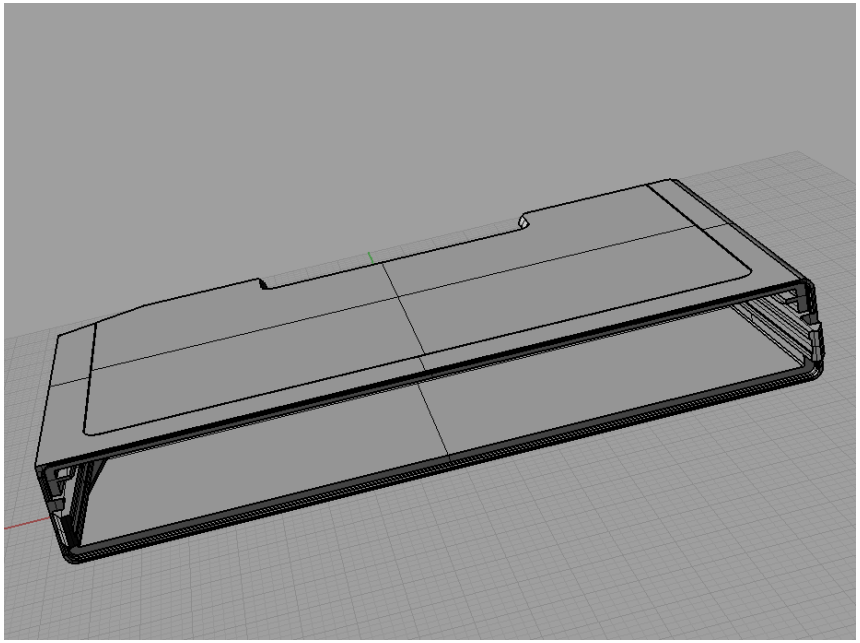
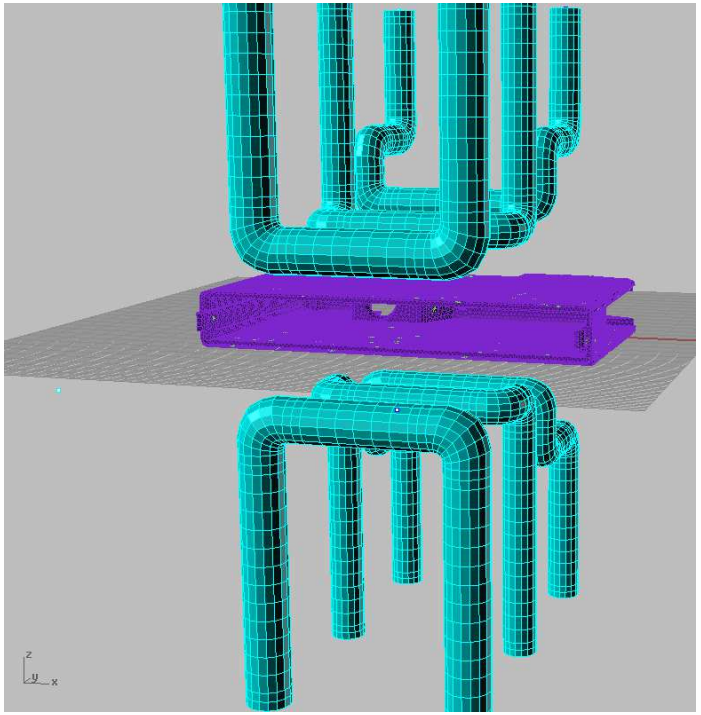
1. Carriage Model

- As shown in the figure below, the hallow interior of this part is the crucial area
- With traditional cooling channel design, this is mostly the area with heat accumulation. This will cause inward warp during injection molding process

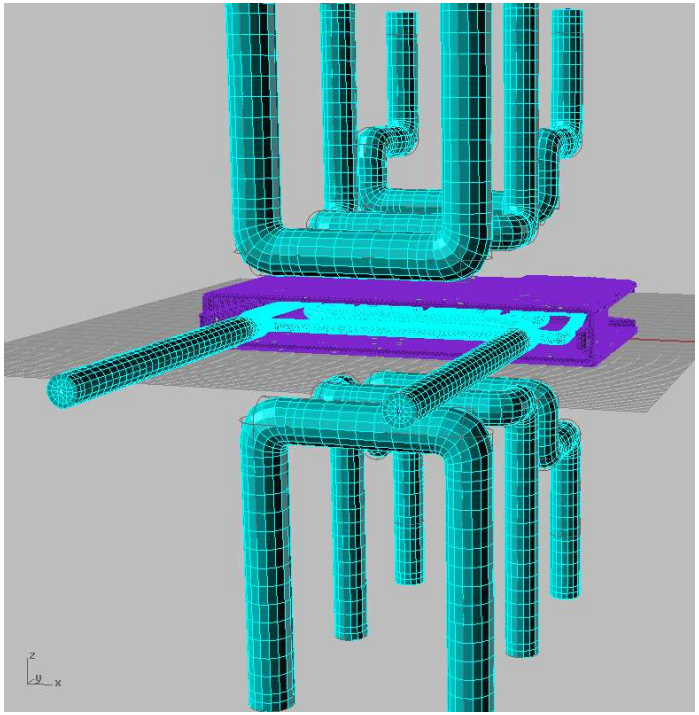


Cooling Channel Design

- The conventional design has no cooling channel inside the hallow interior
- With conformal cooling design, warp can be reduced



Conventional

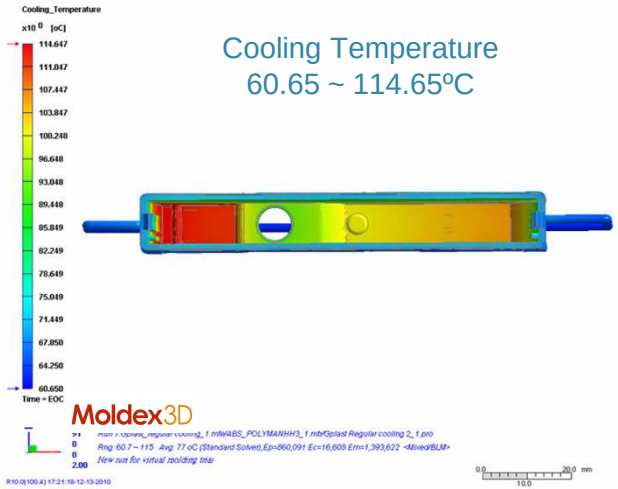


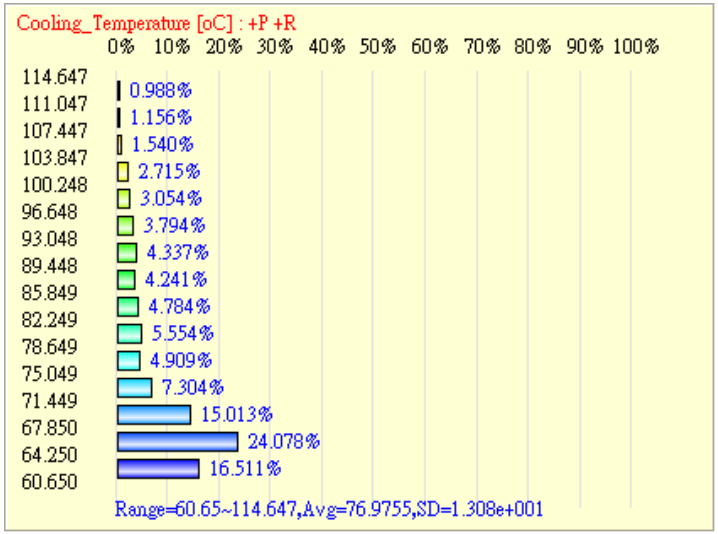
Conformal

Cooling Analysis - Cooling Temperature

Conventional Cooling

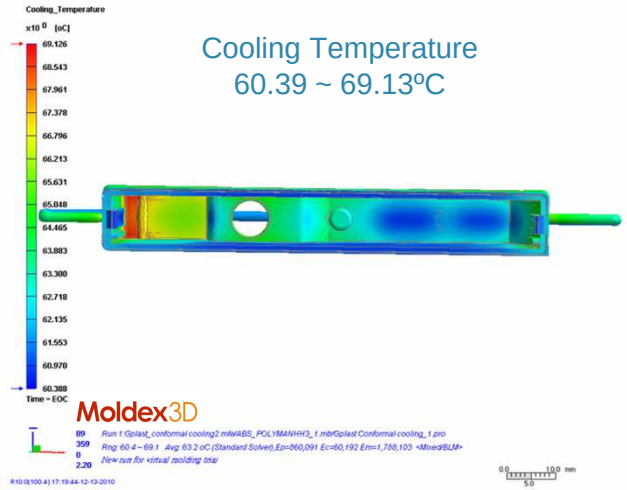
Cooling Temperature
60.65 ~ 114.65ºC

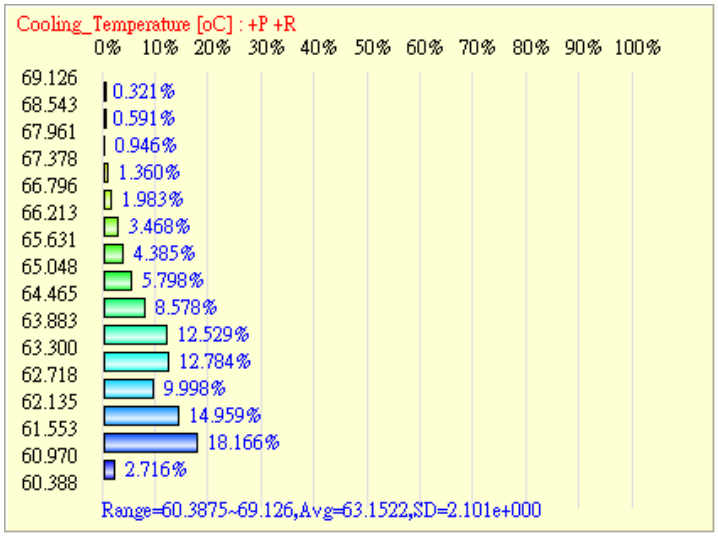




Conformal Cooling

Cooling Temperature
60.39 ~ 69.13ºC





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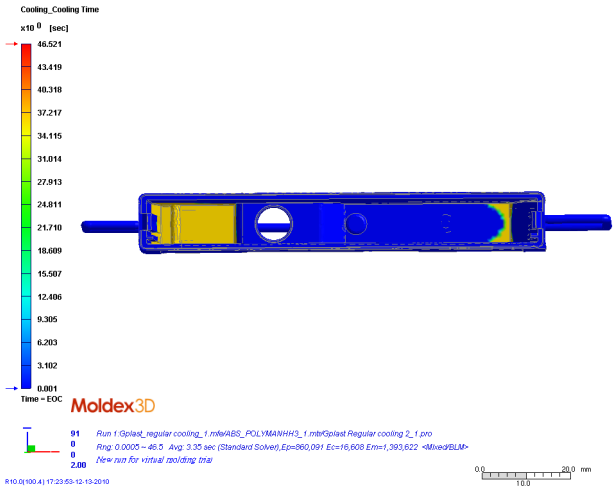
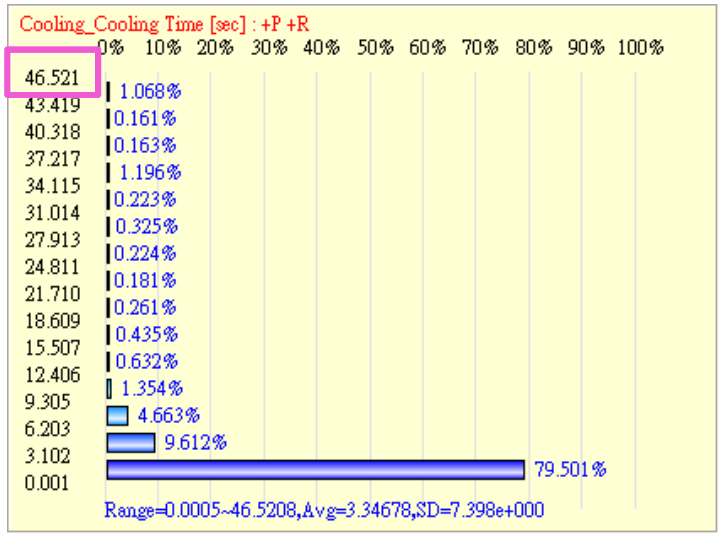
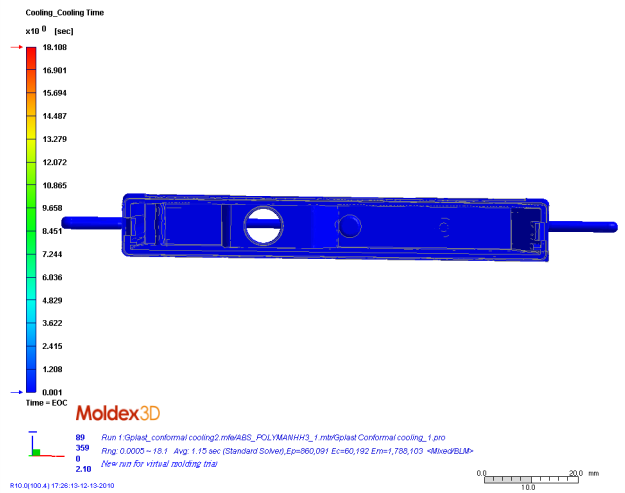
Cooling Analysis - Cooling Time

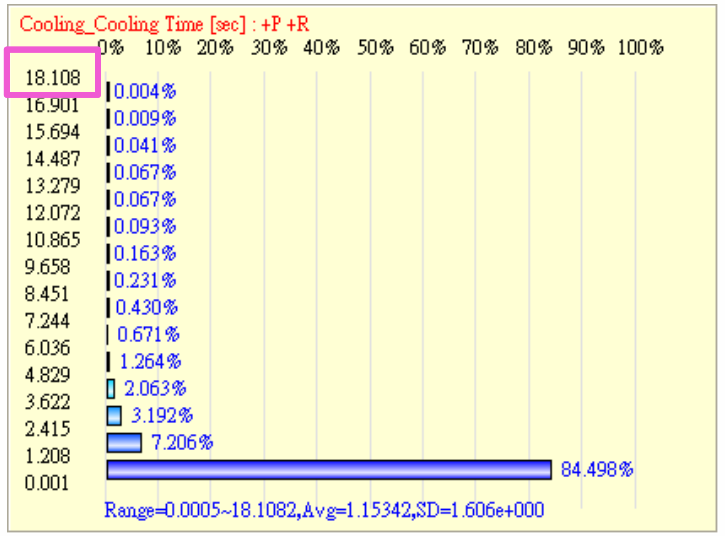
Conventional Cooling





Conformal Cooling





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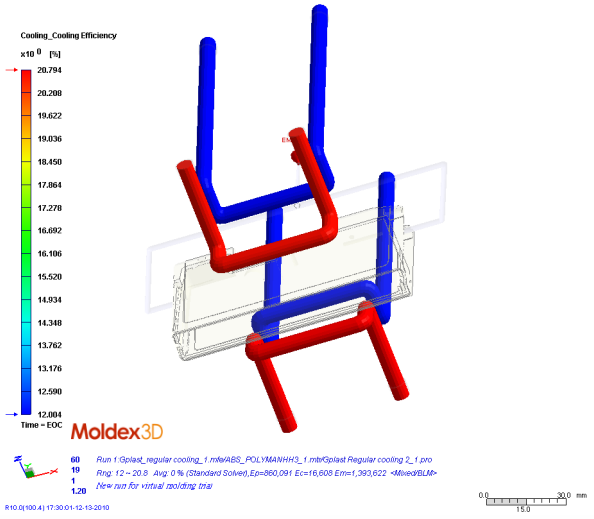
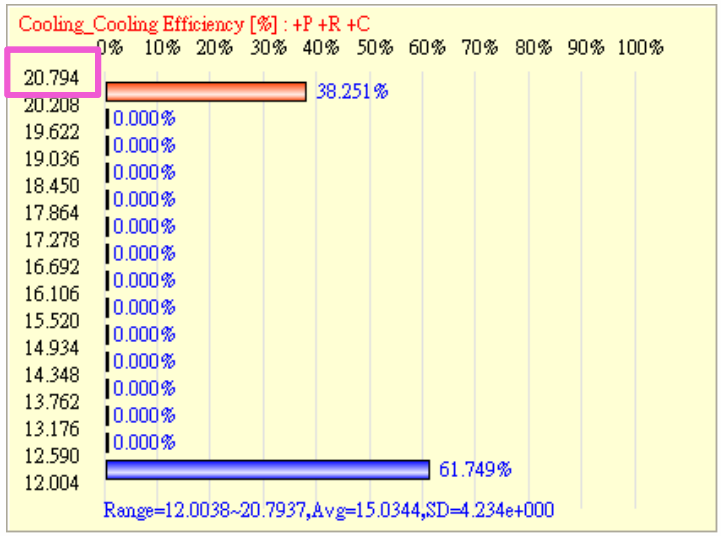
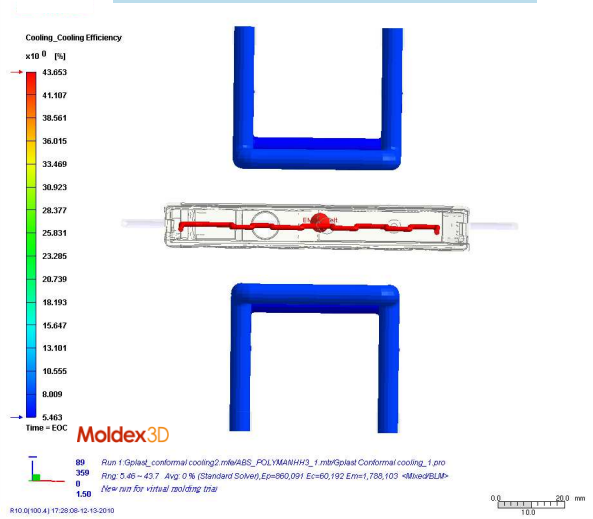
Cooling Analysis - Cooling Efficiency

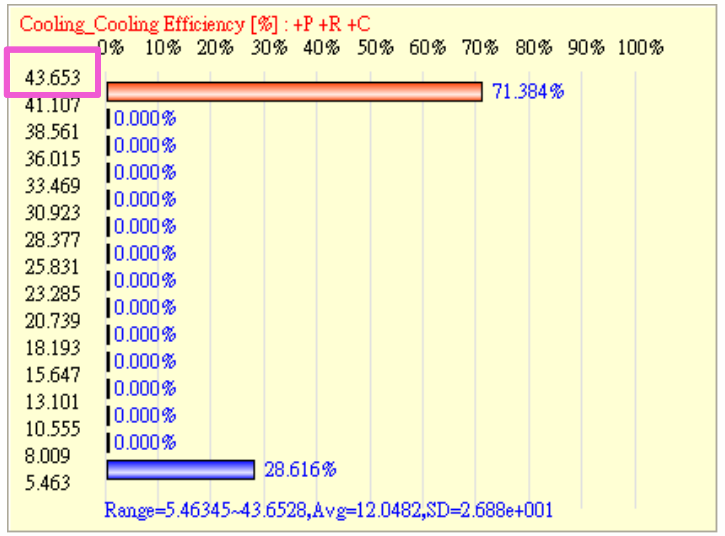
Conventional Cooling





Conformal Cooling





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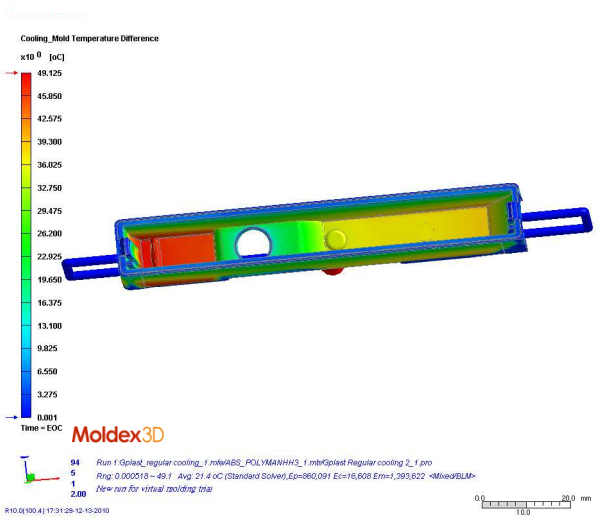
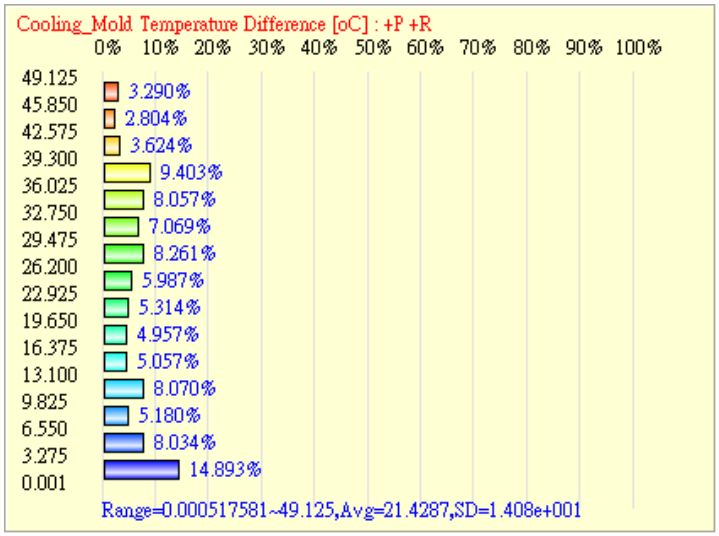
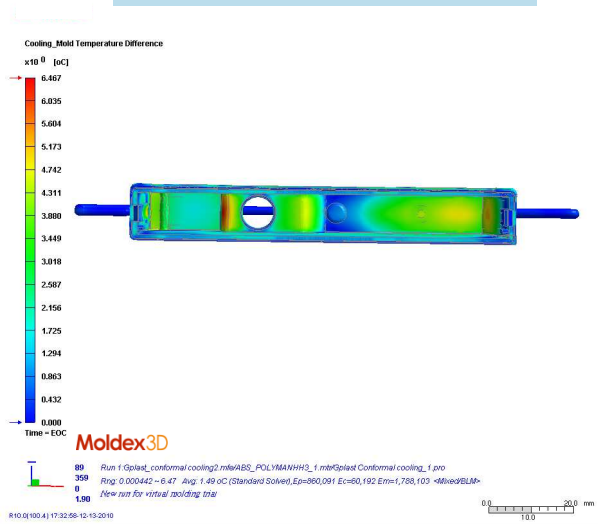
Cooling Analysis - Mold Temp Difference

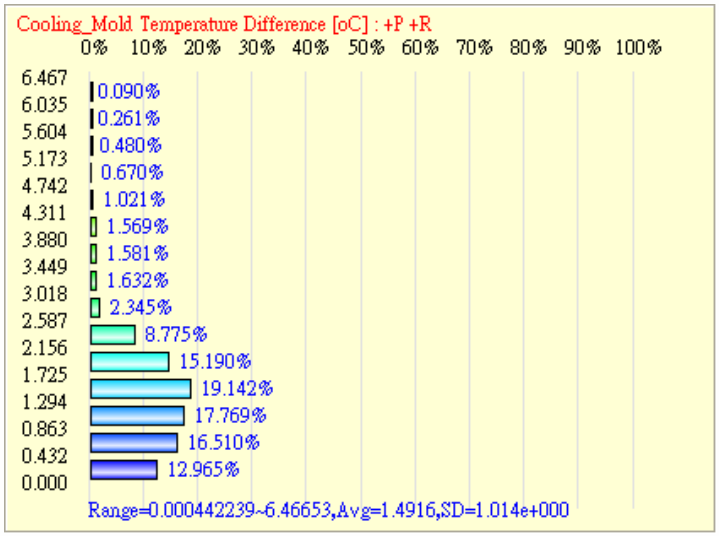
Conventional Cooling





Conformal Cooling





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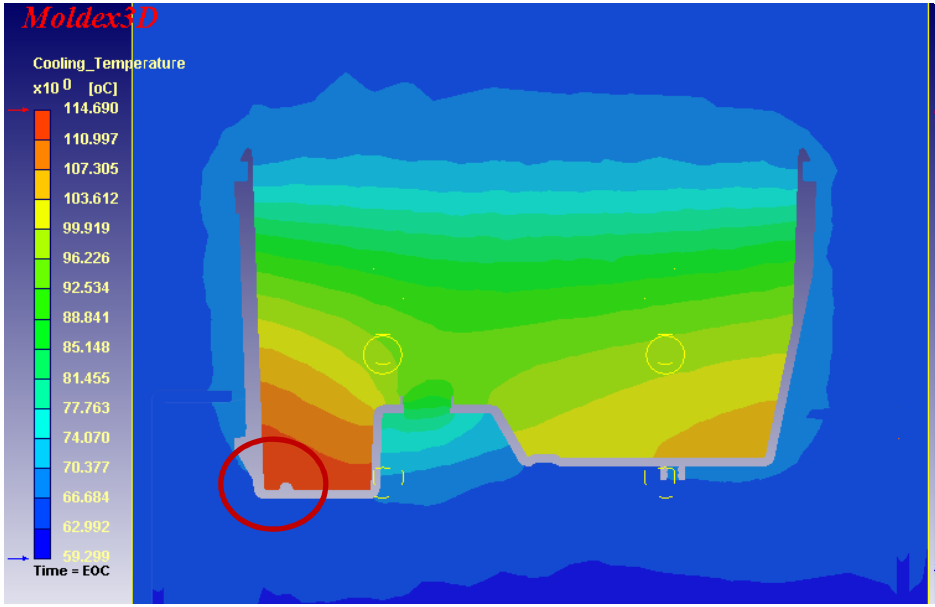
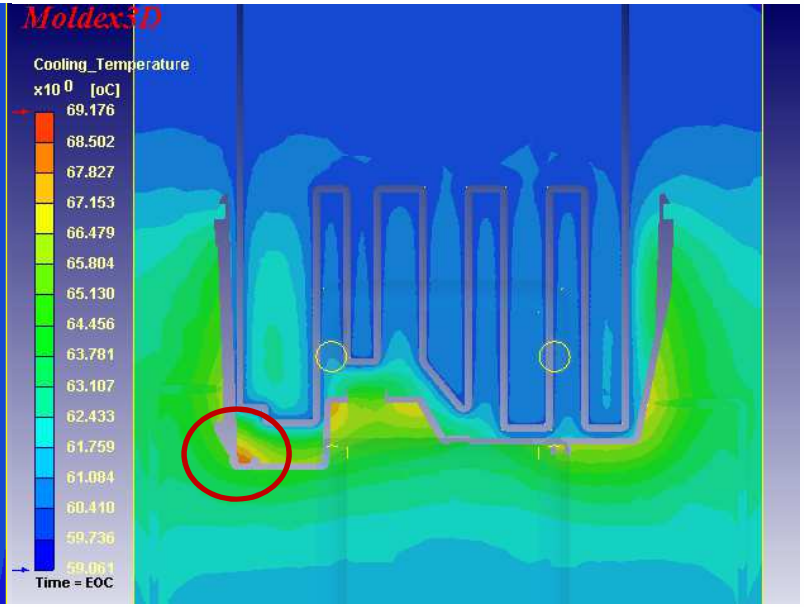
Cooling Analysis - Mould Temperature

- The two figures below show the mould temperature distribution of conventional and conformal cooling design
- We can see the maximum temperature drops from 114.7ºC to 69.2ºC



Conventional Cooling



Conformal Cooling

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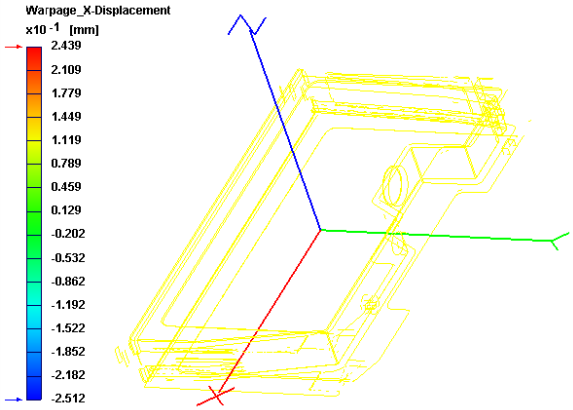
Result Summary

- For this case, the z-direction warp is the most concerned point
- Compare the conventional cooling system design with conformal cooling design, z-direction warp reduced by 87%



	Conventional	Conformal	Improved (%)
X	-0.25 ~ 0.24 mm	-0.26 ~ 0.25 mm	-3
Y	-0.11 ~ 0.13 mm	-0.1 ~ 0.12mm	11
Z	-0.68 ~ 0.66 mm	-0.08 ~ 0.09 mm	87
Total	0 ~ 0.69 mm	0 ~ 0.27mm	61

Displacement comparison

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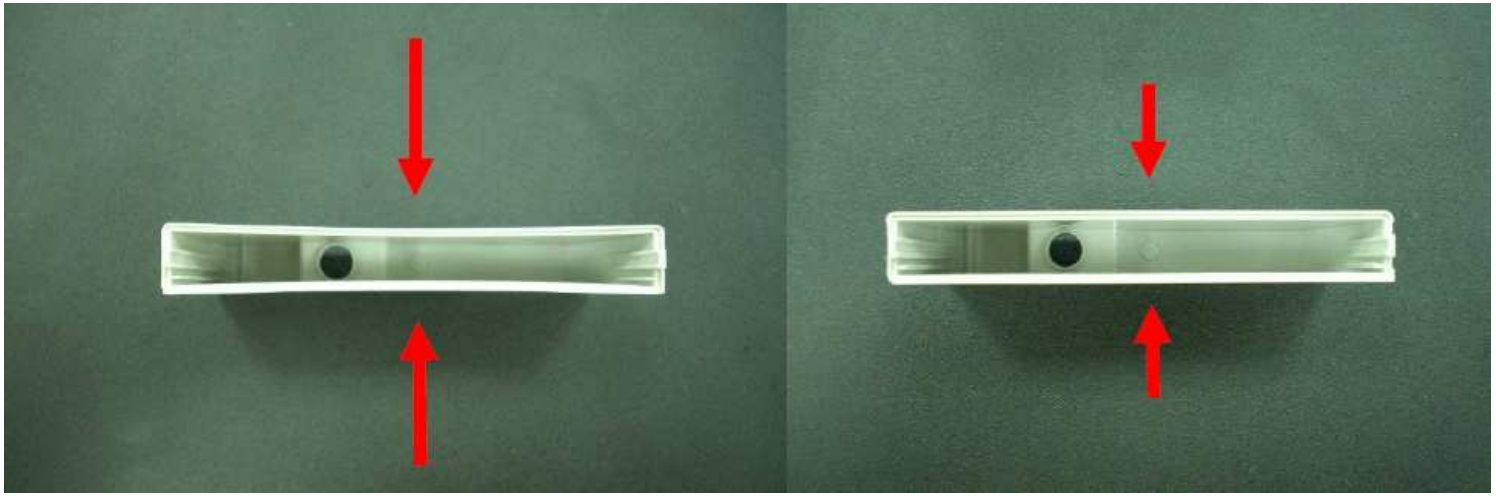
Result Summary (Cont.)

> From the photo of actual product, we can also see the warpage improvement is significant in z direction



Conventional Cooling

Conformal Cooling

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Summary

- Product quality and cycle time are two important issues in injection molding process. Conformal cooling is an effective way to shorten cycle time and improve product quality at the same time

- By using Moldex3D, transient temperature can be predicted. Moldex3D offers a useful tool to predict the effects on conformal cooling design

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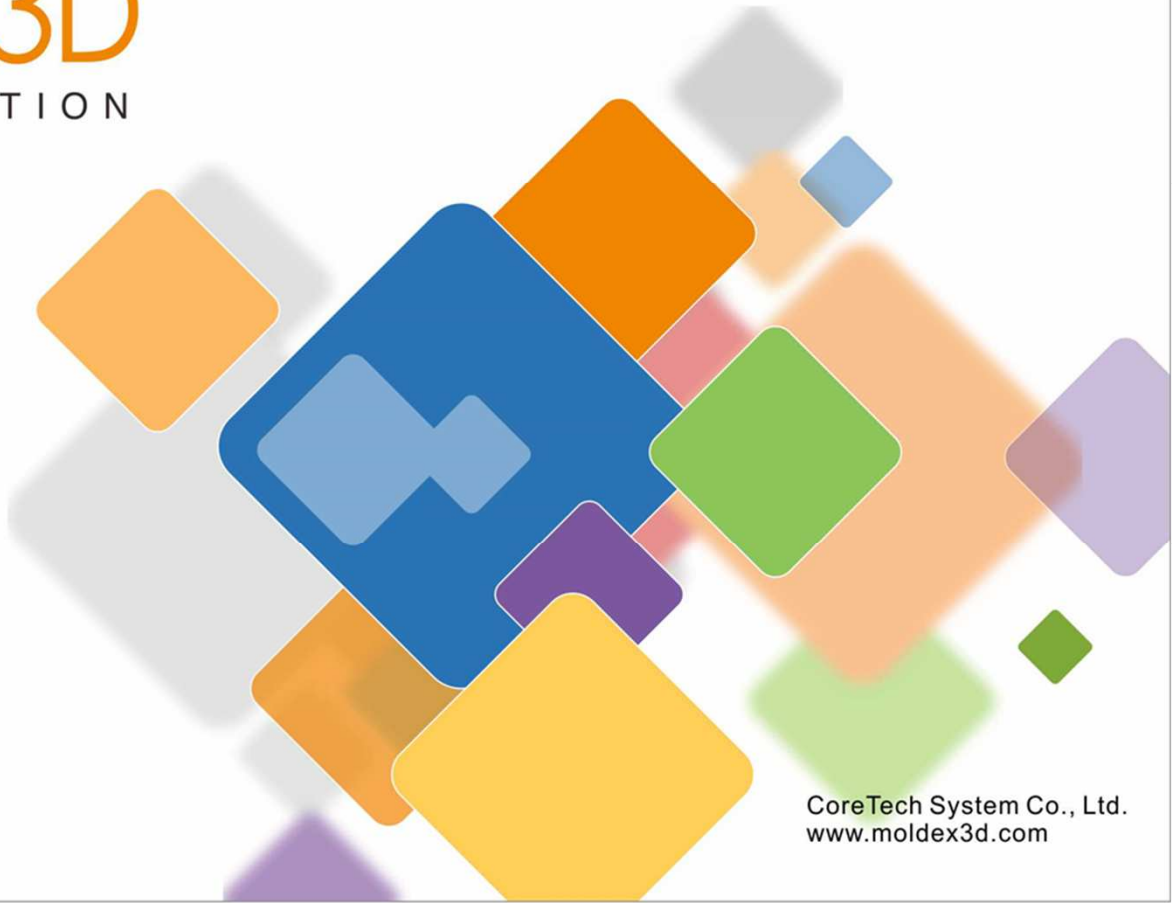
MOLDING INNOVATION



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