### Moulding Innovation Day 2023

Project Setup, Best Practice, Workflow

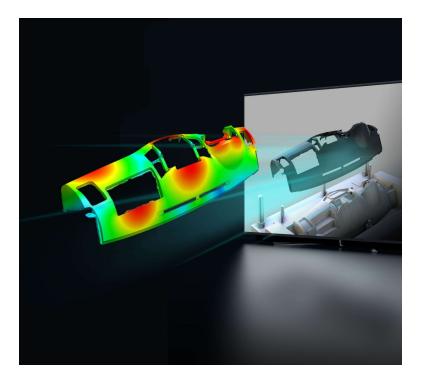
**Michelle Tung** 

Moldex 3D

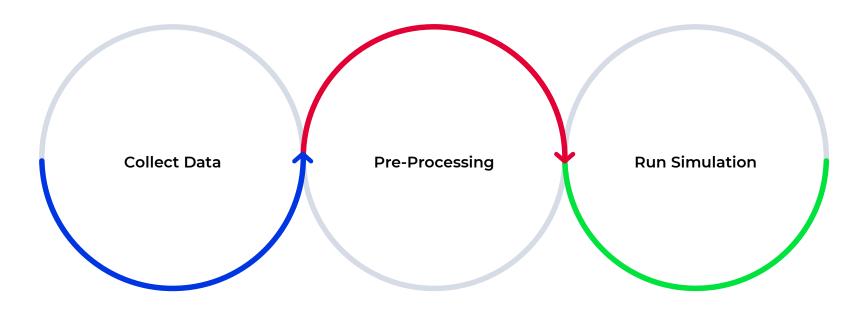


## Purpose

- 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







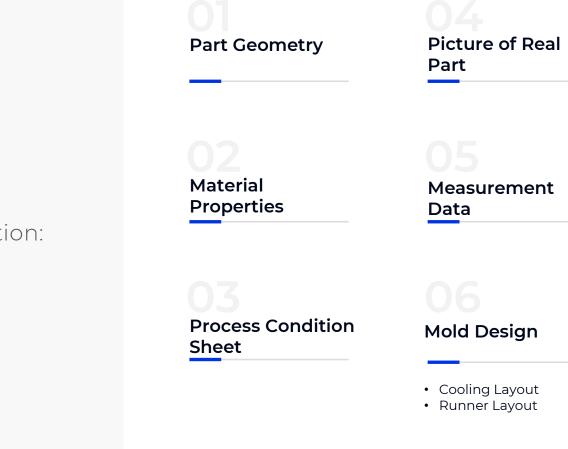
# stepl Collect Data

Runo4: 0 13 sec(Copy of Run 1) Runo4: 0 12 sec As Model-Demo\_Run3 mag

Analysis-F.P.W.

-1

S



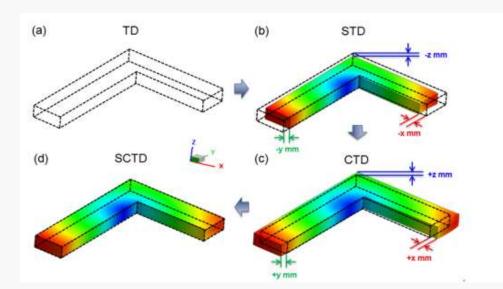
## Step 1. Collect Data

The key data for simulation:

### **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. ٠



(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)



02

03

04

06

## **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.



02 Material Properties

**03** Process Condition Sheet

**04** Picture of Real Part

**05** Measurement Data

## **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

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

#### 2. Process Condition

-	ection īme	Sec	Packing Time	Sec	Note : Unit of speed, pressure is needed					
	Screw Po	sition				VP Position				
	Section	Speed	Pressure	Position		Section	Pressure	Time		
	I					1				
Fill	II				Pack	П				
					Fack	III				
	IV				IV	IV				
	V					V				
Mel	t Temp.			°C Air Te		mp.				
Mold Temp.		Core	Core ℃ □Cavity ℃			ant	1			
Coo Rat	olant Flow e			cc/sec	Cooli	ng Time	S			
Cod	lant Type	U Wate	er [	Oil	Mold	Open		Sec		

### **Ol** Part Geometry

### **02** Material Properties

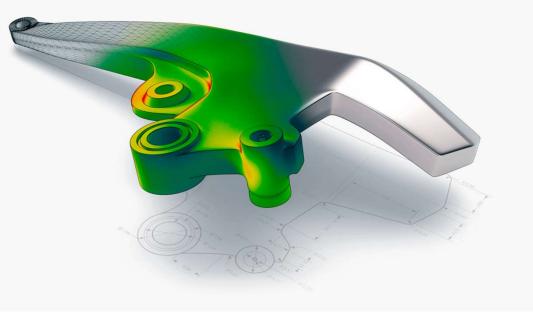
### 03 Process Condition Sheet

**O4** Picture of Real Par

**05** Measurement Data

## **Picture of the real part Measurement data**





**Ol** Part Geometry

**O2** Material Properties

**03** Process Condition Sheet

04 Picture of Real Part

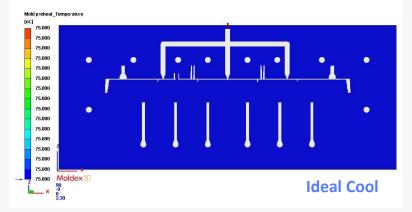
05 Measurement Data

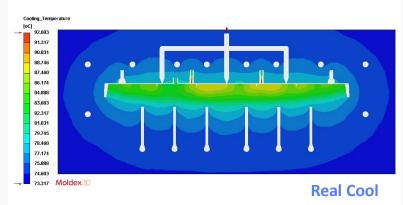
## Mold Design Cooling layout

### 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.





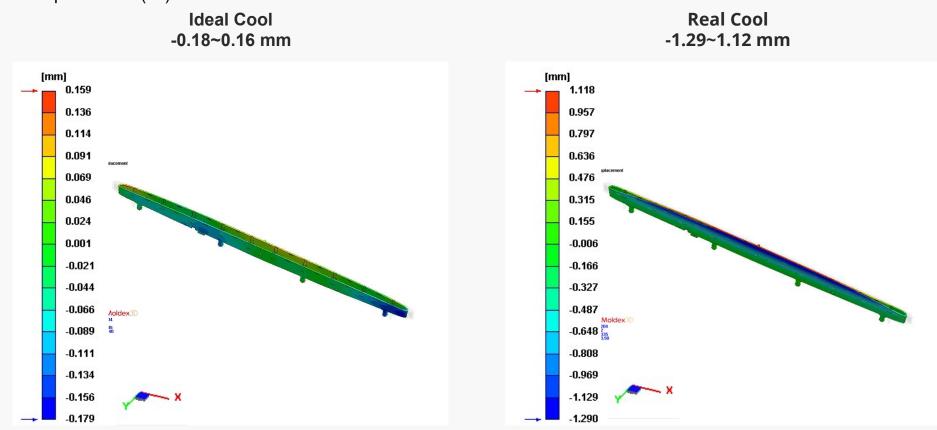
### **Ol** Part Geometry

### **02** Material Properties

**03** Process Condition Sheet

**04** Picture of Real Part

**05** Measurement Data

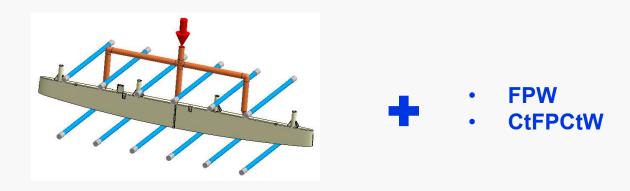


Example: Comparison between ideal cool vs Real cool

Y-Displacement (x5)

### 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.

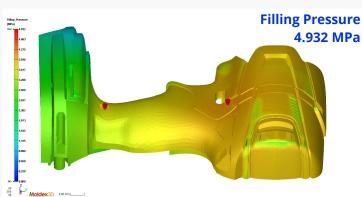


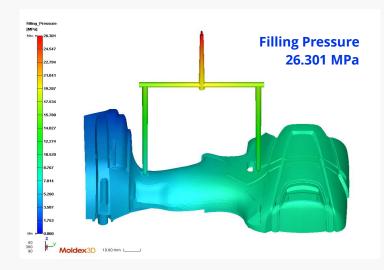
If there is heat accumulation, the warpage result will be very sensitive to the cooling design, We must run one more simulation with real cooling design before tooling.

## 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.





### **O1** Part Geometry

**02** Material Properties

**03** Process Condition Sheet

**04** Picture of Real Part

**05** Measurement Data

## **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

**O1** Mesh Resolution

**Process Condition Setting** 

**Computation Parameter Setting** 

#### • eDesign Mesh Setting: Cavity

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

vel setti	ng		
vel			
2	3	4	5
	vel		vel

Mesh level 4 and 5 are suggested

Meshing Control options	Ĩ
Ensure enough mesh layers	enabled
Raise number of elements in meshi	ing level 5
Around 2.00 million	



#### **Mesh Resolution**

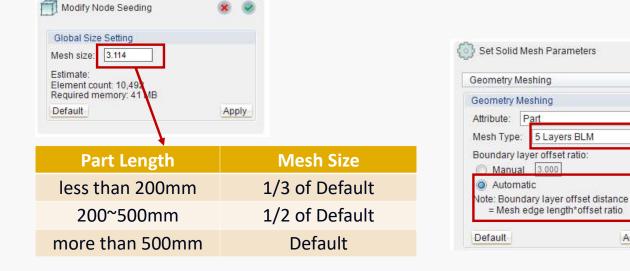
**02** Process Condition Setting

03

Computation Parameter Setting

#### • BLM Mesh Setting: Cavity

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





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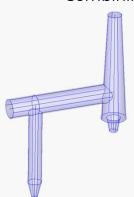
Advanced

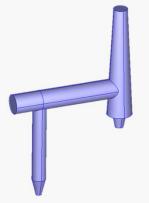
**02** Process Condition Setting

**O3** Computation Parameter Setting

#### **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

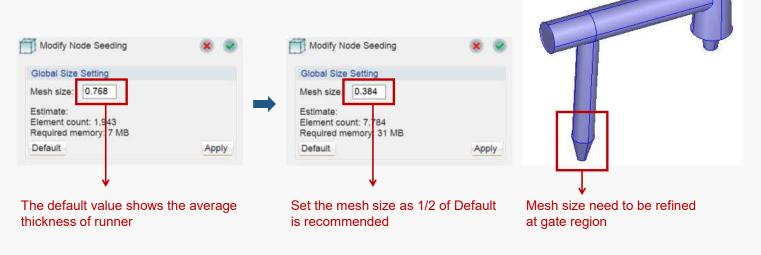
#### **UI** Mesh Resolution

**O2** Process Condition Setting

**) 5** Computation Paramete Setting

#### 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.



Mesh Resolution

### 02

**Process Condition Setting** 

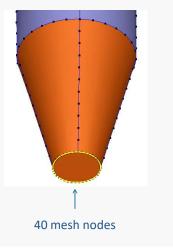
03

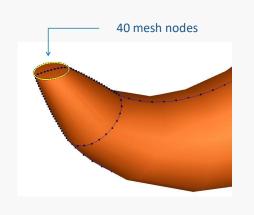
Computation Parameter Setting

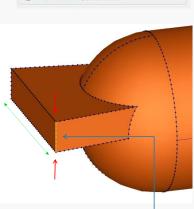
#### Node Seeding for Geometric Gate

- 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.

Sp	ecify by:	
0	Number of segments:	7
0	Mesh size: 11.310	







7 segments in thickness direction

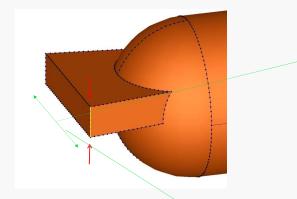
### Mesh Resolution

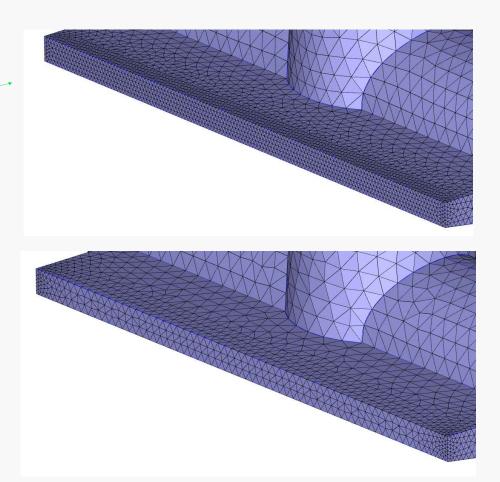
**02** Process Condition Setting

03

Computation Parameter Setting

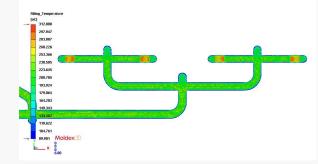
Need to adjust node seeding at the adjacent side

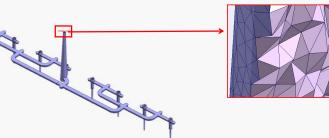




#### Example: Importance of Mesh Resolution

#### **Coarse Mesh**







## 0

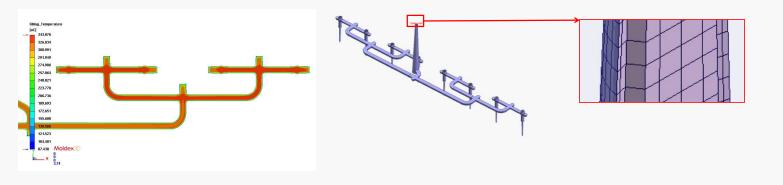
#### Mesh Resolution

## 02

03

**Computation Parameter** 

#### Dense Mesh

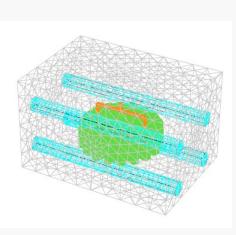


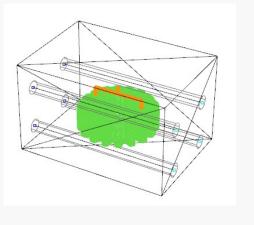
#### Mesh Setting: Mold Base

- 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





### 01

#### **Mesh Resolution**

02

**Process Condition Setting** 

### 03

Computation Parameter Setting



- > Higher memory requirement
- More accurate than default

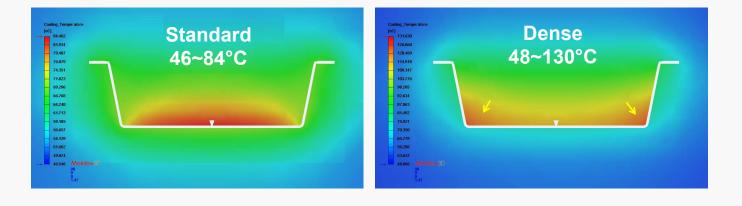
Computation Parameter		?	X
Flow/Pack Cool Warp	Stress VE/Optics		
Cooling channel analysis by			
		2.4	
Run cooling channel network analys	15		
+ Opening : 3		^	
+ Filling : 10			
+ Packing : 3			
- Solver parameters :			
Max. cycle number : 10			
Type: Maximum variation of	f mold temperature		
Temperature difference (of	C): 1.000		
- Multi-time steps output for	all cycles		
<ul> <li>Mold Preheat</li> </ul>			
Hultiple time steps output sett	ing :		
Mold preheating : 3			
<ul> <li>Moldbase mesh resolution</li> </ul>	Data Editor		×
Accuracy level : Standard	Moldbase Resolution		
<	Accuracy level : Standa	erd 💌	
	Standa	rd	
	Explanation: Dense option could get more mes requires more memory.	h resolution , but	
		OK Cancel	1

02

**Process Condition Setting** 

### 03

Computation Parameter Setting



## Step 2. Pre-Processing

The essentials in pre-processing stage

**Mesh Resolution** 

02

**Process Condition Setting** 

Computation Parameter Setting

## **Process Condition Setting** Proper Input Conditions

### roper 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



### 02

#### **Process Condition Setting**

**O3** Computation Parameter Setting

### **Process Condition Setting** How to Input the Process Condition

Ma	ker		Clamp forc		120	) Ton 斗	njection rate	cc/sec	
Gra	ade		Shot weigh	t		3	Screw Diameter	35 mm	
			Injecti pressi		150	MPa S	Screw stroke	mm	
2. F	rocess Co	ondition							
	ection ïme	Sec	Packing Time	5 Sec	Note	: Unit of	f speed, pressure	is needed	
	Screw Po	osition		100 mm		VP Pos	sition	20mm	
	Section	Speed	Pressure	Position		Section	Pressure	Time	
	1	20mm/s		90mm		I	130 MPa	2 sec	
Fill	П	50mm/s		80mm	Dack		100 MPa_	2 sec	
	III	30mm/s		15mm	Fack	- 111	85 MPa	3 sec	
	IV					IV			
	V					V			
	Screw Position         100 mm         VP Position         20mm           Section         Speed         Pressure         Position         Section         Pressure         Time           I         20mm/s         90mm         I         130 MPa         2 sec           III         50mm/s         80mm         III         130 MPa         2 sec           III         30mm/s         15mm         Pack         III         85 MPa         3 sec           IV         V         V         V         V         250 °C         Air Temp.         25 °C								
Me		Core °	C Cavi	ty 50℃	Coola Temp			50 °C	
_	d Temp.								
Mo	olant Flow		1	80 cc/sec	Cooli	n <mark>g Time</mark>		13.7 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	ť

\_\_\_\_\_

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 62.36 Stepwise 56.13 Injection Velocity (mm/sec) OPolyline 49.89 Stroke time 43.65 0.735169 sec 37.42 Injecting volume 31.18 96.2112 cm^3 24.95 18.71 12.47 6.24 0.00 100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00 Profile Advisor. Ram Position (mm) Capture. Section Section-1 Section-2 Section-3 Section-4 Ram Position (mm) 100 90 80 15 OK Injection Velocity (mm/sec) 20 50 30 20 Cancel

### 01

**Mesh Resolution** 

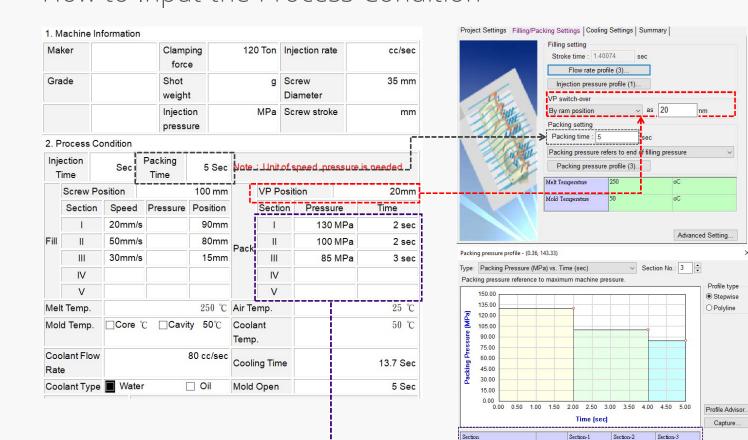
### 02

#### **Process Condition Setting**

### 03

Computation Parameter Setting

### **Process Condition Setting** How to Input the Process Condition



Time (sec)

Packing Pressure (MPa)

4

100

130

5

85

OK

Cancel

### **Ol** Mesh Resolution

02

03

Computation Parameter Setting

**Process Condition Setting** 

How to Input the Process Condition

#### Project Settings Filling/Packing Settings | Cooling Settings | Summary | 1. Machine Information Filling setting Maker Clamping 120 Ton Injection rate cc/sec Stroke time : 1.40074 force Flow rate profile (3). Injection pressure profile (1)... Grade Shot g Screw 35 mm VP switch-over weight Diameter By ram position Injection MPa Screw stroke mm Packing setting pressure Packing time : 5 Packing pressure refers to end of filling pressure 2. Process Condition Packing pressure profile (3). Injection Packing 5 Sec Note : Unit of speed, pressure is needed Melt Temperature Sec Time Time Mold Temperature Screw Position 100 mm VP Position 20mm Speed Pressure Position Pressure Time Section Section 20mm/s 90mm 130 MPa 2 sec Project Settings | Filling/Packing Settings Cooling Settings | Summary | Fill Ш 50mm/s 80mm 11 100 MPa 2 sec Pack Item Ш 30mm/s 15mm Ш 85 MPa 3 sec Cooling method IV IV Initial Mold Temperature Air Temperature V V Eject Temperature 250 °C Air Temp. 25 °C Melt Temp. Cooling Time 50 °C Mold-Open Time Mold Temp. □Core °C □Cavity 50°C Coolant Mold preheat Temp. 80 cc/sec Coolant Flow Cooling Time 13.7 Sec Rate Coolant Type 🔳 Water 🗌 Oil Mold Open 5 Sec

**Mesh Resolution** 

### 02

sec

~ as 15

sec

Cooling Channel/Heating Rod.

20

mm

Advanced Setting.

Value

General

25

100

13.7

Setting

Mold Metal Material. Part Insert Initial Temperature Estimate Cooling Time.

Unit

oC

oC

oC

sec

- -

0C

oC

#### **Process Condition Setting**

03

## **Process Condition Setting** How to Input the Process Condition

Ma	ker		Clam		12	0 Ton Ir	njection ra	te	cc/sec	
Gra	ade		Shot weigh	t		•	Screw Diameter			
			Inject press			MPa S	crew stro	ke	mm	
2 0	Process Co	ndition	piess			_				
		Jianon	_							
	ection ïme	Sec	Packing Time	5 Sec	Note	: Unit of	speed, p	ressure i	s needed	
	Screw Po	sition		100 mm		VP Pos	ition		20mm	
	Section	Speed	Pressure	Position		Section	Press	ure	Time	
	1	20mm	6	90mm		I	130	MPa	2 sec	
Fill	II	50mm/s	6	80mm	Pack	II	100	MPa	2 sec	
	- 111	30mm	6	15mm	I dek	III	8	5 MPa	3 sec	
	IV					IV				
	V					V				
Mel	t Temp.			250 ℃	Air Te	mp.			25 °C	
Mol	d Temp.	Core		ty 50℃	Coola Temp				50 °C	
Coc Rat	olant Flow e			80 cc/sec	Cooli	n <mark>g Time</mark>			13.7 Sec	
Coc	lant Type	Wate	r	Oil	Mold	Open			5 Sec	

**O1** Mesh Resolution

### 02

#### **Process Condition Setting**

03

Computation Parameter Setting

Reference for Process Condition Setting

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

Injection volume	Injection time in seconds							
(cm <sup>3</sup> )	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							

	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

### **O1** Mesh Resolution

### 02

#### **Process Condition Setting**

03

Computation Paramete Setting\_\_\_\_

Reference for Process Condition Setting

Injection	Specific	Viscosity	Injection	Holding	Mould cavity pre	ssure	Injection	Specific	Viscosity	Injection	Holding	Mould cavity pres	ssure
material	weight (g/cm <sup>3</sup> )		pressure (bar)	pressure (bar)	Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)	material	weight (g/cm <sup>3</sup> )		pressure (bar)	pressure (bar)	Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
	1		Amorpho	us thermoplas	1					Semi-crysta	lline thermop	lastics	
PS	1.05	М	650-1,550	300-700	0.75-0.5	150-350	PE soft	0.91-0.93	L	600-1,350	300-800	0.85-0.7	200-600
SB	1.04	М	650-1,550	350-800	0.75-0.5	200-400	PE rigid	0.94-0.96	M	600-1,350	300-800	0.75-0.5	200-600
SAN	1.08	М	650-1,550	350-900	0.75-0.5	250-450	PP	0.9	M	800-1,400	500-1,100	0.75-0.5	300-650
ABS	1.03-1.07	М	650-1,550	400-900	0.75-0.5	300-550			N	,			
PVC - rigid <sup>1,2</sup>	1.38-1.40	Н	1,000-1,550	500-900	0.6-0.4	250-500	PA4.6	1.18	L	650-1,550	550-1,050	0.85-0.7	450-750
PVC - soft <sup>2</sup>	1.20-1.35	М	400-1,550	300-600	0.75-0.5	150-300	PA6	1.13	L	450-1,550	400-750	0.85-0.7	350-550
CA	1.26-1.32	М	650-1,350	300-650	0.85-0.7	250-450	PA6.6	1.14	L	650-1,550	550-1,050	0.85-0.7	450-750
CAB	1.16-1.22	М	650-1,350	300-900	0.75-0.5	250-450	PA6.10	1.06	L	450-1,550	350-750	0.85-0.7	300-500
CP	1.19-1.23	М	650-1,350	400-700	0.75-0.5	200-350	PA11	1.04	L	450-1,550	400-800	0.85-0.7	350-550
PMMA	1.18	Н	1,000-1,400	500-1,150	0.6-0.4	350-550	PA12	1.02	М	550-1,550	400-1,000	0.75-0.5	350-550
Modified PPE	1.06-1.10	М	1,000-1,600	600-1,200	0.75-0.5	350-600	PA	1.12	М	900-1,300	450-800	0.75-0.5	350-450
PC	1.20-1.24	Н	1,000-1,600	600-1,300	0.6-0.4	350-650	amorphous						
PAR	1.2	Н	1,000-1,600	600-1,300	0.6-0.4	350-650	POM	1.41-1.42	L	800-2,000	700-1,500	0.85-0.7	550-1,050
PSU	1.27	Н	900-1,400	500-1,100	0.6-0.4	400-600	PET	1.34-1.37	L	800-1,500	550-1,050	0.85-0.7	450-750
PES	1.37	Н	900-1,400	500-1,100	0.6-0.4	400-600	PBT	1.29	L	800-1,550	500-1,000	0.80.7	400-700
PEI	1.87	M	750-1,550	400-750	0.85-0.7	350-650	PPS	1.34	L	750-1,500	400-750	-	350-600
PAI	1.38	Н	750-1,550	500-1,050	0.85-0.7	450-750	FEP <sup>1</sup>	2.14-2.17	Н	1,000-1,500	500-1,000	0.6-0.4	300-600
							ETFE <sup>1</sup>	1.70	Н	1,000-1,500	500-1,000	0.6-0.4	300-600
									п				
							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	М	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

O1 Mesh Resolution

### 02

#### **Process Condition Setting**

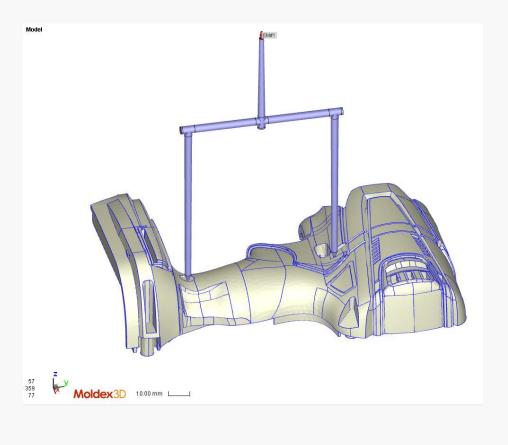
03 Computation Par

Setting

Reference: Arburg, 2004, Practical Guide to injection moulding

### Example: How to Decide the Process Condition

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





### 02

#### **Process Condition Setting**

**O3** Computation Parameter 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:

Injection volume	Injection time in seconds					
(cm <sup>3</sup> )	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					

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 <sup>3</sup> )	Viscosity	Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
		· · ·	Amorpho	us thermoplas	tics	
PS	1.05	М	650-1,550	300-700	0.75-0.5	150-350
SB	1.04	М	650-1,550	350-800	0.75-0.5	200-400
SAN	1.08	М	650-1,550	350-900	0.75-0.5	250-450
ABS	1.03-1.07	М	650-1,550	400-900	0.75-0.5	300-550
PVC – rigid <sup>1,2</sup>	1.38-1.40	Н	1,000-1,550	500-900	0.6-0.4	250-500
PVC - soft <sup>2</sup>	1.20-1.35	М	400-1,550	300-600	0.75-0.5	150-300
CA	1.26-1.32	М	650-1,350	300-650	0.85-0.7	250-450
CAB	1.16-1.22	М	650-1,350	300-900	0.75-0.5	250-450
СР	1.19-1.23	М	650-1,350	400-700	0.75-0.5	200-350
PMMA	1.18	Н	1,000-1,400	500-1,150	0.6-0.4	350-550
Modified PPE	1.06-1.10	М	1,000-1,600	600-1,200	0.75-0.5	350-600
PC	1.20-1.24	Н	1,000-1,600	600-1,300	0.6-0.4	350-650



### 02

#### **Process Condition Setting**

03

Computation Parameter

Example: How to Decide the Process Condition

#### **Ol** Mesh Resolution

### 02

#### **Process Condition Setting**

#### 03

Computation Parameter Setting

### • Cavity volume: 58 c.c.

#### Material: ABS

#### • Process condition:

Filling time: 1-1.5 sec

#### > Packing pressure:

- **4**0-90 MPa
- 80% of injection pressure at EOF
- Packing time:
- > Cooling time:

Injection material	Specific Visco weight (g/cm <sup>3</sup> )	Viscosity	osity Injection pressure (bar)	Holding pressure (bar)	Mould cavity pressure	
					Relationship with (x) highest holding pressure stage	Expected cavity pressure (bar)
	201		Amorpho	us thermoplas	stics	
PS	1.05	М	650-1,550	300-700	0.75-0.5	150-350
SB	1.04	М	650-1,550	350-800	0.75-0.5	200-400
SAN	1.08	М	650-1.550	350-900	0.75-0.5	250-450
ABS	1.03-1.07	М	650-1,550	400-900	0.75-0.5	300-550
PVC – rigid <sup>1,2</sup>	1.38-1.40	Н	1,000-1,550	500-900	0.6-0.4	250-500
PVC - soft <sup>2</sup>	1.20-1.35	М	400-1,550	300-600	0.75-0.5	150-300
CA	1.26-1.32	М	650-1,350	300-650	0.85-0.7	250-450
CAB	1.16-1.22	М	650-1,350	300-900	0.75-0.5	250-450
СР	1.19-1.23	М	650-1,350	400-700	0.75-0.5	200-350
PMMA	1.18	Н	1,000-1,400	500-1,150	0.6-0.4	350-550
Modified PPE	1.06-1.10	М	1,000-1,600	600-1,200	0.75-0.5	350-600
PC	1.20-1.24	Н	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:
    - **D** 40-90 MPa
    - 80% of injection pressure at EOF
  - Packing time:
    - Default for first run
    - Depends on gate freeze time
  - > Cooling time:

<pre><prediction_of_gate_ereeze_tip< pre=""></prediction_of_gate_ereeze_tip<></pre>	me≥,
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

#### **O1** Mesh Resolution

#### 02

#### **Process Condition Setting**

#### 03

# **Computation Parameter Setting** Computation Parameters: Predict Gate Freeze

#### • "Predict Gate Freeze Time", Criterion:

- Freeze Temp (°C)
- Flow Rate (cc/sec)
- Part Weight Deviation (default setting)
- Estimate the effective packing time
- Find the gate freeze time in log file.

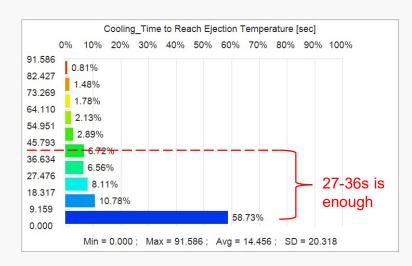
<prediction gate-freeze="" of="" td="" time<=""><td>e&gt;</td></prediction>	e>
Freeze Time of Gate #1	= 4.008 sec
Max Gate Temperature	= 131.395 Degree C
Total Gate Flow Rate	= 0.000303237 cc/sec
Freeze Time of Gate #2	= 4.008 sec
Max Gate Temperature	= 124.51 Degree C
Total Gate Flow Rate	= 7.4362e-005 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

Standard analysis	
C Fast analysis	
C Customize	
Viscous heating	🔽 Non-isothermal
Stabilized calculation	Non-newtonian flow
Compressible flow	
Gravitational force : cm/sec^2	
Example : ( 0, 0, -980 ) for z-gra	vity
<b>X</b> : 0 <b>Y</b> : 0	Z: 0
+ Packing: 3	,
adding. J	,
Estimate required cooling time	
	•
Estimate required cooling time	e iterion:
Estimate required cooling time     V     Predict gate freeze time cr     V     Freeze temperature(oC	e iterion:
Estimate required cooling time     V     Predict gate freeze time cr     V     Freeze temperature(of)	a iterion: C) 1
Estimate required cooling time     V     Predict gate freeze time cr     V     Freeze temperature(oC     V     Flow rate(cc/sec) <	a iterion: C) 1
Estimate required cooling time     V Predict gate freeze time cr     V Freeze temperature(of     V Flow rate(cc/sec) <     V Part weight deviation(%)	a iterion: C) 1
Estimate required cooling time     V     Predict gate freeze time cr     V     Freeze temperature(of     V     Flow rate(cc/sec) <     V     Part weight deviation(%     Run fiber orientation analysis	e iterion: 2) 1 1 5/sec) < 0.1

# **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:
    - **D** 40-90 MPa
    - 80% of injection pressure at EOF
  - Packing time:
    - Default for first run
    - **D** Depends on gate freeze time
  - > Cooling time:
    - Default for first run
    - 80-90% of cavity reached the ejected temperature





## 02

#### **Process Condition Setting**

03

# Step 2. Pre-Processing

The essentials in pre-processing stage

**Mesh Resolution** 

**Process Condition 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-tothickness (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		?	
Flow/Pack   🖸 Cool   🔟 War	p 🛛 🔄 Stress 🗠 🖸 VE/Optics	1	
Solver : Enhanced-P			•
G Standard			
Stand Stand Enhanced-P C Fast Viscoelastic F			
C Customize			
Viscous heating	☑ Non-isothermal		
✓ Stabilized calculation	🔽 Non-newtonian flow		
Compressible flow			
Multiple time steps output setti	옷중감		^
Setting Method: Filling Time	e (sec)		
+ Filling : 10 + Packing : 3			
Estimate required cooling time			
+ V Predict gate freeze time cri			
Run fiber orientation analysis			
- Particle Tracer			
Particle tracking from			
Weld line particle			Y

## 01

**Mesh Resolution** 

# 02

**Process Condition Setting** 

#### 03

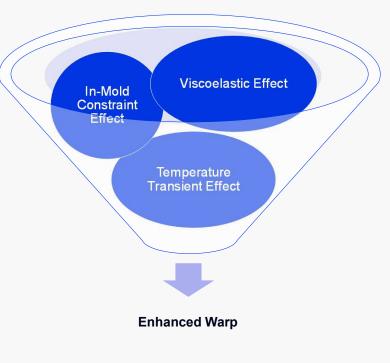
# **Computation Parameter Setting**

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



## **Ol** Mesh Resolution

**O2** Process Condition Setting

03

#### **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

Solver : Enhanced-P	-	Solver : Enhanced	
Standard analysis		Fiber-Reinforced Material Option	
C Fast analysis		Calibrate experimental composite mechanical properties	
C Customize		Consider fiber orientation effect	
Viscous heating 🔽 Non-isothermal		Micro-mechanics model :	
Stabilized calculation		Mori-Tanaka model	0
Compressible flow			
Gravitational force cm/sec^2		Options	
Example : ( 0, 0, -980 ) for z-gravity		Solver parameters :	
× In + In		— Max. no. iteration: 50000	
X: 0 Y: 0 Z: 0		Convergence tolerance : 5e-05	
		Remove runner in calculation	
Predict gate freeze time criterion:	^ I	Remove overflow in calculation	
Run fiber orientation analysis		🖃 🛄 Run buckling analysis	
- Particle Tracer		<ul> <li>Number of buckling mode : 5</li> </ul>	
Particle tracking from :		— Max. no. iteration: 500	
Weld line particle		Convergence tolerance : 5e-05	
Extend Packing Calculation to cooling phase			Default
Extend Packing Calculation to end of cooling			
Consider crystallization effect			
✓ Use solid state properties for shrinkage			

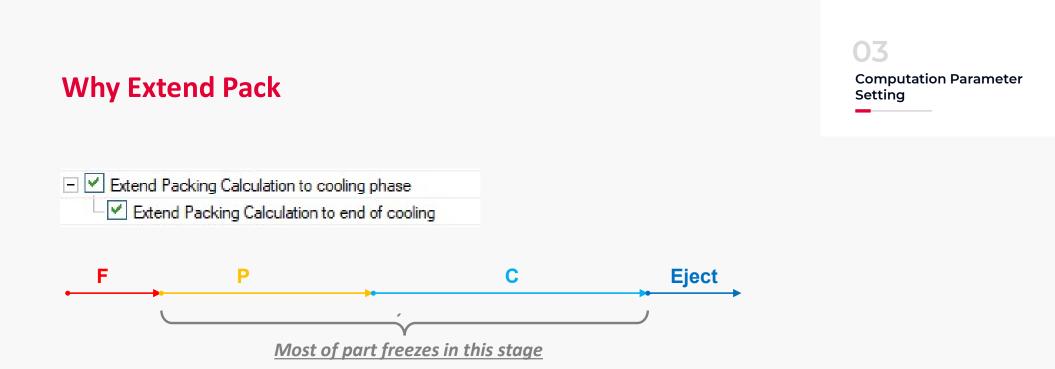


#### **Enable the options**

- 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

Solver : Enhanced-P	-	Solver : Enhanced	
Standard analysis		- Fiber-Reinforced Material Option	
Fast analysis		Calibrate experimental composite mechanical properties	
C Customize		Consider fiber orientation effect	
Viscous heating Viscous heating		Micro-mechanics model :	
Stabilized calculation Vision Non-newtonian flow		Mori-Tanaka model	1
Compressible flow			
Gravitational force : cm/sec <sup>2</sup>		Options	
Example : (0, 0, -980) for z-gravity		- Solver parameters :	
		Max. no. iteration : 50000	
X: 0 Y: 0 Z: 0		Convergence tolerance : 5e-05	
		Remove runner in calculation	
Predict gate freeze time criterion:	^	Remove overflow in calculation	
Run fiber orientation analysis		- Run buckling analysis	
<ul> <li>Particle Tracer</li> </ul>		<ul> <li>Number of buckling mode : 5</li> </ul>	
Particle tracking from :	1	– Max. no. iteration : 500	
Weld line particle		Convergence tolerance : 5e-05	
Extend Packing Calculation to cooling phase			Default
Extend Packing Calculation to end of cooling			Derdan
Consider crystallization effect			
Use solid state properties for shrinkage			
- our and state properties for annihildge			





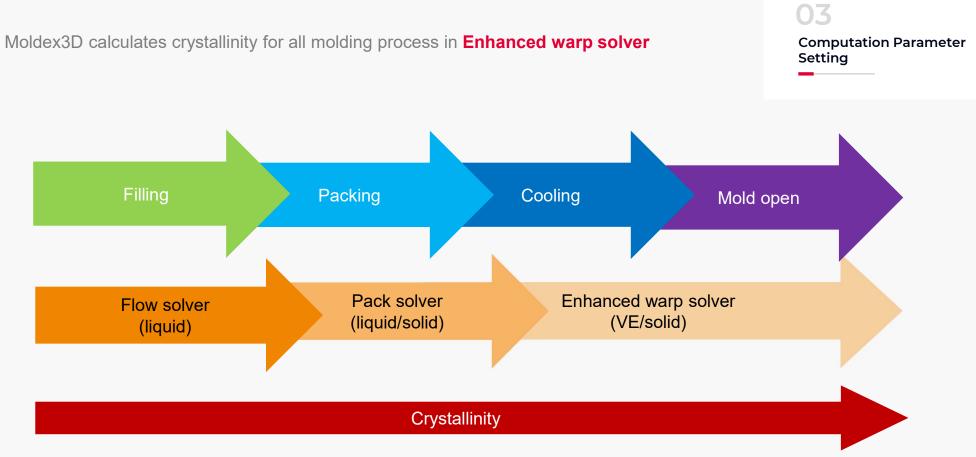
with "Extend Pack" option, the warp solver will automatically find out when the part is frozen and appropriate for the warpage calculation until EOC.

#### **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

Solver : Enhanced-P	-	Solver : Enhanced	
Standard analysis		Fiber-Reinforced Material Option	
← Fast analysis		Calibrate experimental composite mechanical properties	
C Customize		Consider fiber orientation effect	
Viscous heating 🔽 Non-isothermal		Micro-mechanics model :	
Stabilized calculation  V Non-newtonian flow		Mori-Tanaka model	
Compressible flow			
Gravitational force : cm/sec^2		Options	
Example : ( 0, 0, -980 ) for z-gravity		Solver parameters :	
		— Max. no. iteration:50000	
X: 0 Y: 0 Z: 0		Convergence tolerance : 5e-05	
		Remove runner in calculation	
Predict gate freeze time criterion:	^	Remove overflow in calculation	
Run fiber orientation analysis		E Run buckling analysis	
- Particle Tracer		<ul> <li>Number of buckling mode : 5</li> </ul>	
Particle tracking from :		— Max. no. iteration: 500	
Weld line particle		Convergence tolerance : 5e-05	
Extend Packing Calculation to cooling phase		De	fault
Extend Packing Calculation to end of cooling			
Consider crystallization effect			
Use solid state properties for shrinkage	122		





Better calculation for crystallinity leads to better warpage prediction

#### **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

Solver : Enhanced-P	-	Solver : Enhanced	
Standard analysis		- Fiber-Reinforced Material Option	
C Fast analysis		Calibrate experimental composite mechanical properties	
C Customize		Consider fiber orientation effect	
Viscous heating Viscous heating		Micro-mechanics model :	
Stabilized calculation 🔽 Non-newtonian flow		Mori-Tanaka model	
Compressible flow			_
Gravitational force : cm/sec^2		Options	
Example : (0, 0, -980) for z-gravity		Solver parameters :	
		- Max. no. iteration : 50000	
X: 0 Y: 0 Z: 0		Convergence tolerance : 5e-05	
		Remove runner in calculation	
+ Predict gate freeze time criterion:	^	Remove overflow in calculation	
Run fiber orientation analysis		🖃 🔲 Run buckling analysis	
- Particle Tracer		<ul> <li>Number of buckling mode : 5</li> </ul>	
Particle tracking from :		– Max. no. iteration: 500	
Weld line particle		Convergence tolerance : 5e-05	
Extend Packing Calculation to cooling phase		Defa	th a
Extend Packing Calculation to end of cooling			
Consider crystallization effect     Use solid state properties for shrinkage			

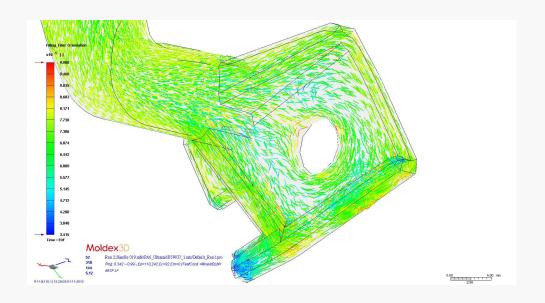


## **Fiber Analysis in Flow**

## The orientation can be used to predict

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





#### **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

Solver : Enhanced-P	<b>_</b>	Solver : Enhanced	
Standard analysis		- Fiber-Reinforced Material Option	
Fast analysis		Calibrate experimental composite mechanical properties	
C Customize		Consider fiber orientation effect	
Viscous heating 🔽 Non-isothermal		Micro-mechanics model :	
Stabilized calculation 🛛 🔽 Non-newtonian flo	300	Mori-Tanaka model	10
Compressible flow			_
Gravitational force : cm/sec^2		Options	
Example : (0, 0, -980) for z-gravity		<ul> <li>Solver parameters :</li> </ul>	
		- Max. no. iteration:50000	
X: 0 Y: 0 Z: 0		Convergence tolerance : 5e-05	
- <b>- - -</b>		Remove runner in calculation	
+ V Predict gate freeze time criterion:	^ ^	Remove overflow in calculation	
Run fiber orientation analysis		Run buckling analysis	
- Particle Tracer		<ul> <li>Number of buckling mode : 5</li> </ul>	
Particle tracking from :		– Max. no. iteration:500	
Weld line particle		Convergence tolerance : 5e-05	
Extend Packing Calculation to cooling phase		De	fault
Consider crystallization effect			
Use solid state properties for shrinkage			
ose solid state properties for shirtikage	12.45		





## **Calibration of Experimental Mechanical Properties**

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

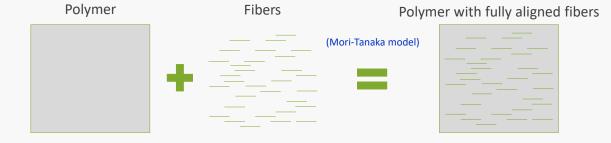
Theoretical data (using *Mori-Tanaka model* )

Experimental data





 $\rightarrow$  In previous version, it was regarded as "polymer with fully aligned fibers" before.



## **Calibration of Experimental Mechanical Properties**

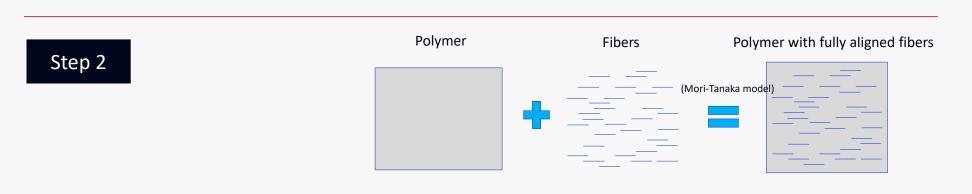
#### 03 **Computation Parameter** Setting

Experimental specimen Fiber properties Polymer The experimental mechanical properties will be decomposed into polymer properties along with



the known fiber properties. After the

Step 1

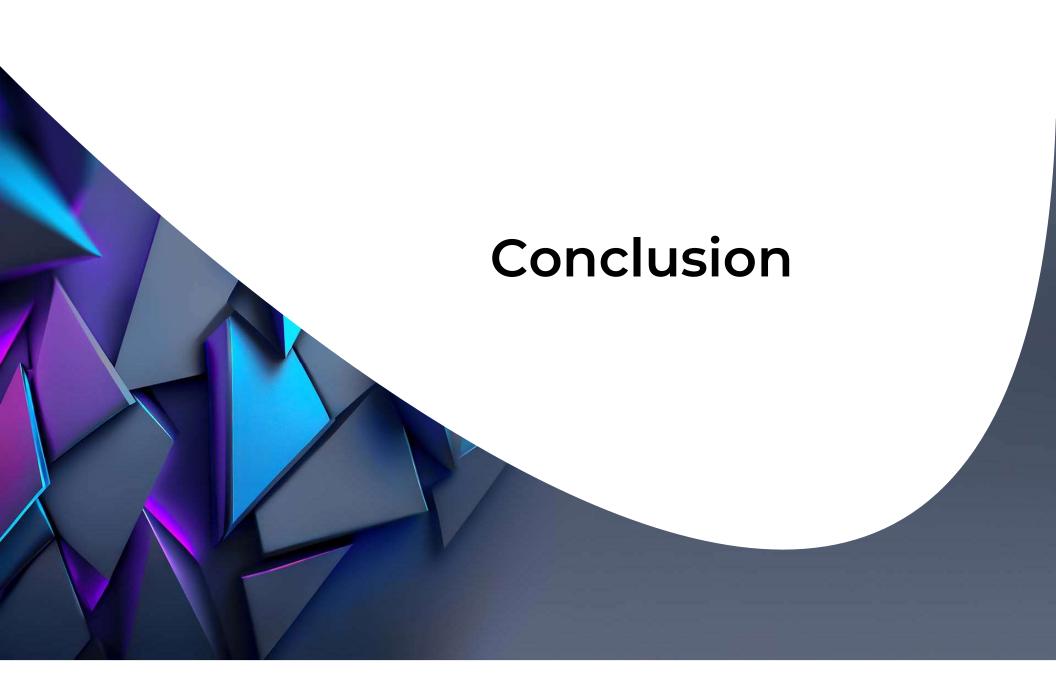


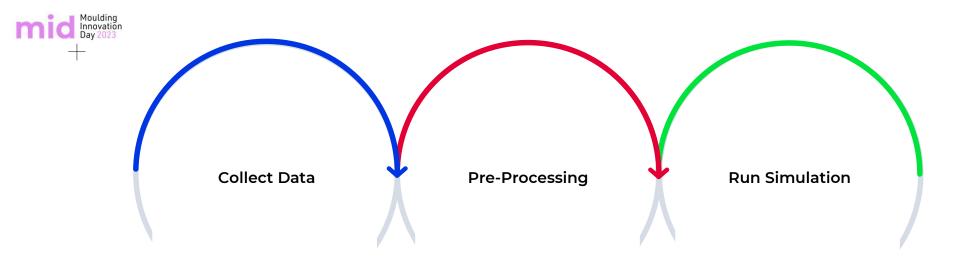
# **Summary**

# 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.



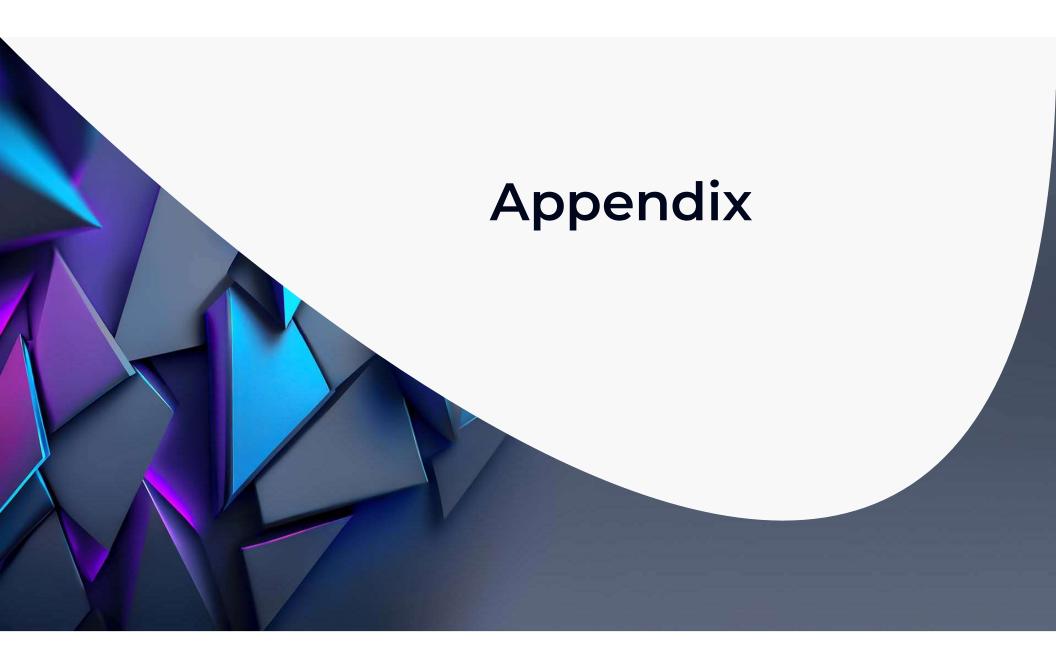


- Part Geometry
- Material Properties
- Mold Design
  - Runner Layout
  - Cooling Layout
- Process Condition
- Picture of Real Part
- Measurement Data

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

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

# Thank you



# Process Conditions: VP Follow Packing Pressure

• Better predict clamping force / sprue pressure

6	Filling setting	
	Filling/Packing Advanced Setting	
	Mold Boundary Condition Injection Options	
1		
1	Criteria for short shot	
1	Maximum filling time : 2.6 sec (Filling time : 2 sec )	
1	VP switch-over option	
1		
0	VP switch-over follow packing pressure profile	

# **Fiber Orientation**

#### **Use iARD Modelling**

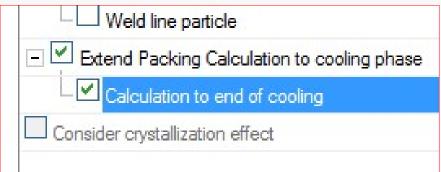
- Long Fiber (over 100 Aspect Ratio)
  - ≻ Ci: .01
  - ≻ Cm: 1
  - > Alpha: 0.1
- Short Fiber (under 100 Aspect Ratio)
  - ≻ Ci: .005
  - ≻ Cm: 0
  - > Alpha: 0.7

Filler type :	Short fibe	er		•
Aspect ratio :	20		Original: 2	:0
Weight(%) :	40	-1	č	
leffery Hydrod 4th orientati		clos	ure :	
IBOF				•
Rotary Diffusio	on			
Modelling		ARI	0	-
Ci Cm		.005		
Fiber-Matrix Ir RPR model	100000000000000000000000000000000000000	or :	.7	
Advanced Cal Consider	concentra	tion	calculation	

# 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**



	Computat	ion Parame	eter	?
Row/Pack 👼 Cool 🏼 Warp 🛸	Stress 9 VE/Op	tics 🛛 进 Task Ma	inager	
Solver : Enhanced-P				~
() Standard analysis				
Customize				
Viscous heating	~	Non-isothermal		
Stabilized calculation	~	Non-Ne <u>w</u> tonian flo	N	
Compressible flow				
Gravitational force : cm/	/sec^2			
Example : (0, 0, -980) for z-gravity				
X: 0 Y:	0	Z: 0		
X U 1.	0	Z: 0		
				•
Packing : 3     Estimate required cooling time				
Predict gate freeze time criterion	12			
Run fiber orientation analysis				
- Particle Tracer				
Particle tracking from :				
Weld line particle				
- Extend Packing Calculation to c	cooling phase			
Calculation to end of cooling	j.			
Consider crystallization effect				
				~
<				>
Advanced				<u>D</u> efault
10				
Template setting				K Cance
				Cance

# Computation Parameters: Solver Accuracy

Number	Accuracy	Computation Time	C Computation Paramet	er [ 👔 🔤
	Accuracy		Flow/Pack  Goo	I 🍠 Warp 🚵 Stress 🍥 VE/Optics 🚇 Task Manager
			Solver : Enhanced	I₽ <b>→</b>
		1	Standard anal	Advanced Options for Filling/Packing Solver
Number	Accuracy	Computation Time	<ul> <li>Fast analysis</li> <li>Customize</li> </ul>	Accuracy/Performance Venting Wall Slip BC
		•	Viscous heatir V Stabilized calc Compressible	Flow Solver :
Defaults:			Gravitational force Example : ( 0, 0, -	© Accurate
eDesign Levels			X: 0	Customized
1&2:20				Stable Fast
			<ul> <li>Multiple time ste</li> <li>Setting Meth</li> </ul>	
3 & 4 : 5			Filing : 3	Criterion for stopping calculation
5:3			+ Packing : 3	Fill percentage     99.95 %
			🛨 🛄 Predict gate	Exclude runner volume
BLM: 1 for geometry runner, 3 for line runner			Run fiber orienta	O Unfilled element count 10
High shear imbalance cases 0.25 is recommended			Particle ti	
recommended		Extend Pack	Default	