

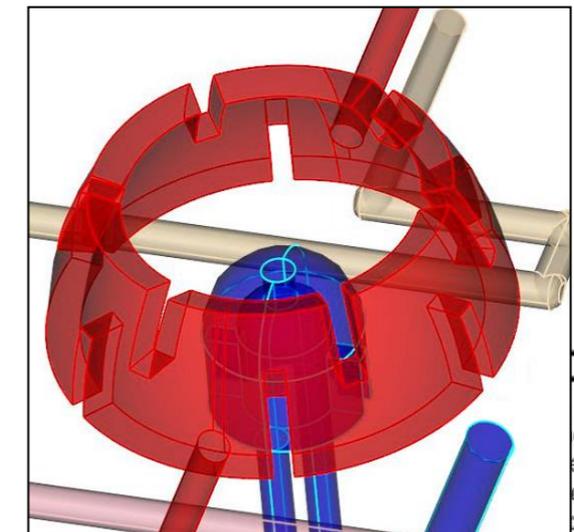
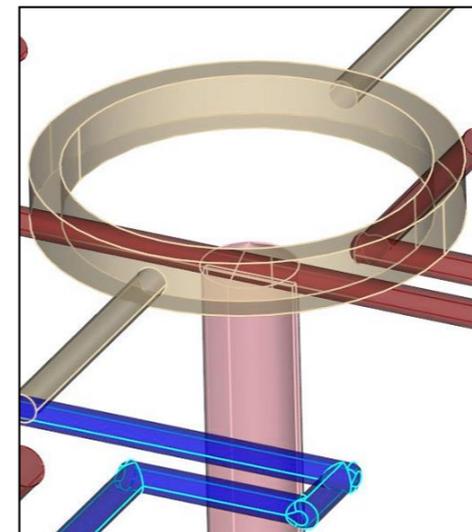
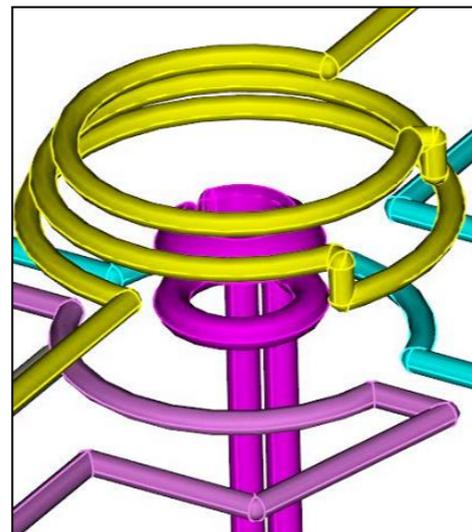
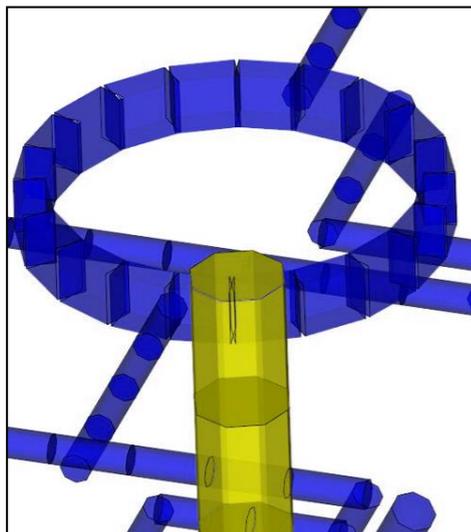
# 3차원 형상 냉각 기술 (3D Conformal Cooling)

2015.05.13

ED&C 박기윤 대리  
ky.park@ednc.com

# Class summary

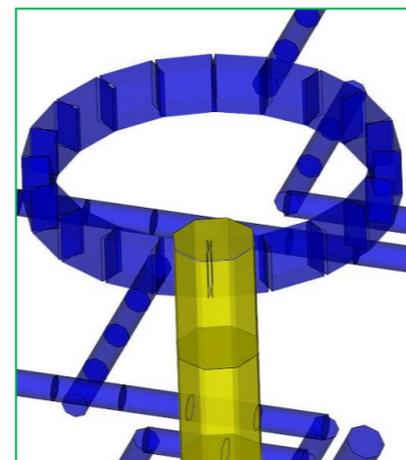
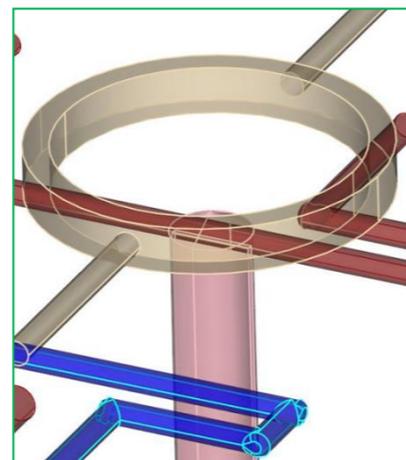
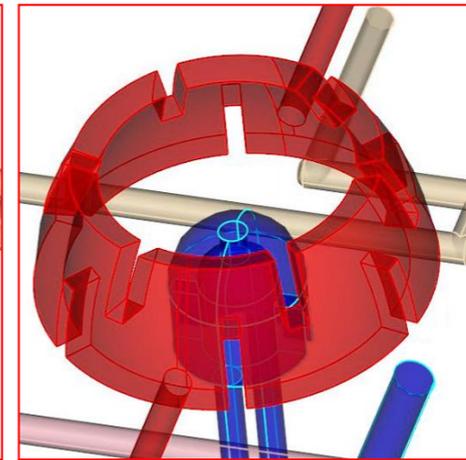
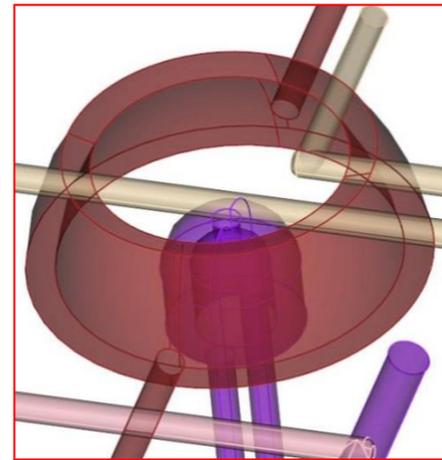
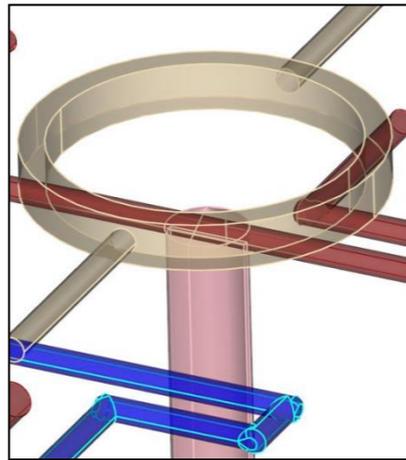
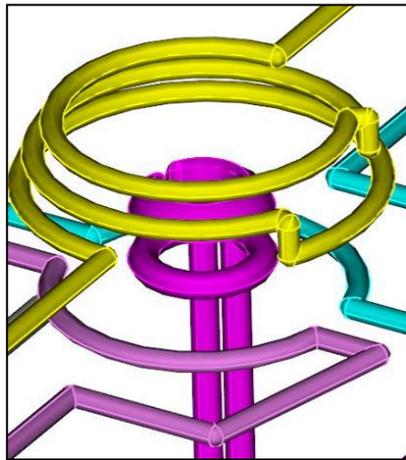
- 냉각해석 시 Beam channel과 3D channel의 비교 및 3D 형상냉각 해석의 소개
- 고려조건 :
  - 냉각채널 Beam
  - 냉각채널 적층방식
  - 3D 형상 냉각채널
  - 3D 형상 냉각채널 형상변경



# 목표

At the end of this class, you will be able to:

- 3D 형상냉각해석 방법을 익힘
- 3D Baffle과 3D 형상냉각의 효율 확인
- 3D 형상냉각 디자인 변경에 따른 효율 확인
- 3D Baffle과 Beam Baffle의 차이점 확인

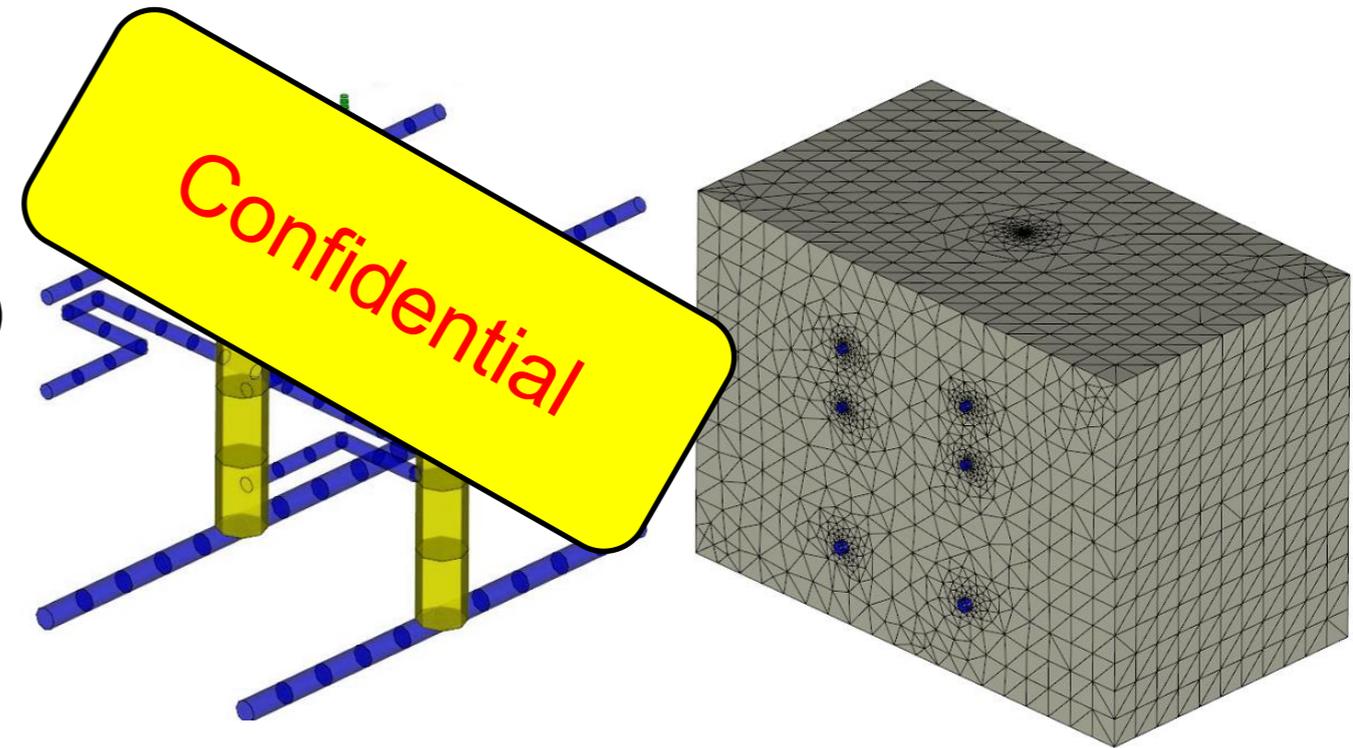


# 3D Conformal Cooling 소개

# Cool FEM 해석 기법

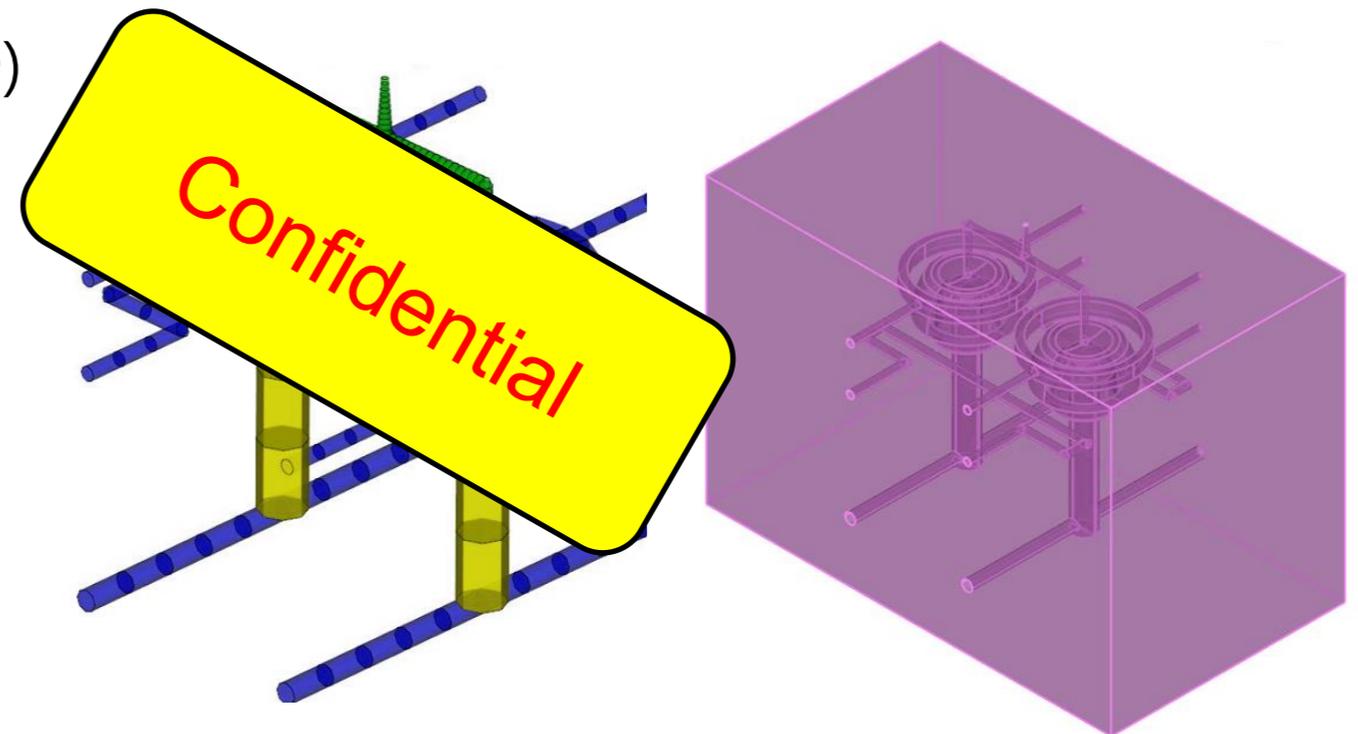
## 1. Mold Surface Wizard(FEM)

1. 제품 모델링
2. Runner 모델링 (Beam or 3D CAD)
3. Channel 모델링 (Beam)



## 2. Mold Block(FEM)

1. 제품 모델링
2. Runner 모델링 (Beam or 3D CAD)
3. Channel 모델링 (Beam)
4. 금형 모델링 (3D CAD)



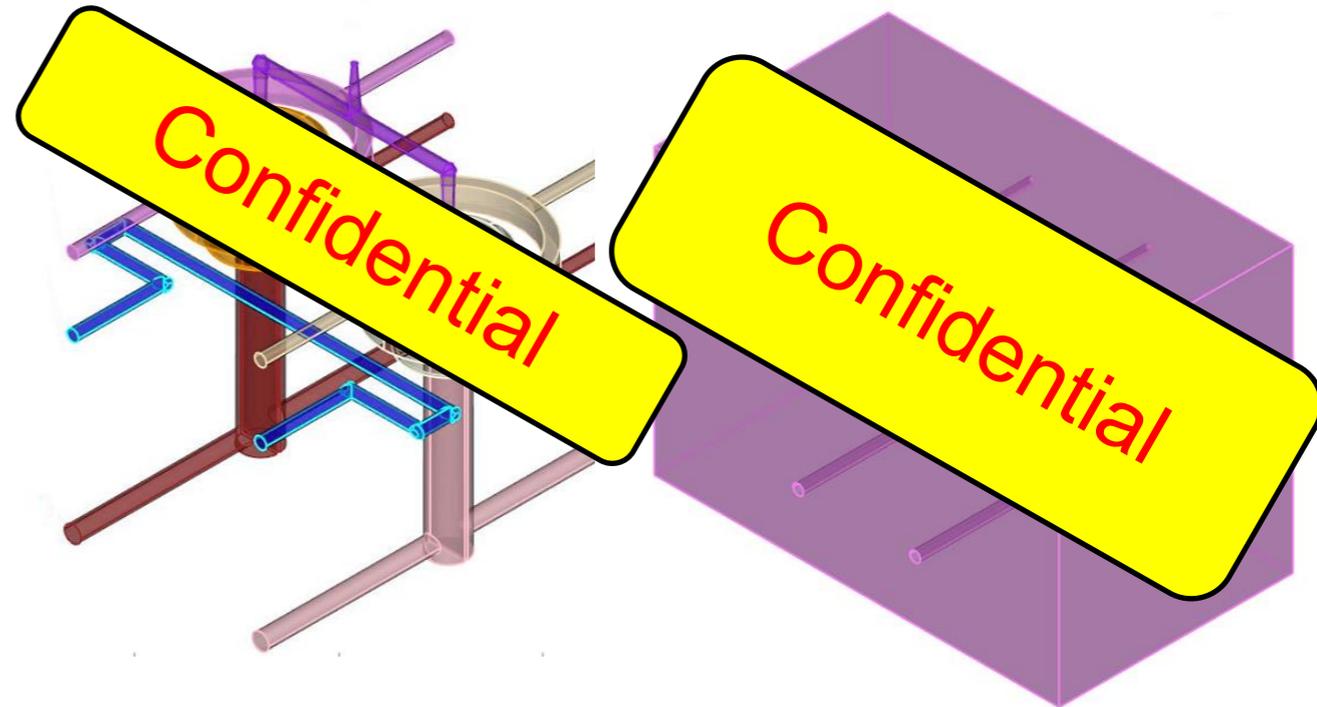
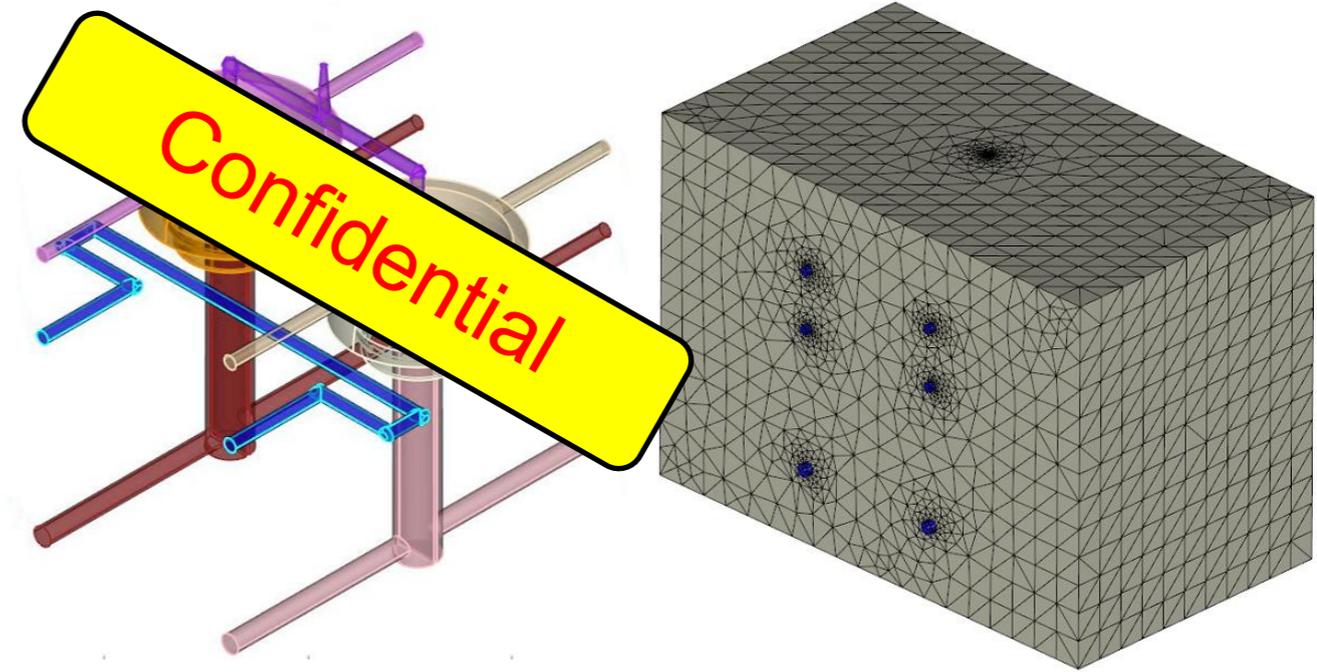
# Conformal Cooling 해석 기법

## 1. Mold Surface Wizard(FEM)

1. 제품 모델링
2. Runner 모델링 (Beam or 3D CAD)
3. **Channel 모델링 (3D CAD)**

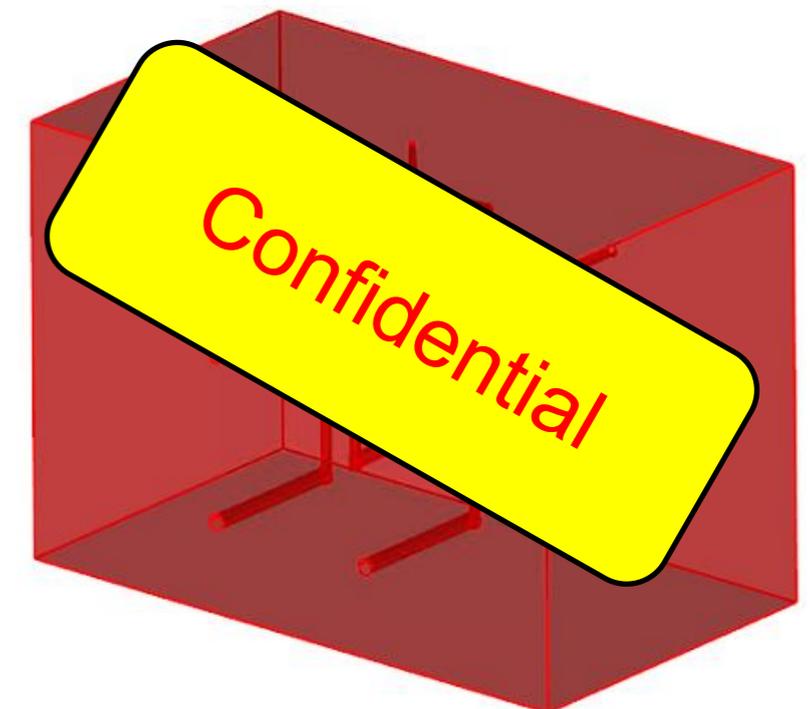
## 2. Mold Block(FEM)

1. 제품 모델링
2. Runner 모델링 (Beam or 3D CAD)
3. **Channel 모델링 (3D CAD)**
4. 금형 모델링 (3D CAD)



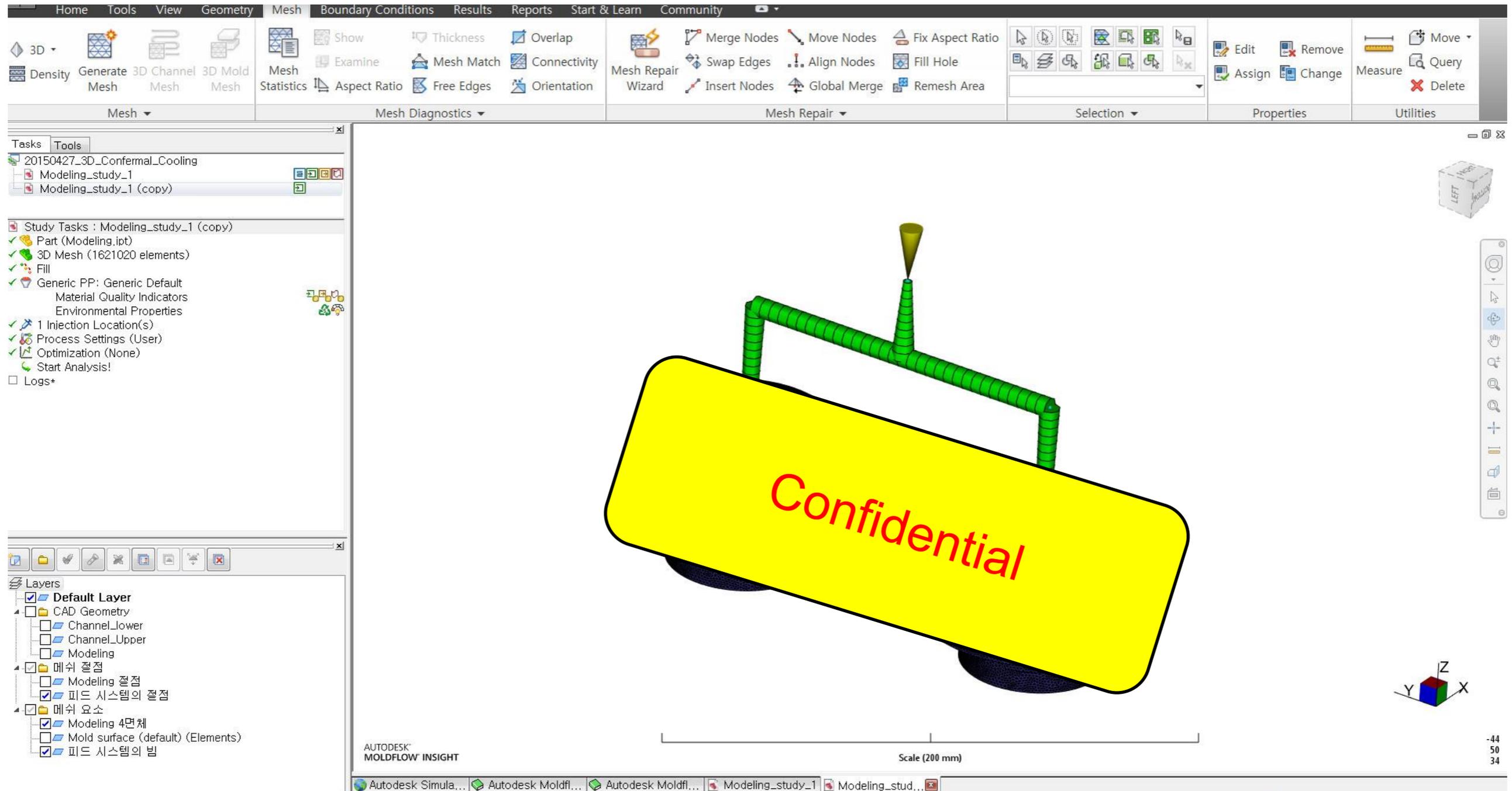
# Conformal Cooling 해석

- 제품 모델링 - 3D CAD
  - Runner 모델링 - 3D CAD or Beam
  - Channel 모델링 - 3D CAD
  - 금형 모델링 - 3D CAD
- 
- CAD를 이용한 모델링 수정 능력



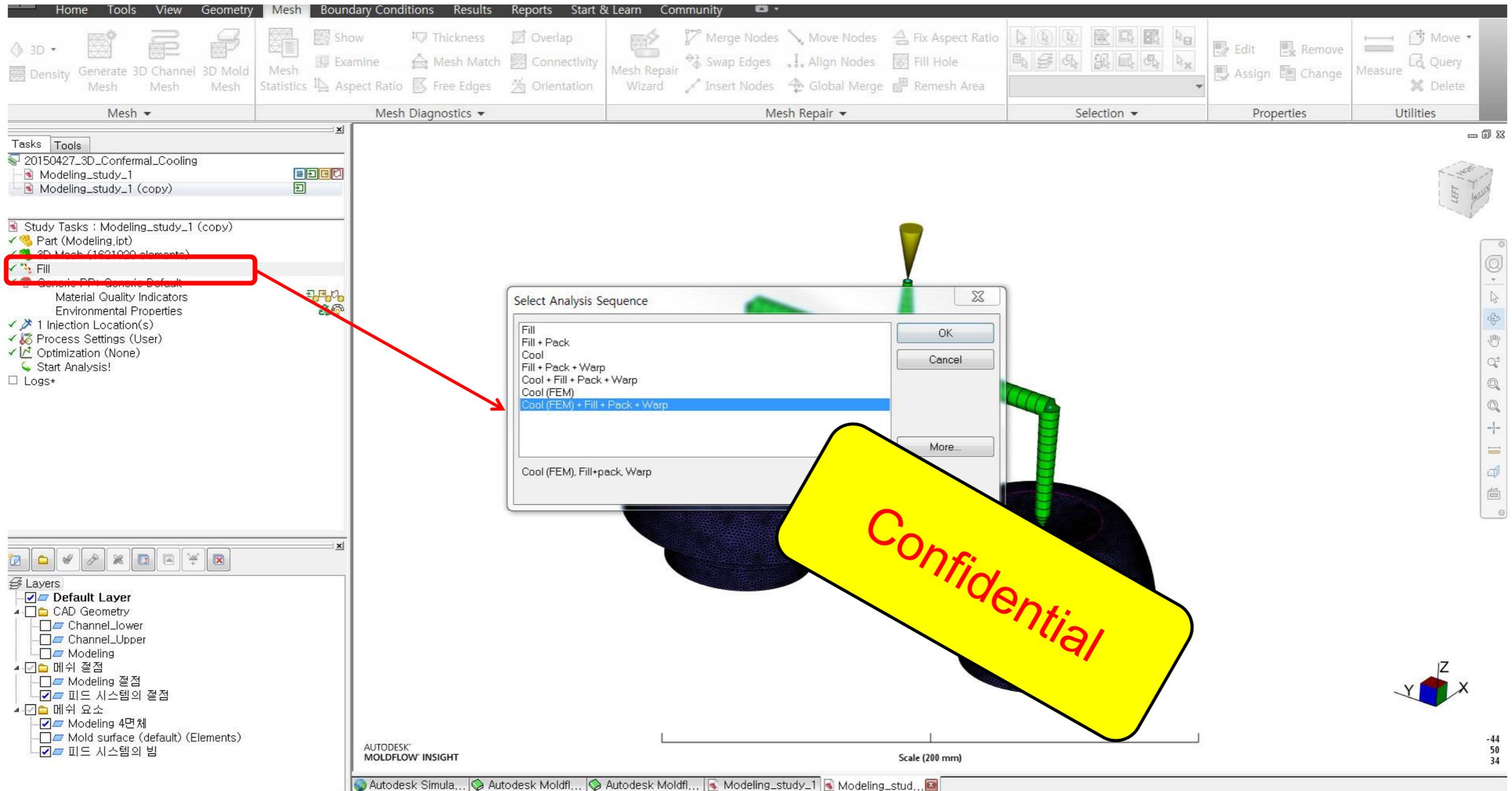
# Conformal Cooling 해석

## ■ 제품 및 Runner Mesh 생성



# Conformal Cooling 해석

- 해석 시퀀스 Cool(FEM)+Fill+Pack+Warp 선택



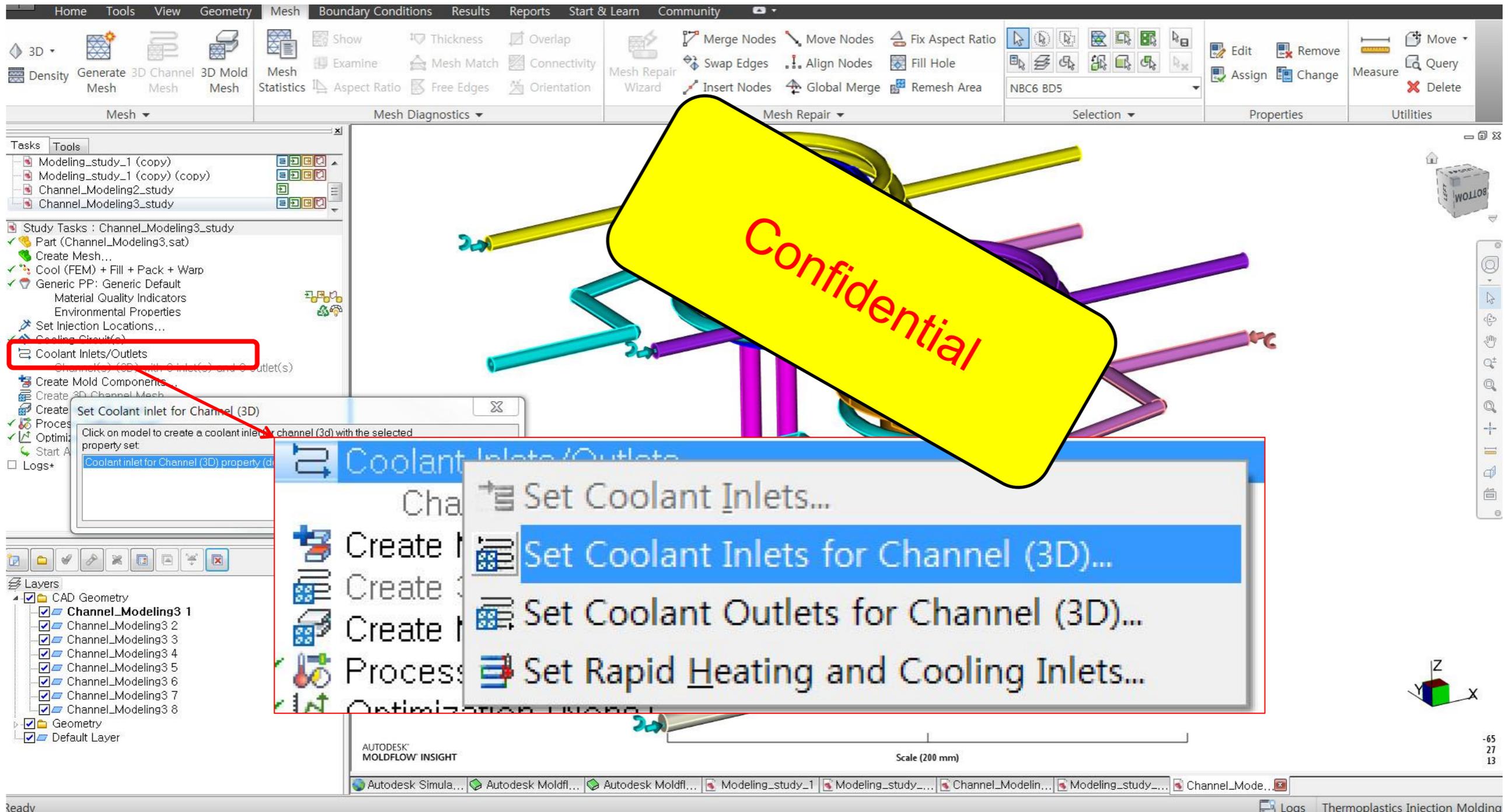
# Conformal Cooling 해석

- 3D 냉각 채널 Import

The screenshot displays the Autodesk Moldflow Insight software interface. The top menu bar includes Home, Tools, View, Geometry, Mesh, Boundary Conditions, Results, Reports, Start & Learn, and Community. The toolbar contains various tools for modeling and simulation. The task pane on the left shows the current study tasks, including '20150427\_3D\_Conformal\_Cooling', 'Modeling\_study\_1', and 'Modeling\_study\_1 (copy)'. The central 3D model shows a mold cavity with a cooling channel. A yellow 'Confidential' watermark is overlaid on the image. The 'Add Cooling Channel(s) (3D)...' dialog box is open, showing options for 'Solid 3D' and 'Direct Import using Autodesk Moldflow Design Link'. A red box highlights the 'Add Cooling Channel(s) (3D)...' button in the dialog box.

# Conformal Cooling 해석

- 3D 냉각 채널 CAD에 Inlets 설정



# Conformal Cooling 해석

- 3D 냉각 채널 CAD에 Outlets 설정

The screenshot displays the Autodesk Moldflow Insight software interface. The top ribbon shows various toolbars including 'Mesh', 'Boundary Conditions', and 'Results'. The left-hand 'Tasks' pane lists several steps, with 'Cooling Circuit(s)' highlighted in red. A dialog box titled 'Set Coolant outlet for Channel (3D)' is open, showing a list of property sets. Below it, a context menu is visible with the option 'Set Coolant Outlets for Channel (3D)...' selected. The central 3D model shows a complex channel structure with multiple colored ports (yellow, purple, cyan) representing inlets and outlets. A large yellow 'Confidential' watermark is placed over the 3D model. The bottom status bar indicates 'Scale (200 mm)' and the current window title is 'Channel\_Modeling3\_1'.

# Conformal Cooling 해석

## 3D 냉각채널의 Mesh 생성

The screenshot shows the Autodesk Moldflow Insight software interface. The main window displays a 3D model of a mold with cooling channels. A large yellow watermark with the word "Confidential" is overlaid on the model. The left sidebar shows the "Study Tasks" tree, with "Create 3D Channel Mesh..." highlighted in red. The bottom status bar shows the progress of the mesh generation process.

**Mesh Log**

Mesh Log	Analysis Log	Cool (FEM)	Fill+pack	Warp	Cool (FEM)-Check	Fill+pack-Check	Warp-Check
Maximum edge length for 3D channels:							
Resolution factor:		1.0000					
Fluid gap elements:		1					
Enhancement layers:		3					

This process will generate meshes only for 3D channels and unmeshed 1D circuits.  
Curves for circuits that have already been meshed will not be remeshed.

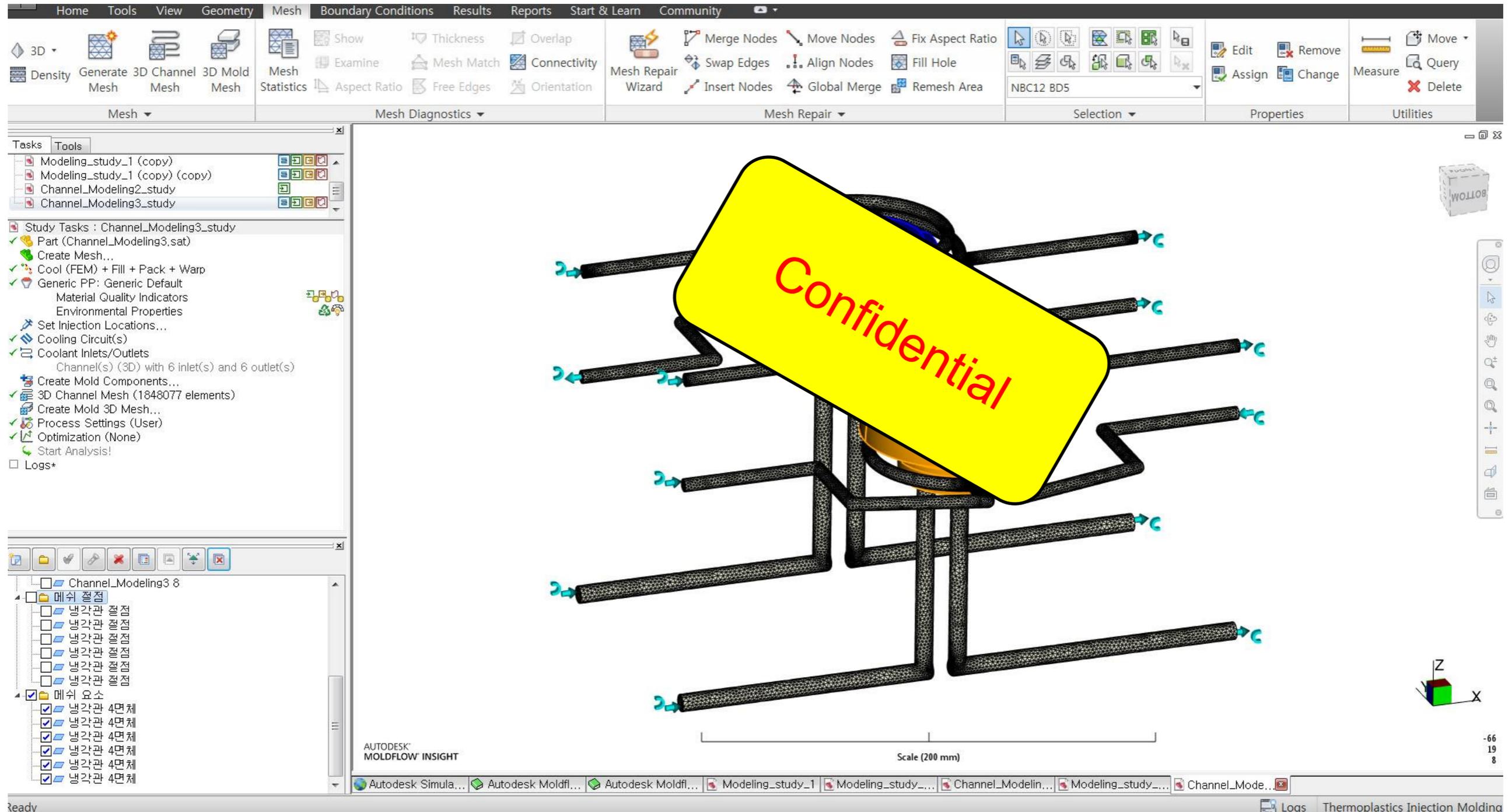
Percent 10 done ....  
Percent 15 done ....

Generating 3D channel mesh  
Percent 20 done ....

Start 3D channel mesh generation...  
\*C1900316

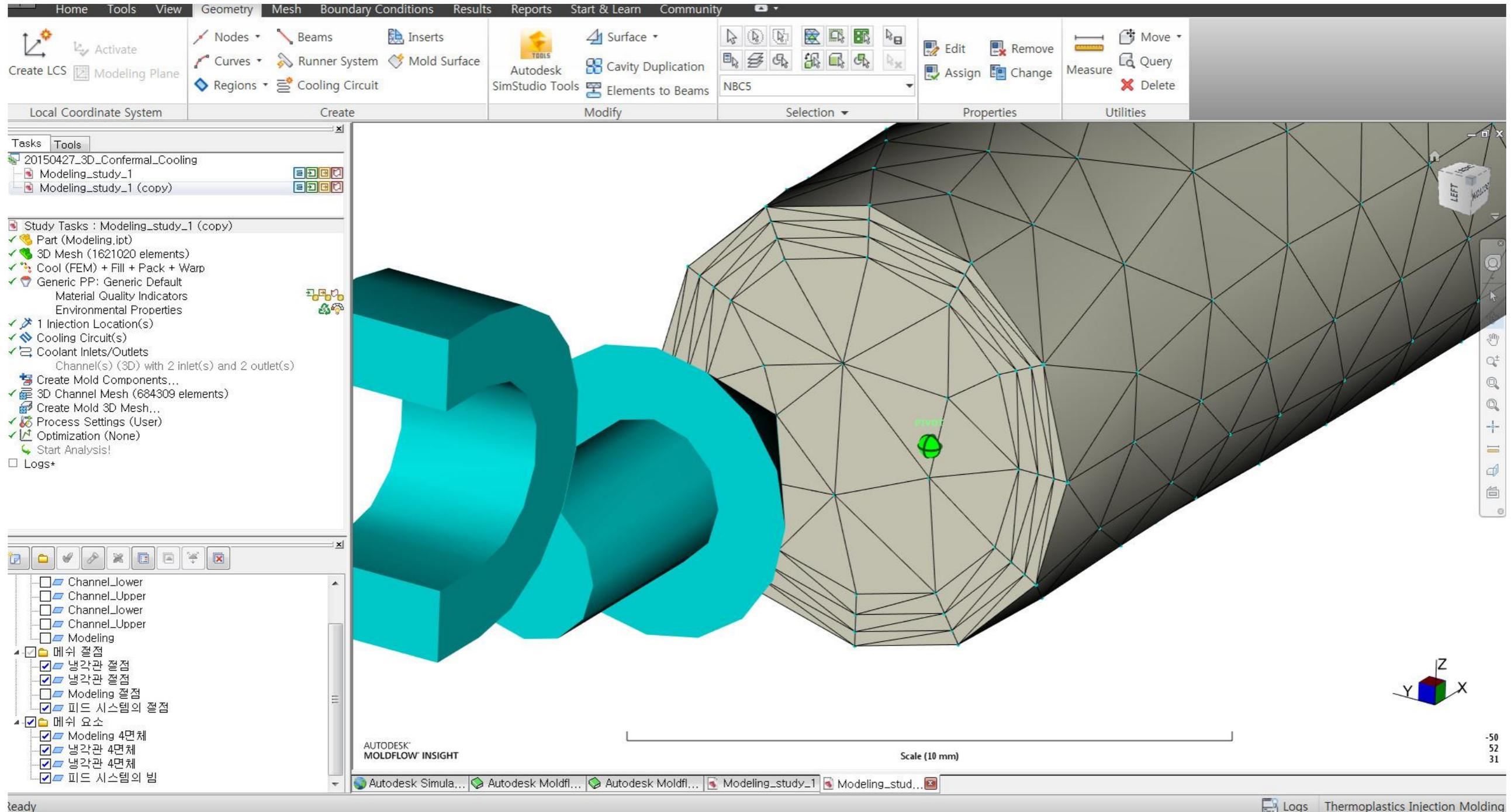
# Conformal Cooling 해석

- 3D 냉각채널의 Mesh 생성 완료



# Conformal Cooling 해석

## 3D 냉각채널의 Mesh 확인



# Conformal Cooling 해석

- 3D 냉각 채널 CAD에 Inlets 속성설정(온도 및 유량)

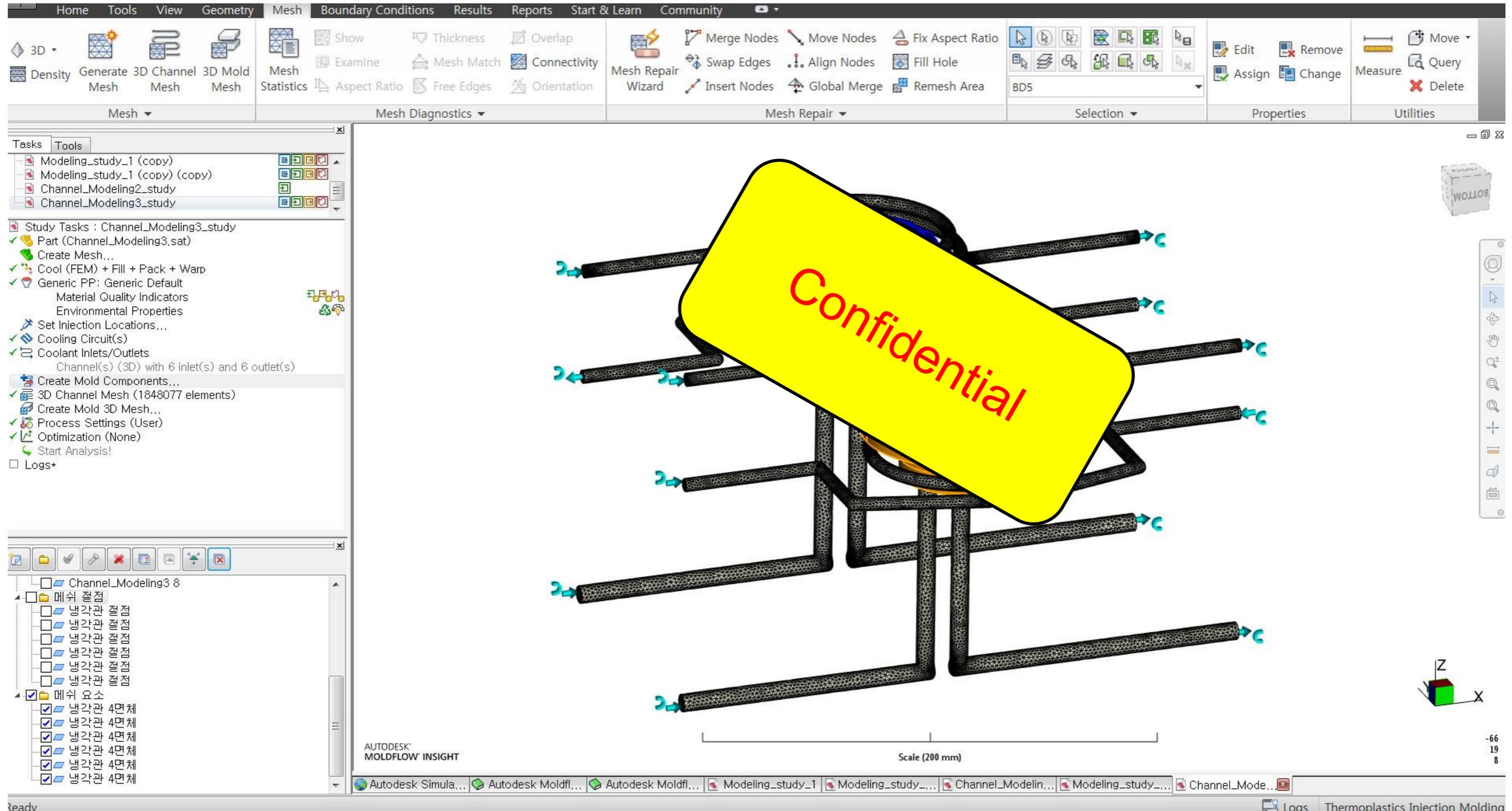
The screenshot displays the Autodesk Moldflow Insight software interface. The main window shows a 3D model of a cooling channel with several inlets. A dialog box titled "Coolant inlet for Channel (3D)" is open, showing the following settings:

- Coolant:** Water (pure) #1
- Channel (3D) control:** Specified flow rate, Flow rate: 10 lit/min (0:1,2e+004)
- Coolant inlet temperature:** 60 C [-120:500]
- Name:** Coolant inlet for Channel (3D) property (default)
- Apply to all entities that share this property

The software interface includes a top menu bar (Home, Tools, View, Geometry, Mesh, Boundary Conditions, Results, Reports, Start & Learn, Community), a toolbar, a task pane on the left, and a 3D view area with a coordinate system and a scale bar (Scale (200 mm)).

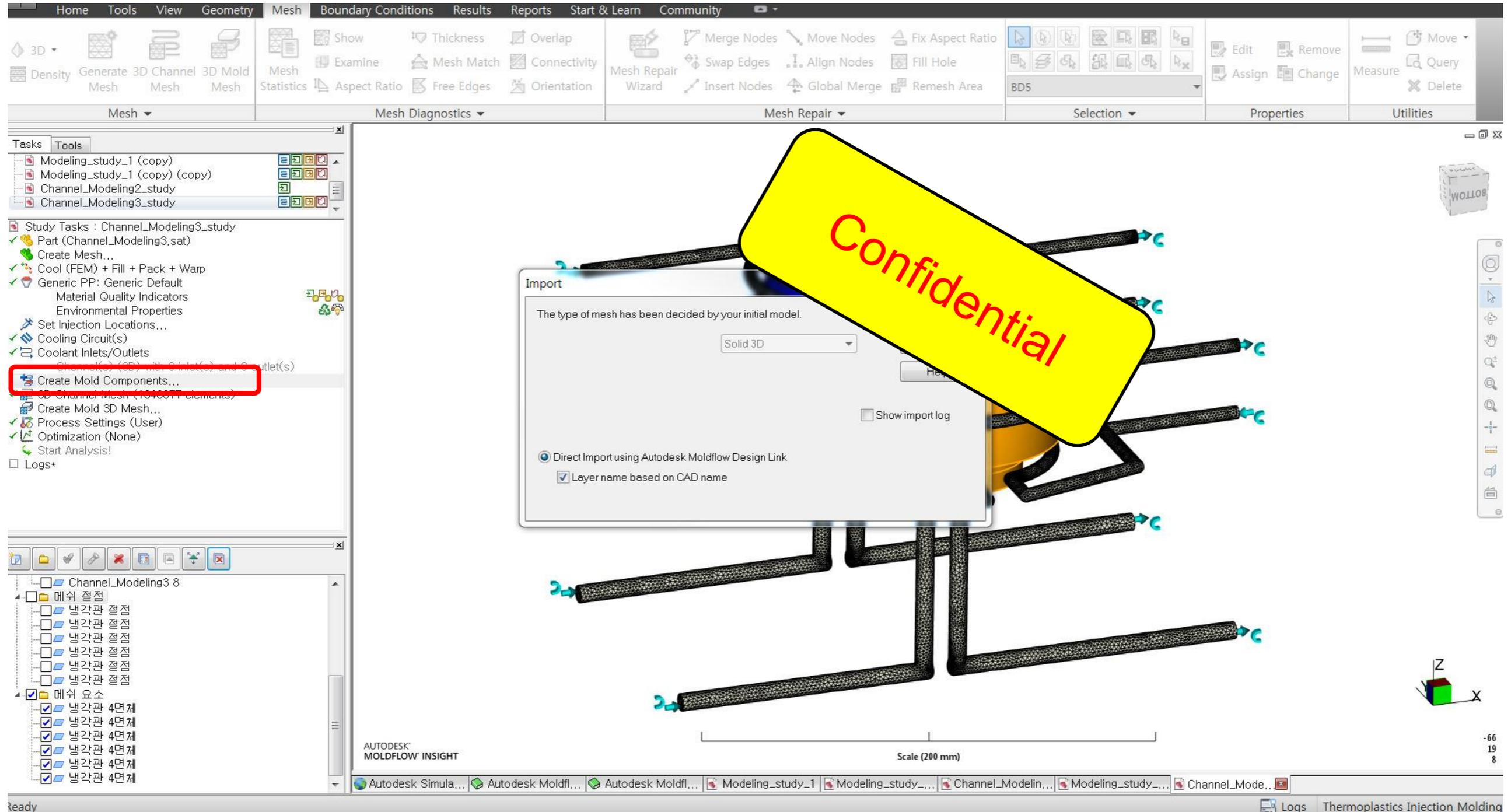
# Conformal Cooling 해석

- 3D 냉각 채널 CAD에 Inlets 속성설정 완료



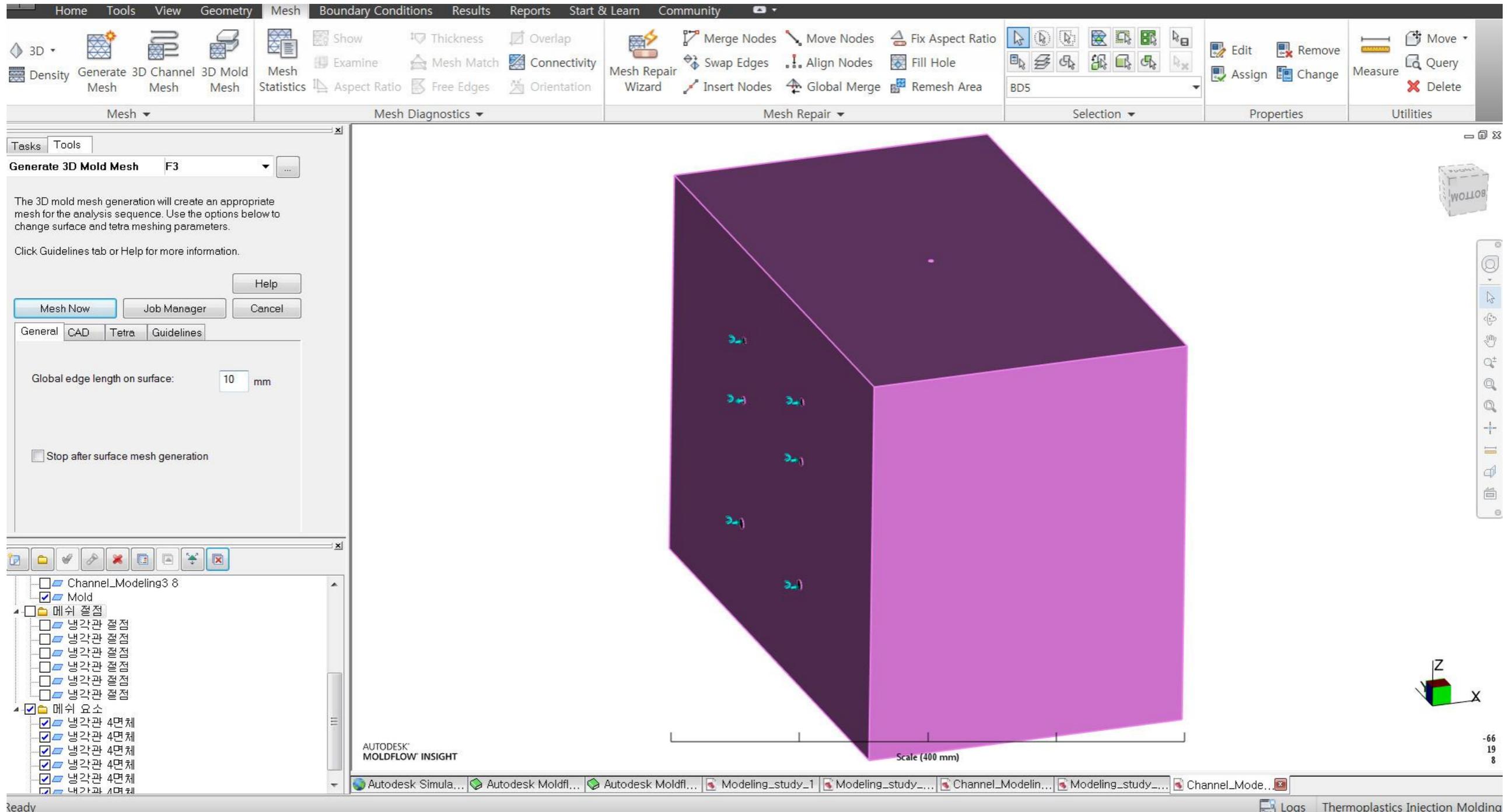
# Conformal Cooling 해석

## ■ 3D Moldblock Import



# Conformal Cooling 해석

## ■ 3D Moldblock Mesh 생성 1



# Conformal Cooling 해석

## 3D Moldblock Mesh 생성 완료

The screenshot displays the Autodesk Moldflow Insight software interface. The top menu bar includes Home, Tools, View, Geometry, Mesh, Boundary Conditions, Results, Reports, Start & Learn, and Community. The Mesh ribbon is active, showing various meshing tools like Density, Generate Mesh, 3D Channel Mesh, and 3D Mold Mesh. The left-hand pane shows a task tree for 'Channel\_Modeling3\_study', including 'Part (Channel\_Modeling3.sat)', 'Create Mesh...', 'Cool (FEM) + Fill + Pack + Warp', and '3D Channel Mesh (1848077 elements)'. The central 3D view shows a dark purple mold block with a fine, conformal mesh. The bottom log window displays the following information:

```

Mesh Log | Analysis Log | Cool (FEM) | Fill+pack | Warp | Cool (FEM)-Check | Fill+pack-Check | Warp-Check
Percent 73 done ....
Percent 75 done ....
Percent 77 done ....
Percent 80 done ....
Percent 85 done ....
Percent 90 done ....
Percent 95 done ....
Percent 100 done ....
Meshing complete
Removing disconnected nodes
Execution time
Mesh commenced at Mon Apr 27 18:55:14 2015
Mesh completed at Mon Apr 27 18:56:24 2015
CPU time used 83.16 s
Total elapsed time: 70.25 s
    
```

# Conformal Cooling 해석

- 공정조건 설정하기1 (기존 Tip&Tech의 FEM 냉각해석을 참고하세요)

The screenshot displays the Autodesk Moldflow Insight interface. The main window shows a 3D model of a mold with cooling channels highlighted in green. A 'Process Settings Wizard - Cool (FEM) Settings' dialog box is open, showing the following parameters:

- Melt temperature: 230 C
- Mold-open time: 10 s (0:600)
- Mold-close time before injection: 0 s [0:600]
- Injection + packing + cooling time: 169 s [0:6000]
- Mold temperature options: Transient within cycle

The 'Advanced options...' button is visible at the bottom of the dialog box. The background shows a 3D model of a mold with cooling channels highlighted in green. The status bar at the bottom indicates 'Scale (200 mm)' and 'AUTODESK MOLDFLOW INSIGHT'.

# Conformal Cooling 해석

- Mesh 수 및 컴퓨터 정보
  - 제품 mesh : 1,479,476
  - 3D Channel mesh : 1,848,077
  - Mold 3D mesh : 791,137
  - 컴퓨터 정보

시스템	
등급:	 Windows 체험 지수
프로세서:	Intel(R) Xeon(R) CPU X5550 @ 2.67GHz 2.66 GHz (2개 프로세서)
설치된 메모리(RAM):	48.0GB

 Study Tasks : Conformal_Cooling_Case1_Channel
 Part (Channel_Modeling3.sat)
 3D Mesh (1479476 elements)
 Cool (FEM) + Fill + Pack + Warp
 TYRIL 867 E: Trinseo EUR
Material Quality Indicators
Environmental Properties
 1 Injection Location(s)
 Cooling Circuit(s)
 Coolant Inlets/Outlets
Channel(s) (3D) with 6 inlet(s) and 6 outlet(s)
 1 Mold Component(s)
1 CAD Mold Component(s)
 3D Channel Mesh (1848077 elements)
 Mold 3D Mesh (791137 elements)
 Process Settings (Default)
 Optimization (None)
 Analysis complete

# Conformal Cooling 해석

- 해석시간 = Cool(FEM) + Fill, Pack + Warp  
**6hr, 40min** = 4hr, 42min + 1hr, 55min + 3min

Mesh Log	Analysis Log	Cool (FEM)	Fill+pack	Warp	Machine
Transient cooling analysis completed					
Execution time					
Analysis commenced at	Thu Apr 30 10:00:00				
Analysis completed at	Fri May 01 09:00:00				
CPU time used	26676.00 s				
equivalent to	7 hr, 24 min				
Elapsed wall clock time	16944.00 s				
equivalent to	4 hr, 42 min				

Mesh Log	Analysis Log	Cool (FEM)	Fill+pack	Warp	Machine
Sink Mark Analysis					
Execution time					
Analysis commenced at	Fri May 01 10:00:00				
Analysis completed at	Fri May 01 12:00:00				
CPU time used	32955.23 s				
equivalent to	9 hr, 9 min				
Elapsed wall clock time	6911.00 s				
equivalent to	1 hr, 55 min				

Mesh Log	Analysis Log	Cool (FEM)	Fill+pack	Warp	Machine Set
Trans-Y	534323	-4.1610e-001	78		
Trans-Z	530511	-2.3244e-001	52		
-----					
Execution time					
Analysis commenced at	Fri May 01 10:00:00				
Analysis completed at	Fri May 01 10:05:00				
CPU time used	751.83 s				
Elapsed wall clock time	201.00 s				
equivalent to	0 hr, 3 min				

# Conformal Cooling 해석 결과

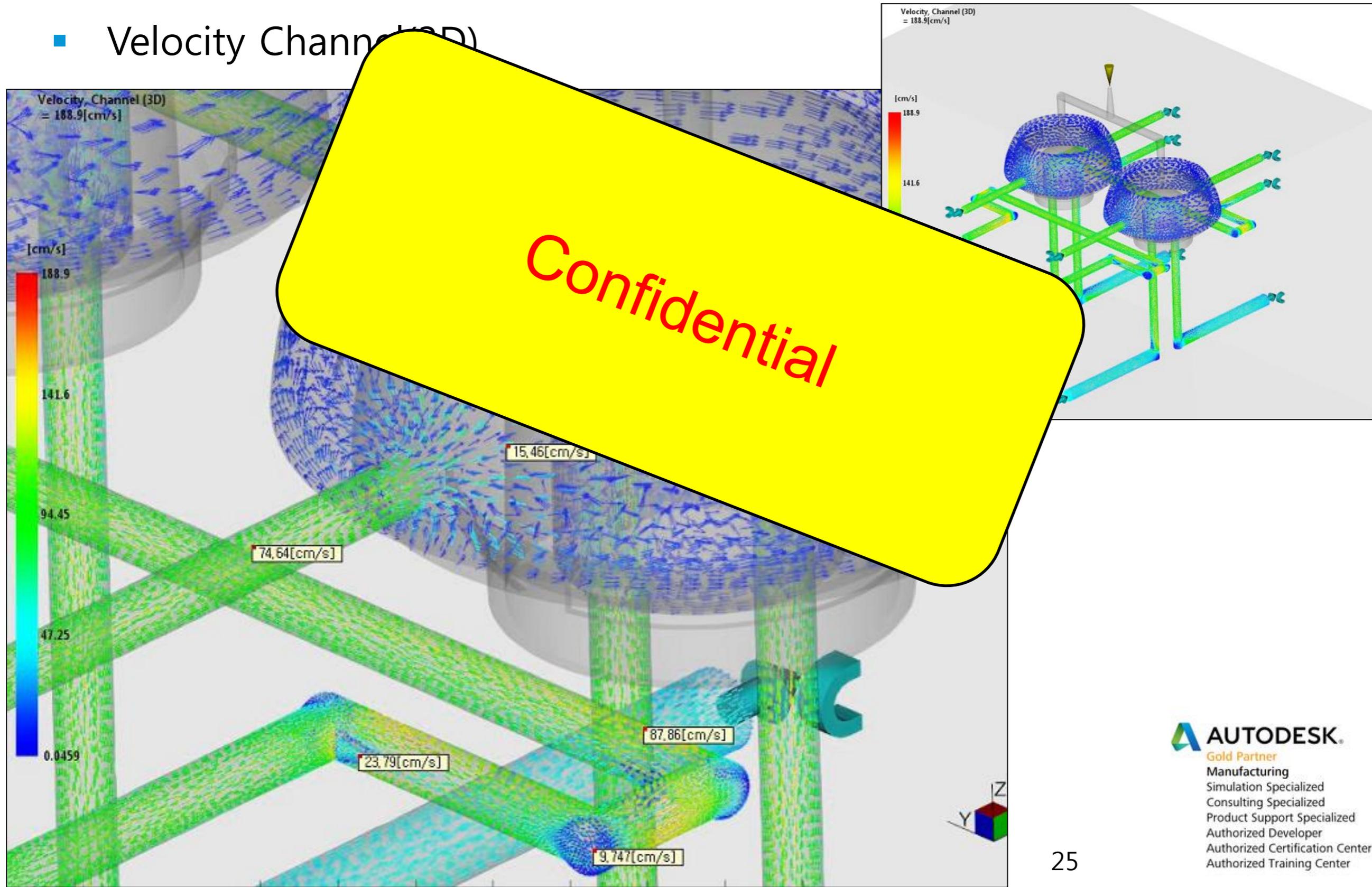
- Conformal Cooling 해석 결과 확인

- ▼  Cool

  - Time to reach ejection temperature, cold runner
  - Time to reach ejection temperature, part
  - Percentage frozen layer
  - Percentage molten layer
  - Velocity, Channel (3D)
  - Temperature, mold (transient)
  - Temperature, mold-cavity interface (transient)
  - Temperature, mold-circuit interface (transient)
  - Temperature, part (transient)
  - Temperature, Channel (3D) (transient)
  - Pressure, Channel (3D)

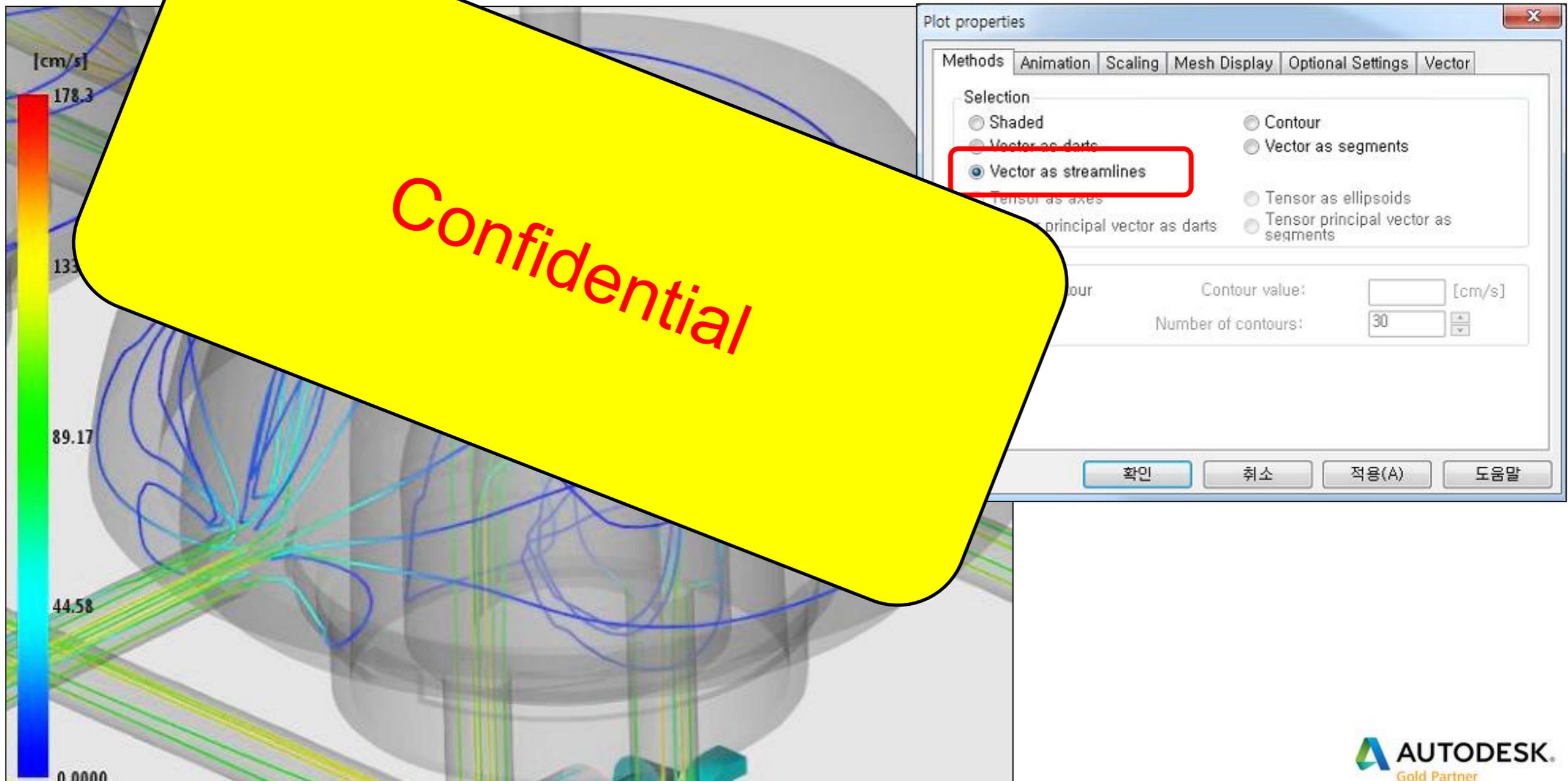
# Conformal Cooling 해석 결과

- Velocity Channel (3D)



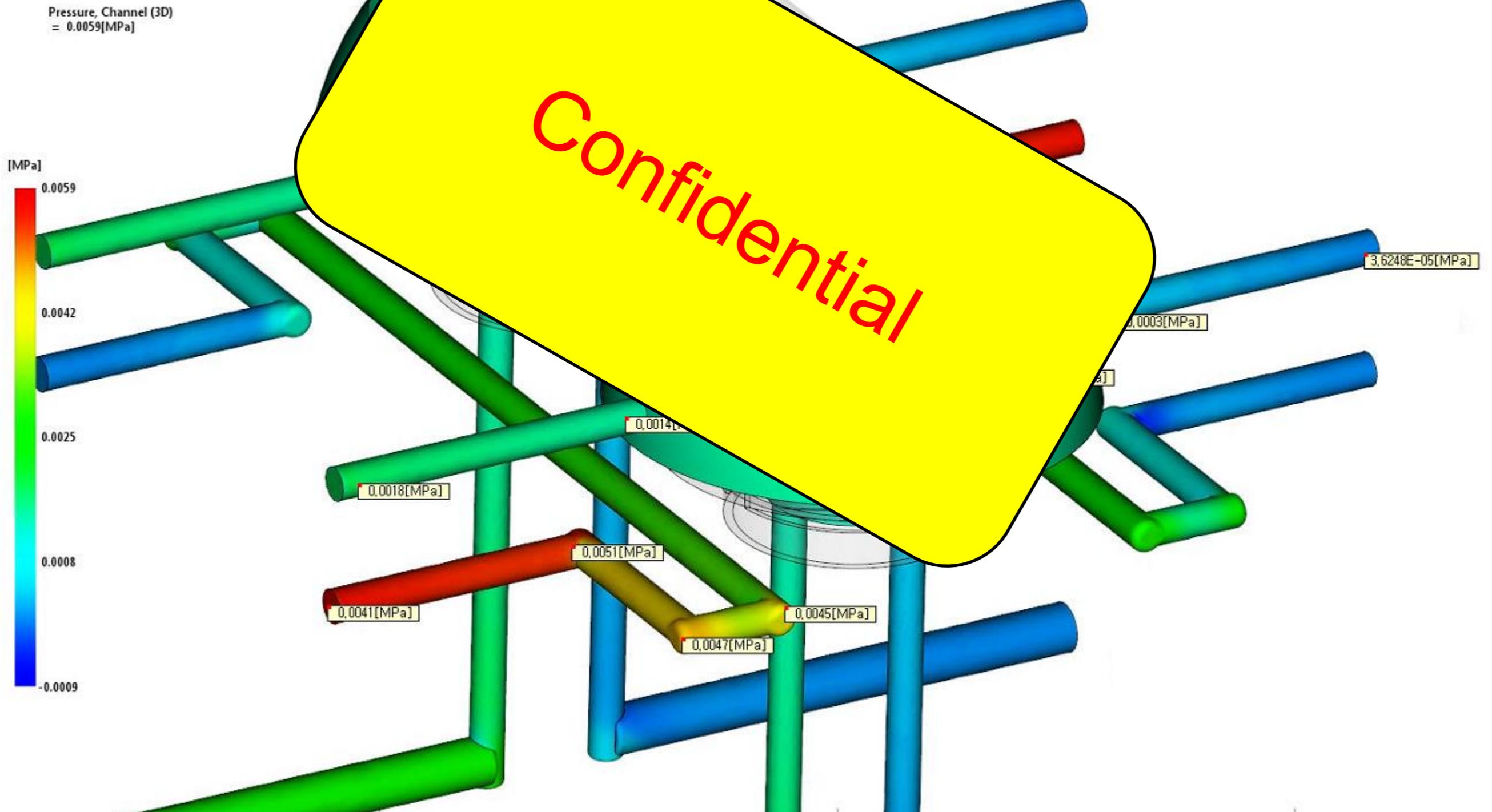
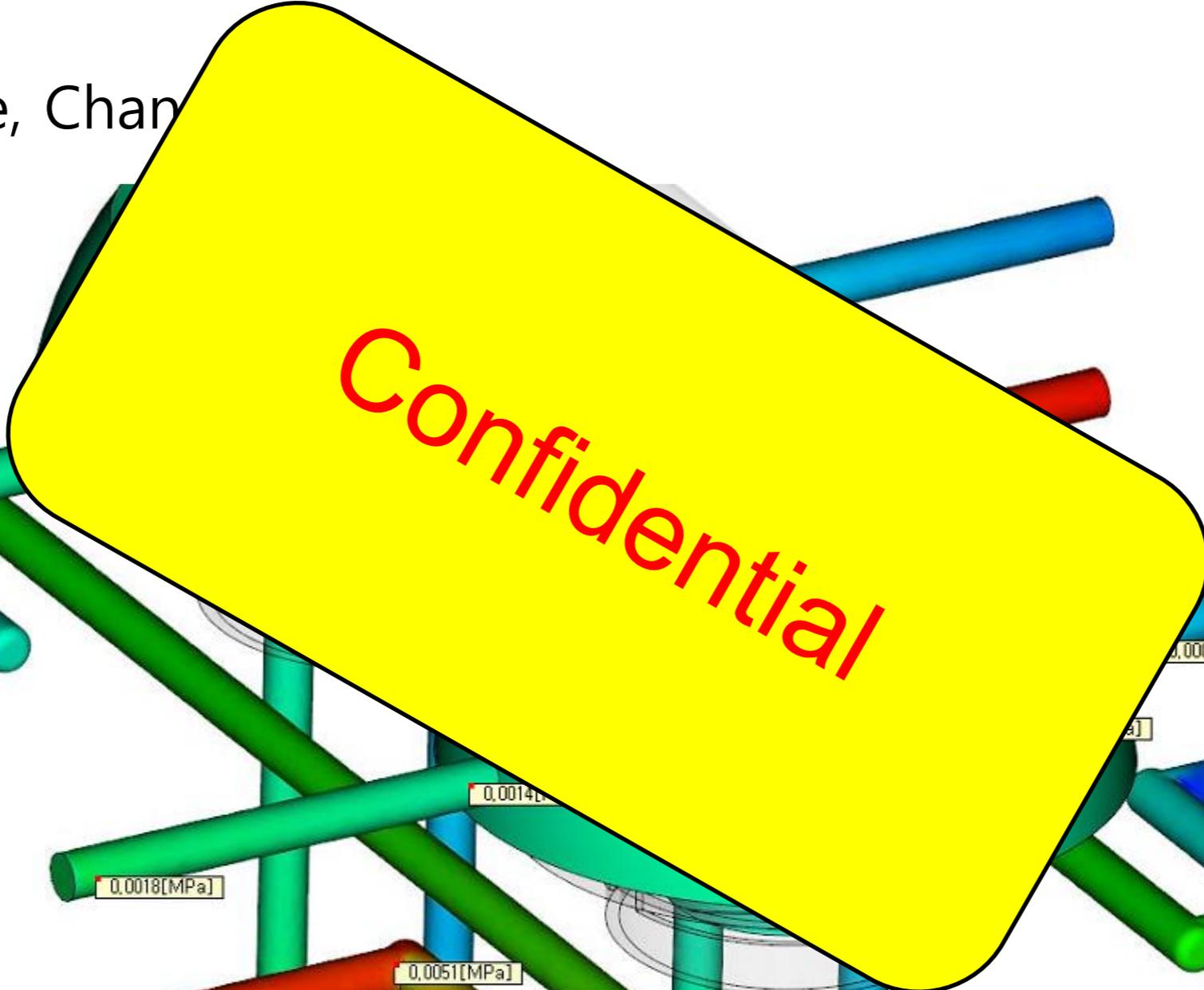
# Conformal Cooling 해석 결과

- Velocity Channel(3D) – Streamlines 이용



# Conformal Cooling 해석 결과

- Pressure, Chan

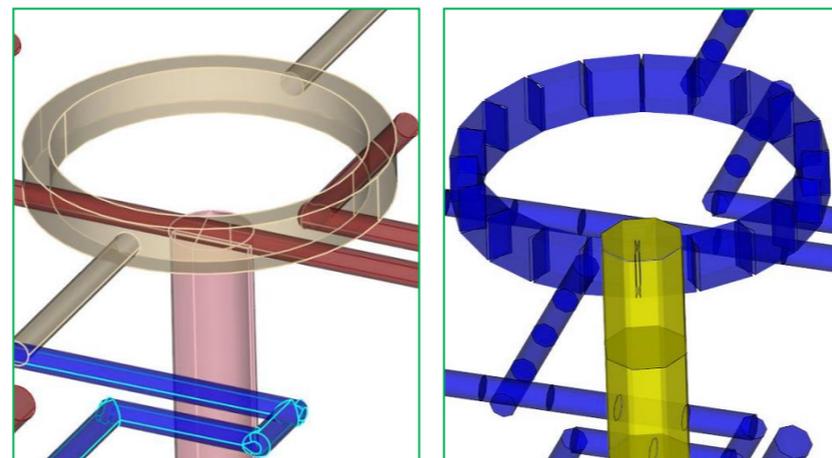
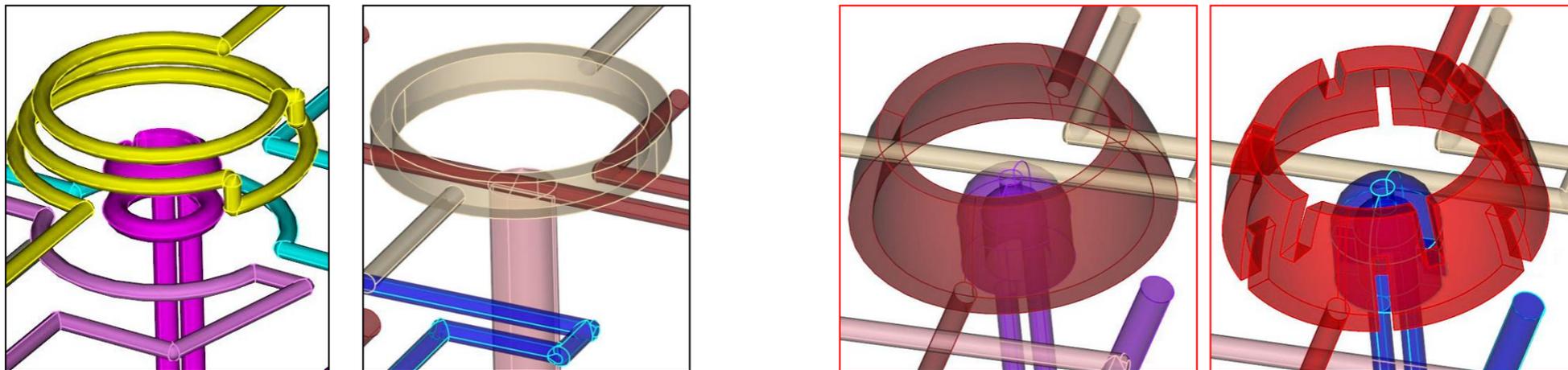


# Correlation Study

# 목표

At the end of this class, you will be able to:

- 3D 형상냉각해석 방법을 익힘
- 3D Baffle과 3D 형상냉각의 효율 확인
- 3D 형상냉각 디자인 변경에 따른 효율 확인
- 3D Baffle과 Beam Baffle의 차이점 확인

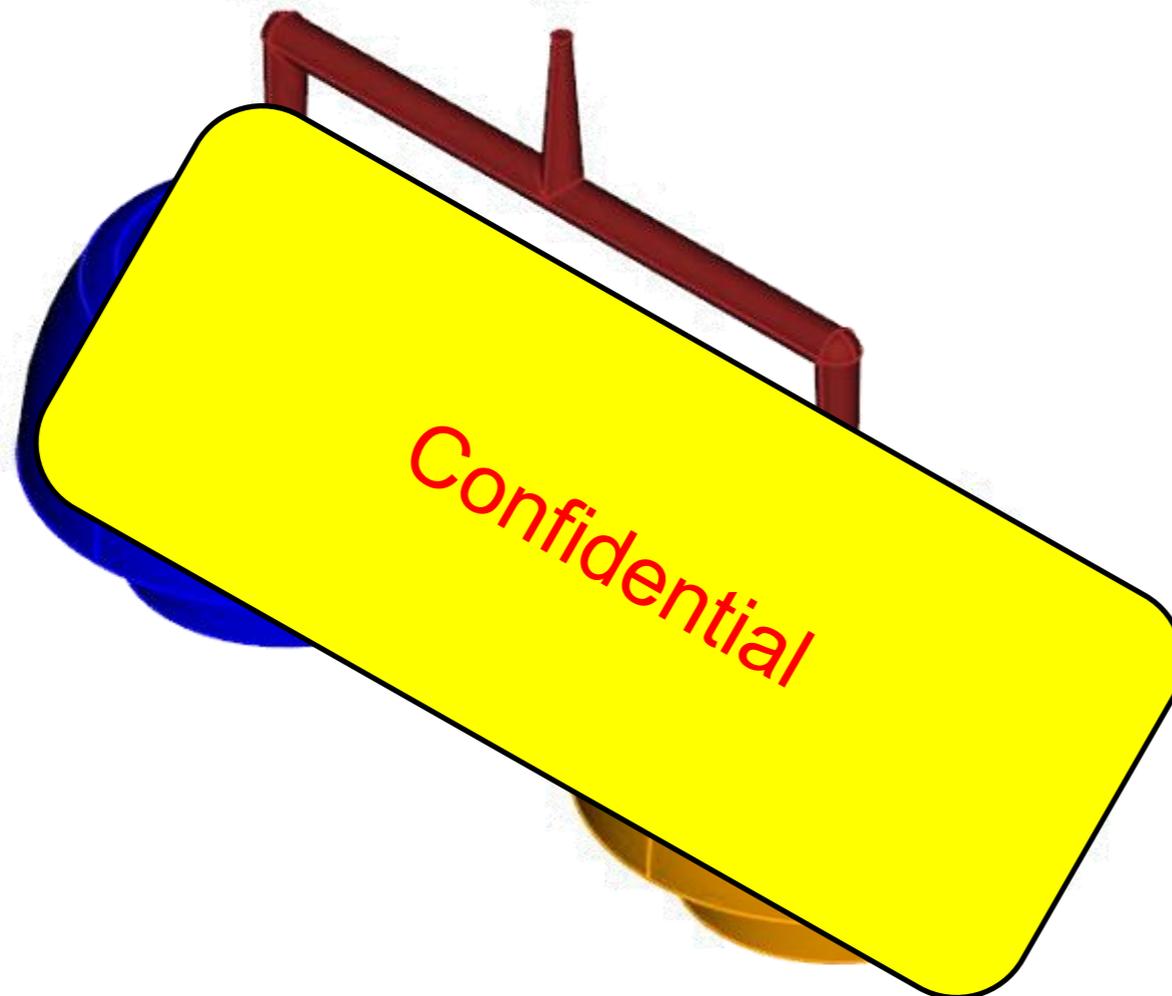


# Study Motivation

- 해석의 목적 :  
금형의 냉각효율을 높이는 방법 및  
Beam Baffle과 3D Baffle의 차이점 확인
- 다음사항을 결정하는데 도움이 됨 :
  - 3D 형상냉각의 디자인
  - 냉각해석 시 Beam Baffle or 3D Baffle의 선택

# Molding Trials

- 플라스틱 용기
- Material
  - Trinseo EUR (SAN)
  - 냉각의 효율을 높여서 Cycle time을 줄이는 것



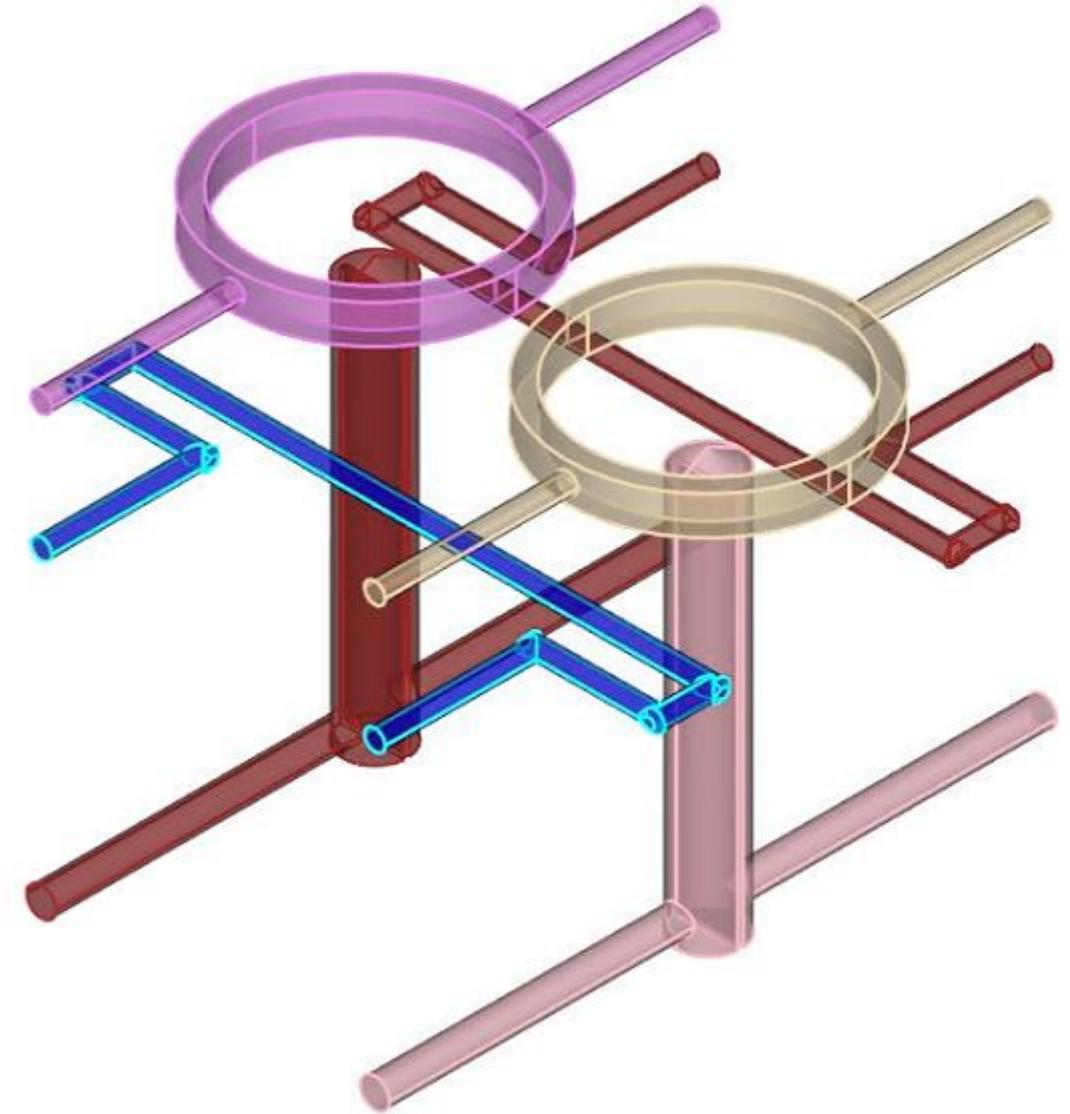
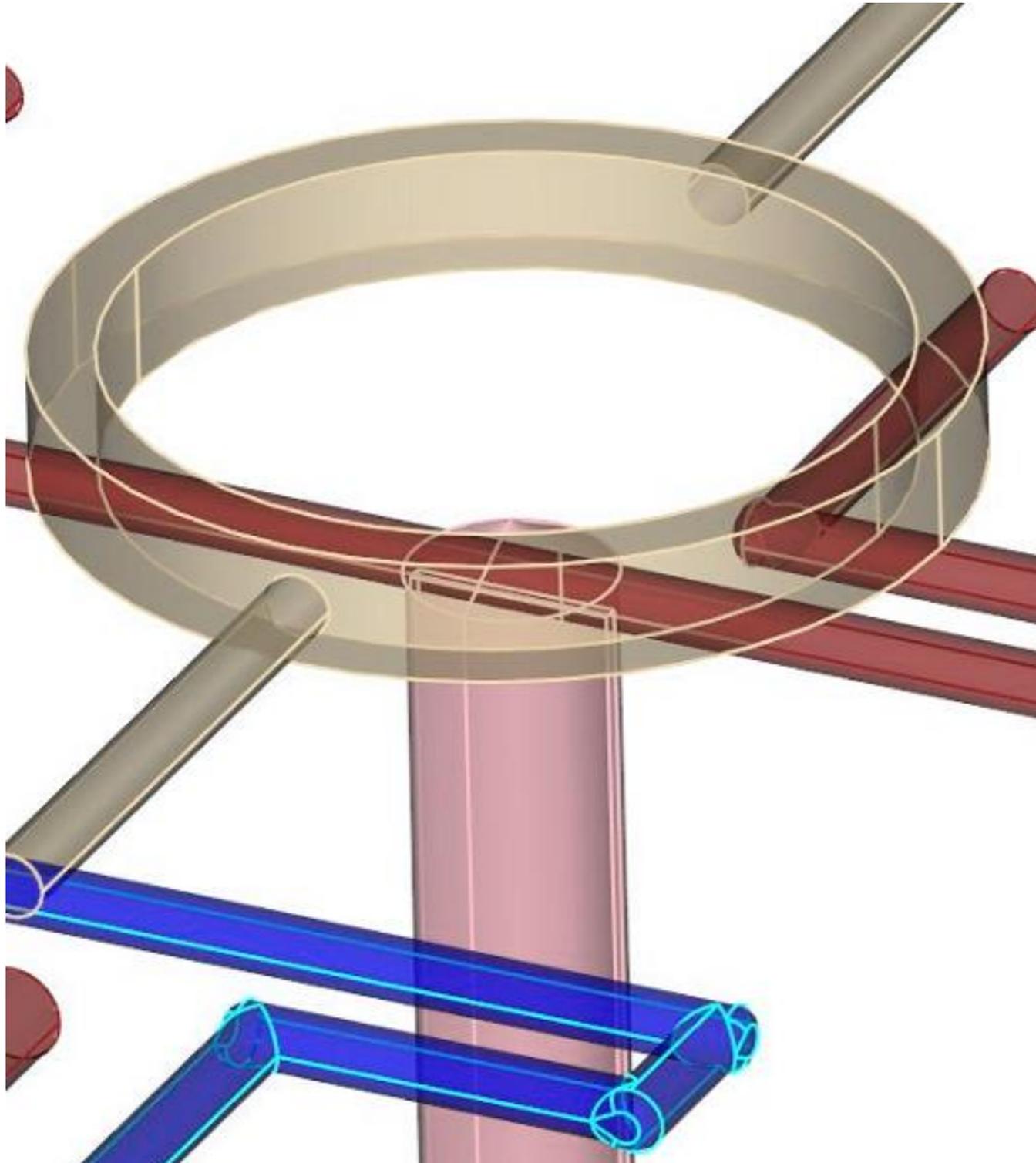
# Molding Trials

- Model



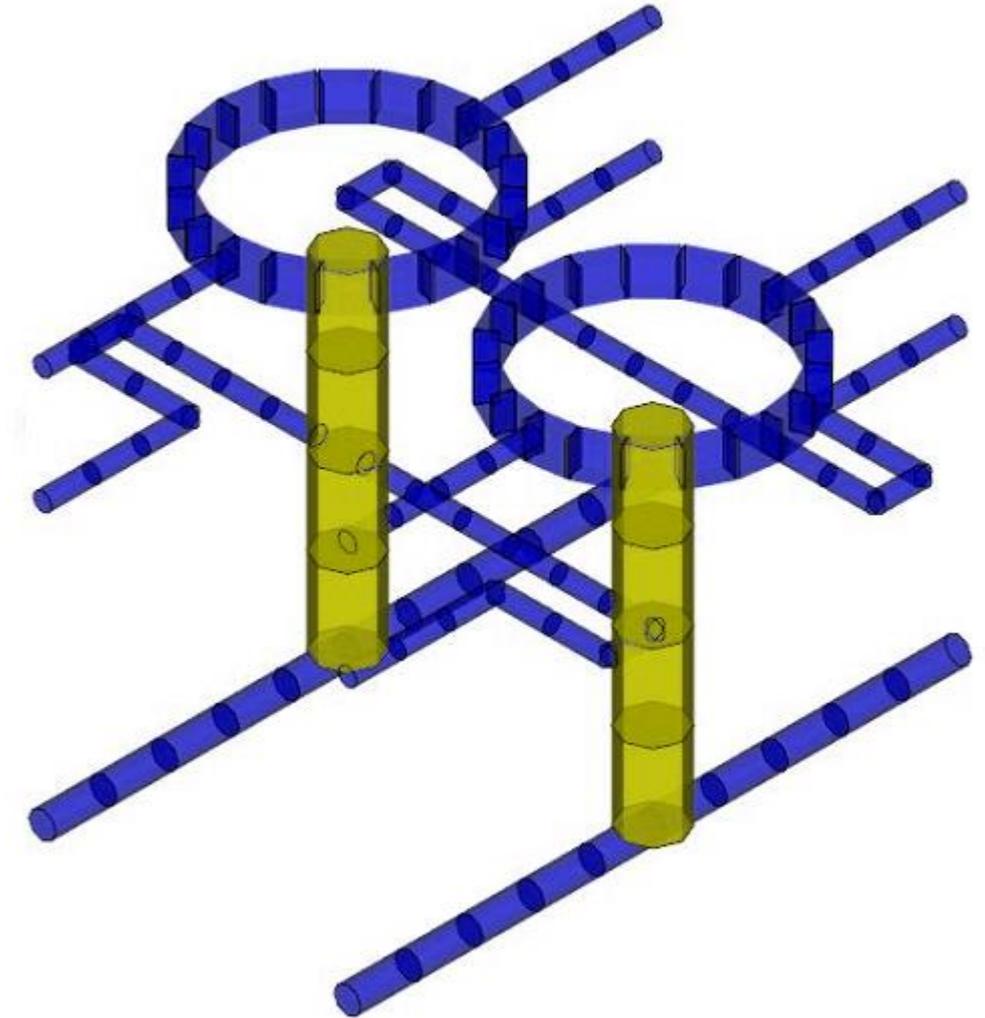
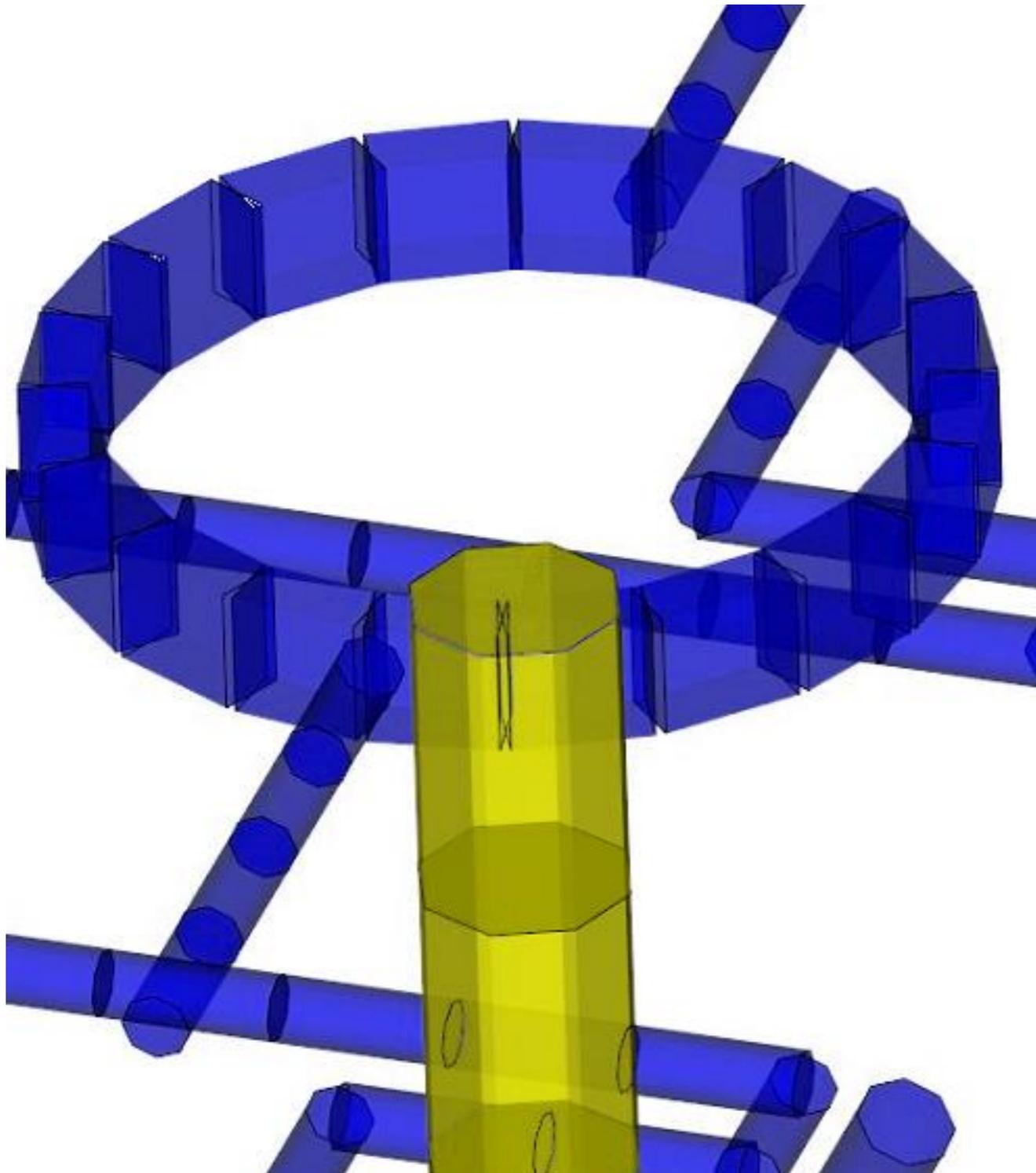
# Molding Trials

- 냉각채널-3D Baffle



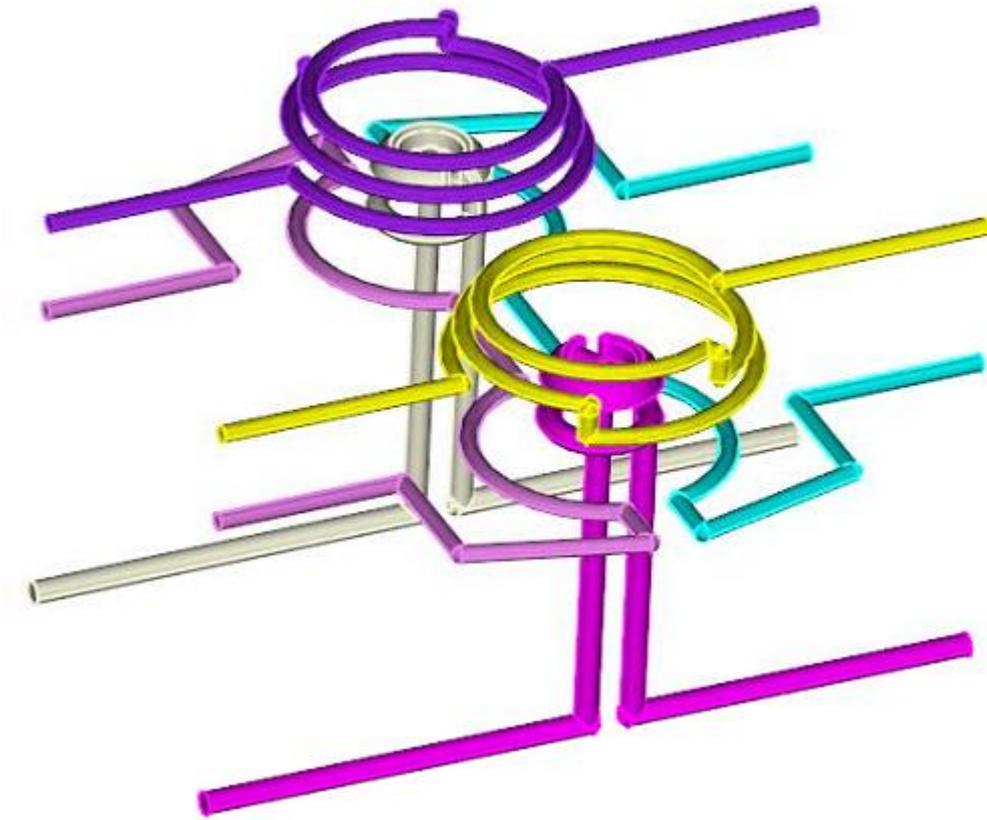
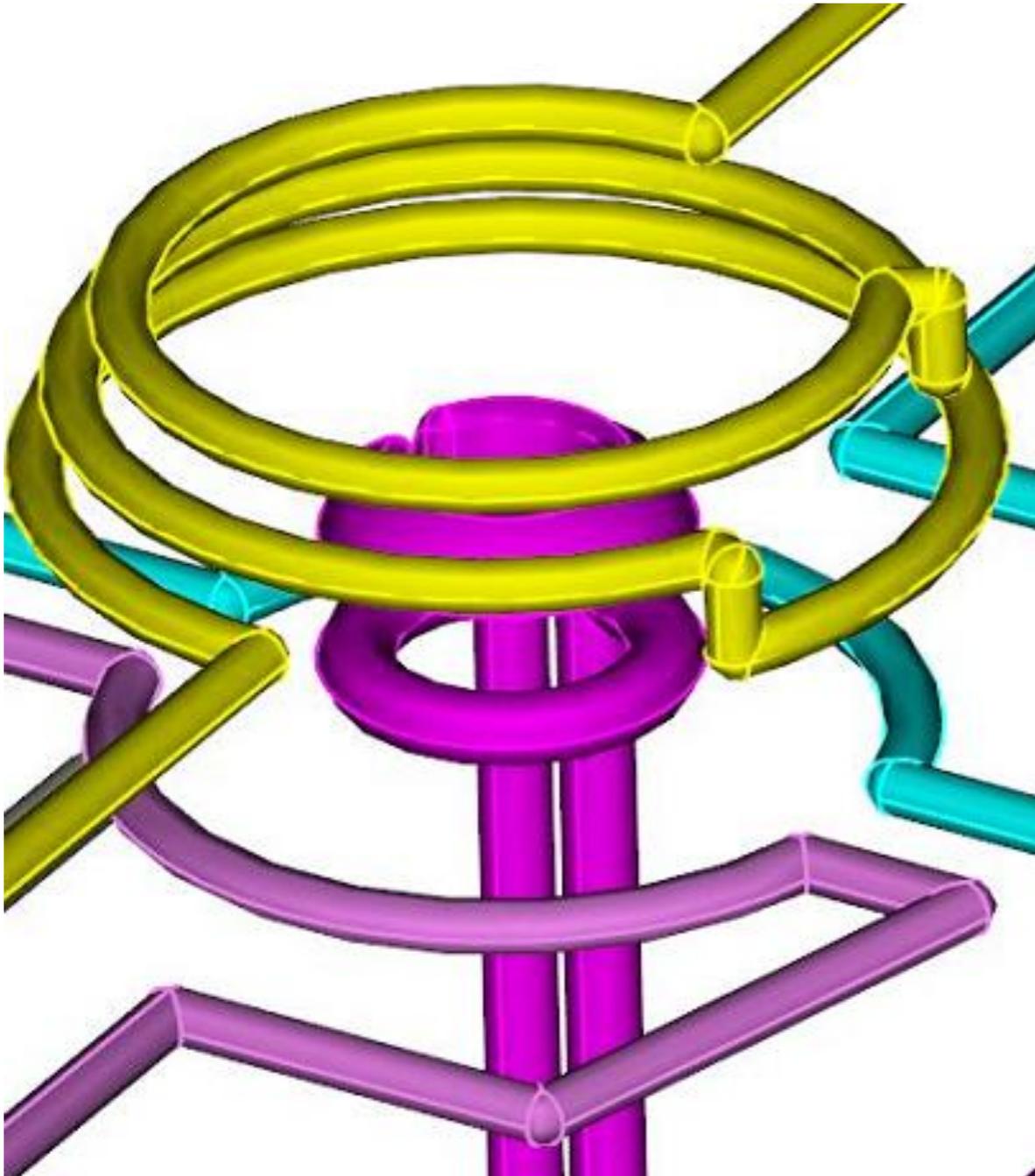
# Molding Trials

- 냉각채널- Beam Baffle



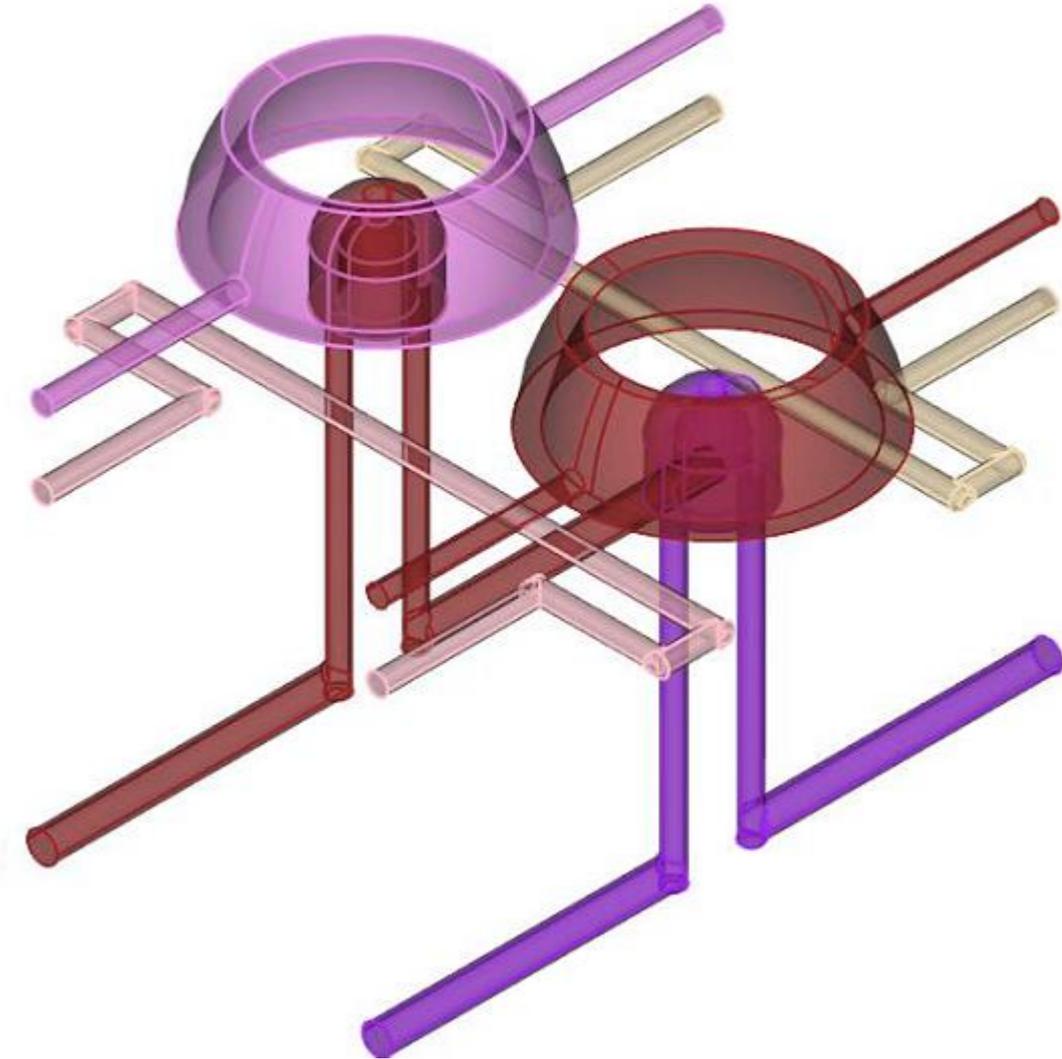
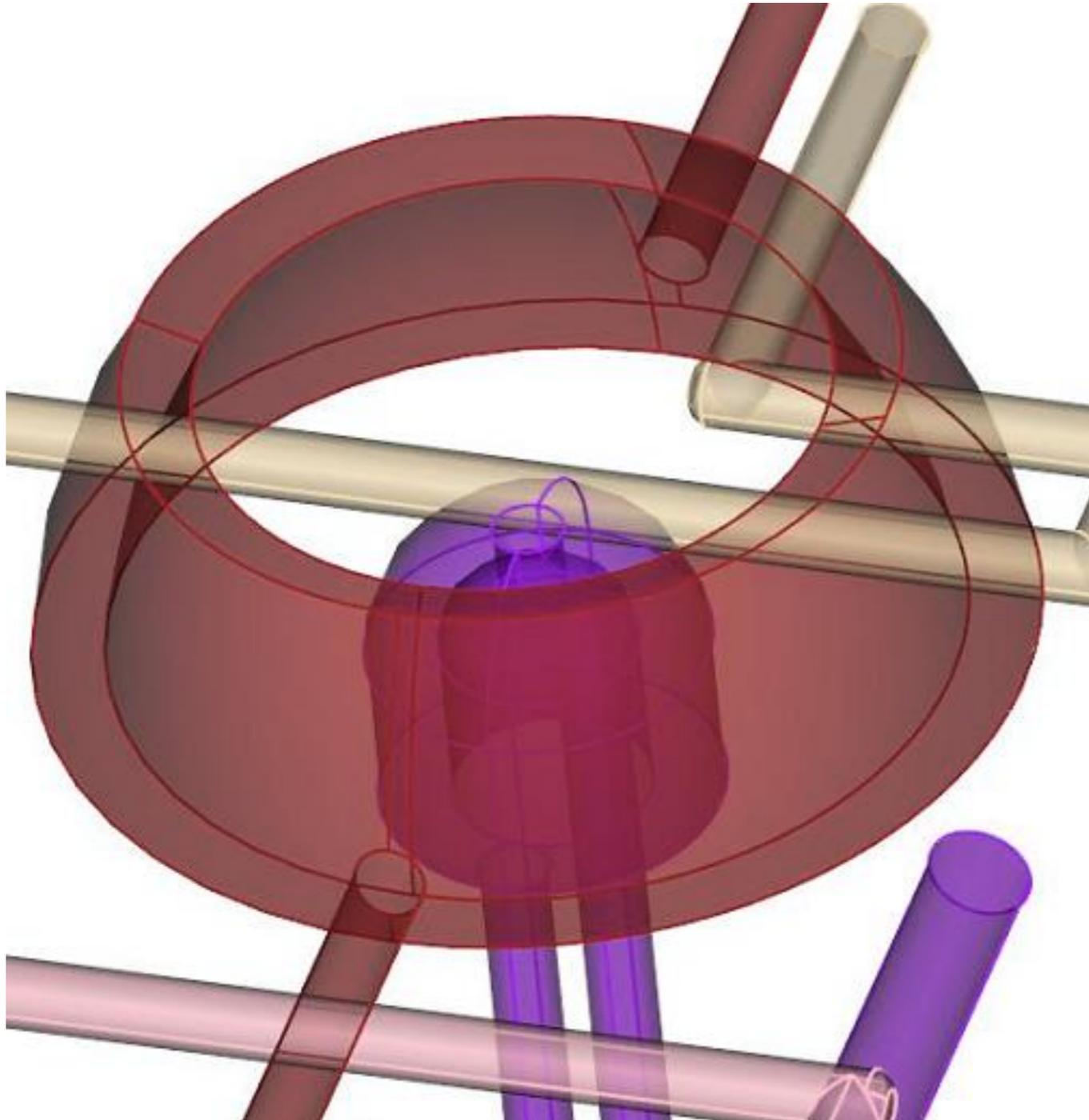
# Molding Trials

- 냉각채널-3D Channel



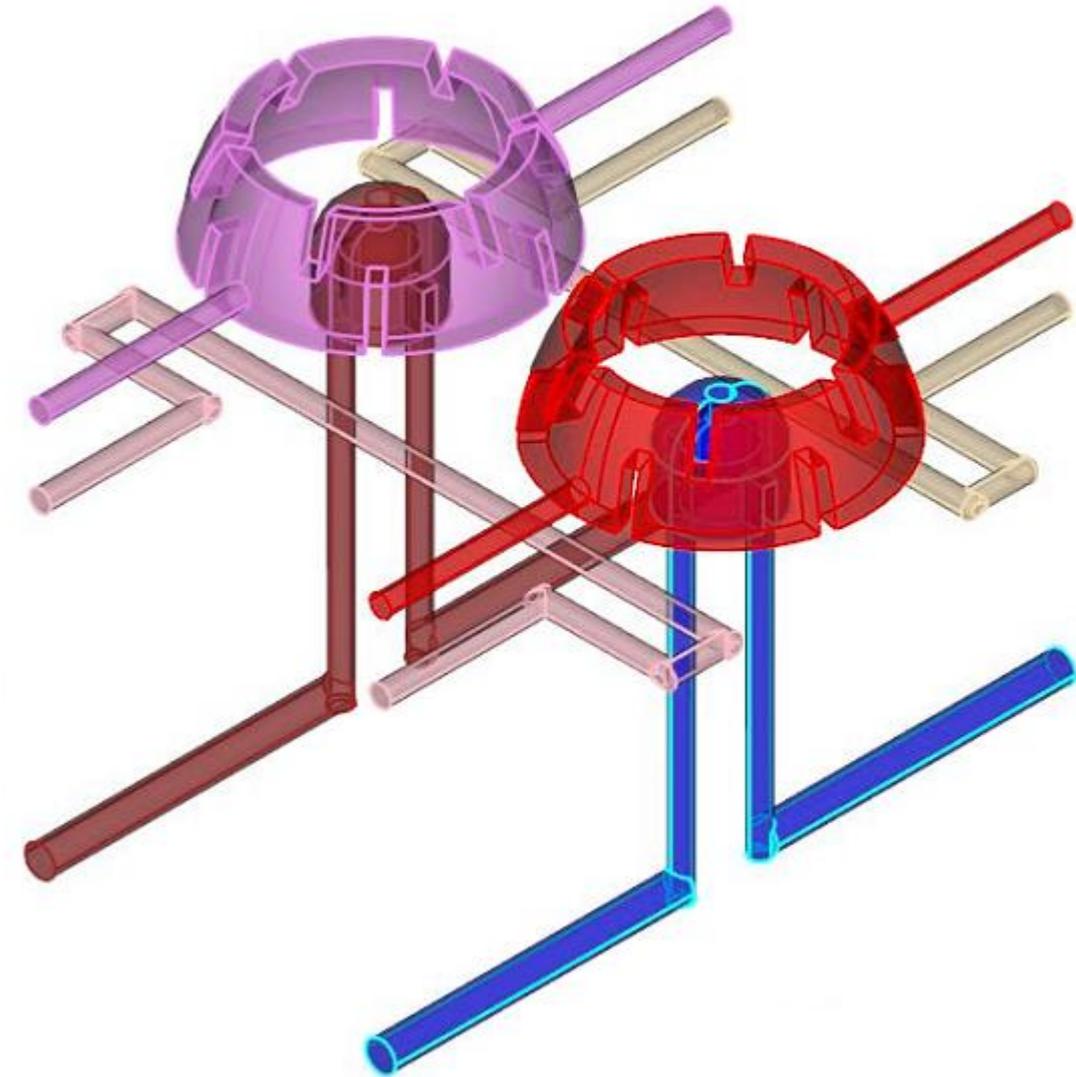
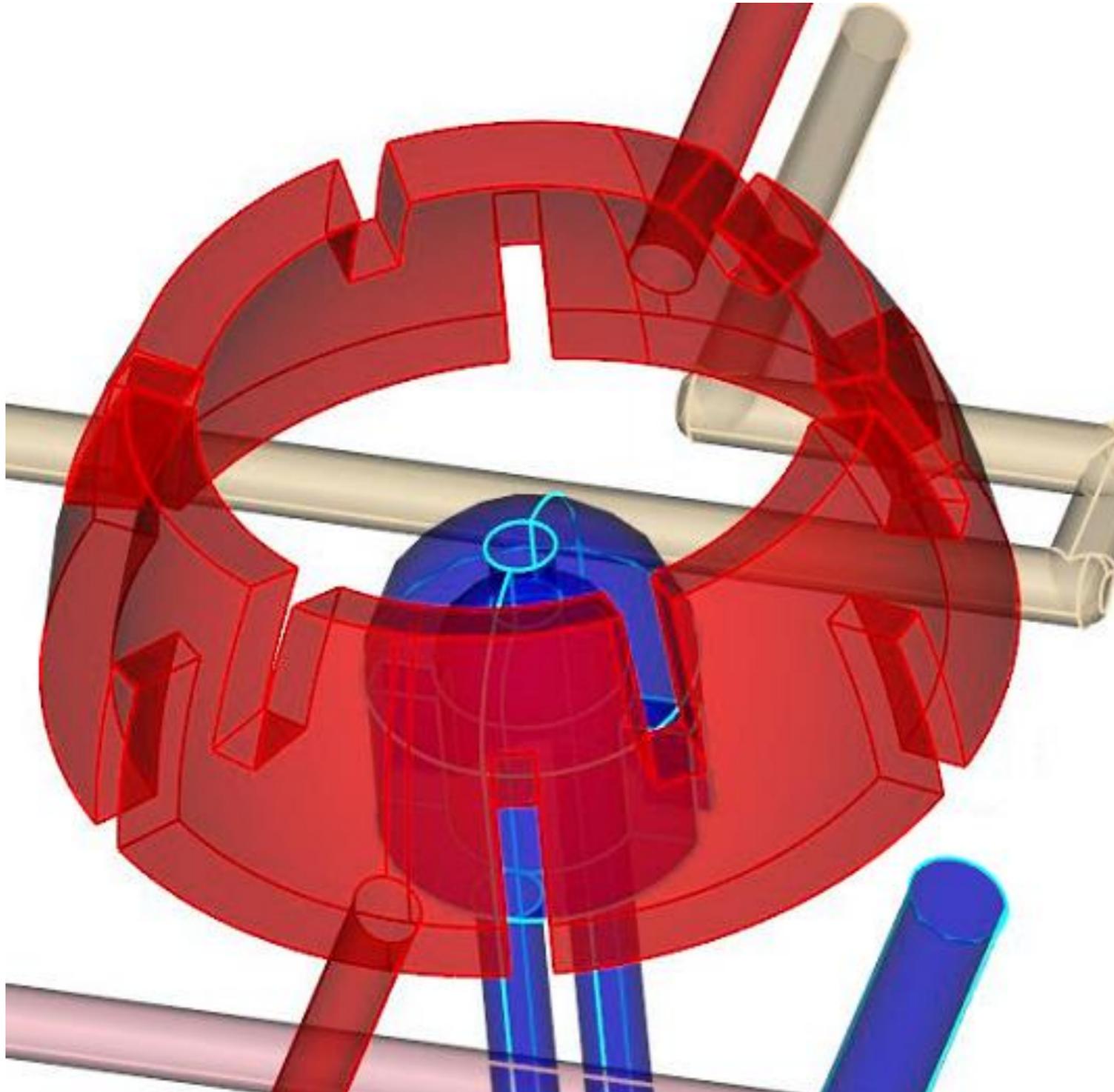
# Molding Trials

- 냉각채널-3D 형상 냉각

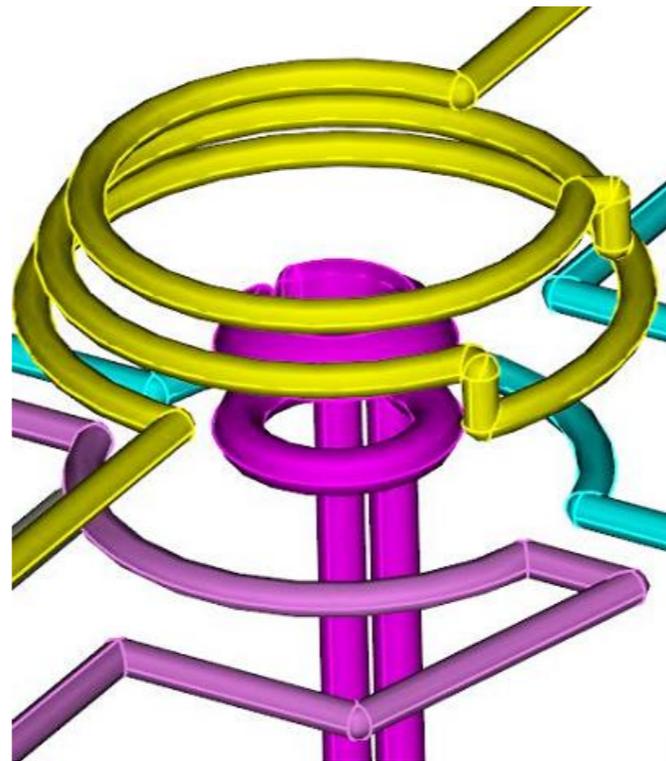
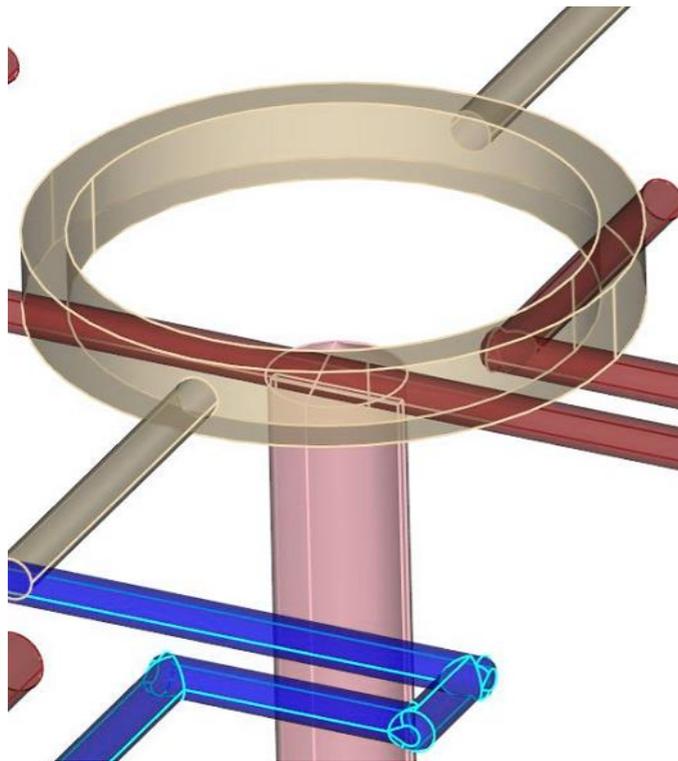


# Molding Trials

- 냉각채널-3D 형상 냉각 수정

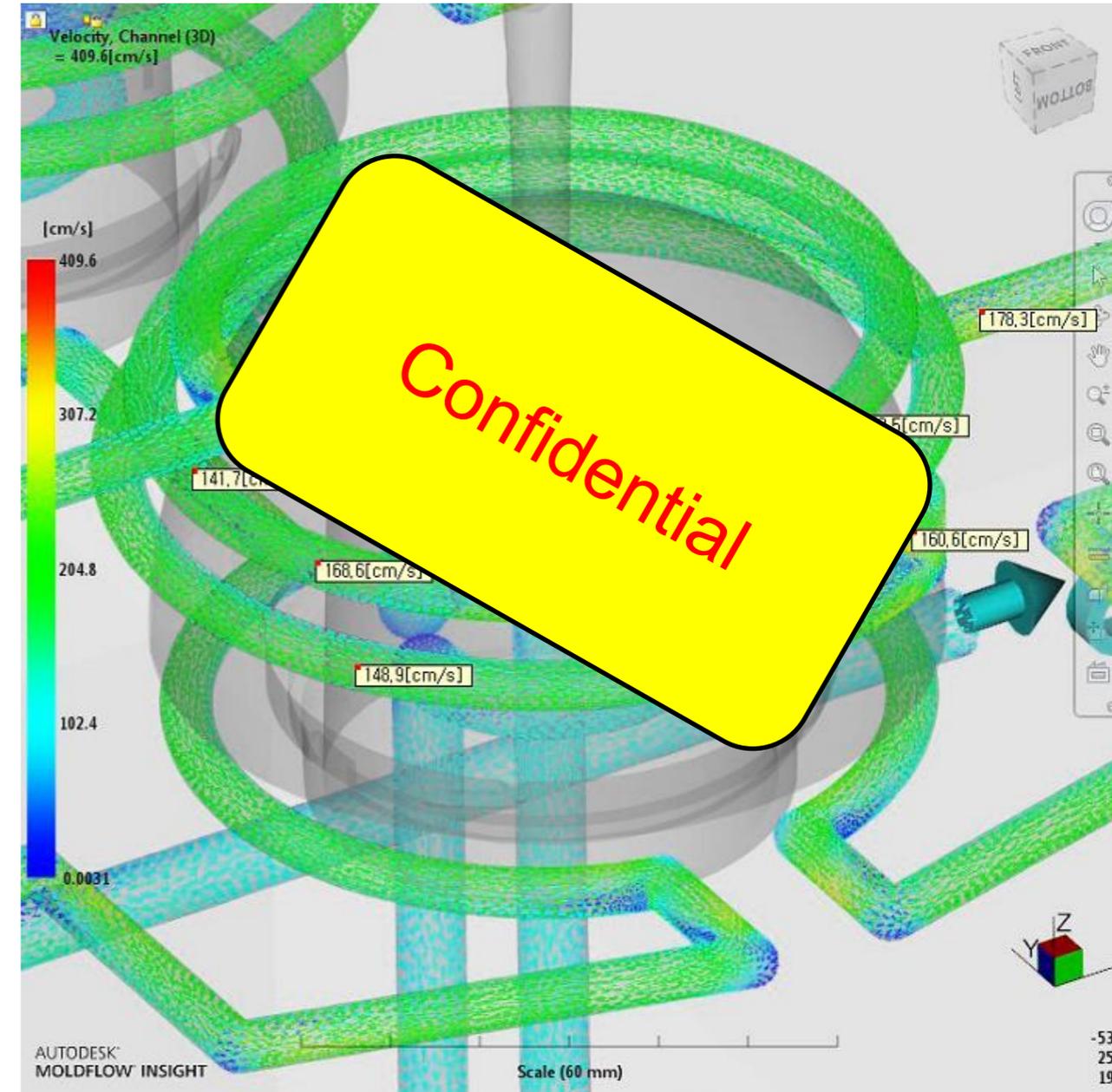
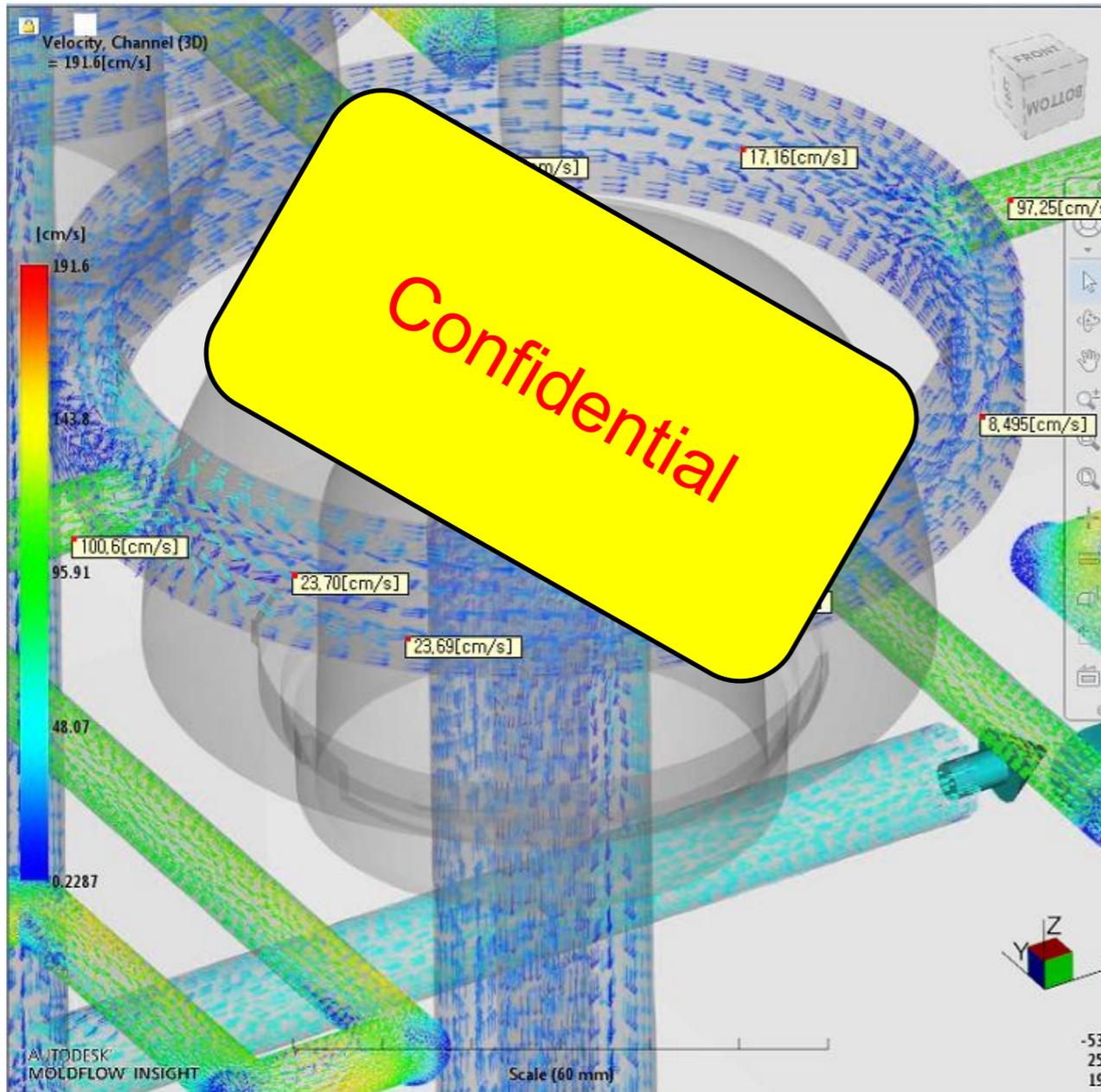


# 3D Baffle과 3D 형상냉각의 효율 확인



# Molding Trials

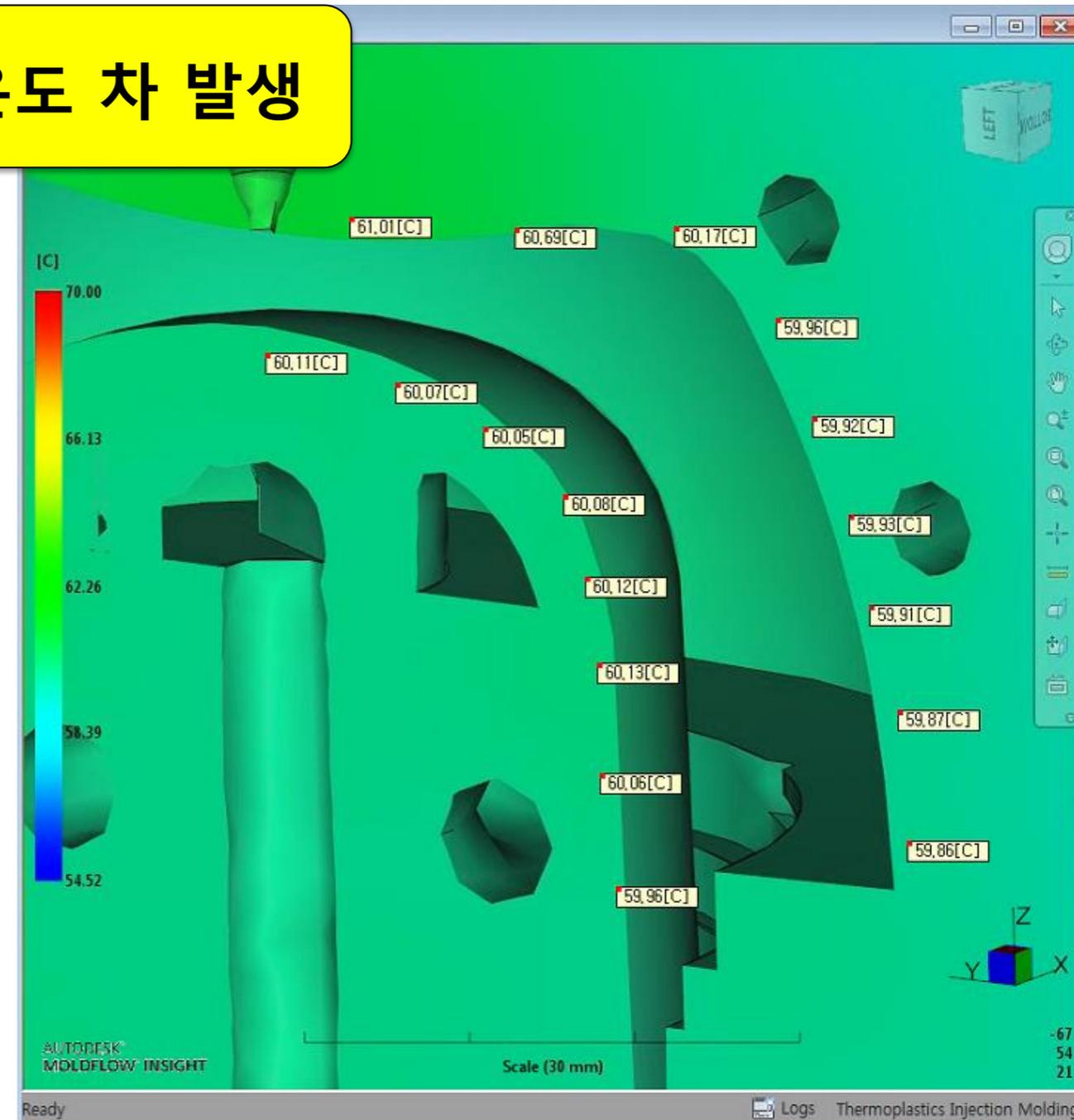
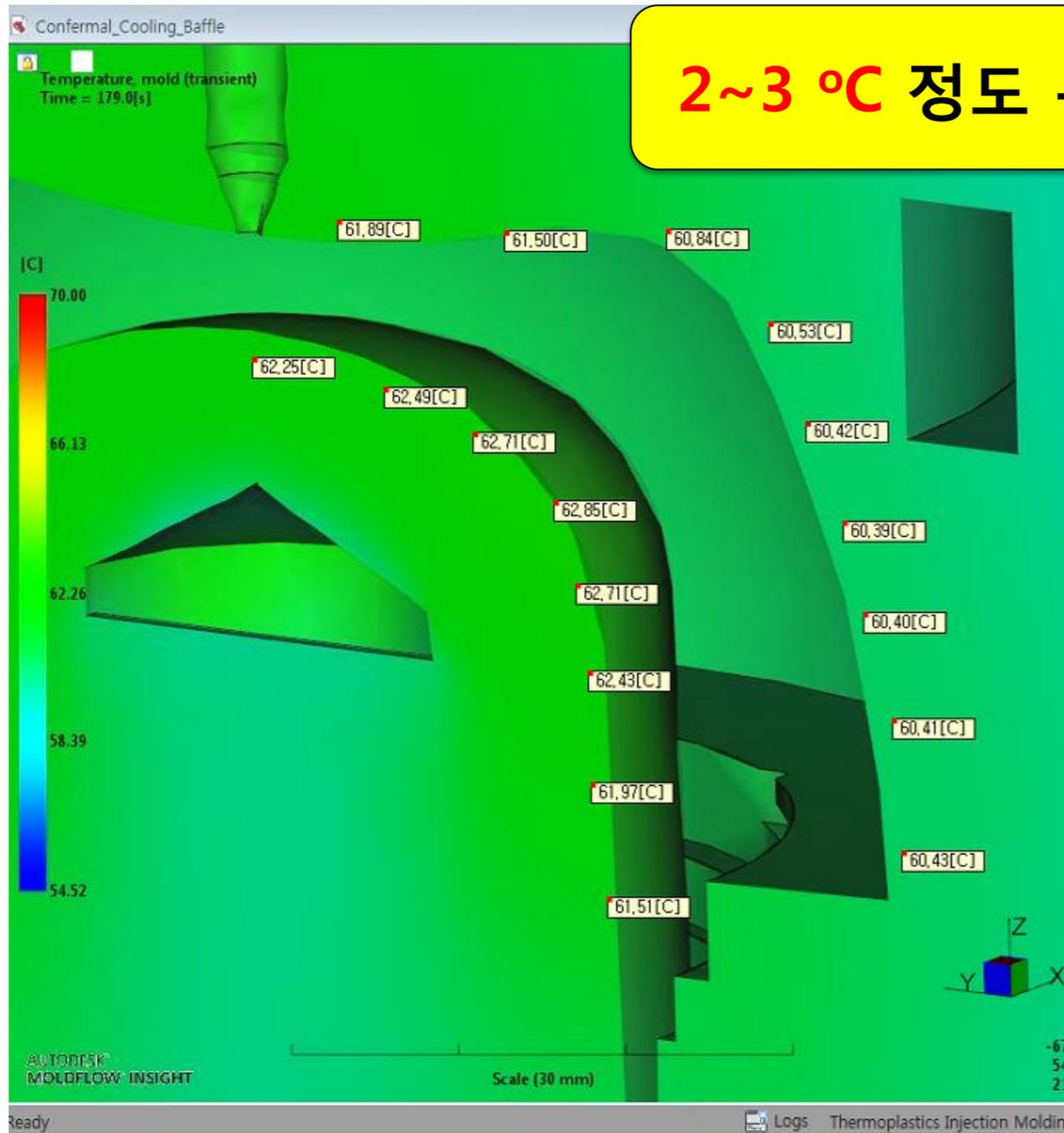
- 기존의 배플보다 냉각수의 정체 현상 및 유량이 개선됨을 확인



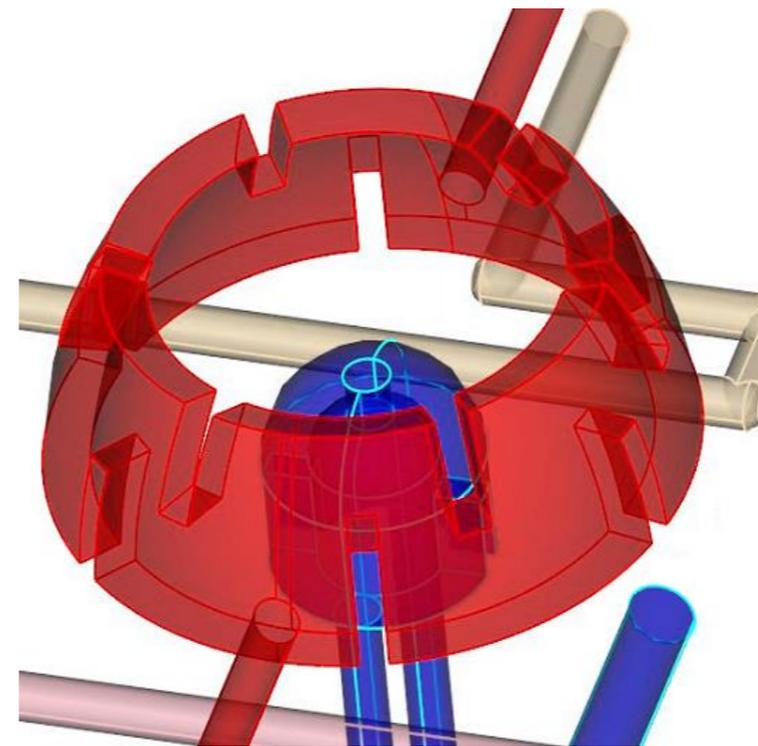
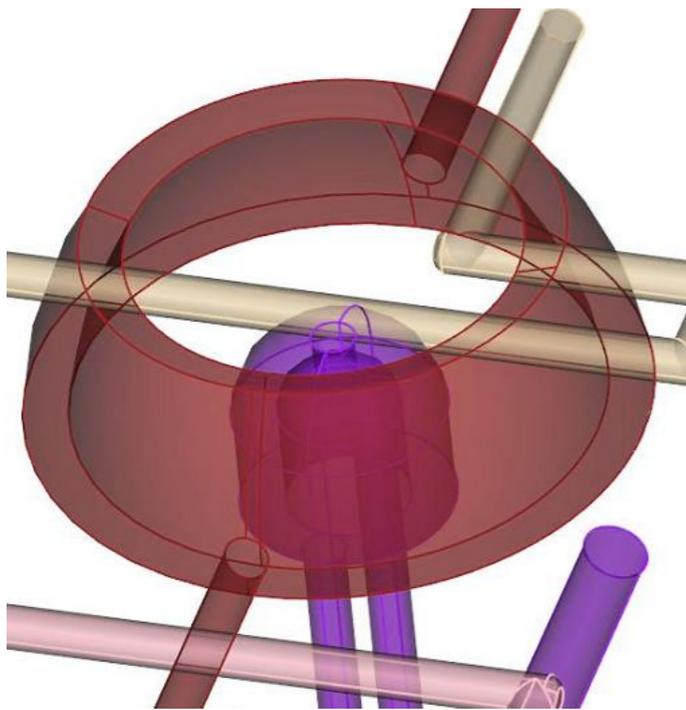
# Molding Trials

- 금형의 표면온도가 2°C 정도 차이남.

2~3 °C 정도 온도 차 발생

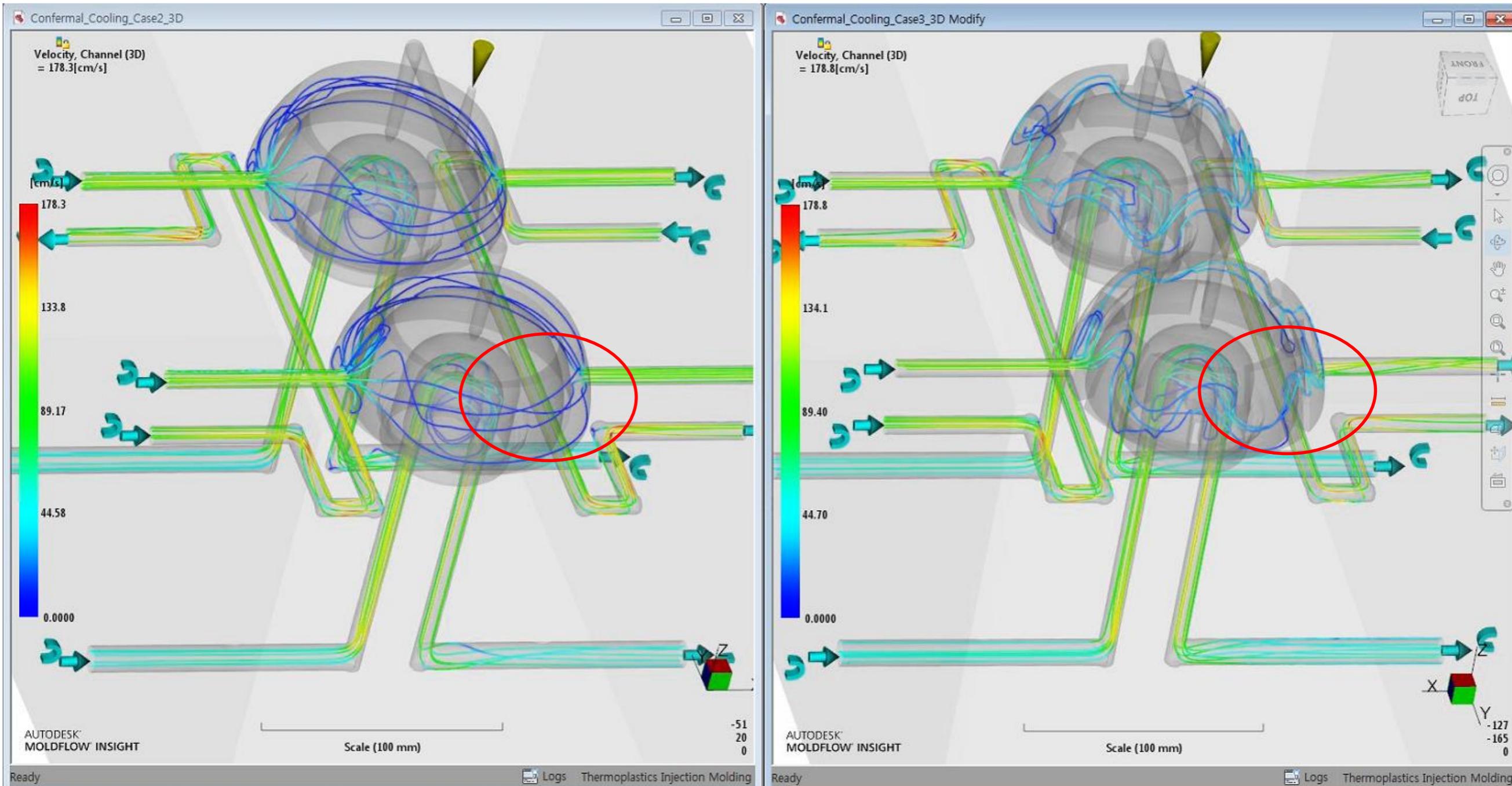


# 3D 형상냉각 디자인 변경에 따른 효율 확인



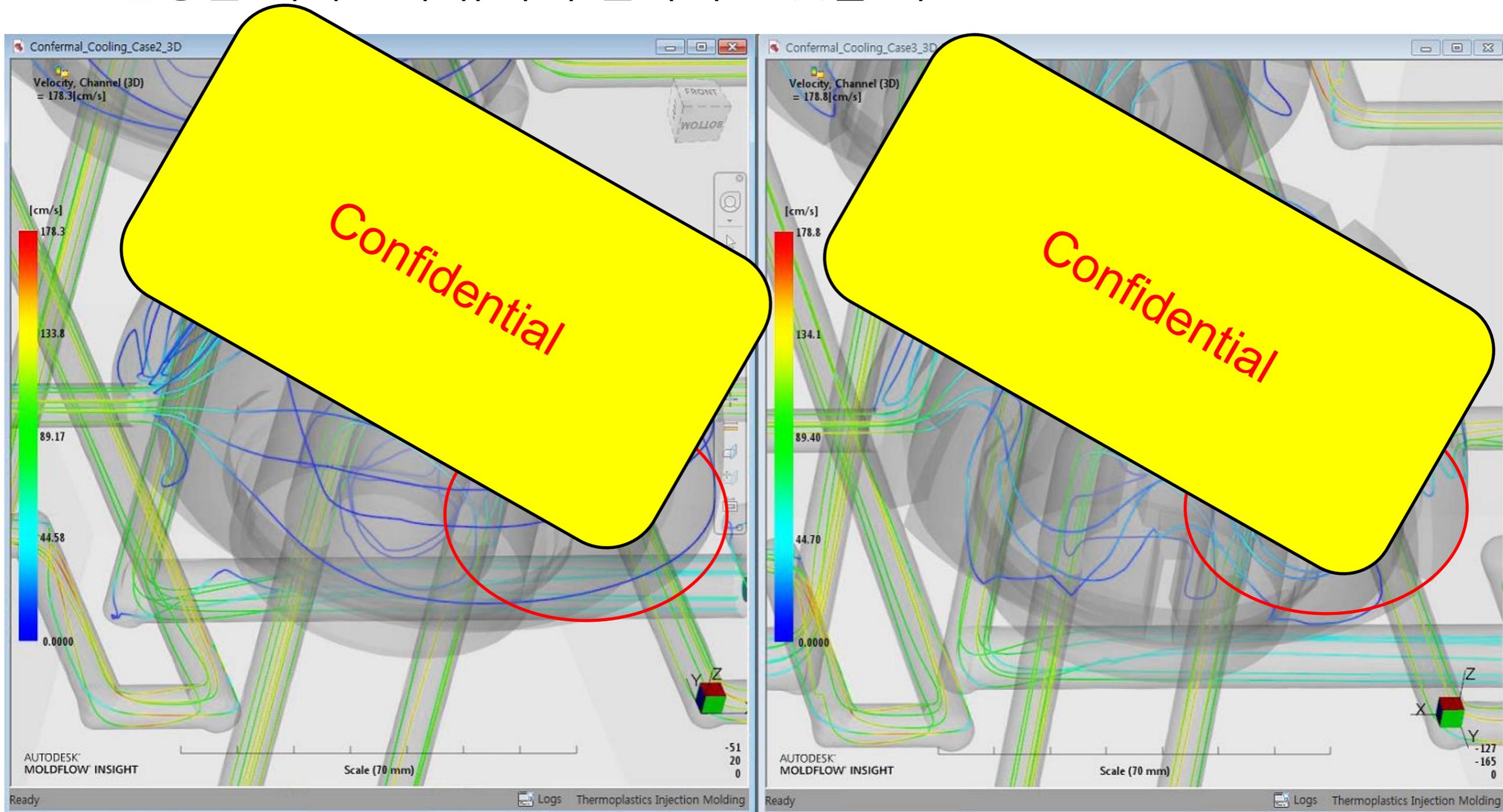
# Molding Trials

- Velocity Channel(3D) – Streamlines 이용



# Molding Trials

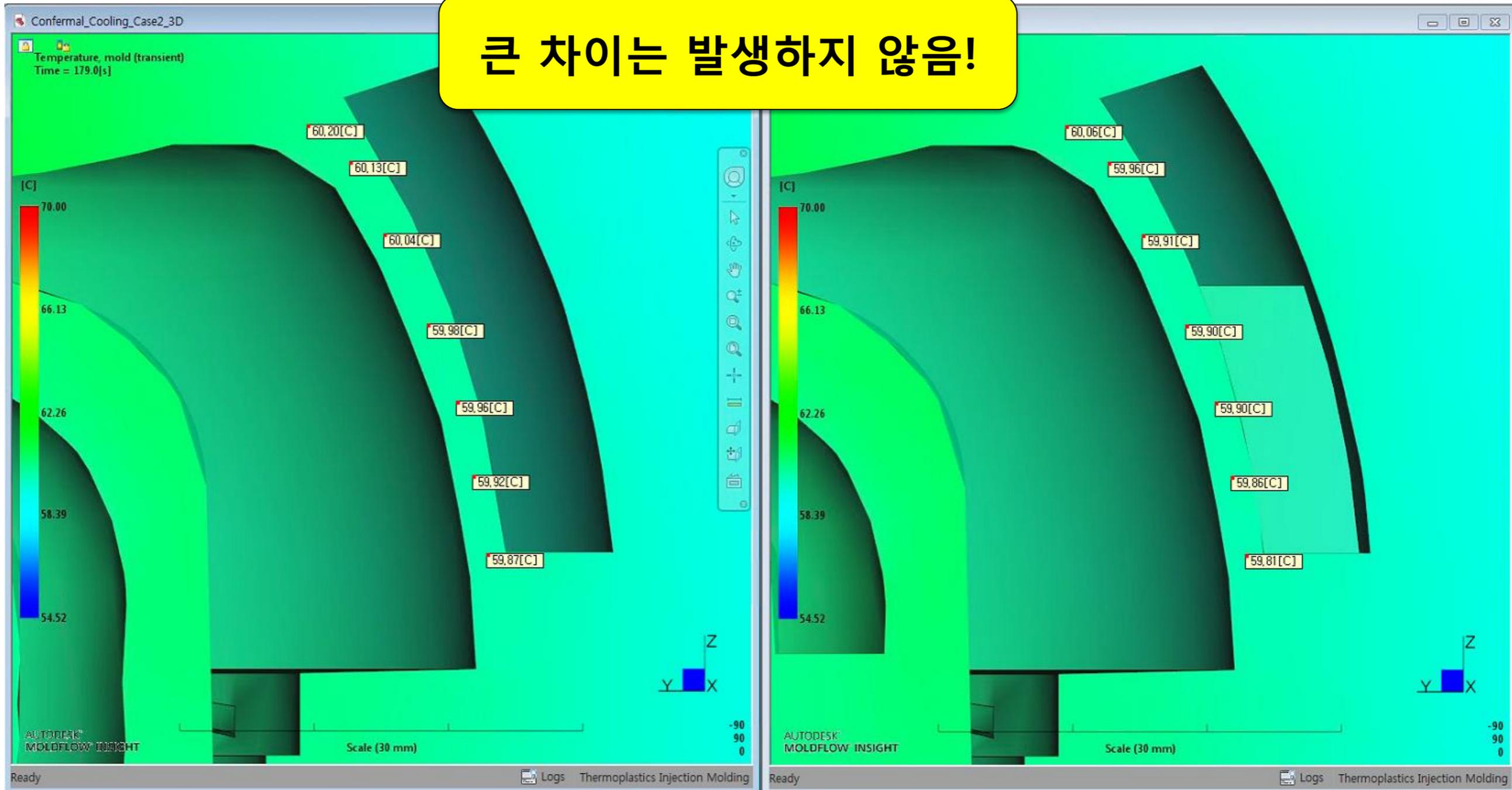
- 변경된 디자인이 유속이 빨라지는 것을 확인.



# Molding Trials

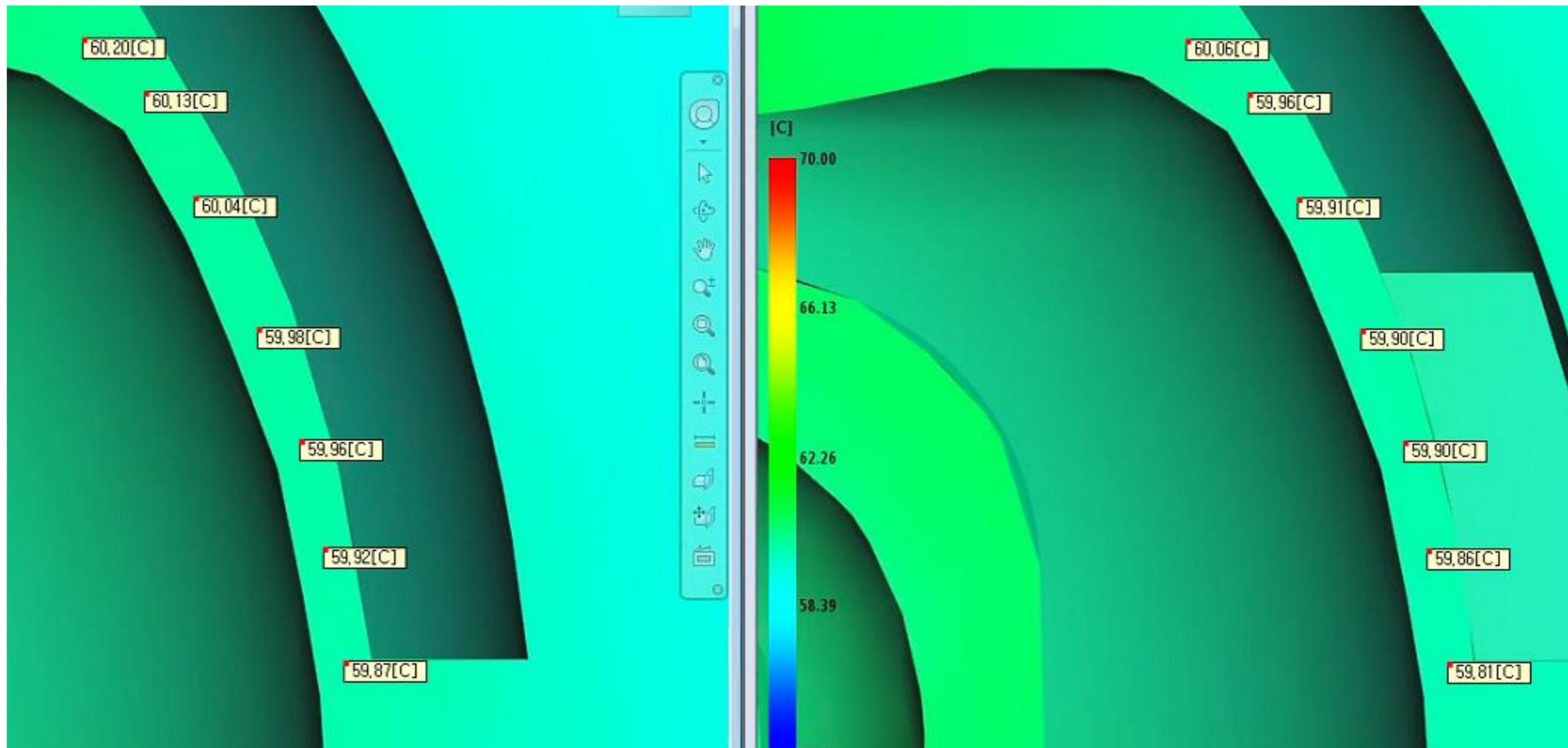
- 금형의 표면온도는 크게 바뀌지 않음. Why?

**큰 차이는 발생하지 않음!**

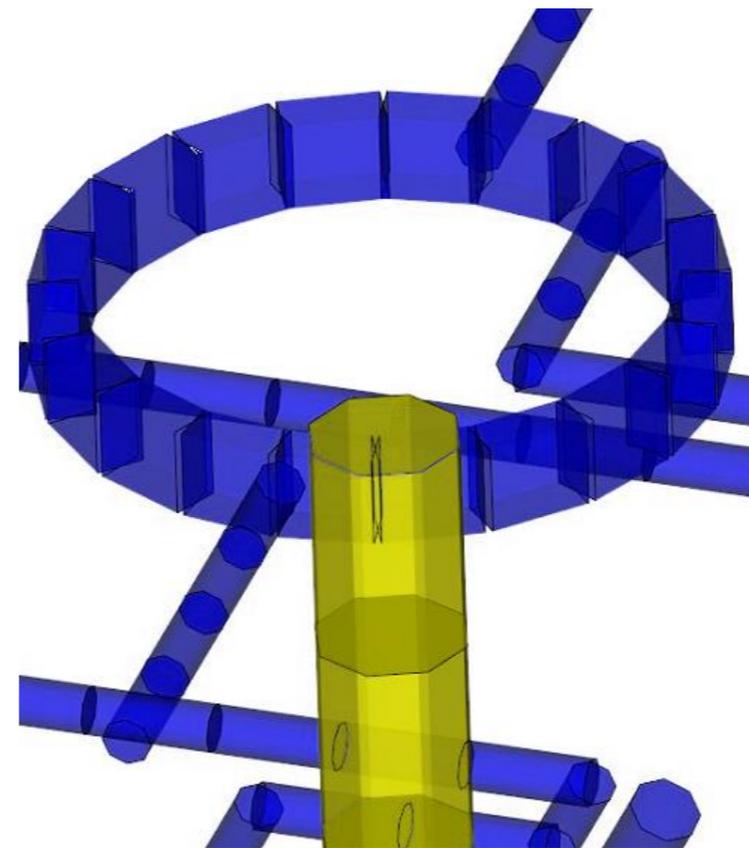
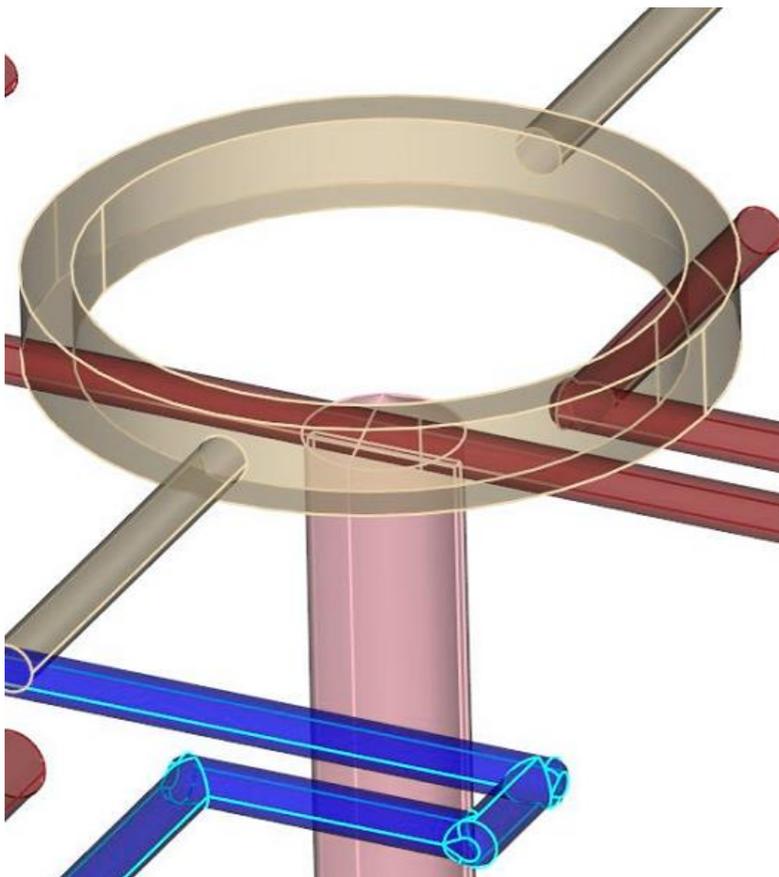


# Molding Trials

- 금형의 표면온도는 크게 바뀌지 않음. Why?
- 냉각에 영향을 미치는 인자...
  - 냉각채널의 크기, 제품과의 거리, 냉각수 온도, 냉각형상...

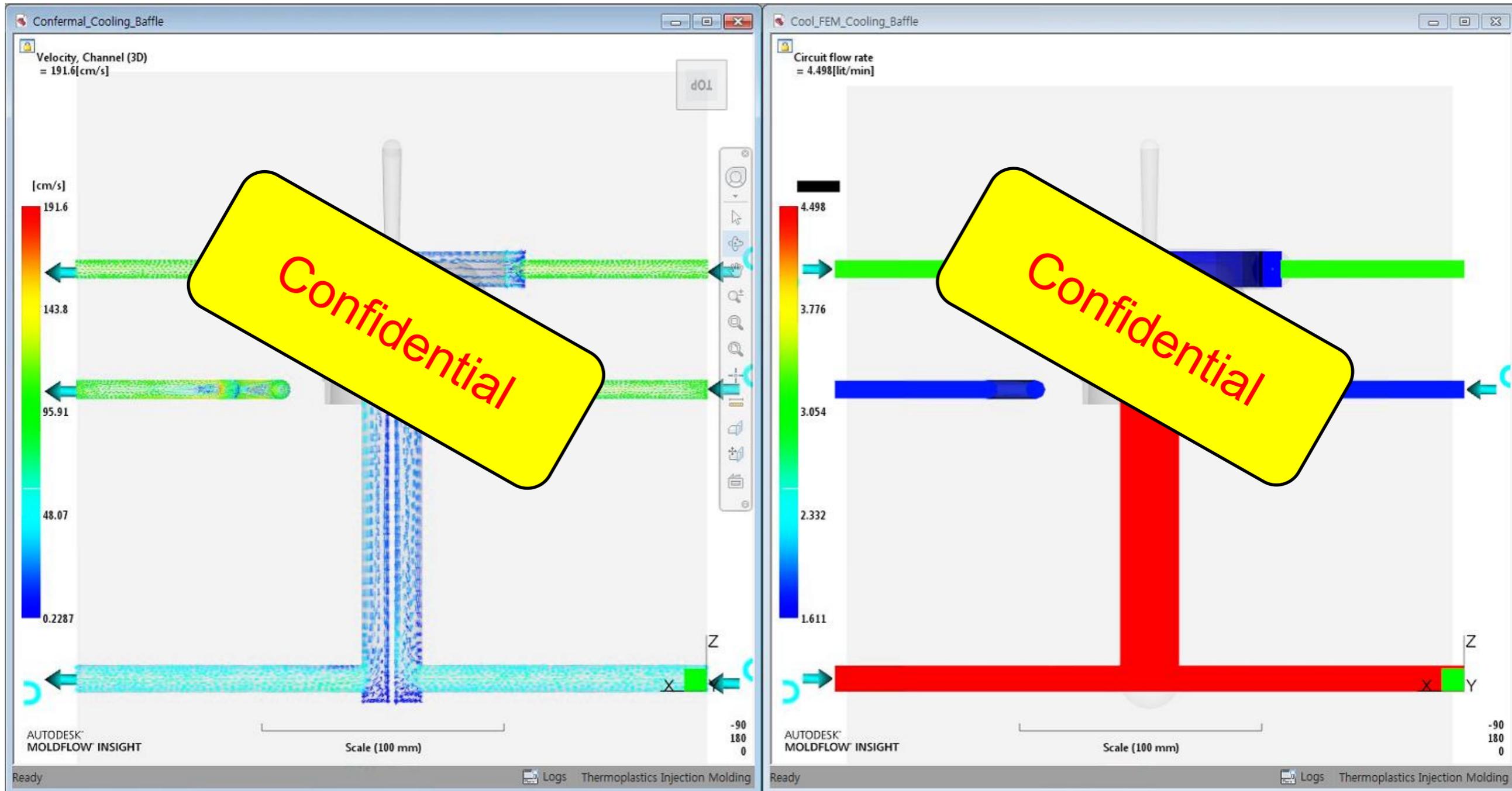


# 3D Baffle과 Beam Baffle의 차이점 확인



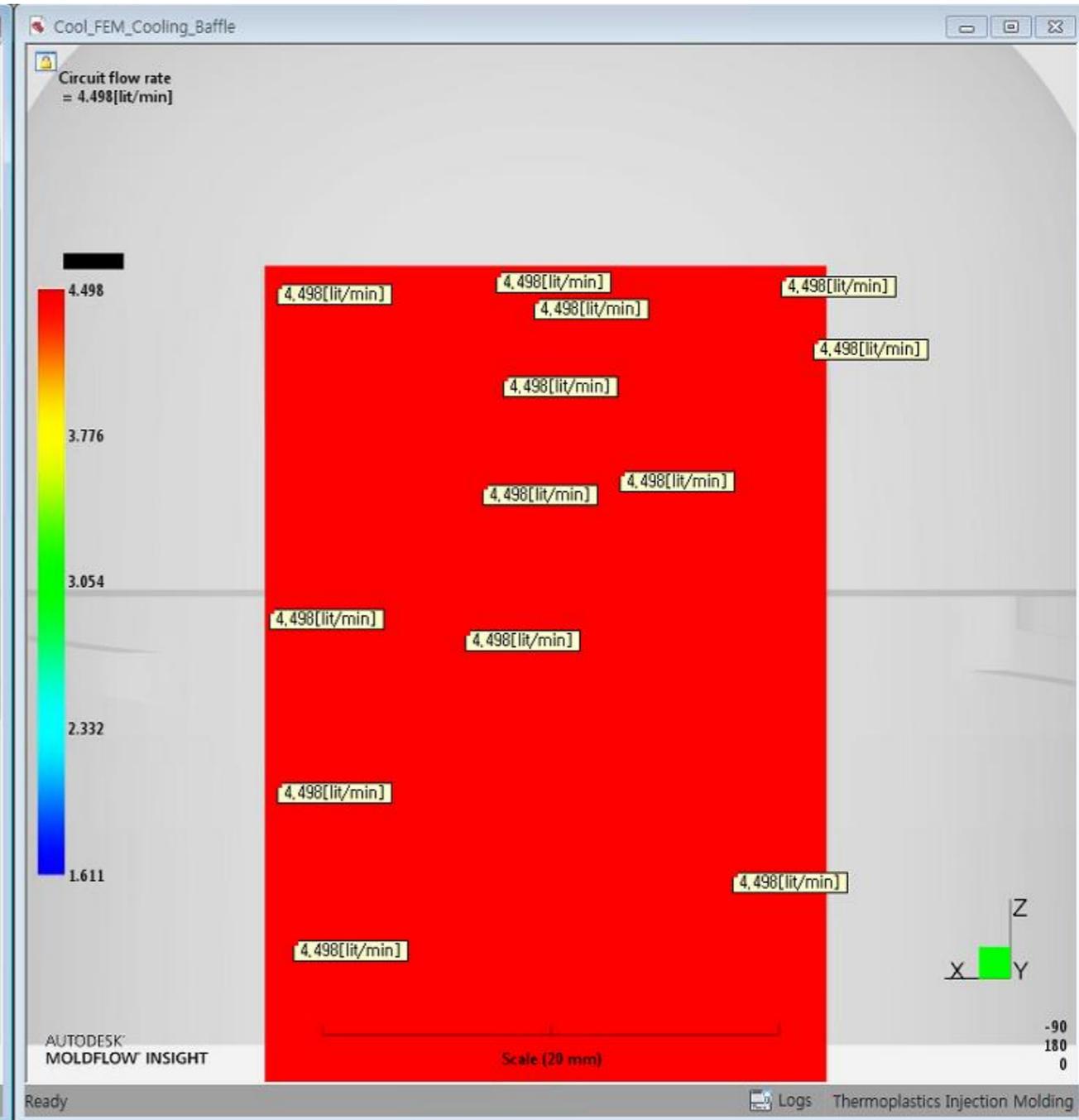
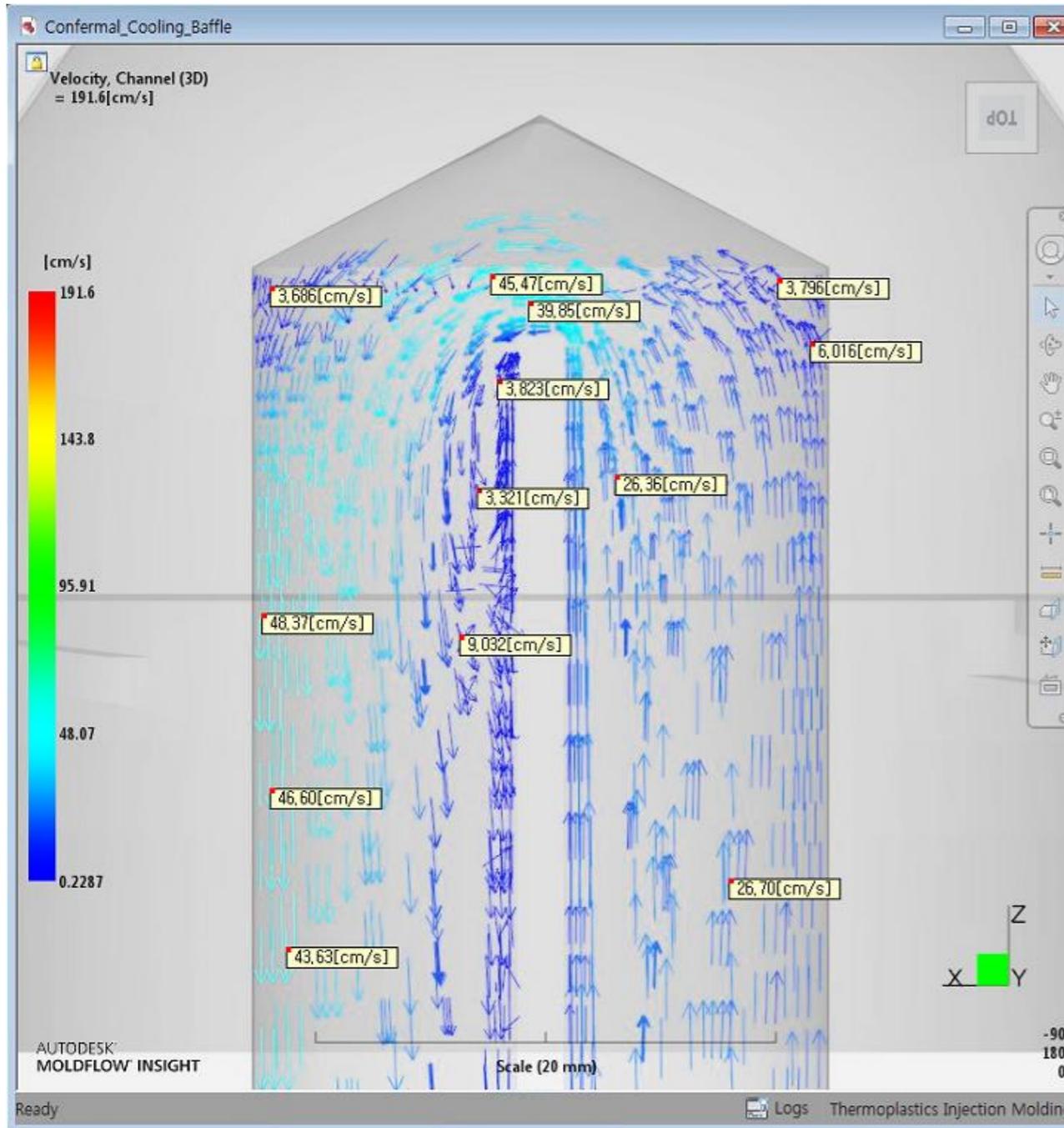
# Molding Trials

- 3D Conformal 채널 VS Beam Baffle



# Molding Trials

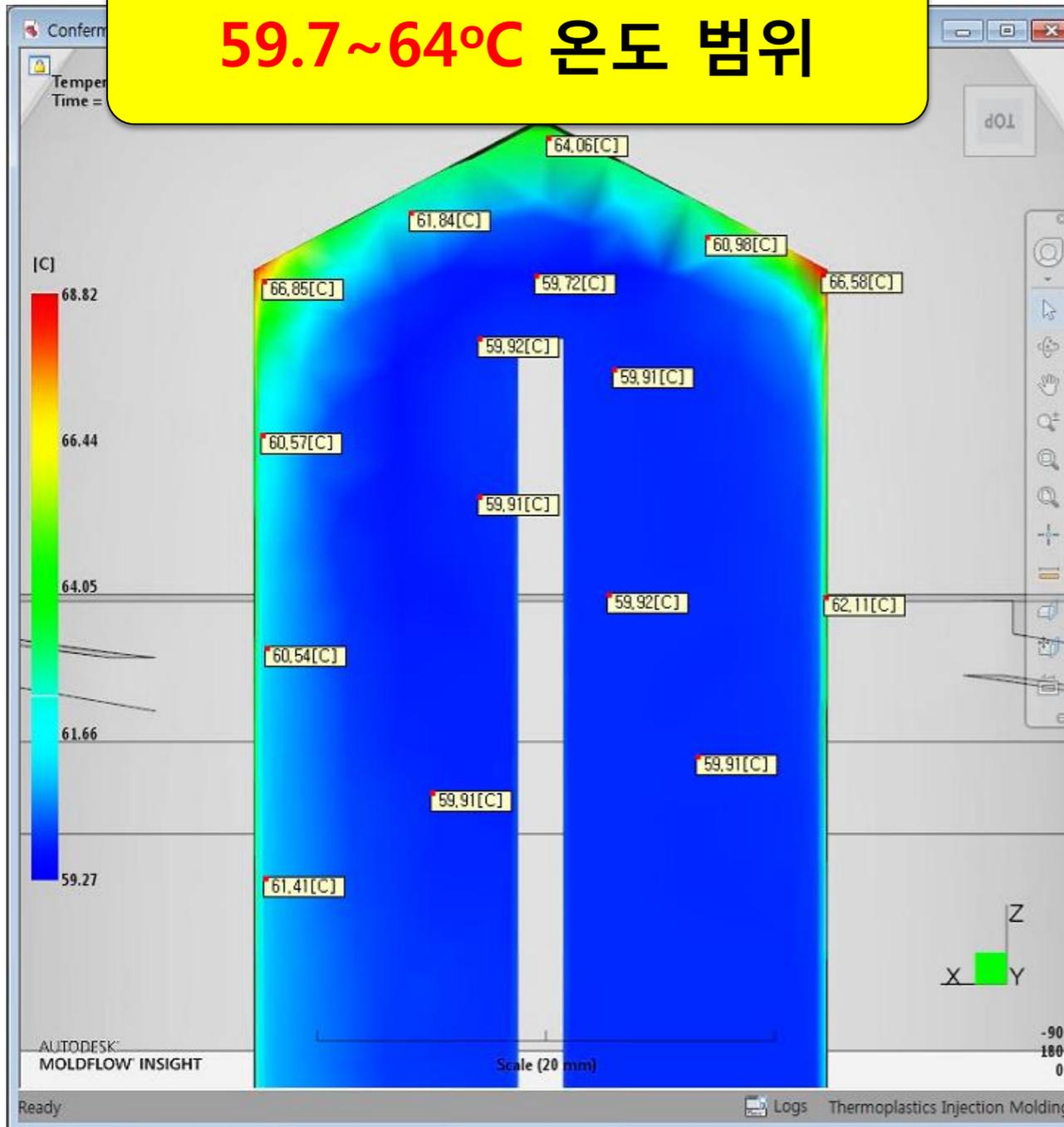
- 유속 및 유량 확인 (정체현상 확인)



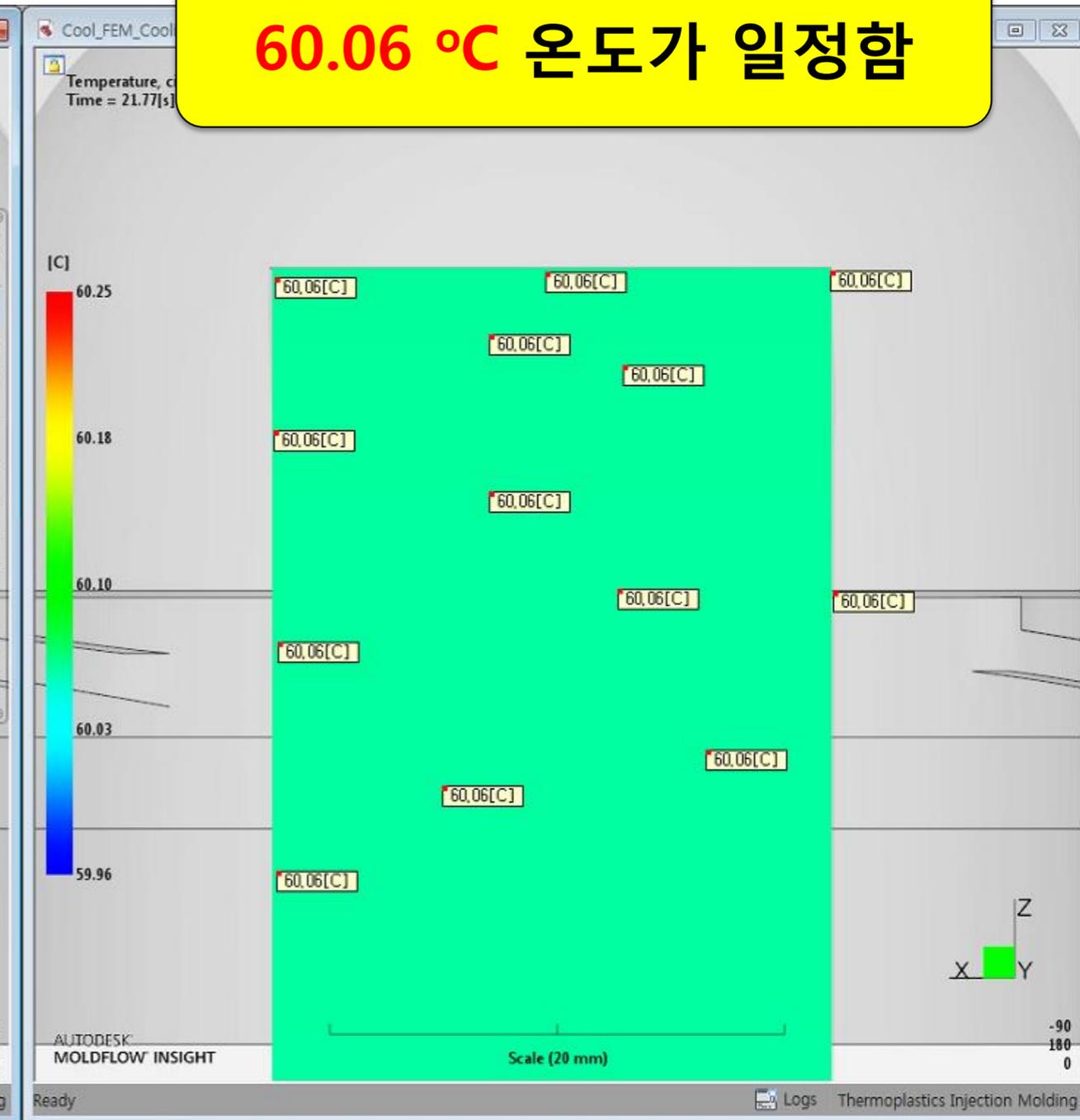
# Molding Trials

- 3D Conformal 채널 VS Beam Baffle - 냉각수 온도 확인 결과 1

**59.7~64°C 온도 범위**



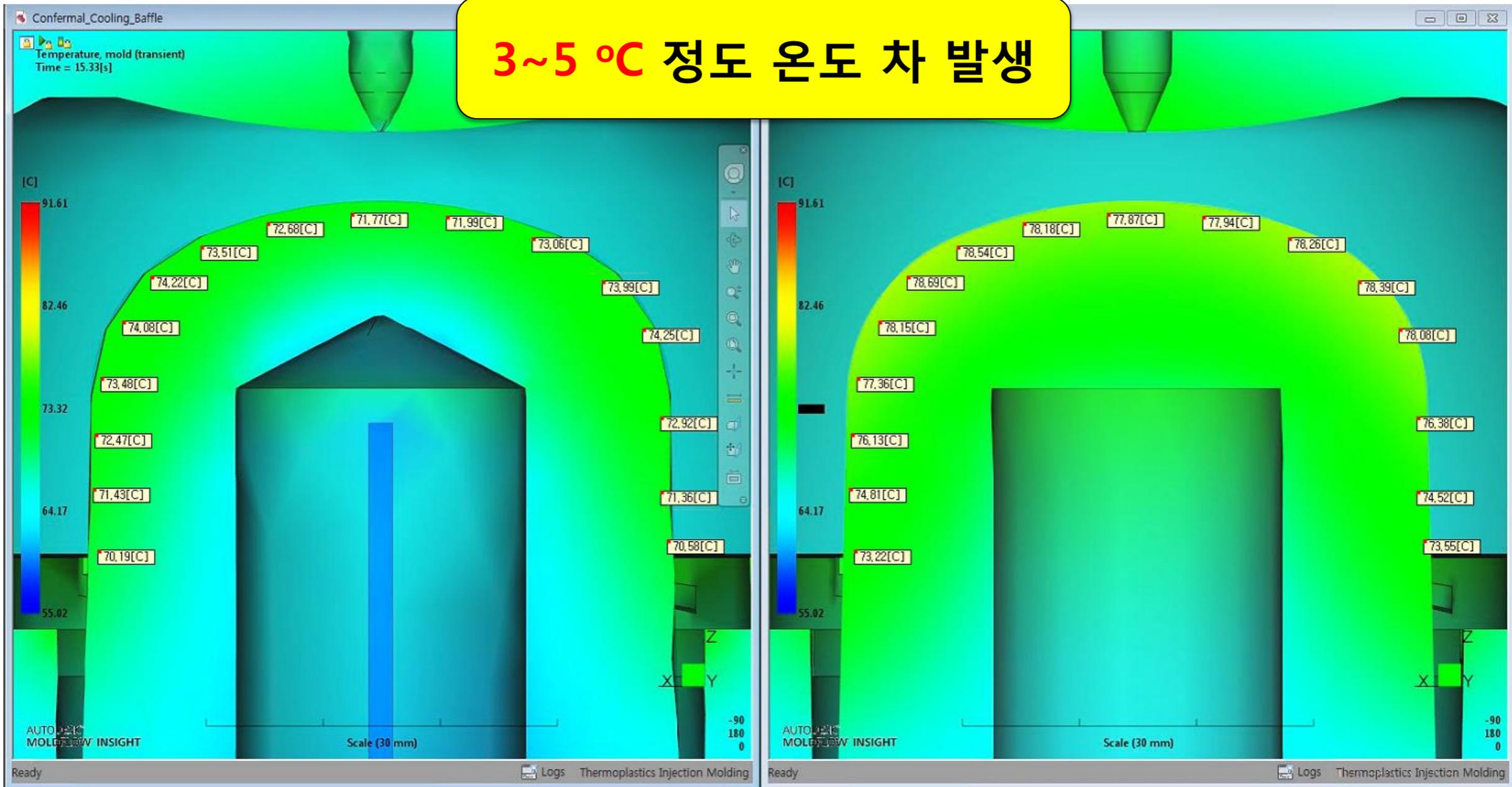
**60.06 °C 온도가 일정함**



# Molding Trials

- 3D Conformal 채널 VS Beam Baffle – 금형의 표면온도 확인

**3~5 °C 정도 온도 차 발생**

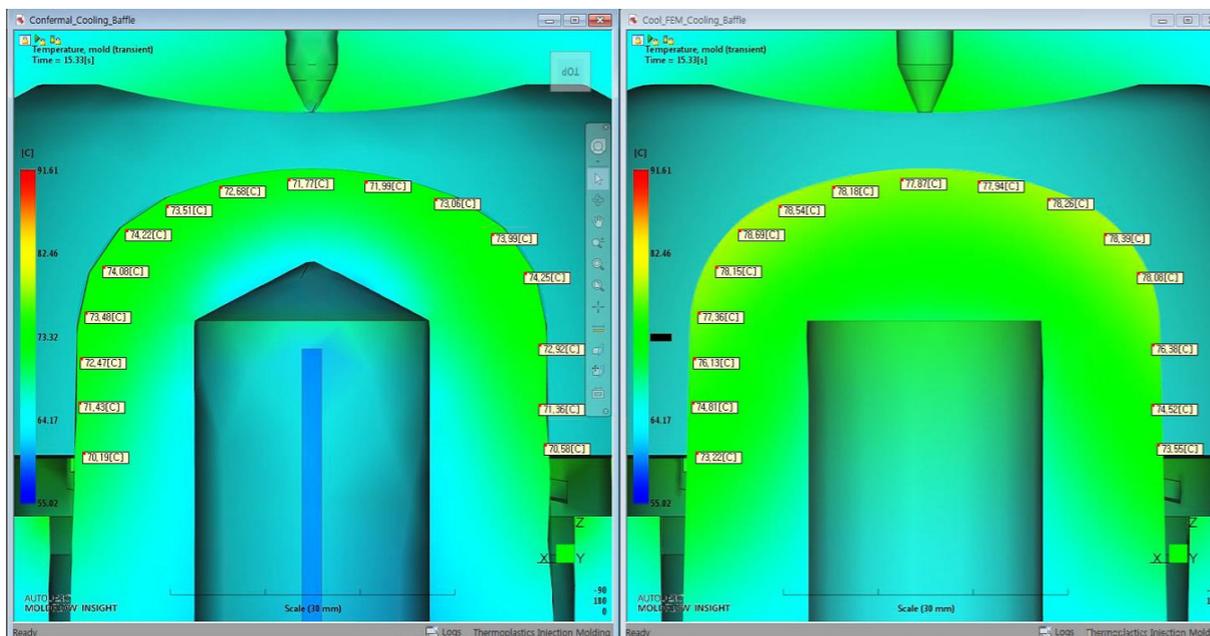


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# Conclusions

1. 3D Conformal 냉각채널을 이용하면 **Baffle에서의 정체 위치를 파악**할 수 있음.
2. 3D Baffle보다 **3D Channel 냉각효율이 높음.**
3. 3D 형상 냉각의 **디자인이 변경하여 정체현상을 줄였으며, 유속도 높였음**
4. **3D Baffle이 Beam Baffle보다 실제와 더 유사한 냉각이 가능하며, 냉각효율도 높음**



# 감사합니다