mid Moulding Innovation Day 2023

Project Setup, Best Practice, Workflow

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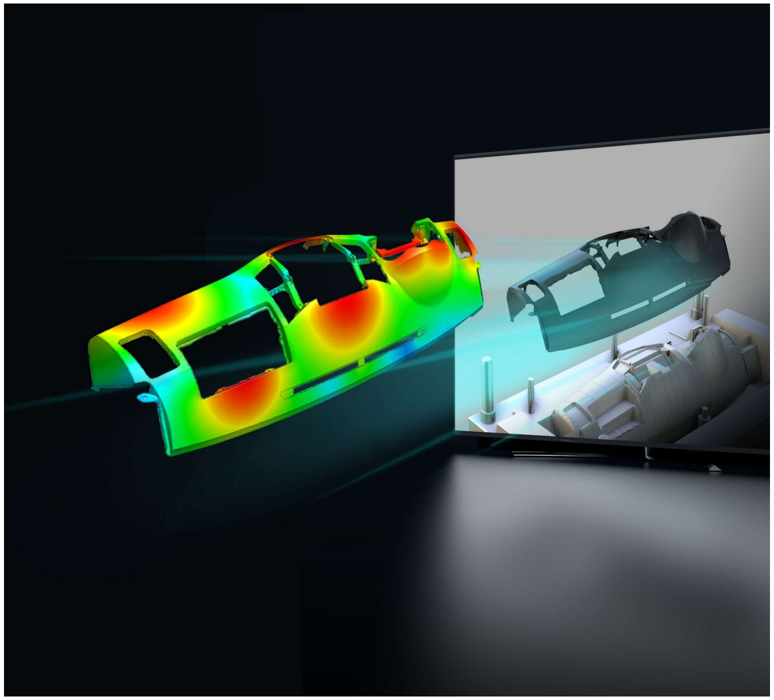
Moldex3D

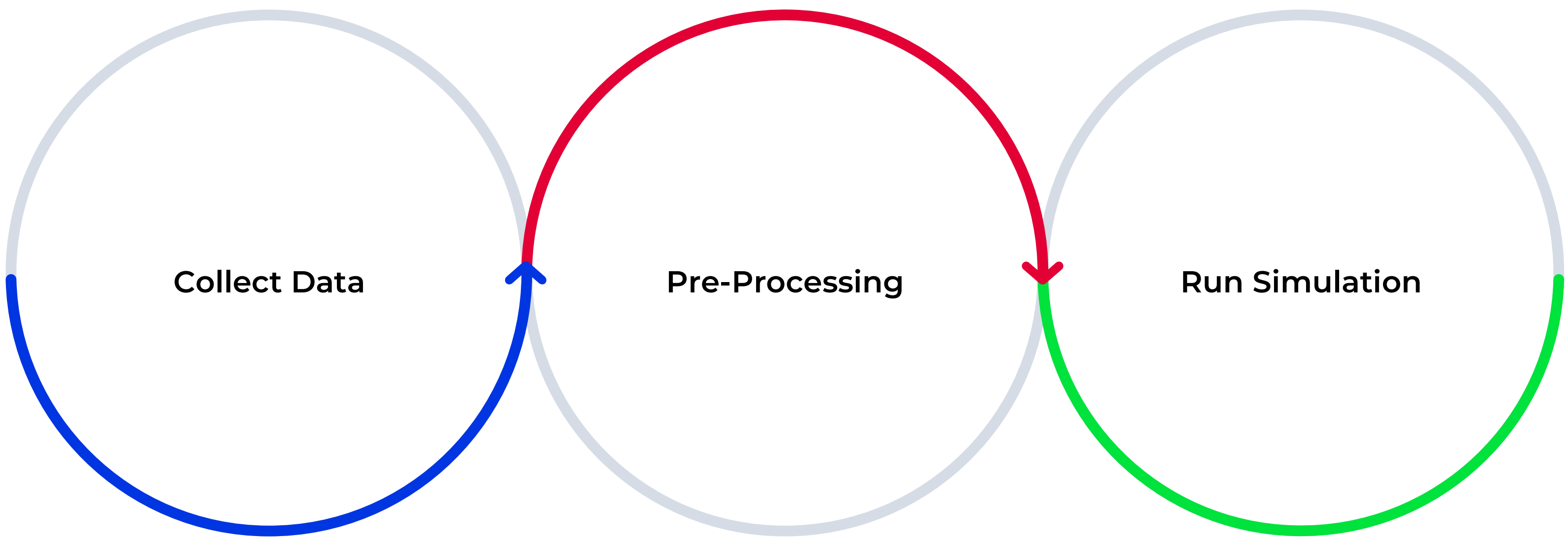
Purpose

- **We have been experiencing the case with:**
  - **Inaccurate results**
  - **Unreasonable results**

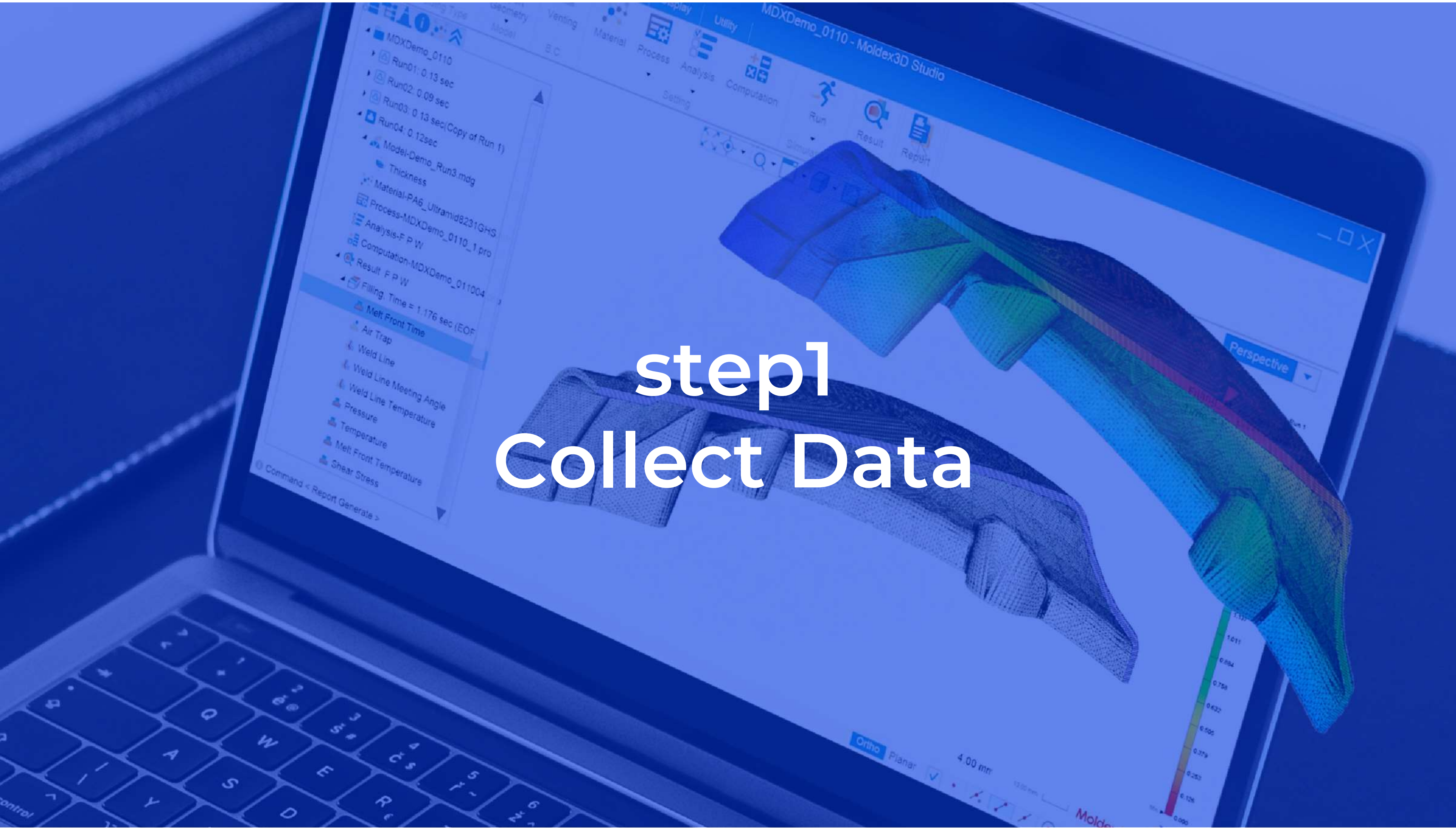
- **We want to propose a practical workflow to help partners overcome these issues**
  - **Result accuracy is highly dependent on input accuracy**



Moulding Innovation Day 2023



step1
Collect Data



Step 1.
Collect Data

The key data for simulation:

01
Part Geometry

02
Material Properties

03
Process Condition Sheet

04
Picture of Real Part

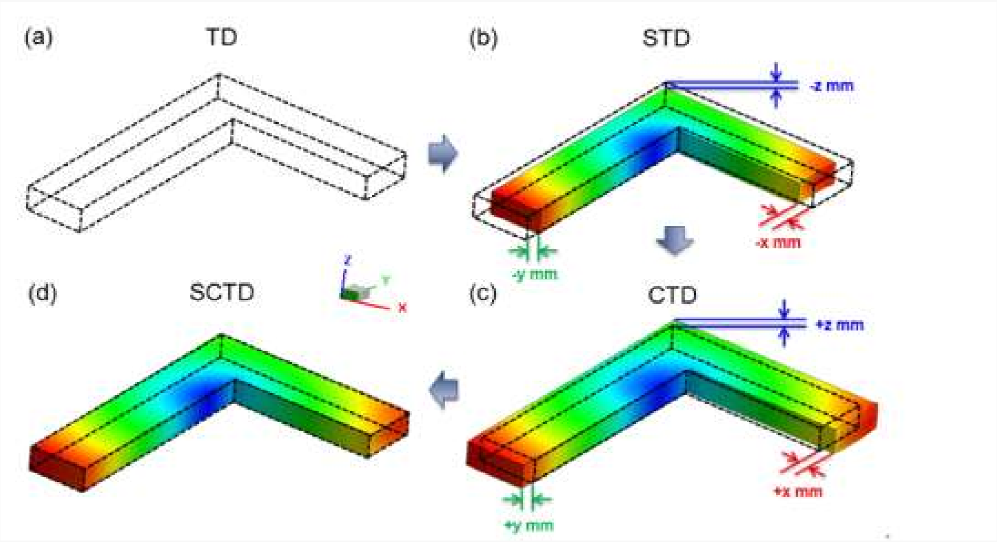
05
Measurement Data

06
Mold Design

- Cooling Layout
- Runner Layout

Part Geometry

- **The CAD file of part must have the correct dimension.**
  - Check what the unit of the CAD file, mm, cm or inch
  - Confirm if the customer has modified the tool during mold trial stage.



(a) TD: Target Design (with desired dimension)
(b) STD: Simulation result of the Target Design (TD)
(c) CTD: Compensate Target Design is the modified design with the reverse of STD shrinkage
(d) SCTD: Simulation result of the Compensate Target Design (SCTD)

Material Properties

- **Material Family and Grade Name**
- **Following material information is needed for a case:**
    - Material of Part
        - Viscosity
        - PVT
        - Mechanical properties
    - Material of Mold/Mold insert
        - Thermal conductivity/Heat capacity
    - Material of part insert
        - Thermal conductivity/Heat capacity
        - Mechanical properties
- **Find the material properties from Moldex3D lab or material suppliers are recommended.**
- **Alternative material is the last option.**

Process Condition Sheet

Key data for process condition:

- Machine Information
  - Screw Diameter
  - Injection Pressure
  - Clamping Force
- Filling Condition
  - Screw Position
  - Screw Speed vs Position
- Packing Condition
  - VP Position
  - Packing Pressure vs Time
- Cooling Condition
  - Cooling Time
  - Coolant Type
- Others
  - Melt Temp.
  - Mold Temp (Core/Cavity).
  - Unit

1. Machine Information

Maker		Clamping force	Ton	Injection rate	cc/sec
Grade		Shot weight	g	Screw Diameter	mm
		Injection pressure	MPa	Screw stroke	mm

2. Process Condition

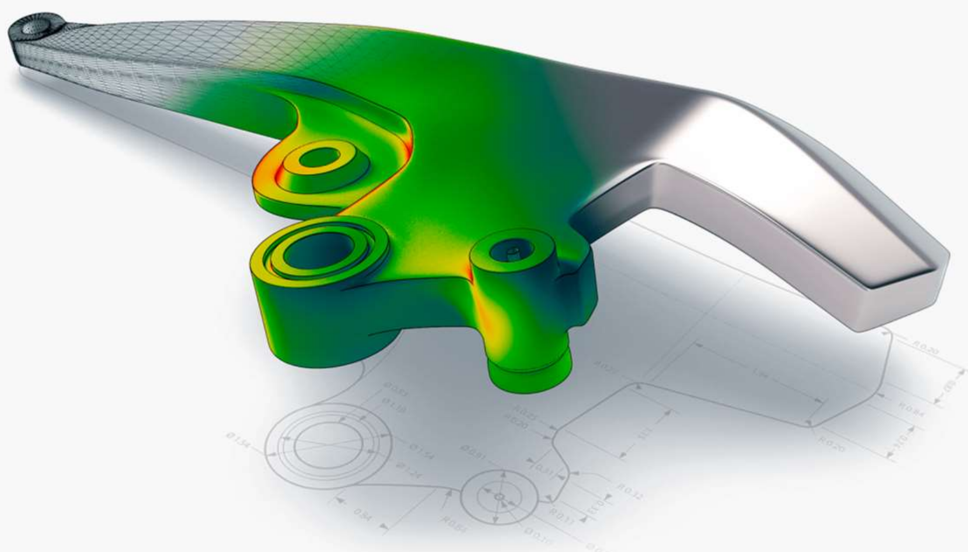
Injection Time	Sec	Packing Time	Sec	Note：Unit of speed, pressure is needed

Fill	Screw Position			
	Section	Speed	Pressure	Position
	I			
	II			
	III			
	IV			
	V			

Pack	VP Position		
	Section	Pressure	Time
	I		
	II		
	III		
	IV		
	V		

Melt Temp.	℃	Air Temp.	℃
Mold Temp.	☐Core ℃ ☐Cavity ℃	Coolant Temp.	℃
Coolant Flow Rate	cc/sec	Cooling Time	Sec
Coolant Type	☐ Water ☐ Oil	Mold Open	Sec

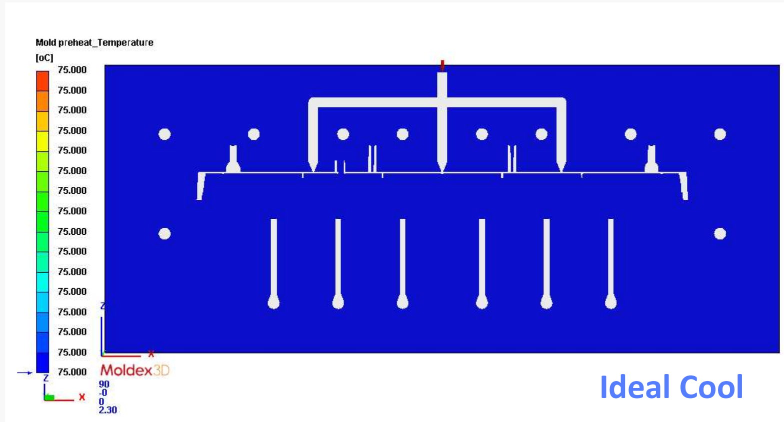
Picture of the real part
Measurement data



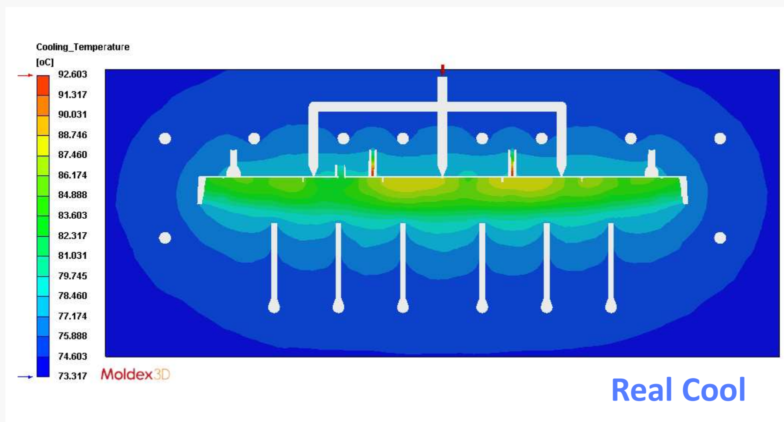
Mold Design *Cooling layout*

The Impact of Cooling System

- FPW (Ideal cool) : Assume the mold temperature distribution is uniform.



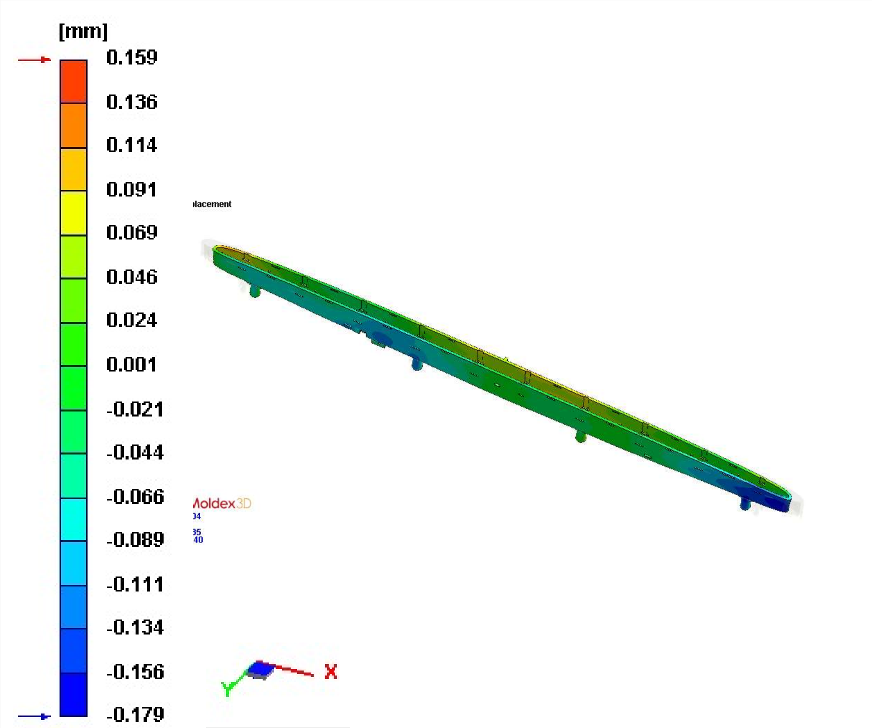
- CtFPCtW (Real cool): Mold temperature distribution is determined by cooling channel, coolant type and process condition.



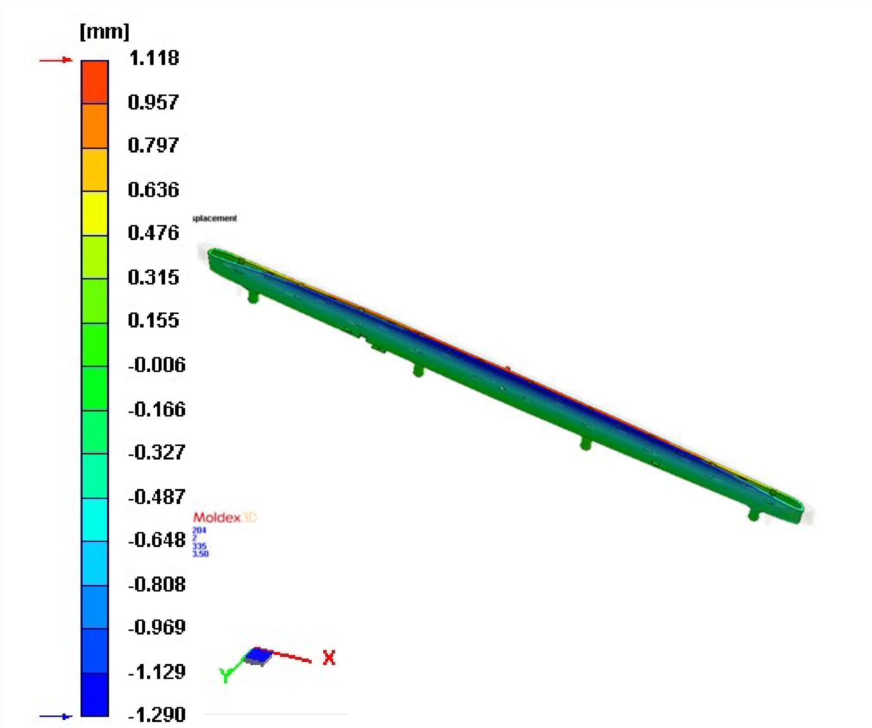
Example: Comparison between ideal cool vs Real cool

Y-Displacement (x5)

Ideal Cool
-0.18~0.16 mm

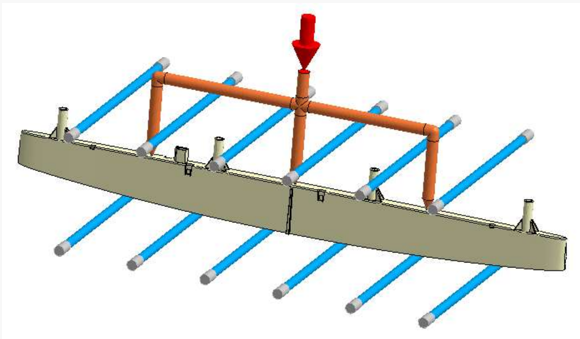


Real Cool
-1.29~1.12 mm



What Should We Do if We Don't have the Cooling Design?

› If the user doesn't have the cooling layout, create a simple cooling layout and run both FPW and CtFPCtW in order to find out if there is heat accumulation.



➕

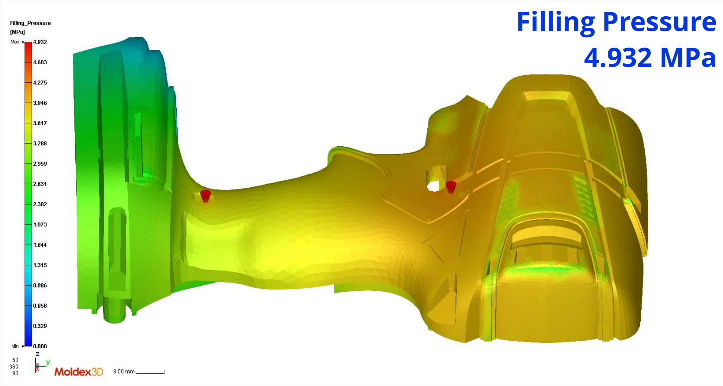
- **FPW**
- **CtFPCtW**

› If there is heat accumulation, the warpage result will be very sensitive to the cooling design, We must run one more simulation with real cooling design before tooling.

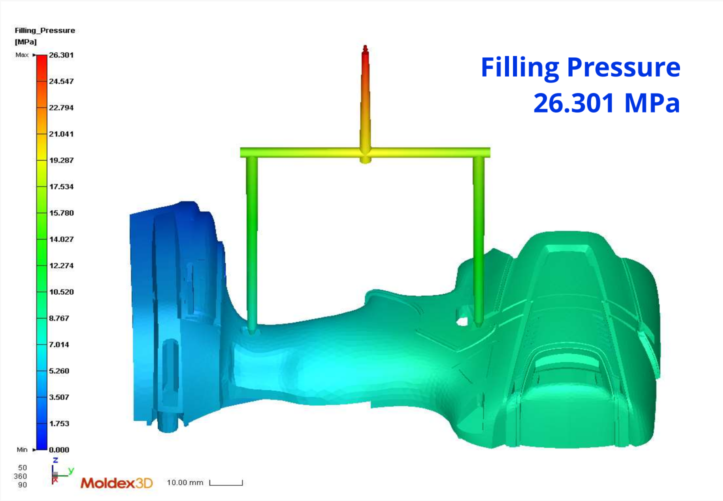
Mold Design *runner layout*

The Impact of runner system

- The required injection pressure will be underestimated without a runner system, furthermore the packing effect will be different to the real situation.



- Shear heating effect in the runner system won't be considered if the simulation was done with gates only.



Summary

Step 1.
Collect Data

The key data for simulation:

- Collecting all the necessary data and checking the correctness of all the information are the key to a successful case.

- If we are not able to collect all the required data, then we must be aware of the potential problems when we ignore the cooling, runner or use the alternative material.

step2
Pre-processing

Step 2.
Pre-Processing

The essentials in
pre-processing stage

01

Mesh Resolution

02

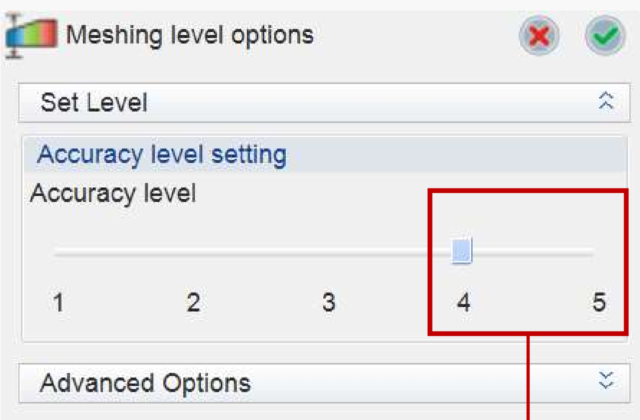
Process Condition Setting

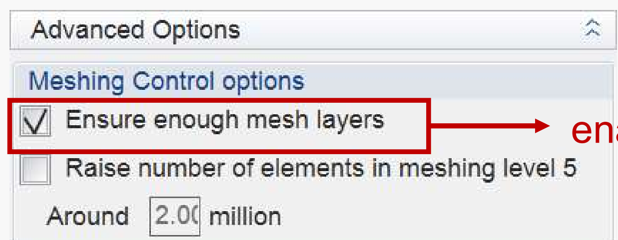
03

Computation Parameter Setting

Meshing Resolution

- **eDesign Mesh Setting: Cavity**
  - Mesh level suggestion: 4 or 5
  - Ensure enough mesh layers: enabled
  - More accurate = more computation time



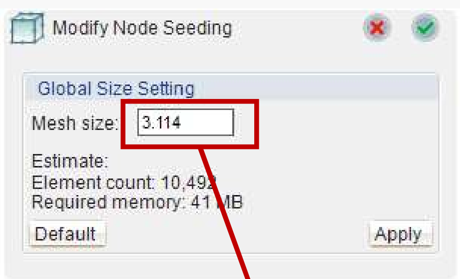


enabled

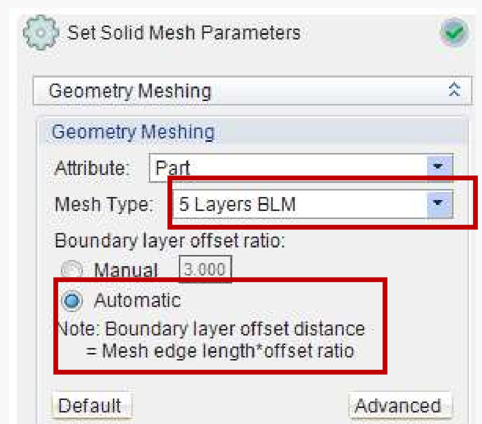
Mesh level 4 and 5 are suggested

Meshing Resolution

- **BLM Mesh Setting: Cavity**
  - Mesh size: Depended on the part size
  - Mesh type: 5 Layers BLM
  - Offset ratio: Automatic



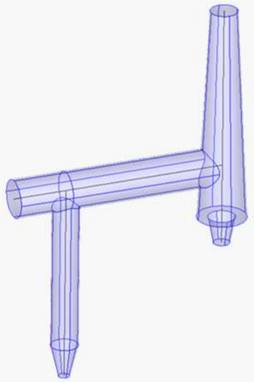
Part Length	Mesh Size
less than 200mm	1/3 of Default
200~500mm	1/2 of Default
more than 500mm	Default



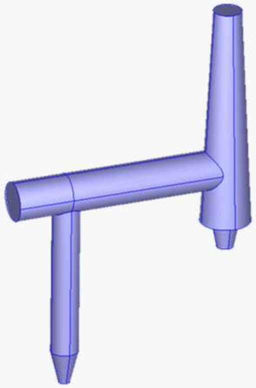
Meshing Resolution

Mesh Setting: Runner

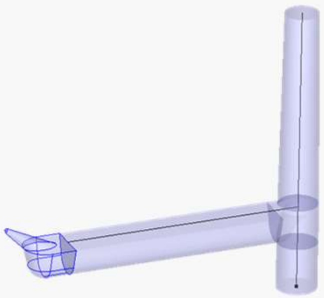
- Recommended: Line defined runner
  - Draw center lines for your runner and attributing size/shape
- 2nd Choice: Geometric runner/gate
  - Used when runner geometry is too complicated to draw center lines
  - Combining the line defined runner and geometry gate is suggested



Line Defined Runner



Geometric runner

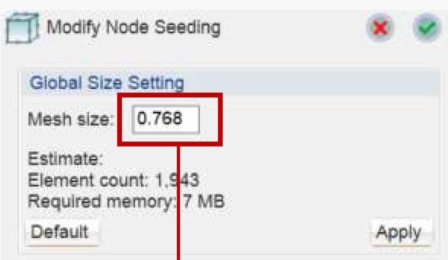


Geometric gate + Line defined runner

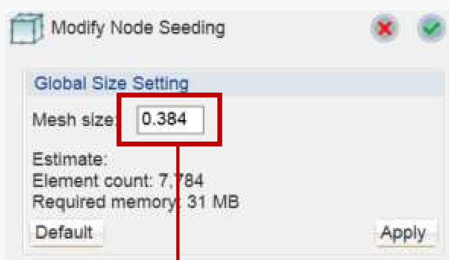
Meshing Resolution

Node Seeding for Geometric Runner

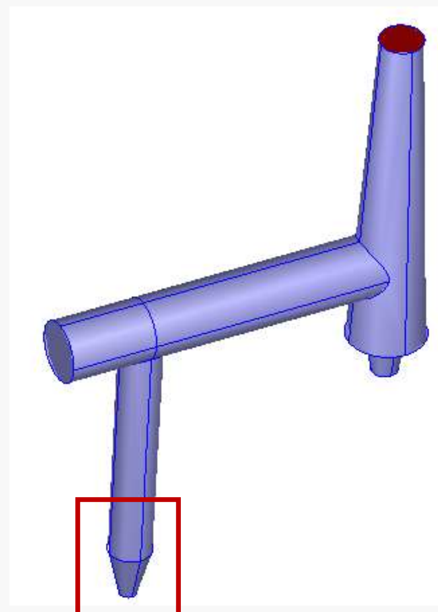
- When we are using geometric runner, the dense Mesh is required.
  - Do the Node seeding without cavity
  - Mesh Size for Runner: 1/2 Default.
  - Mesh Size for Gate: Total 40 nodes around the gate.



The default value shows the average thickness of runner



Set the mesh size as 1/2 of Default is recommended

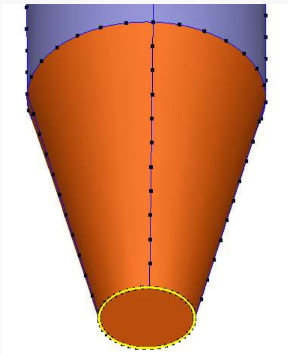


Mesh size need to be refined at gate region

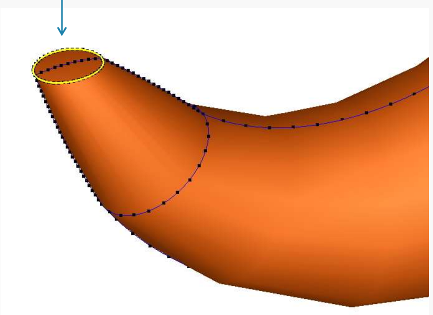
Meshing Resolution

Node Seeding for Geometric Gate

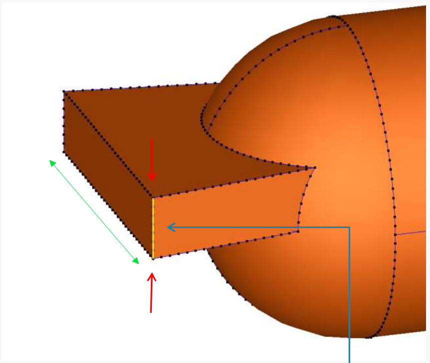
- The mesh size of the gate region need to be refined
    - Minimum of 40 mesh nodes around the gate is recommended.
    - A least 7 segments in thickness direction for fan/edge gate.



40 mesh nodes



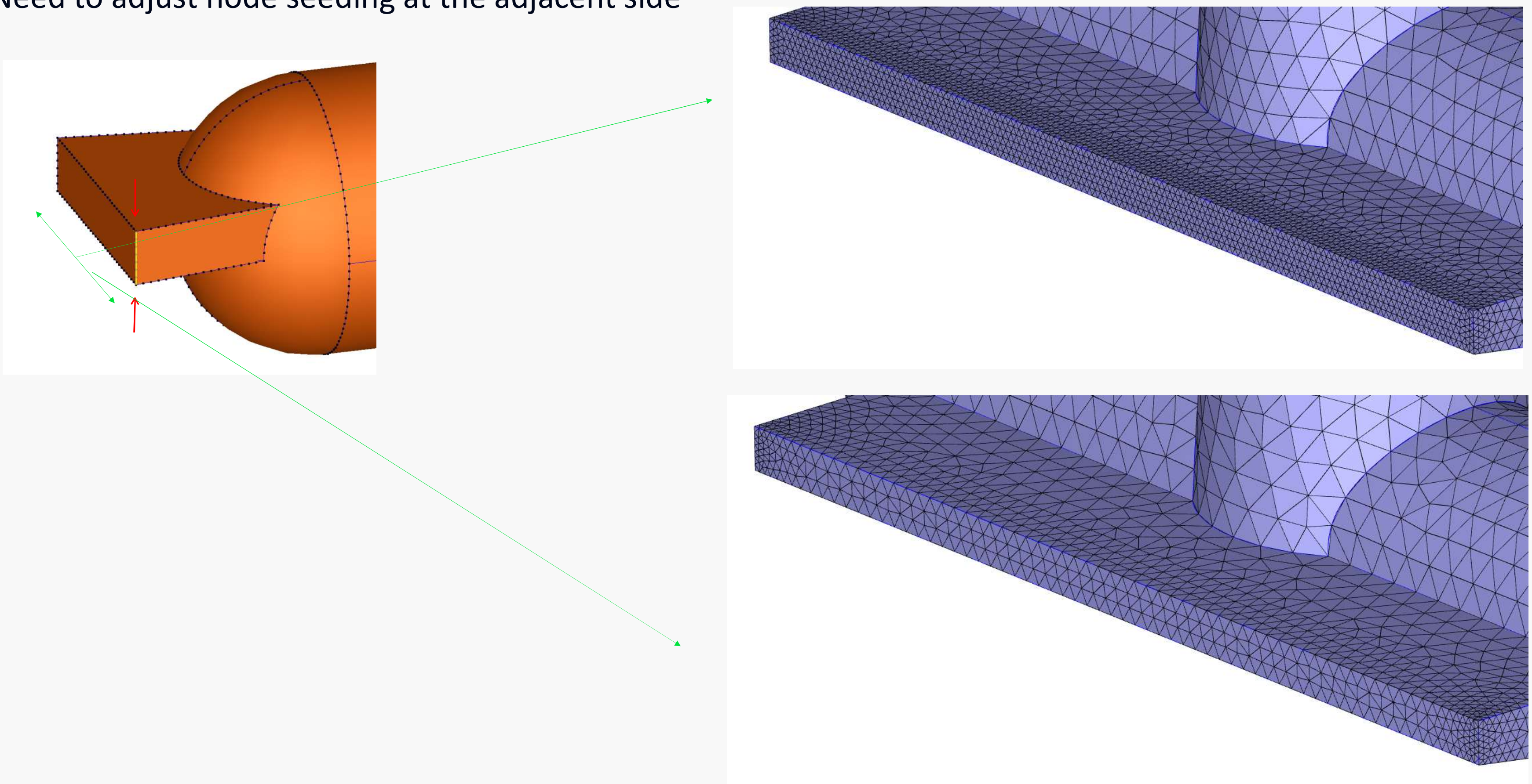
40 mesh nodes



7 segments in thickness direction

Meshing Resolution

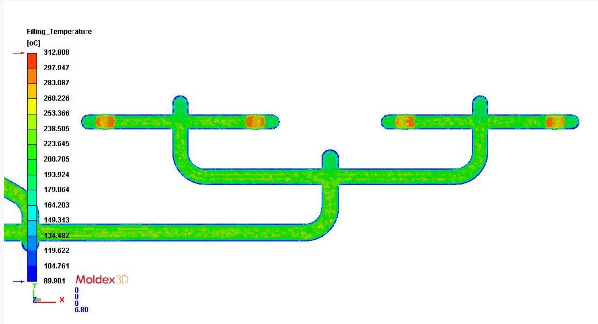
Need to adjust node seeding at the adjacent side

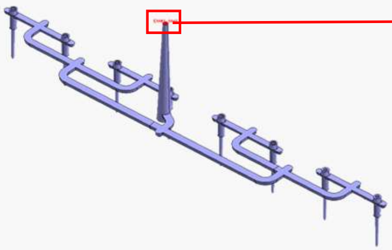


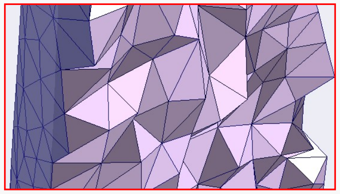
Meshing Resolution

Example: Importance of Mesh Resolution

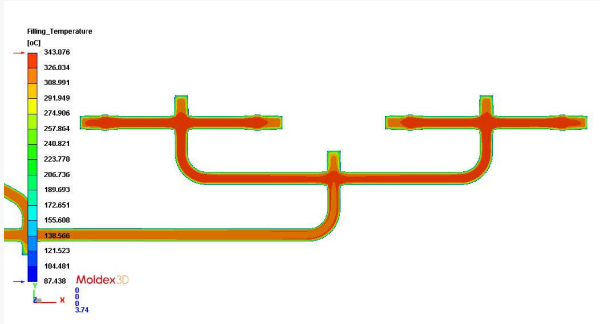
Coarse Mesh

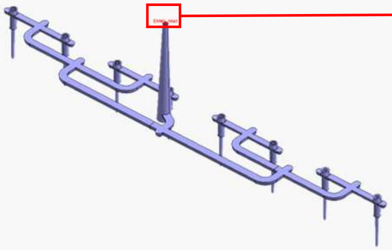


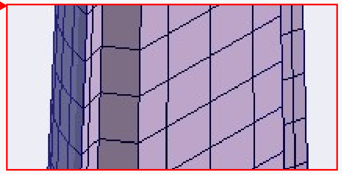




Dense Mesh







01
Mesh Resolution

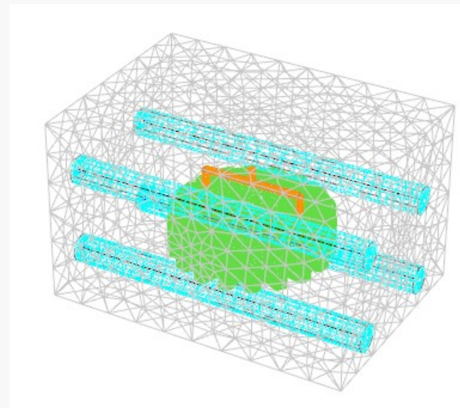
02
Process Condition Setting

03
Computation Parameter Setting

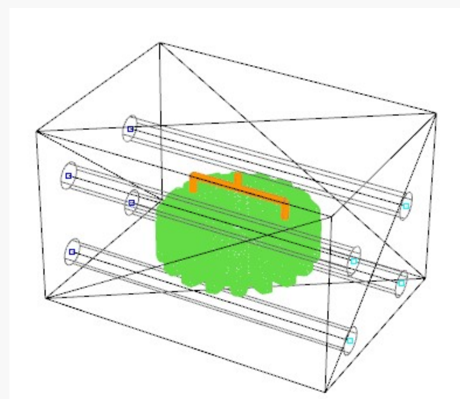
Meshing Resolution

Mesh Setting: Mold Base

- Standard Cool
  - ➢ 3D mesh elements (mold base and cooling lines)
  - ➢ Fulfilled tetra mesh in between
  - ➢ Recommended for detailed thermal analysis



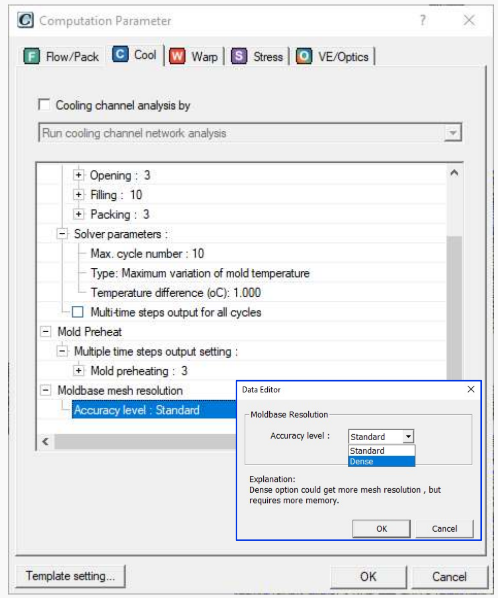
- AutoGrid
  - ➢ 1D and 2D elements for mold base and cooling lines
  - ➢ Designed for eDesign mesh
  - ➢ Accuracy level
    - ① Default
    - ② Dense

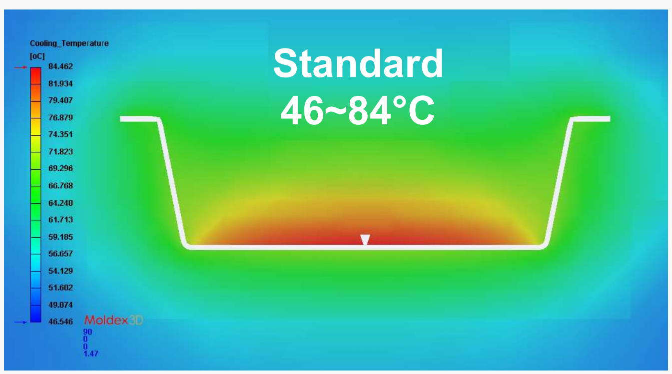


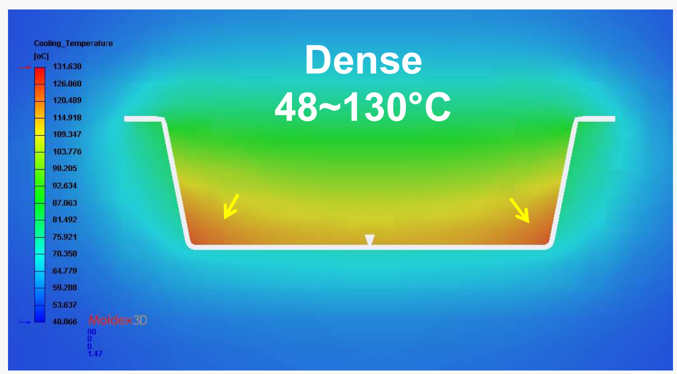
Meshing Resolution

Mesh Setting: Mold Base

- AutoGrid
  - ➢ Accuracy Level: Dense is recommended
  - ➢ Higher memory requirement
  - ➢ More accurate than default







Step 2.
Pre-Processing

The essentials in
pre-processing stage

01

Mesh Resolution

02

Process Condition Setting

03

Computation Parameter Setting

Process Condition Setting

Proper Input Conditions

Proper input conditions lead to better results!

- **Filling Condition**
  - ➢ Filling Time
  - ➢ Flow Profile
- **Packing Condition**
  - ➢ Packing Time
  - ➢ Packing Pressure
- **Cooling Condition**
  - ➢ Coolant type/Coolant temperature
  - ➢ Cooling Time

Process Condition Setting

How to Input the Process Condition

1. Machine Information

Maker		Clamping force	120 Ton	Injection rate	cc/sec
Grade		Shot weight	g	Screw Diameter	35 mm
		Injection pressure	150 MPa	Screw stroke	mm

2. Process Condition

Injection Time	Sec	Packing Time	5 Sec	Note：Unit of speed, pressure is needed

Fill	Screw Position			100 mm	Pack	VP Position		20mm
	Section	Speed	Pressure	Position		Section	Pressure	Time
	I	20mm/s		90mm		I	130 MPa	2 sec
	II	50mm/s		80mm		II	100 MPa	2 sec
	III	30mm/s		15mm		III	85 MPa	3 sec
	IV					IV		
	V					V		

Melt Temp.	250 ℃	Air Temp.	25 ℃
Mold Temp.	☐Core ℃ ☐Cavity 50℃	Coolant Temp.	50 ℃
Coolant Flow Rate	80 cc/sec	Cooling Time	13.7 Sec
Coolant Type	■ Water ☐ Oil	Mold Open	5 Sec

the only information necessary for machine mode is in the Summary tab.

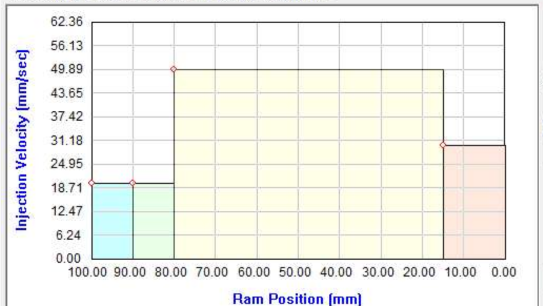
Summary | Injection Unit | Clamp Unit | General | Screw Info

Item	Content	Unit
Maker	Custom	
Grade	Custom	
Last modified date (yy/mm/dd)		
Comment		
Screw Diameter	35	mm
Screw Stroke	120	mm
Shot Weight	120	g
Injection Pressure	150	MPa
Injection Rate	60	cm^3/sec
Clamping Force	120	tf

Flow rate profile - (76.08, 61.25)

Type: Injection Velocity (mm/sec) vs. Ram Position (mm) Section No.: 4

☑Consider barrel compression for solver calculation.



Profile type
◉ Stepwise
○ Polyline

Stroke time : 0.735169 sec

Injecting volume : 96.2112 cm^3

Profile Advisor...

Capture...

Section	Section-1	Section-2	Section-3	Section-4	
Ram Position (mm)	100	90	80	15	0
Injection Velocity (mm/sec)	20	20	50	30	30

OK

Cancel

Process Condition Setting

How to Input the Process Condition

1. Machine Information

Maker		Clamping force	120 Ton	Injection rate	cc/sec
Grade		Shot weight	g	Screw Diameter	35 mm
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	IV			
	V			

Pack	VP Position		20mm
	Section	Pressure	Time
	I	130 MPa	2 sec
	II	100 MPa	2 sec
	III	85 MPa	3 sec
	IV		
	V		

Melt Temp.	250 ℃	Air Temp.	25 ℃
Mold Temp.	☐Core ℃ ☐Cavity 50℃	Coolant Temp.	50 ℃
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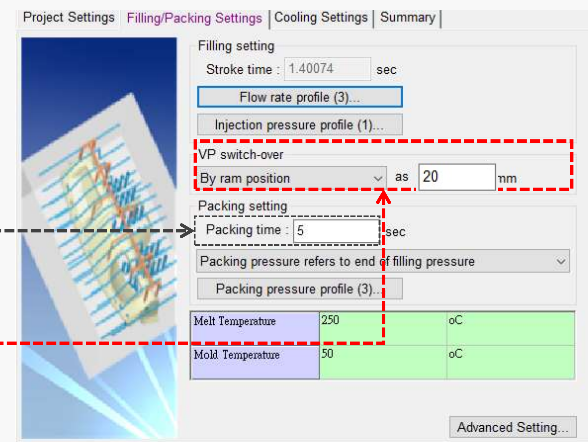

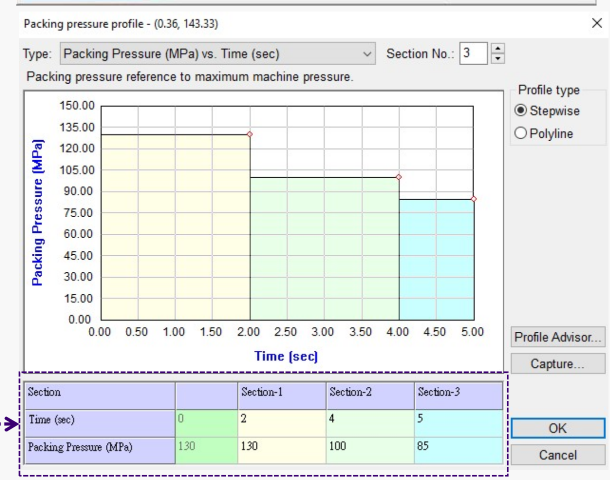

Process Condition Setting

How to Input the Process Condition

1. Machine Information

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Grade		Shot weight	g	Screw Diameter	35 mm
		Injection pressure	MPa	Screw stroke	mm

2. Process Condition

Injection Time		Sec	Packing Time	5 Sec	Note : Unit of speed, pressure is needed			
Fill	Screw Position			100 mm	Pack	VP Position		20mm
	Section	Speed	Pressure	Position		Section	Pressure	Time
	I	20mm/s		90mm		I	130 MPa	2 sec
	II	50mm/s		80mm		II	100 MPa	2 sec
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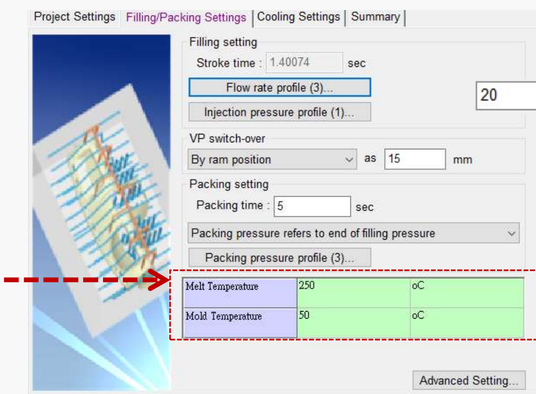
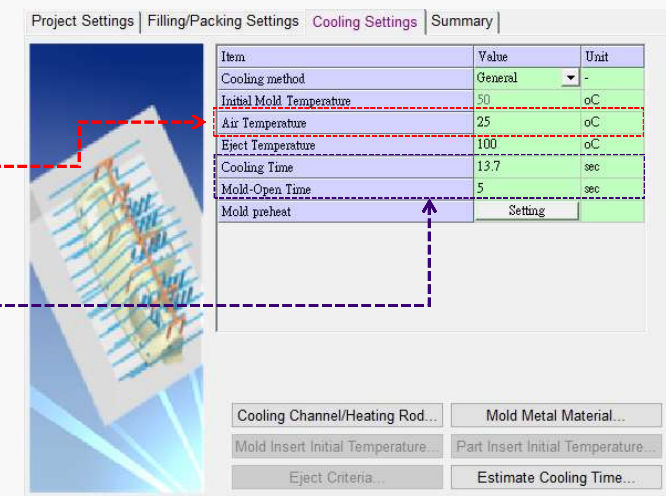
	IV					IV		
	V					V		
Melt Temp.	250 ℃				Air Temp.	25 ℃		
Mold Temp.	☐Core ℃ ☐Cavity 50℃				Coolant Temp.	50 ℃		
Coolant Flow Rate	80 cc/sec				Cooling Time	13.7 Sec		
Coolant Type	■ Water ☐ Oil				Mold Open	5 Sec		





Process Condition Setting

How to Input the Process Condition

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Fill	Screw Position		100 mm
Section	Speed	Pressure	Position
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III	30mm/s		15mm
IV			
V			

Pack	VP Position	20mm
Section	Pressure	Time
I	130 MPa	2 sec
II	100 MPa	2 sec
III	85 MPa	3 sec
IV		
V		

Melt Temp.	250 ℃	Air Temp.	25 ℃
Mold Temp.	☐Core ℃ ☐Cavity 50℃	Coolant Temp.	50 ℃
Coolant Flow Rate	80 cc/sec	Cooling Time	13.7 Sec
Coolant Type	■ Water ☐ Oil	Mold Open	5 Sec

Cooling Channel/Heating Rod | Mold Metal Material | Estimate Cooling Time

Cooling channel

Setting : By flow rate

Channel ID	T (oC)	Q (cm^3/sec)	Coolant	D (mm)	Re
EC1 (Group 4)	50	80	Water	8	23028
EC2 (Group 1)	50	80	Water	-	-
EC3 (Group 2)	50	80	Water	-	-
EC4 (Group 3)	50	80	Water	-	-

Process Condition Setting

Reference for Process Condition Setting

- **If we need to assume the process condition, a reasonable process condition is very important.**

Table 8.3 Recommended values for injection time for low, medium and high viscosity materials

Injection volume (cm^3)	Injection time in seconds		
	Low viscosity	Medium viscosity	High viscosity
1-8	0.2-0.4	0.25-0.5	0.3-0.6
8-15	0.4-0.5	0.5-0.6	0.6-0.75
15-30	0.5-0.6	0.6-0.75	0.75-0.9
30-50	0.6-0.8	0.75-1.0	0.9-1.2
50-80	0.8-1.2	1.0-1.5	1.2-1.8
80-120	1.2-1.8	1.5-2.2	1.8-2.7
120-180	1.8-2.6	2.2-3.2	2.7-4.0
180-250	2.6-3.5	3.2-4.4	4.0-5.4
250-350	3.5-4.6	4.4-6.0	5.4-7.2
350-550	4.6-6.5	6.0-8.0	7.2-9.5

Table 8.4 Viscosity of various plastic types

Viscosity	Plastic Types
Low	PE soft, PA 4.6, PA 6, PA 66, PA 6.10, PA 11, POM, PET, PBT, PPS, TPE
Medium	PS, SB, SAN, ABS, PPO mod., PVC soft, CA, CAB, CP, PE rigid, PP, PA 12, PA amorphous
High	PVC rigid, PMMA, PC, PSU, PES, PEI, PAI, PVDF, FEP, ETFE

Reference: Arburg, 2004, *Practical Guide to injection moulding*

Process Condition Setting

Reference for Process Condition Setting

Injection material	Specific weight (g/cm³)	Viscosity	Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
Amorphous thermoplastics						
PS	1.05	M	650–1,550	300–700	0.75–0.5	150–350
SB	1.04	M	650–1,550	350–800	0.75–0.5	200–400
SAN	1.08	M	650–1,550	350–900	0.75–0.5	250–450
ABS	1.03–1.07	M	650–1,550	400–900	0.75–0.5	300–550
PVC – rigid[1,2]	1.38–1.40	H	1,000–1,550	500–900	0.6–0.4	250–500
PVC – soft[2]	1.20–1.35	M	400–1,550	300–600	0.75–0.5	150–300
CA	1.26–1.32	M	650–1,350	300–650	0.85–0.7	250–450
CAB	1.16–1.22	M	650–1,350	300–900	0.75–0.5	250–450
CP	1.19–1.23	M	650–1,350	400–700	0.75–0.5	200–350
PMMA	1.18	H	1,000–1,400	500–1,150	0.6–0.4	350–550
Modified PPE	1.06–1.10	M	1,000–1,600	600–1,200	0.75–0.5	350–600
PC	1.20–1.24	H	1,000–1,600	600–1,300	0.6–0.4	350–650
PAR	1.2	H	1,000–1,600	600–1,300	0.6–0.4	350–650
PSU	1.27	H	900–1,400	500–1,100	0.6–0.4	400–600
PES	1.37	H	900–1,400	500–1,100	0.6–0.4	400–600
PEI	1.87	M	750–1,550	400–750	0.85–0.7	350–650
PAI	1.38	H	750–1,550	500–1,050	0.85–0.7	450–750

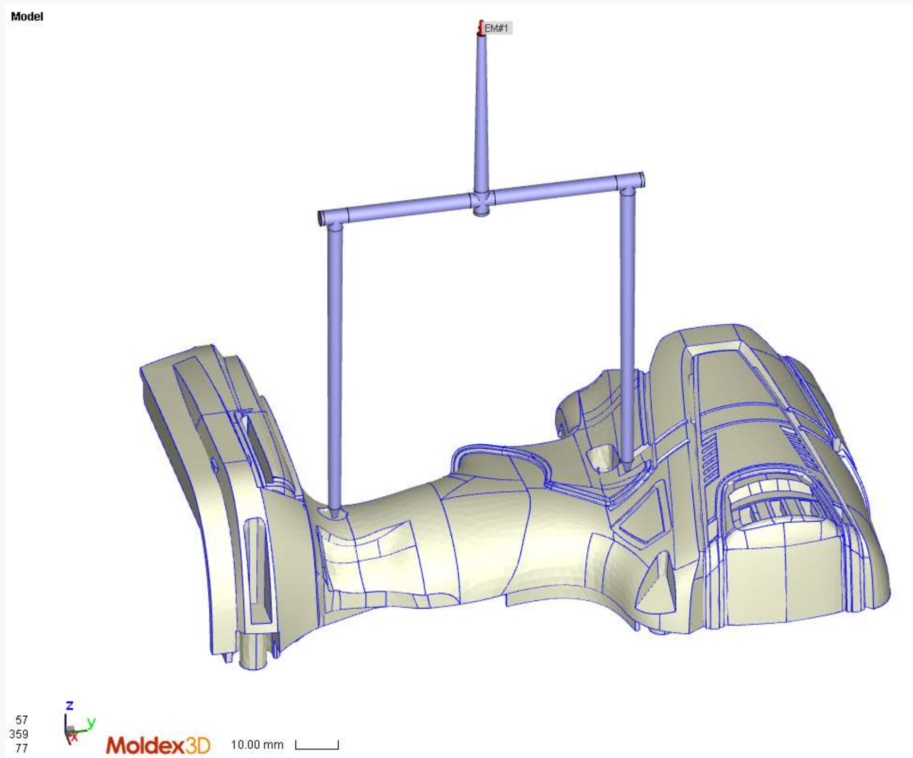
Injection material	Specific weight (g/cm³)	Viscosity	Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
Semi-crystalline thermoplastics						
PE soft	0.91–0.93	L	600–1,350	300–800	0.85–0.7	200–600
PE rigid	0.94–0.96	M	600–1,350	300–800	0.75–0.5	200–600
PP	0.9	M	800–1,400	500–1,100	0.75–0.5	300–650
PA4.6	1.18	L	650–1,550	550–1,050	0.85–0.7	450–750
PA6	1.13	L	450–1,550	400–750	0.85–0.7	350–550
PA6.6	1.14	L	650–1,550	550–1,050	0.85–0.7	450–750
PA6.10	1.06	L	450–1,550	350–750	0.85–0.7	300–500
PA11	1.04	L	450–1,550	400–800	0.85–0.7	350–550
PA12	1.02	M	550–1,550	400–1,000	0.75–0.5	350–550
PA amorphous	1.12	M	900–1,300	450–800	0.75–0.5	350–450
POM	1.41–1.42	L	800–2,000	700–1,500	0.85–0.7	550–1,050
PET	1.34–1.37	L	800–1,500	550–1,050	0.85–0.7	450–750
PBT	1.29	L	800–1,550	500–1,000	0.8–.0.7	400–700
PPS	1.34	L	750–1,500	400–750	–	350–600
FEP[1]	2.14–2.17	H	1,000–1,500	500–1,000	0.6–0.4	300–600
ETFE[1]	1.70	H	1,000–1,500	500–1,000	0.6–0.4	300–600
PAA	1.4–1.64	L	1,000–1,500	350–800	0.85–0.7	300–700
PPA	1.26–1.56	L	700–1,500	350–800	0.85–0.7	300–700
PAEK	1.27–1.49	M	800–1,500	450–800	0.85–0.7	400–700
LCP		L	400–1,500	350–1,000	0.85–0.7	300–800

Reference: Arburg, 2004, *Practical Guide to injection moulding*

Process Condition Setting

Example: How to Decide the Process Condition

- **Cavity volume: 58 c.c.**
- **Material: ABS**
- **Process condition:**
    - ➢ Filling time: ??
    - ➢ Packing pressure: ??
    - ➢ Packing time: ??
    - ➢ Cooling time: ??



Process Condition Setting

Example: How to Decide the Process Condition

- **Cavity volume: 58 c.c.**
- **Material: ABS**
- **Process condition:**
  - ➢ Filling time: 1-1.5 sec
  - ➢ Packing pressure:
  - ➢ Packing time:
  - ➢ Cooling time:

Table 8.3 Recommended values for injection time for low, medium and high viscosity materials

Injection volume (cm^3)	Injection time in seconds		
	Low viscosity	Medium viscosity	High viscosity
1-8	0.2-0.4	0.25-0.5	0.3-0.6
8-15	0.4-0.5	0.5-0.6	0.6-0.75
15-30	0.5-0.6	0.6-0.75	0.75-0.9
30-50	0.6-0.8	0.75-1.0	0.9-1.2
50-80	0.8-1.2	1.0-1.5	1.2-1.8
80-120	1.2-1.8	1.5-2.2	1.8-2.7
120-180	1.8-2.6	2.2-3.2	2.7-4.0
180-250	2.6-3.5	3.2-4.4	4.0-5.4
250-350	3.5-4.6	4.4-6.0	5.4-7.2
350-550	4.6-6.5	6.0-8.0	7.2-9.5

Table 8.4 Viscosity of various plastic types

Viscosity	Plastic Types
Low	PE soft, PA 4.6, PA 6, PA 66, PA 6.10, PA 11, POM, PET, PBT, PPS, TPE
Medium	PS, SB, SAN, ABS, PPO mod., PVC soft, CA, CAB, CP, PE rigid, PP, PA 12, PA amorphous
High	PVC rigid, PMMA, PC, PSU, PES, PEI, PAI, PVDF, FEP, ETFE

Injection material	Specific weight (g/cm^3)	Viscosity	Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
Amorphous thermoplastics						
PS	1.05	M	650–1,550	300–700	0.75–0.5	150–350
SB	1.04	M	650–1,550	350–800	0.75–0.5	200–400
SAN	1.08	M	650–1,550	350–900	0.75–0.5	250–450
ABS	1.03–1.07	M	650–1,550	400–900	0.75–0.5	300–550
PVC – rigid[1,2]	1.38–1.40	H	1,000–1,550	500–900	0.6–0.4	250–500
PVC – soft[2]	1.20–1.35	M	400–1,550	300–600	0.75–0.5	150–300
CA	1.26–1.32	M	650–1,350	300–650	0.85–0.7	250–450
CAB	1.16–1.22	M	650–1,350	300–900	0.75–0.5	250–450
CP	1.19–1.23	M	650–1,350	400–700	0.75–0.5	200–350
PMMA	1.18	H	1,000–1,400	500–1,150	0.6–0.4	350–550
Modified PPE	1.06–1.10	M	1,000–1,600	600–1,200	0.75–0.5	350–600
PC	1.20–1.24	H	1,000–1,600	600–1,300	0.6–0.4	350–650

Process Condition Setting

Example: How to Decide the Process Condition

- **Cavity volume: 58 c.c.**
- **Material: ABS**
- **Process condition:**
  - Filling time: 1-1.5 sec
  - Packing pressure:
    - 40-90 MPa
    - 80% of injection pressure at EOF
  - Packing time:
  - Cooling time:

Injection material	Specific weight (g/cm³)	Viscosity	Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
Amorphous thermoplastics						
PS	1.05	M	650–1,550	300–700	0.75–0.5	150–350
SB	1.04	M	650–1,550	350–800	0.75–0.5	200–400
SAN	1.08	M	650–1,550	350–900	0.75–0.5	250–450
ABS	1.03–1.07	M	650–1,550	400–900	0.75–0.5	300–550
PVC – rigid[1,2]	1.38–1.40	H	1,000–1,550	500–900	0.6–0.4	250–500
PVC – soft[2]	1.20–1.35	M	400–1,550	300–600	0.75–0.5	150–300
CA	1.26–1.32	M	650–1,350	300–650	0.85–0.7	250–450
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CP	1.19–1.23	M	650–1,350	400–700	0.75–0.5	200–350
PMMA	1.18	H	1,000–1,400	500–1,150	0.6–0.4	350–550
Modified PPE	1.06–1.10	M	1,000–1,600	600–1,200	0.75–0.5	350–600
PC	1.20–1.24	H	1,000–1,600	600–1,300	0.6–0.4	350–650

Process ConditionSetting

Example: How to Decide the Process Condition

- **Cavity volume: 58 c.c.**
- **Material: ABS**
- **Process condition:**
  - Filling time: 1-1.5 sec
  - Packing pressure:
    - 40-90 MPa
    - 80% of injection pressure at EOF
  - Packing time:
    - Default for first run
    - Depends on gate freeze time
  - Cooling time:

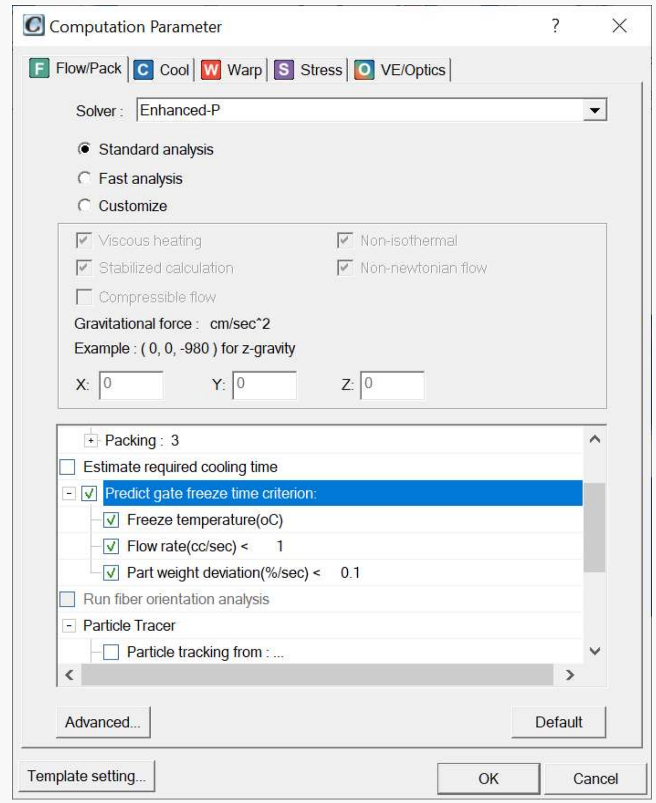
```
<Prediction of Gate-Freeze Time>
  Freeze Time of Gate #1        = 4.008 sec
      Max Gate Temperature      = 131.395 Degree C
      Total Gate Flow Rate      = 0.000303237 cc/sec

  Freeze Time of Gate #2        = 4.008 sec
      Max Gate Temperature      = 124.51 Degree C
      Total Gate Flow Rate      = 7.4362e-005 cc/sec

  Freeze Time of Gate #3        = 4.221 sec
      Max Gate Temperature      = 136.217 Degree C
      Total Gate Flow Rate      = 0.000721582 cc/sec
```

Computation Parameter Setting

Computation Parameters: Predict Gate Freeze

- **"Predict Gate Freeze Time", Criterion:**
  - ➢ Freeze Temp (^{O}C)
  - ➢ Flow Rate (cc/sec)
  - ➢ Part Weight Deviation (default setting)
- **Estimate the effective packing time**
- **Find the gate freeze time in log file.**

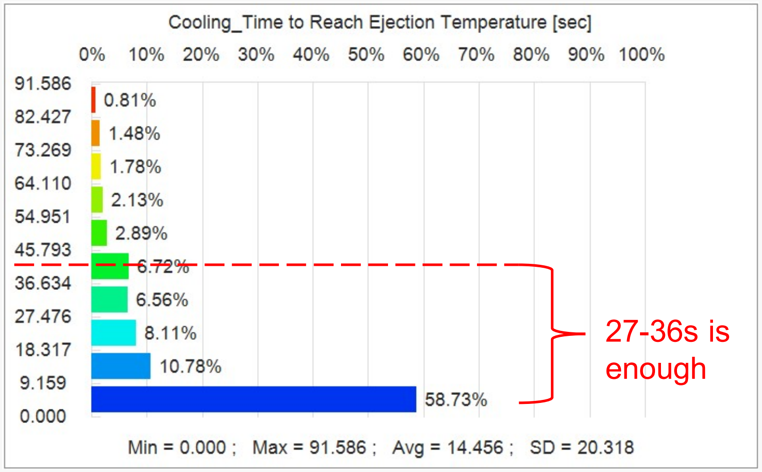
```
<Prediction of Gate-Freeze Time>
    Freeze Time of Gate #1      = 4.008 sec
        Max Gate Temperature    = 131.395 Degree C
        Total Gate Flow Rate    = 0.000303237 cc/sec

    Freeze Time of Gate #2      = 4.008 sec
        Max Gate Temperature    = 124.51 Degree C
        Total Gate Flow Rate    = 7.4362e-005 cc/sec

    Freeze Time of Gate #3      = 4.221 sec
        Max Gate Temperature    = 136.217 Degree C
        Total Gate Flow Rate    = 0.000721582 cc/sec
```



Process Condition Setting

Example: How to Decide the Process Condition

- **Cavity volume: 58 c.c.**
- **Material: ABS**
- **Process condition:**
  - Filling time: 1-1.5 sec
  - Packing pressure:
    - 40-90 MPa
    - 80% of injection pressure at EOF
  - Packing time:
    - Default for first run
    - Depends on gate freeze time
  - Cooling time:
    - Default for first run
    - 80-90% of cavity reached the ejected temperature



Step 2.
Pre-Processing

The essentials in
pre-processing stage

01

Mesh Resolution

02

Process Condition Setting

03

Computation Parameter Setting

Computation Parameter Setting

Computation Parameters: Flow/Pack

Standard solver:

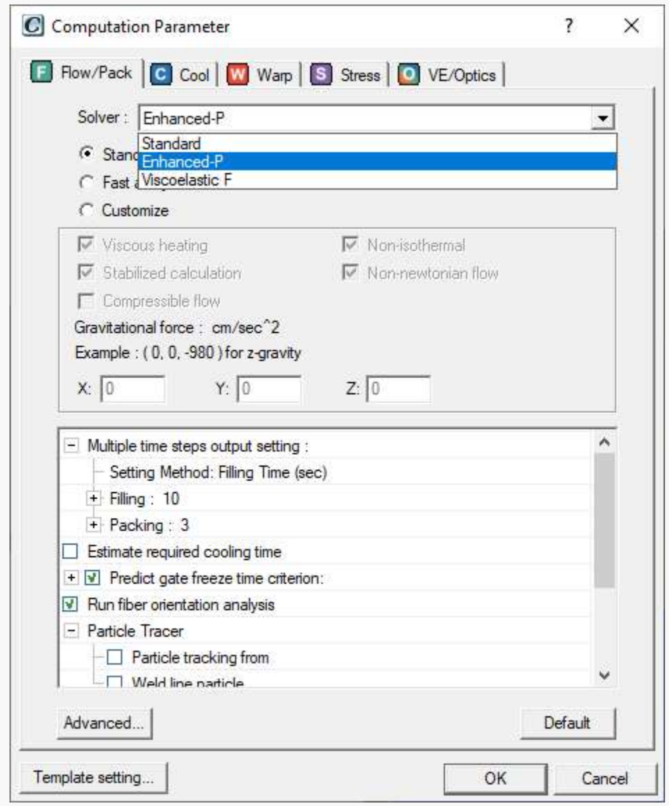
- Fast and simpler simulation
- one-layer or bi-layer solid meshes

Enhanced-P solver (default):

- More accurate and precise for complicated geometric models
- at least 3-layers of solid meshes
- Flow with hesitation phenomena and larger length-to-thickness (L/T) ratio cases

Viscoelastic F solver:

- Consider viscoelastic fluids and support a variety of constitutive equations
- The viscous fluid will upgrade to the viscoelastic fluid for simulating die well, jetting, buckling, bending



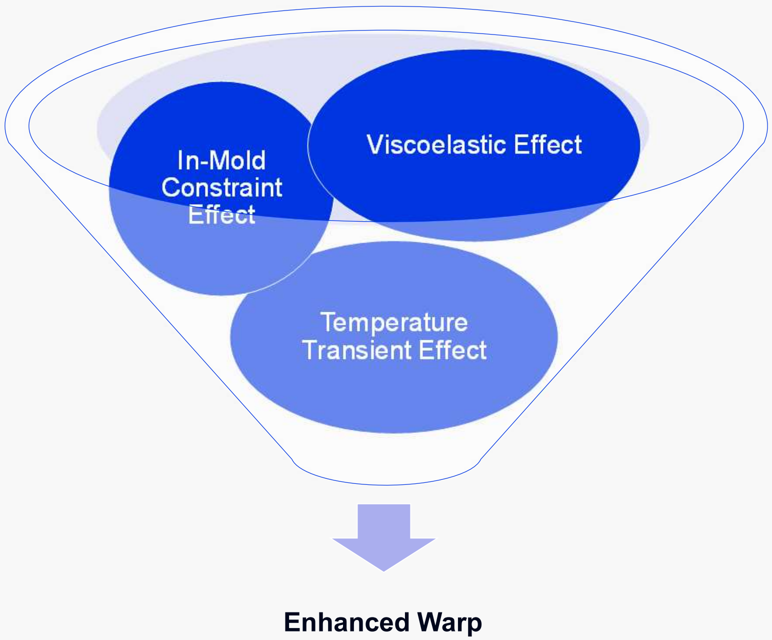
Computation Parameter Setting

Computation Parameters: Warp

Enhanced Warp

Coupling 3 real physics phenomena into "Enhanced Warp"

- In-Mold constraint in the cooling phase, free deformation after ejection
- Viscoelastic effect during solidification process
- Temperature transient effect

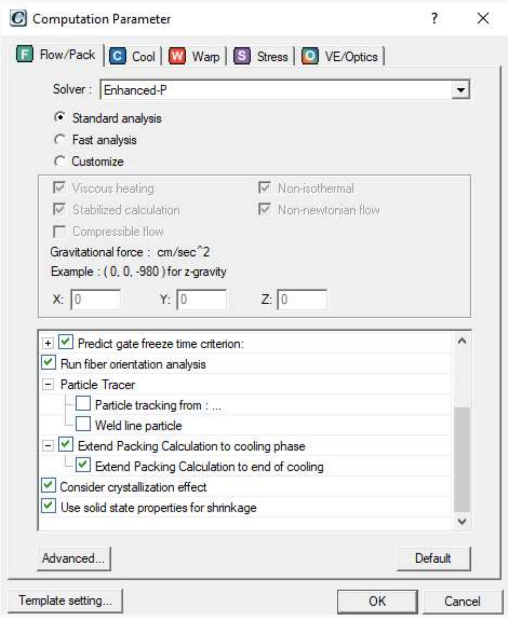


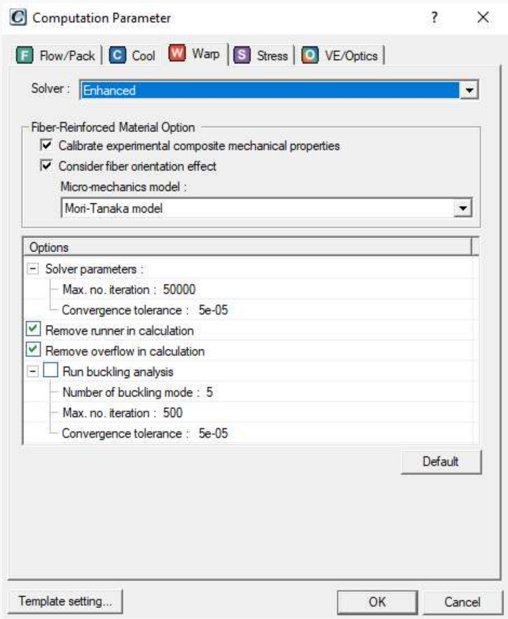
Computation Parameter Setting

Computation Parameters: Enhanced Warp

Enable the options

- Warp solver: Enhanced warp
- Use solid state properties for shrinkage
- Extend Pack to the end of cooling
- Consider crystallization effect
- Run Fiber orientation analysis
- Calibrate experimental composite mechanical properties





Computation Parameter Setting

Computation Parameters: Enhanced Warp

Enable the options

- Warp solver: Enhanced warp
- Use solid state properties for shrinkage
- Extend Pack to the end of cooling
- Consider crystallization effect
- Run Fiber orientation analysis
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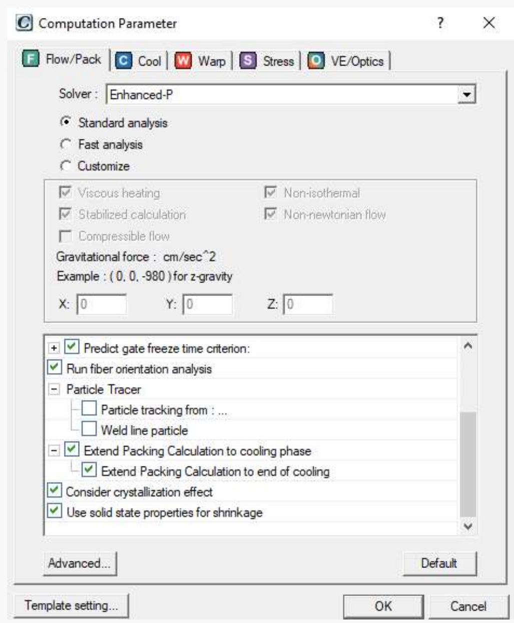
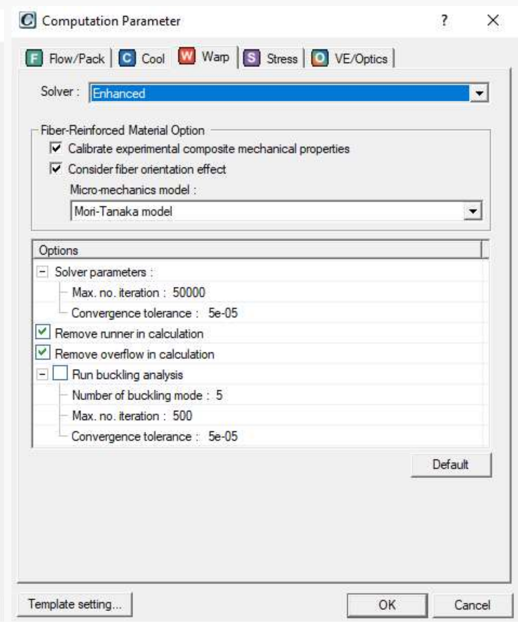
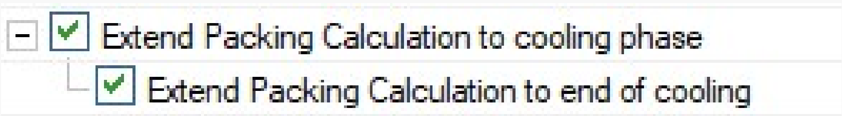
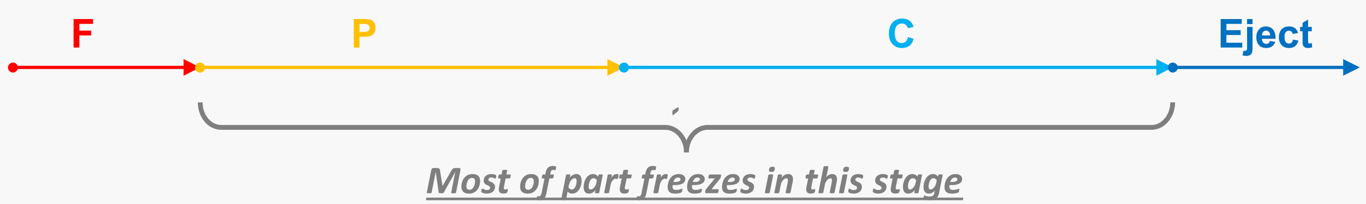




Why Extend Pack





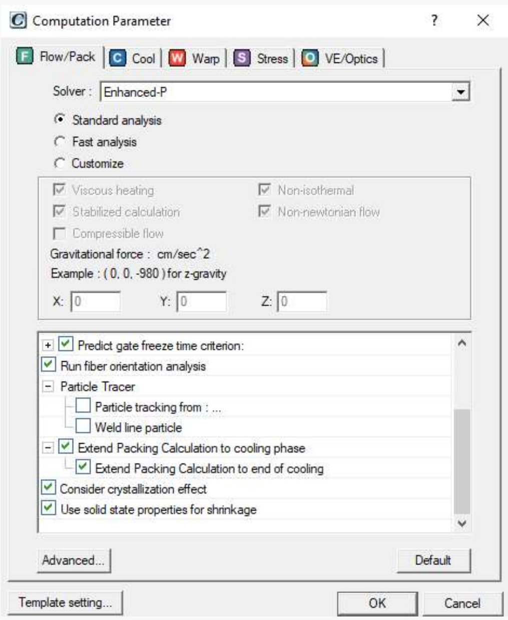
with “Extend Pack” option, the warp solver will automatically find out when the part is frozen and appropriate for the warpage calculation until EOC.

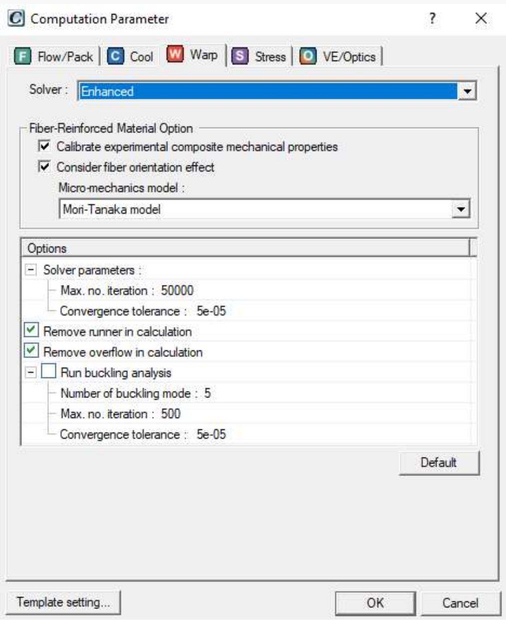
Computation Parameter Setting

Computation Parameters: Enhanced Warp

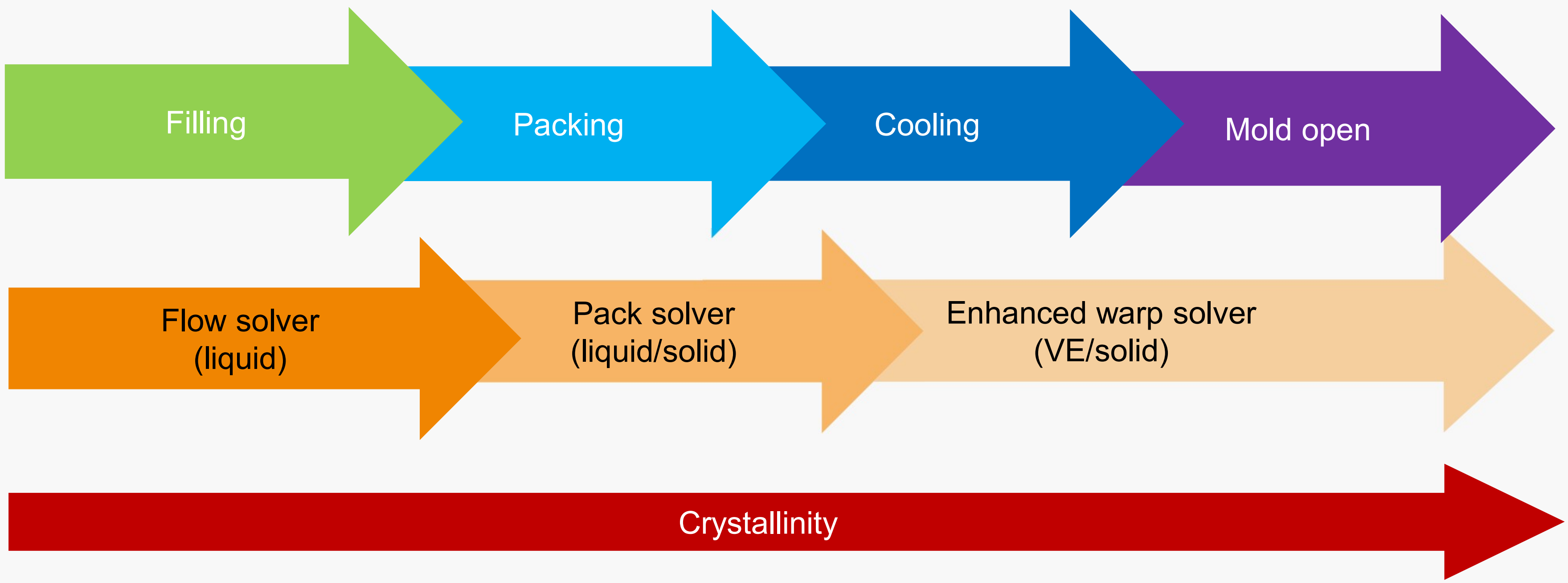
Enable the options

- Warp solver: Enhanced warp
- Use solid state properties for shrinkage
- Extend Pack to the end of cooling
- Consider crystallization effect
- Run Fiber orientation analysis
- Calibrate experimental composite mechanical properties





Moldex3D calculates crystallinity for all molding process in **Enhanced warp solver**



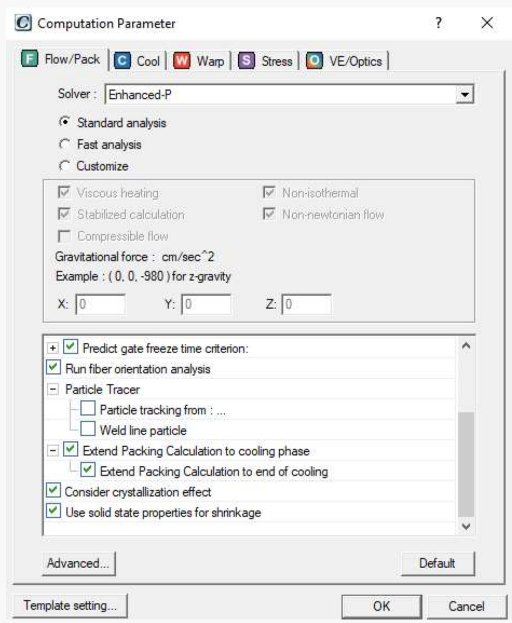
Better calculation for crystallinity leads to better warpage prediction

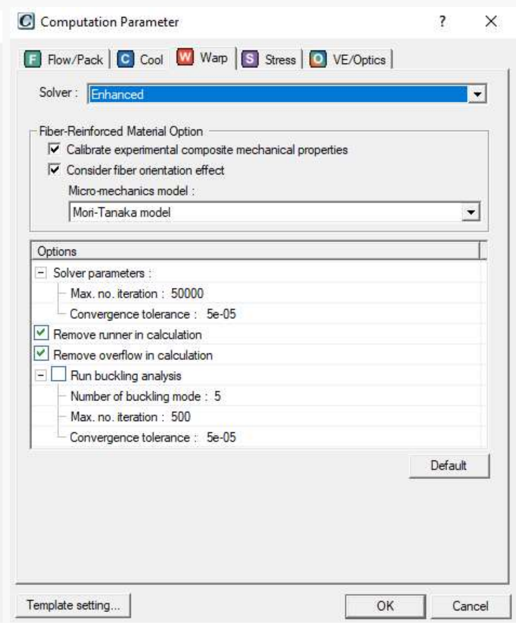
Computation Parameter Setting

Computation Parameters: Enhanced Warp

Enable the options

- Warp solver: Enhanced warp
- Use solid state properties for shrinkage
- Extend Pack to the end of cooling
- Consider crystallization effect
- Run Fiber orientation analysis
- Calibrate experimental composite mechanical properties

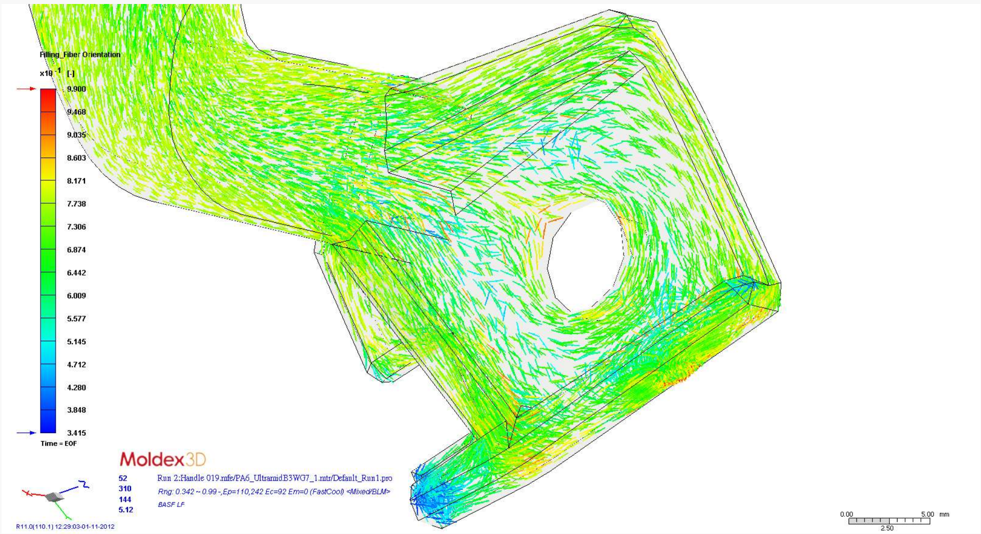




Fiber Analysis in Flow

The orientation can be used to predict

- Shrinkage and warpage behavior
- Mechanical properties
- Other anisotropic properties

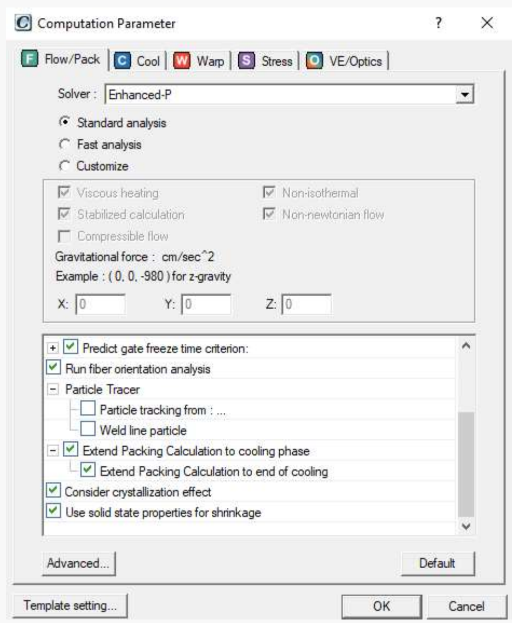


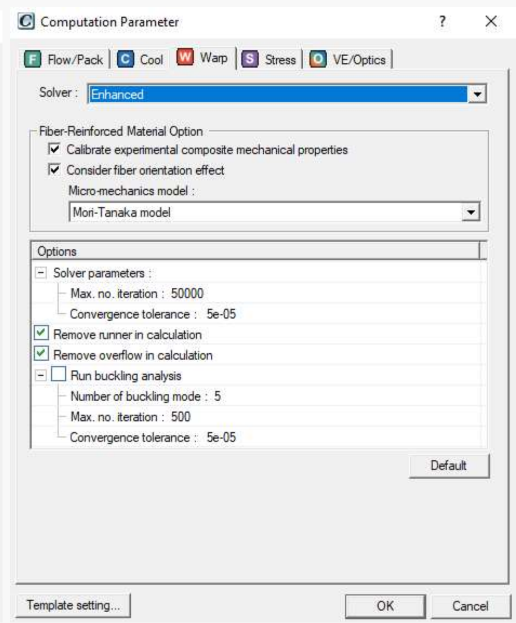
Computation Parameter Setting

Computation Parameters: Enhanced Warp

Enable the options

- Warp solver: Enhanced warp
- Use solid state properties for shrinkage
- Extend Pack to the end of cooling
- Consider crystallization effect
- Run Fiber orientation analysis
- Calibrate experimental composite mechanical properties

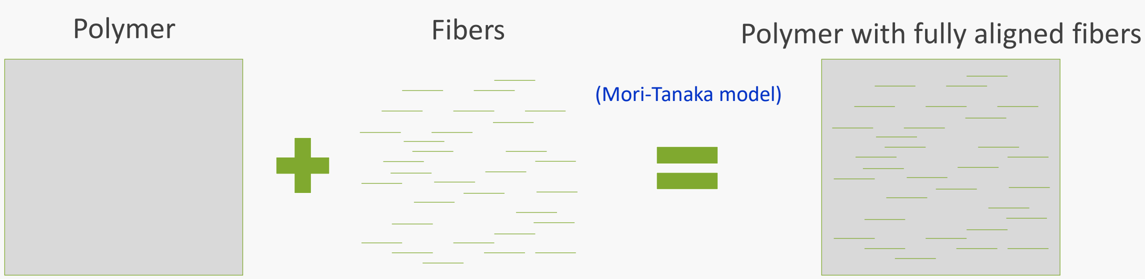




Calibration of Experimental Mechanical Properties

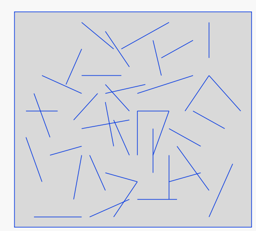
The composite mechanical properties of “polymer with fully aligned fibers” are used for the Warp related analysis.

Theoretical data (using *Mori-Tanaka model*)



Experimental data

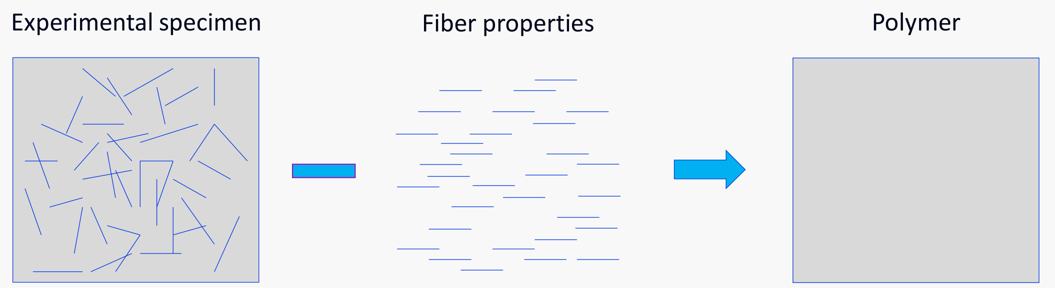
Polymer without fully aligned fibers



→ In previous version, it was regarded as “polymer with fully aligned fibers” before.

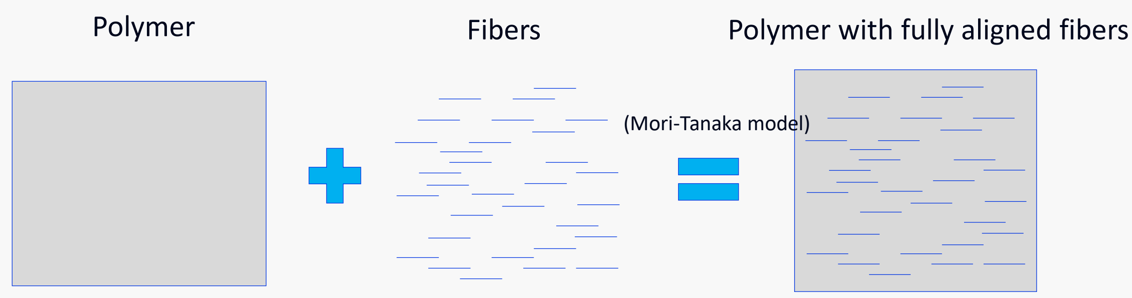
Calibration of Experimental Mechanical Properties

Step 1



The experimental mechanical properties will be decomposed into polymer properties along with the known fiber properties. After the decomposition, the theoretical properties (polymer + fiber) will be used for the Warp analysis.

Step 2



Summary

Step 2. Pre-Processing

The essentials in pre-processing stage

- **Ensuring the mesh resolution and quality are the key point to a successful simulation. Poor mesh might lead to incorrect result or divergent issue.**
- **Process condition table is needed for a precise analysis and must be input correctly into process condition setting.**
- **Enhanced warp is recommended for warpage solver.**

Conclusion

Collect Data

- **Part Geometry**
- **Material Properties**
- **Mold Design**
  - **Runner Layout**
  - **Cooling Layout**
- **Process Condition**
- **Picture of Real Part**
- **Measurement Data**

Pre-Processing

- **Meshing**
  - **Mesh Resolution**
- **Process Setting**
  - **Filling Condition**
  - **Pack Condition**
  - **Cooling Condition**
- **Computation Parameter**
  - **Gate Freeze Time**
  - **Enhanced Warp**

Run Simulation

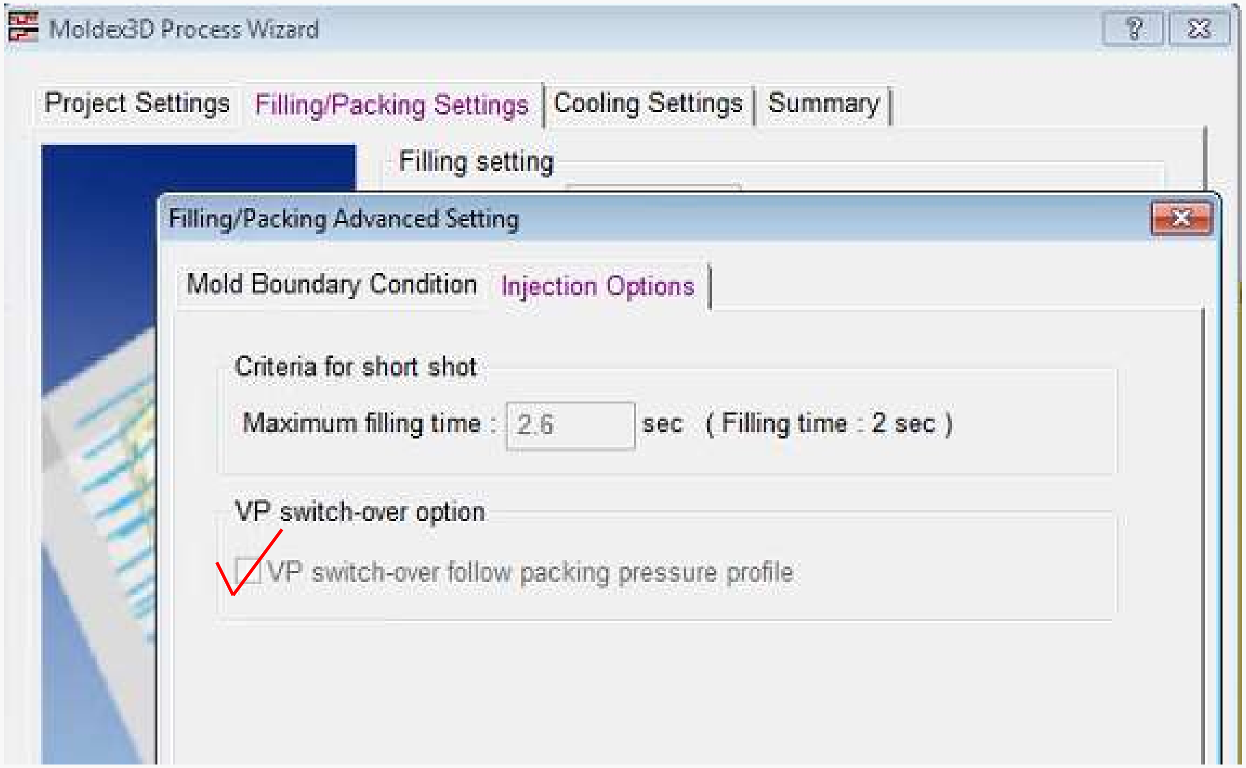
- **Analysis sequence**
  - **Ct F P Ct W**
- **Check Log File**
- **Result Comparison**

Thank you

Appendix

Process Conditions:
VP Follow Packing Pressure

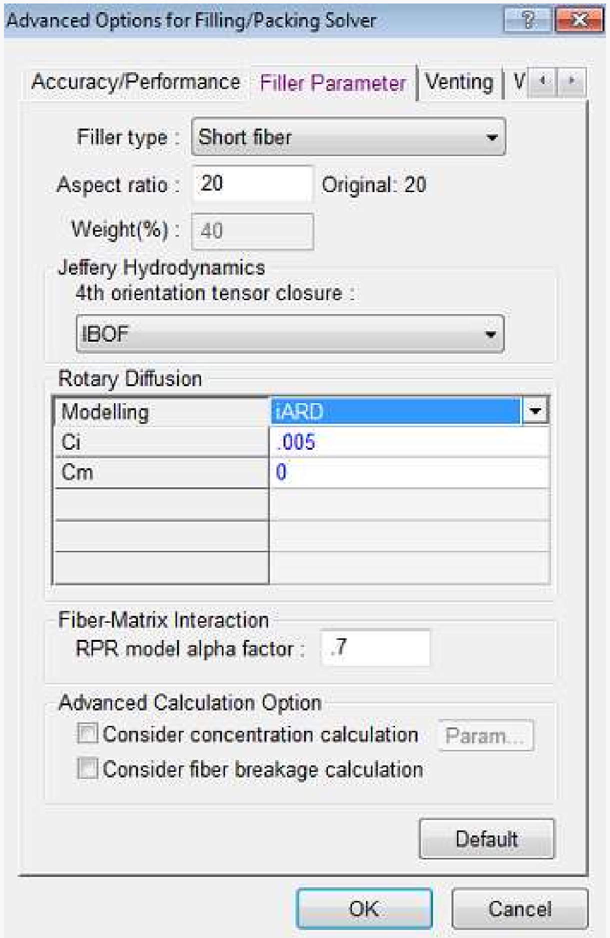
- Better predict clamping force / sprue pressure



Fiber Orientation

Use iARD Modelling

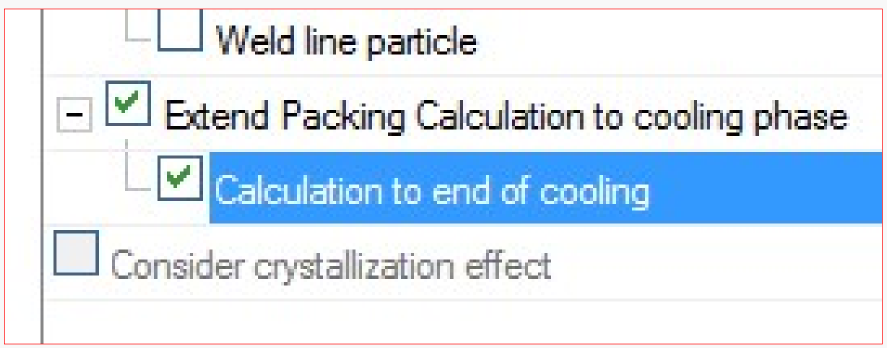
- **Long Fiber (over 100 Aspect Ratio)**
  - Ci: .01
  - Cm: 1
  - Alpha: 0.1
- **Short Fiber (under 100 Aspect Ratio)**
  - Ci: .005
  - Cm: 0
  - Alpha: 0.7

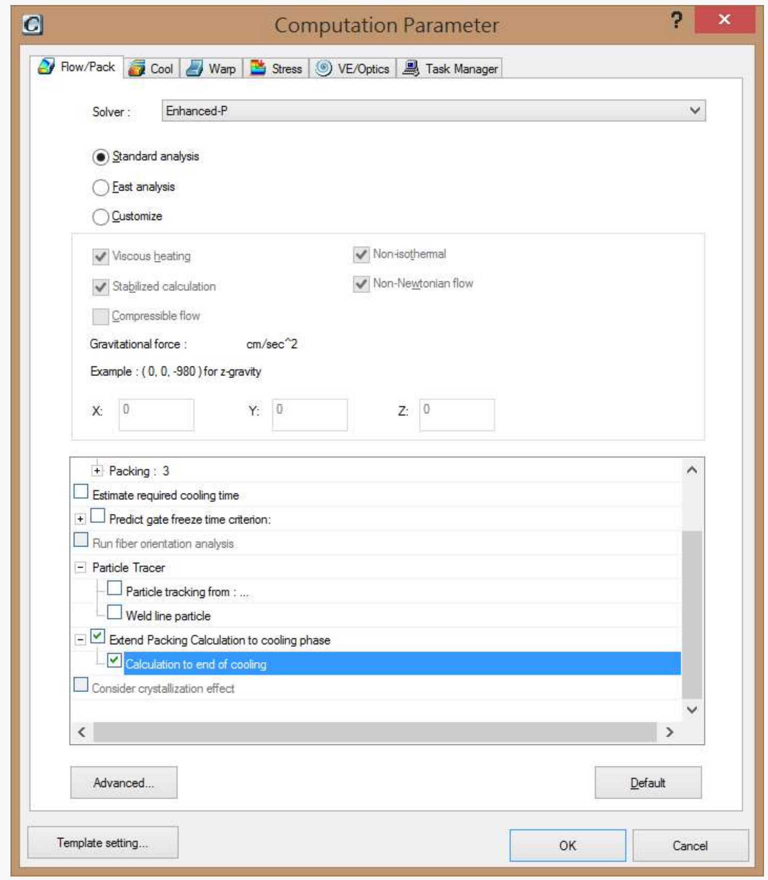


Computation Parameters: Extend Packing

- **Set to “Extend packing calculation to end of cooling”**
- **Benefit**
  - ➢ Make simulation closer to real injection molding process, for better warpage prediction

Recommended: Both Checked





Computation Parameters: Solver Accuracy

↓ Number ↑ Accuracy ↑ Computation Time

↑ Number ↓ Accuracy ↓ Computation Time

Defaults:
eDesign Levels
1 & 2 : 20
3 & 4 : 5
5 : 3
BLM: 1 for geometry runner, 3 for line runner

High shear imbalance cases 0.25 is recommended