mid Moulding Innovation Day 2025

Simulazione dei sistemi di condizionamento e transitori termici

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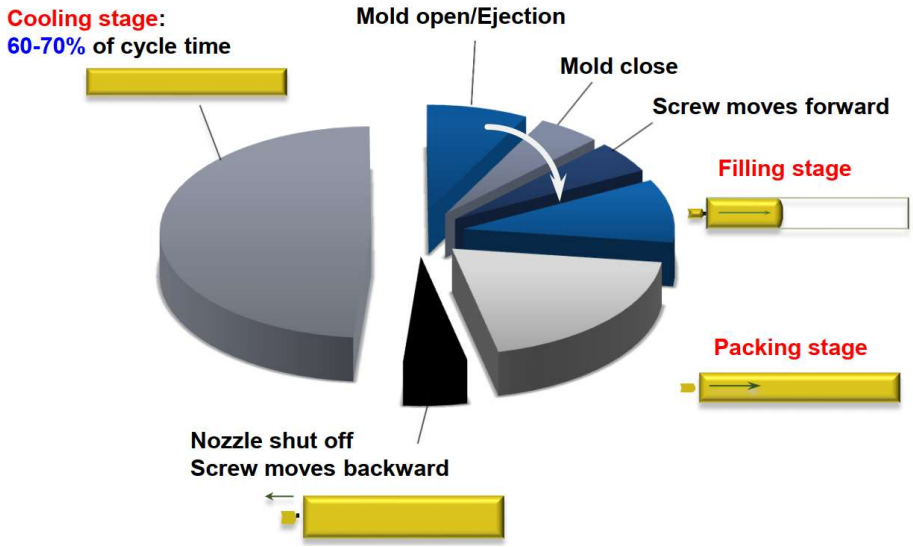
Moldex3D Italia

Moldex3D

- Introduzione
- Funzionalità dell’analisi di raffreddamento
- Funzionalità avanzate
- Caso di studio
- Conclusioni

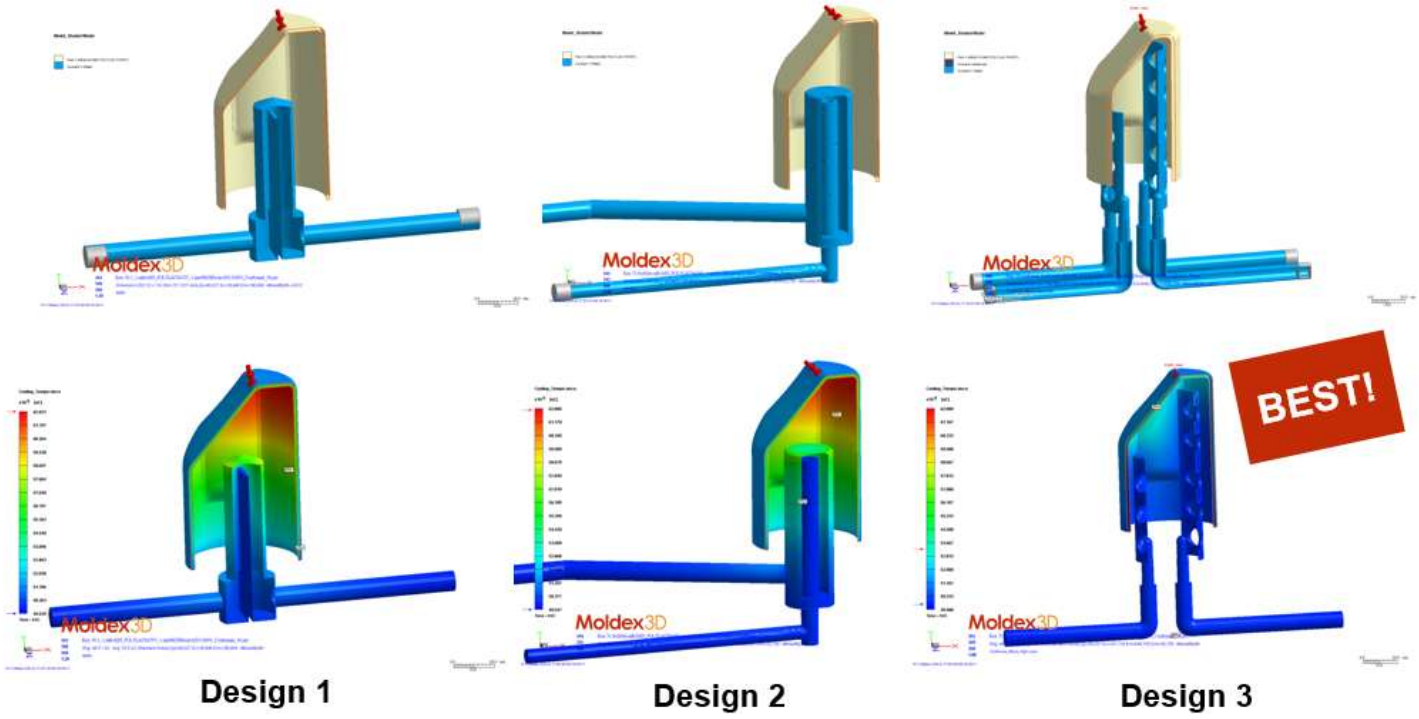
Introduzione

- La fase di raffreddamento è una delle fasi più critiche e determinanti nello stampaggio delle materie plastiche, lo è sia dal punto di vista tecnico che economico.
- Dal punto di vista tecnico perché influenza direttamente la qualità del pezzo.
- Dal punto di vista economico perché incide in modo importante sul tempo ciclo.



L’analisi di raffreddamento in Moldex3D

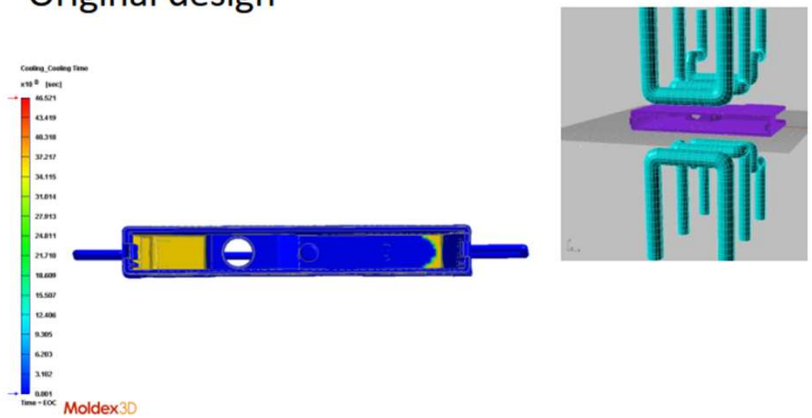
- Convalida e ottimizza il progetto del sistema di raffreddamento.
  - Uniformità della temperatura delle parte migliorata grazie a diversi design di raffreddamento.



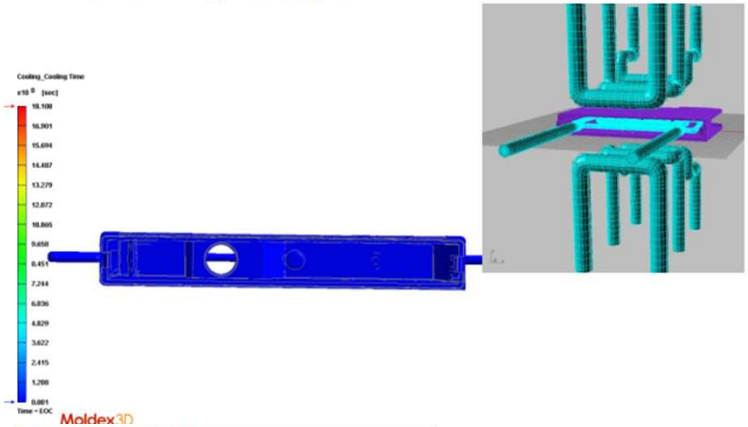
L’analisi di raffreddamento in Moldex3D

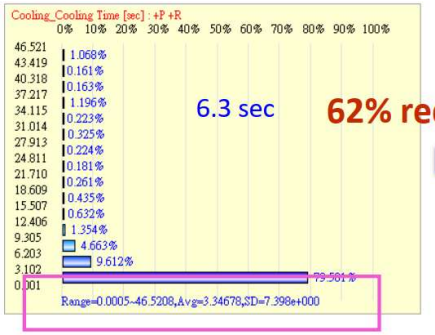
- Stima tempo di raffreddamento necessario.
  - Una migliore progettazione del sistema di raffreddamento può ridurre i tempi di raffreddamento e accorciare il ciclo di produzione.

Original design



New cooling design





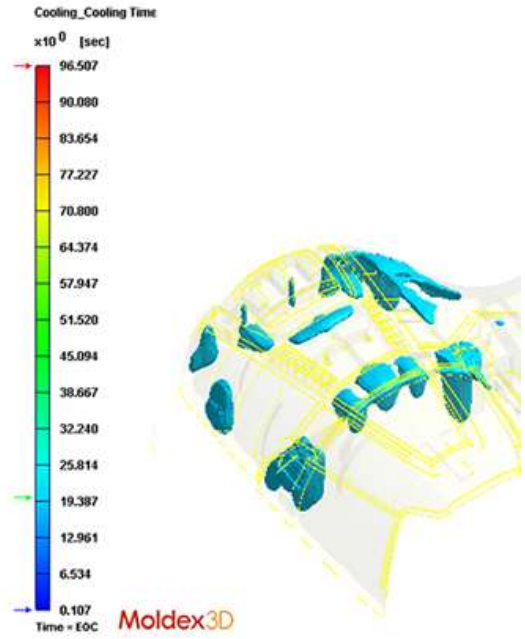
6.3 sec

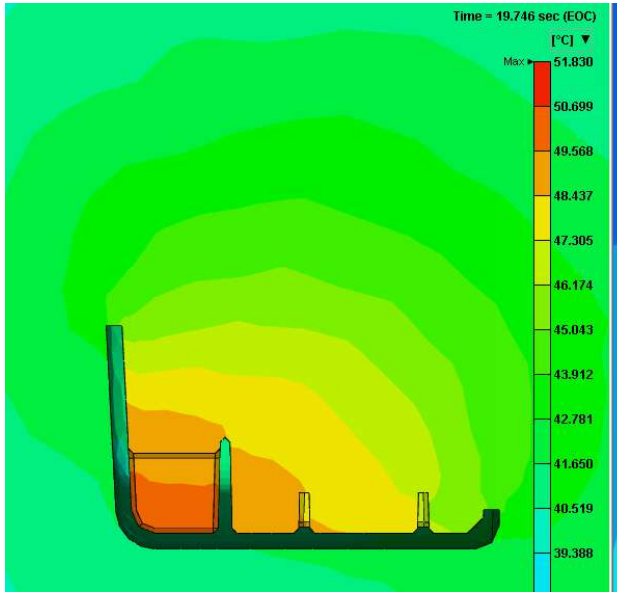
62% reduction

2.4 sec

L’analisi di raffreddamento in Moldex3D

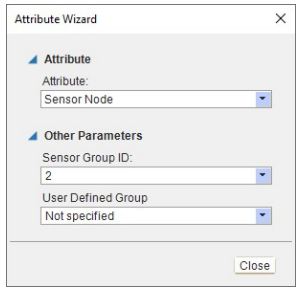
- Simula la distribuzione della temperatura dello stampo e della parte in qualsiasi momento del ciclo in 3D.
  - Aiuta a individuare i punti più caldi così da provare ad eliminarli con diversi progetti di raffreddamento.

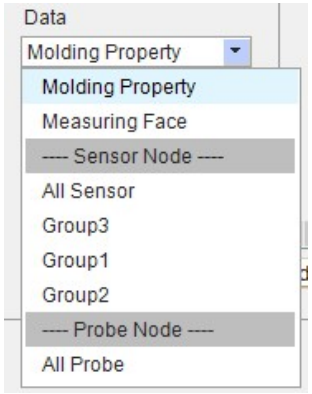


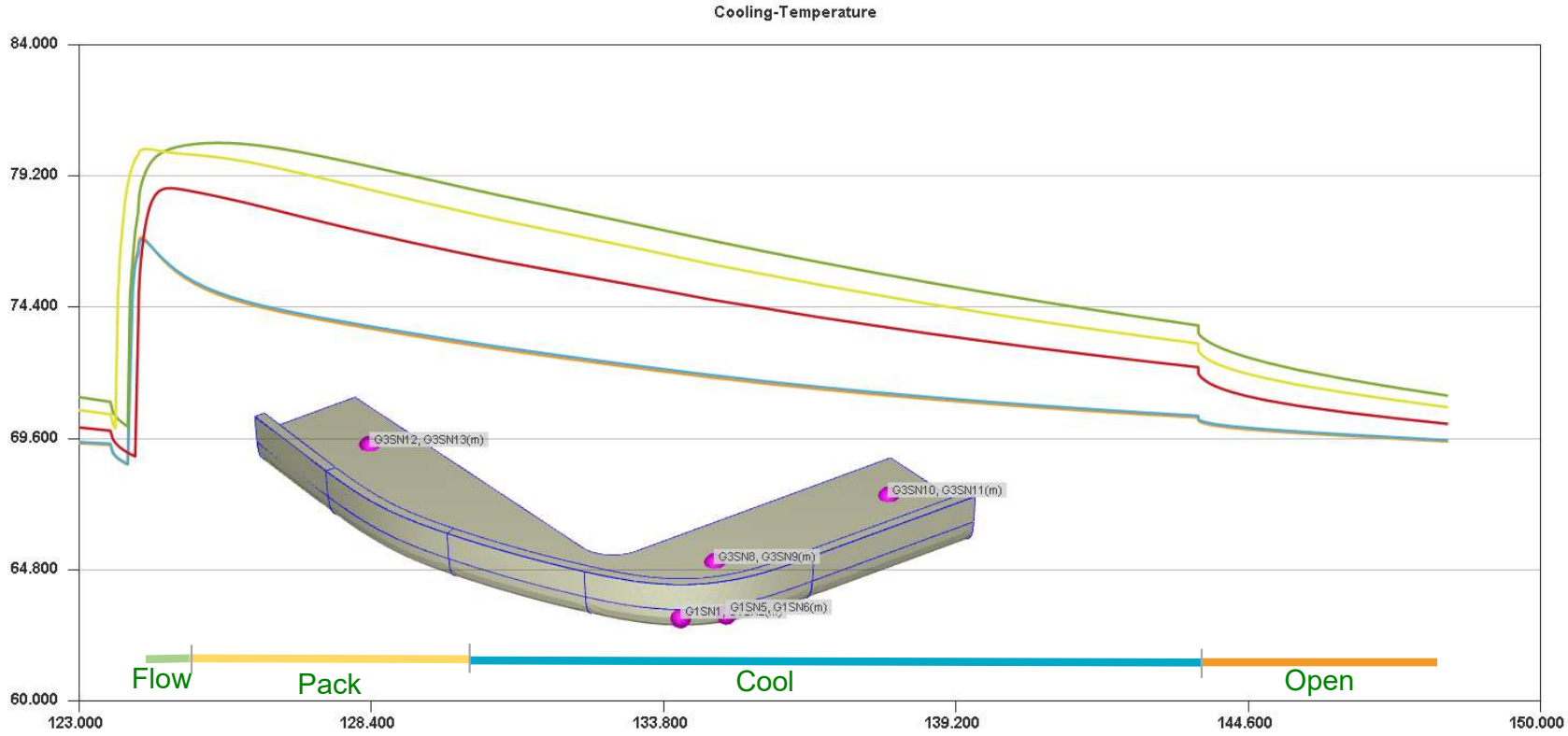


L’analisi di raffreddamento in Moldex3D

- Monitorare la variazione della temperatura dello stampo.
  - Aiuta a comprendere la differenza di velocità di raffreddamento e il tempo di risposta dello stampo.

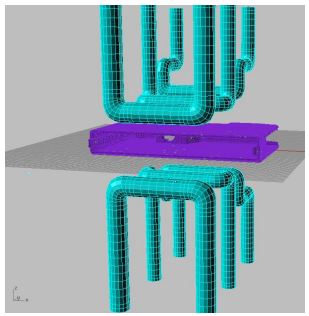


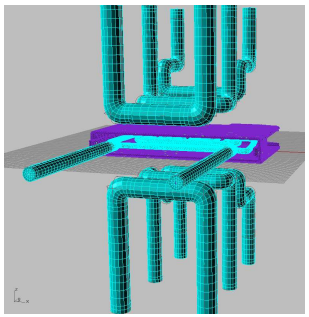


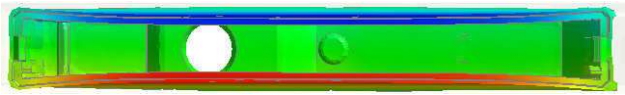


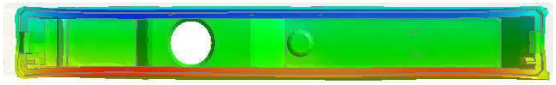
L’analisi di raffreddamento in Moldex3D

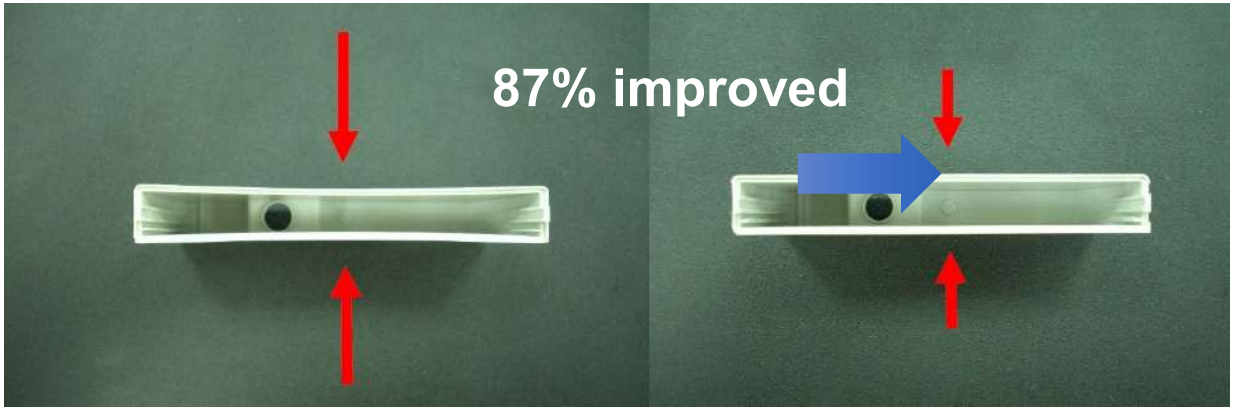
- Valutare l'effetto di raffreddamento sui difetti del prodotto.
  - In particolare le deformazioni e i segni di risucchio.







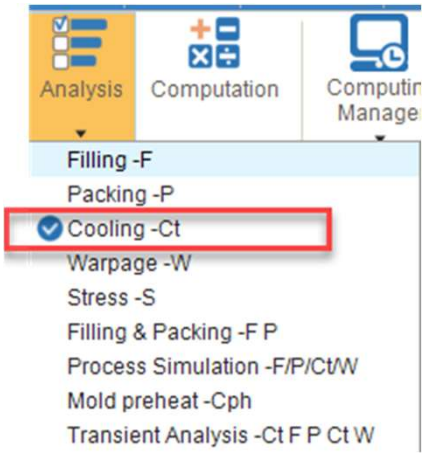


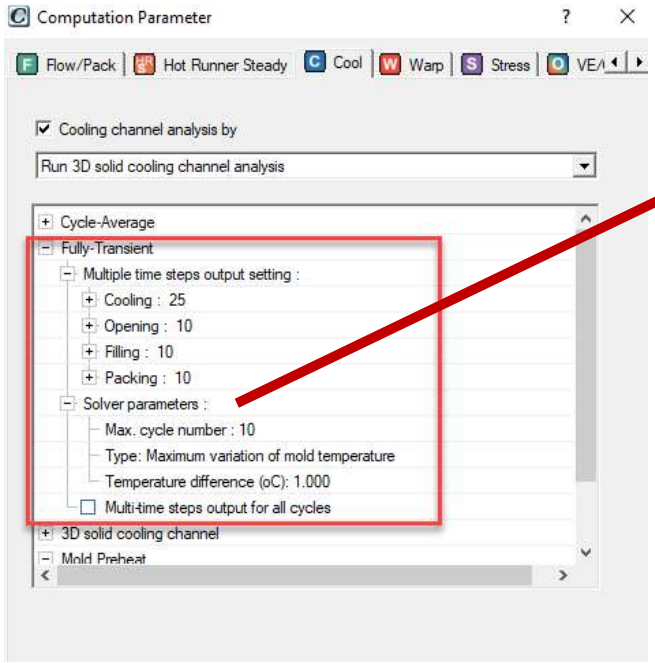


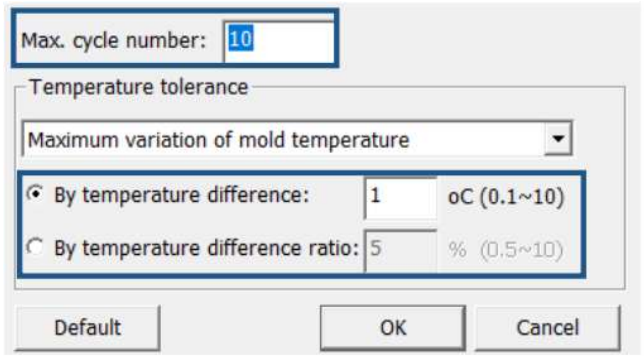
I risucchi corrispondono solitamente alle sezioni delle nervature, dove l'accumulo di massa è maggiore rispetto ad altre aree. Pertanto senza un adeguato raffreddamento della superficie, si possano verificare segni in corrispondenza delle nervature.

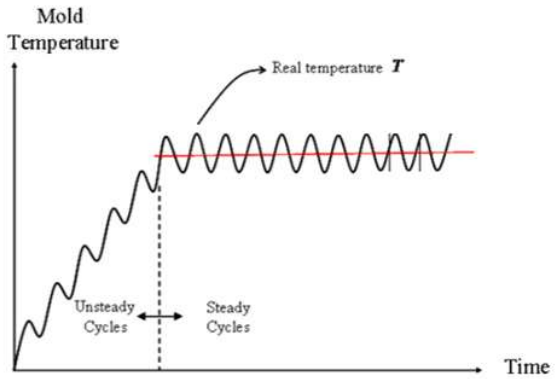
Funzionalità avanzate

- Transient Cool
  - L’analisi di raffreddamento di default in Moldex3D è quella che molto più comunemente è conosciuta come Transient Cool.



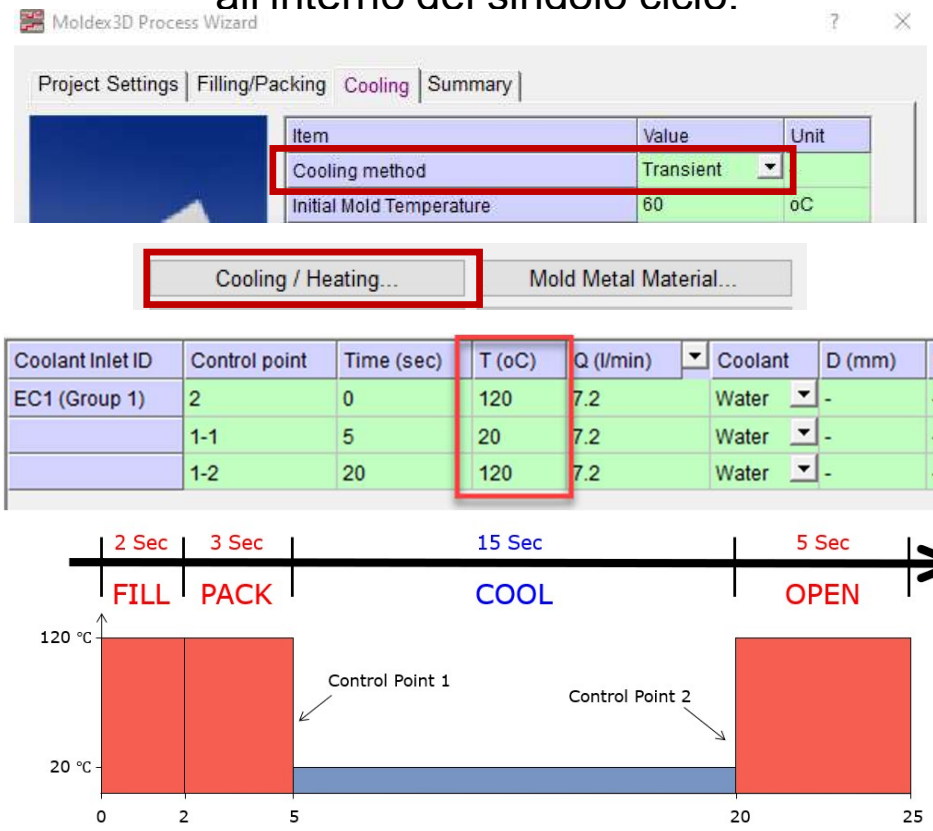


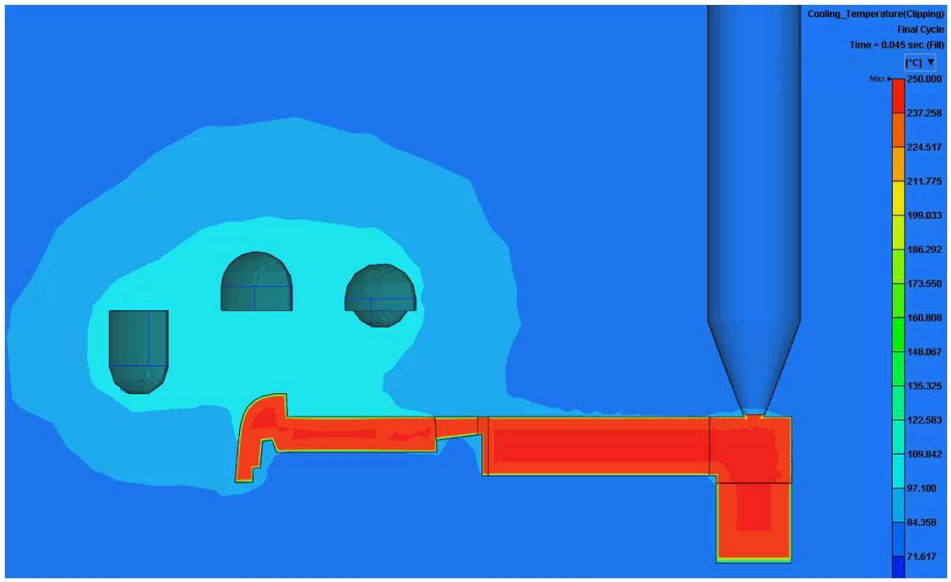




Funzionalità avanzate

- Metodo di raffreddamento Transient.
  - Possibilità di gestire, grazie all'analisi transient, le variazioni di temperatura all'interno del singolo ciclo.



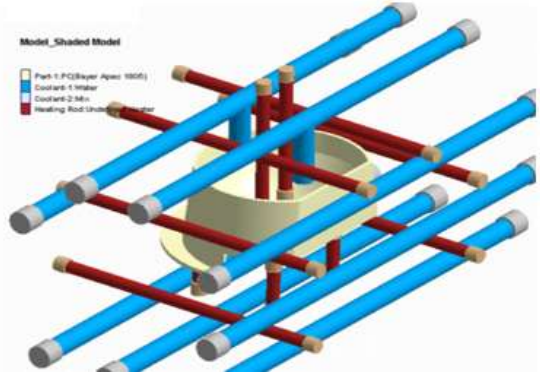


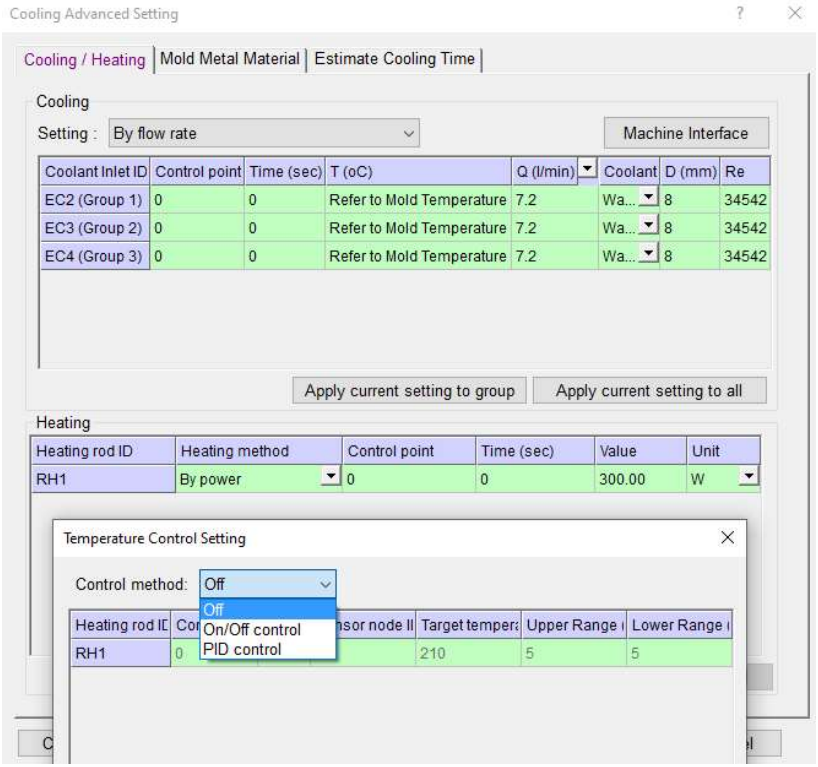
Funzionalità avanzate

- Metodo di raffreddamento Transient.
  - Variazioni di portata nel ciclo e gestione contemporanea di raffreddamenti e resistenze per temperatura o per potenza.

Coolant Inlet ID	Control point	Time (sec)	T (oC)	Q (l/min)	Coolant	D (mm)	Re
EC1 (Group 1)	2	0	100	0	Water	8	0
	1-1	5	100	40	Water	8	364326
	1-2	12	100	0	Water	8	0
EC2 (Group 2)	2	0	100	0	Water	8	0
	2-1	5	100	40	Water	8	364326
	2-2	12	100	0	Water	8	0

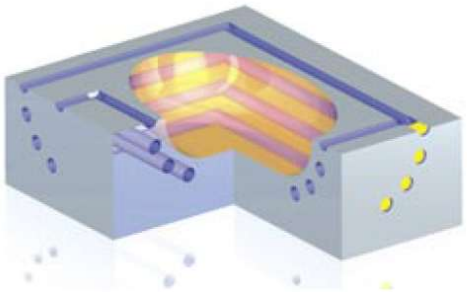
Coolant & Heater Layout



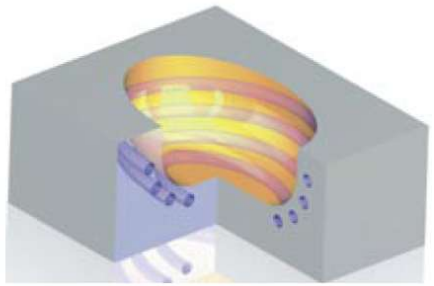


Funzionalità avanzate

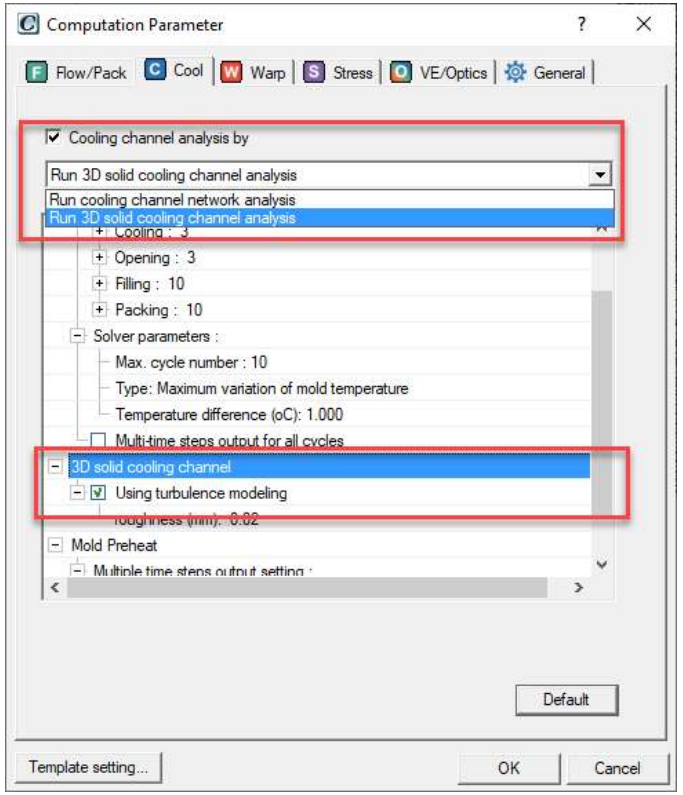
- Cooling channel analysis per raffreddamenti conformali.
  - Prevede la perdita di pressione, la distribuzione di velocità/temperatura all'interno dei canali e gli effetti della rugosità superficiale.



Conventional

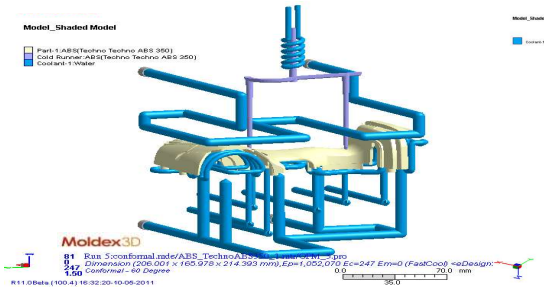


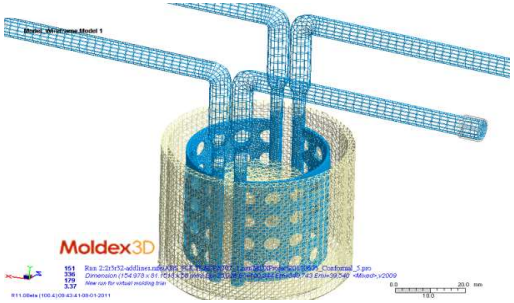
Conformal

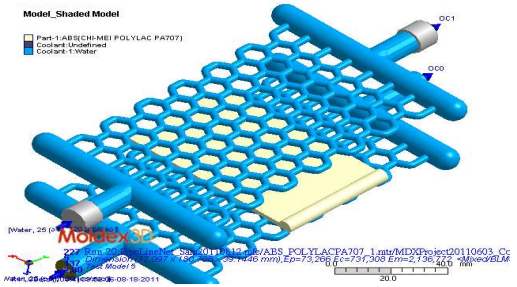


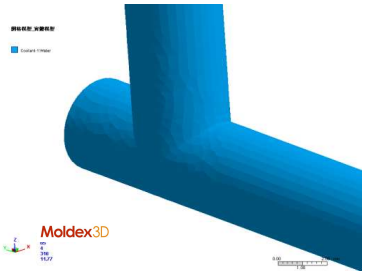
Funzionalità avanzate

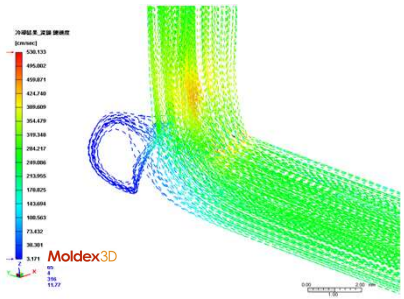
- Moldex3D può aiutare nello sviluppo di geometrie complesse grazie ai risultati specifici dell'analisi CFD.

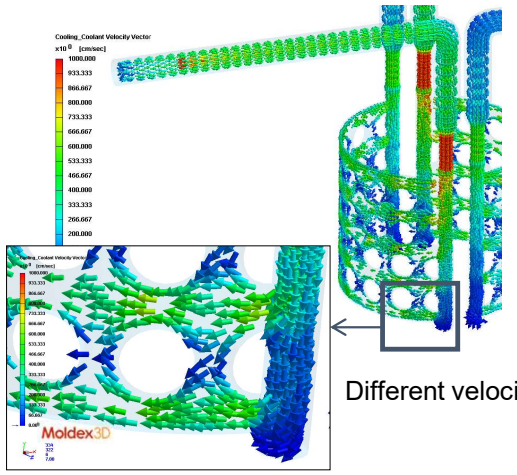










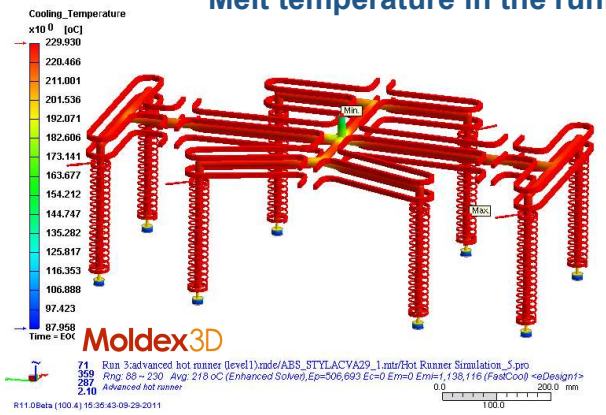


Different velocity

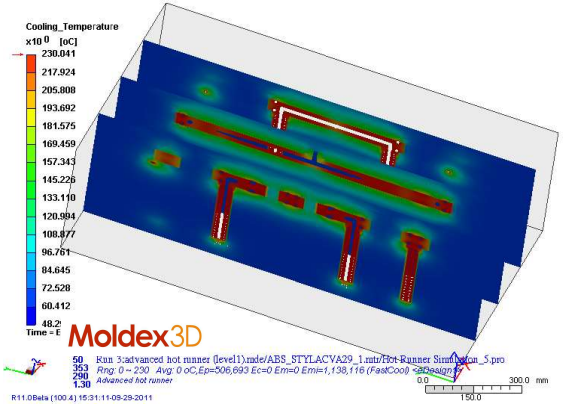
Funzionalità avanzate

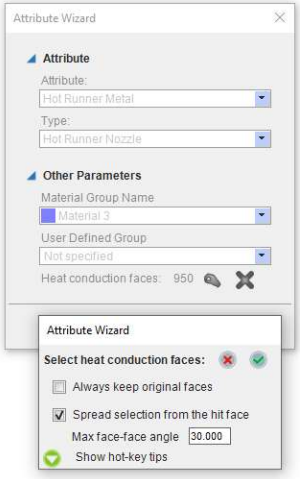
- Simulazione Advanced Hot Runner (AHR)
  - Supporta la modellazione completa della camera calda

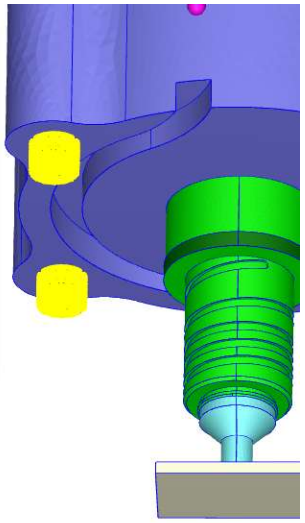
Melt temperature in the runner

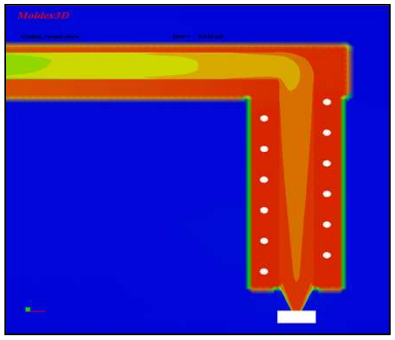


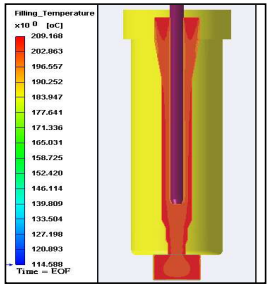
Mold temperature

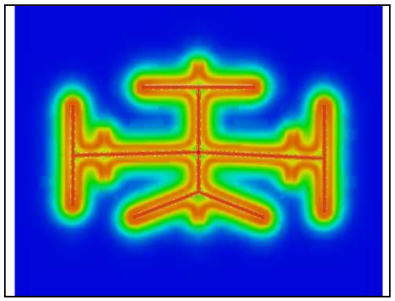


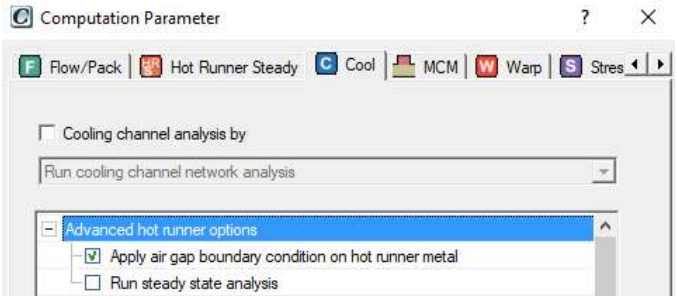






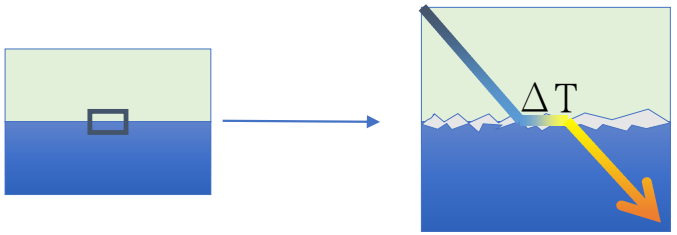


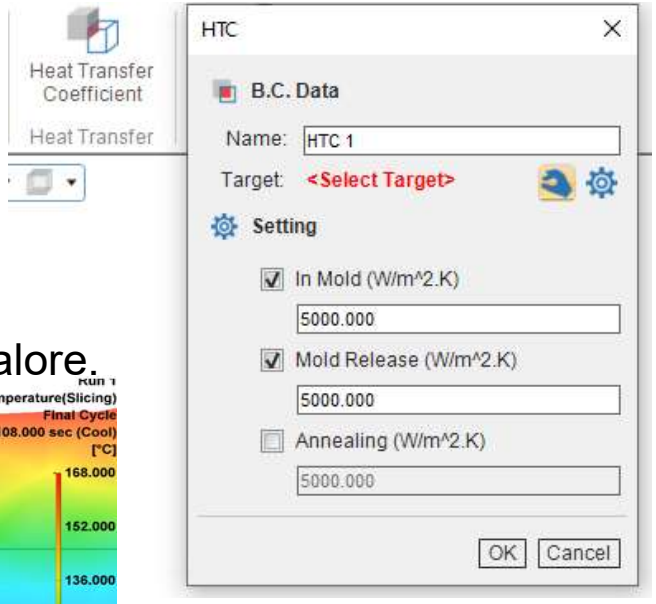




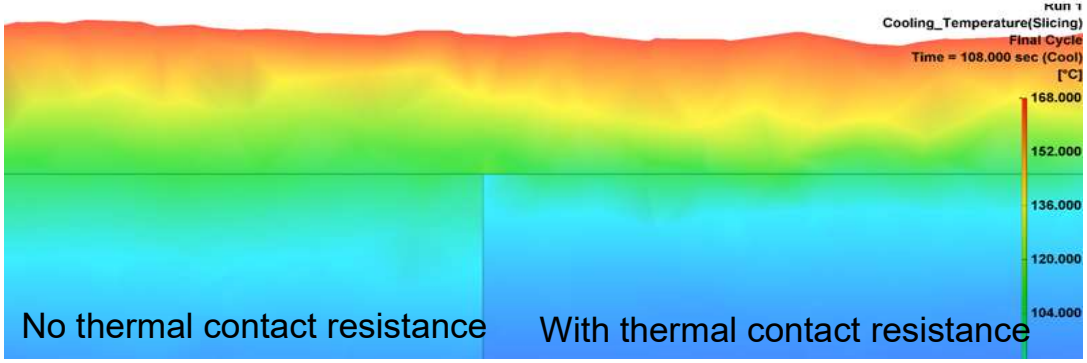
Funzionalità avanzate

- Simulazione dell'effetto di resistenza al contatto termico
  - Nell'analisi di raffreddamento, si presume che gli oggetti siano in perfetto contatto, ma nella realtà ciò non sempre avviene. Dal punto di vista microscopico, si verificheranno degli spazi tra i diversi oggetti. Questo effetto può essere simulato tramite l'HTC (coefficiente di scambio termico).



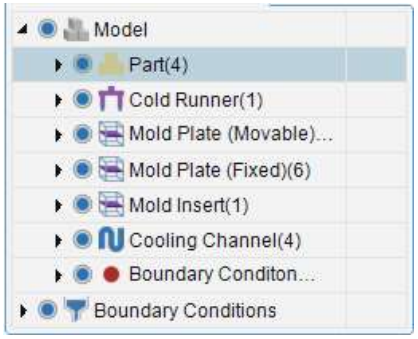


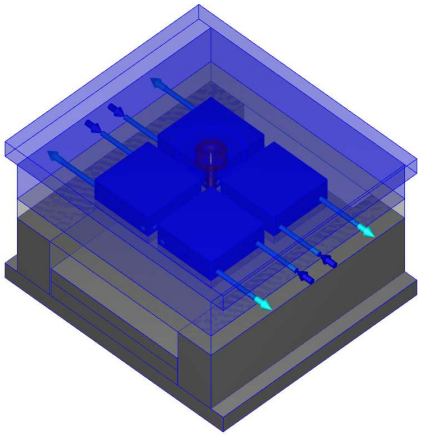
- Dopo aver considerato questo effetto di resistenza al contatto termico, possiamo evitare di sovrastimare il trasferimento di calore.

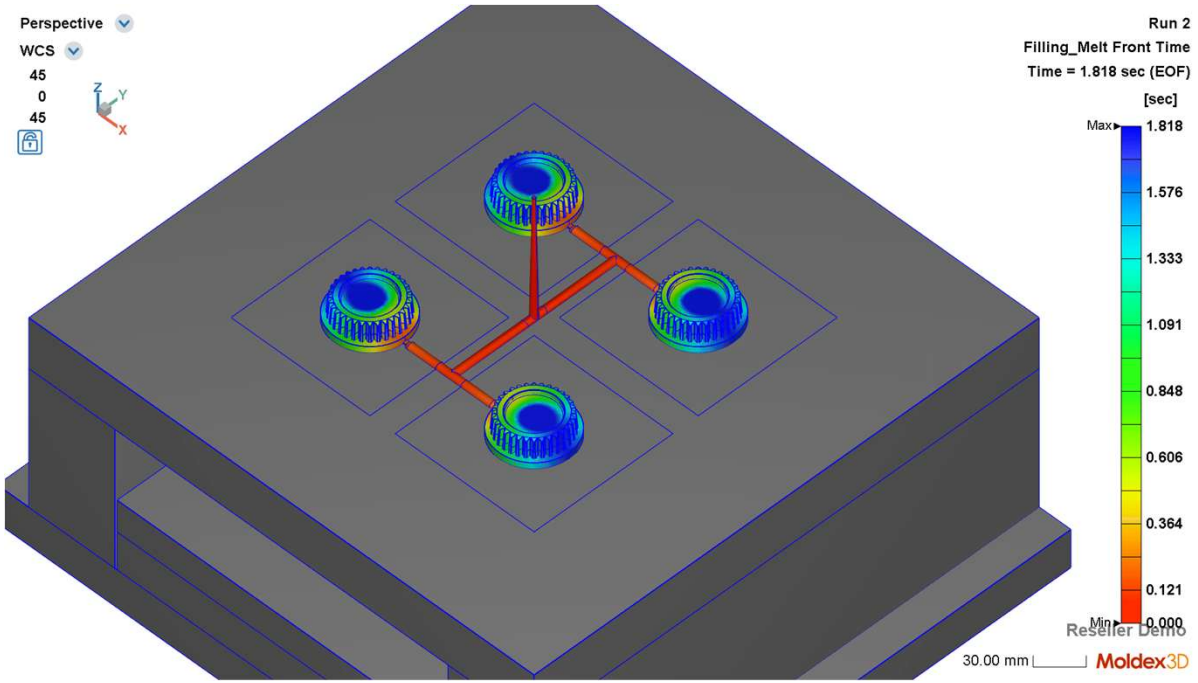


Funzionalità avanzate

- Simulazione con le piastre dello stampo
  - Analisi termica completa con tutti i componenti 3D dello stampo che hanno un impatto importante sulla distribuzione della temperatura.

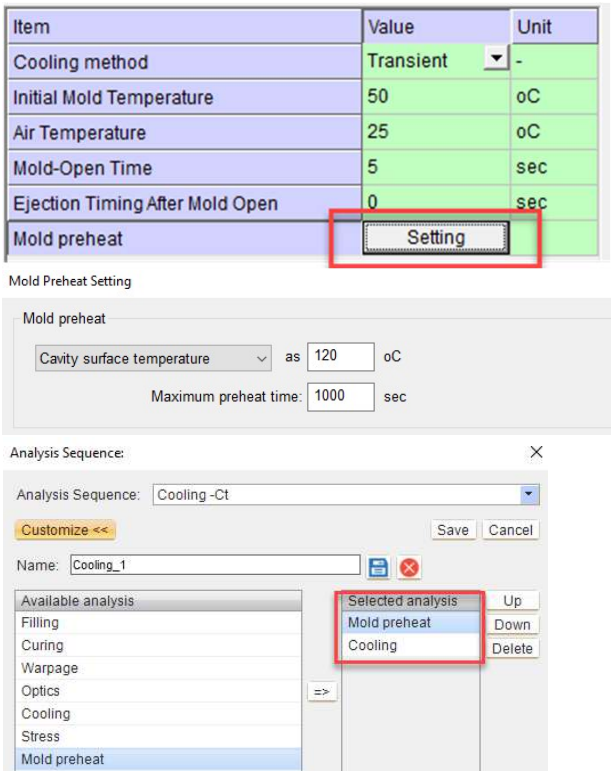


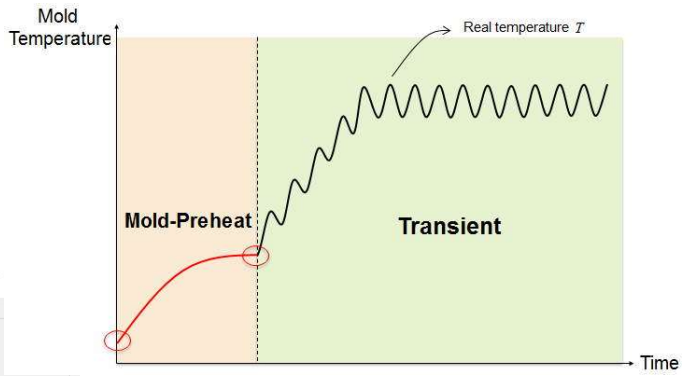


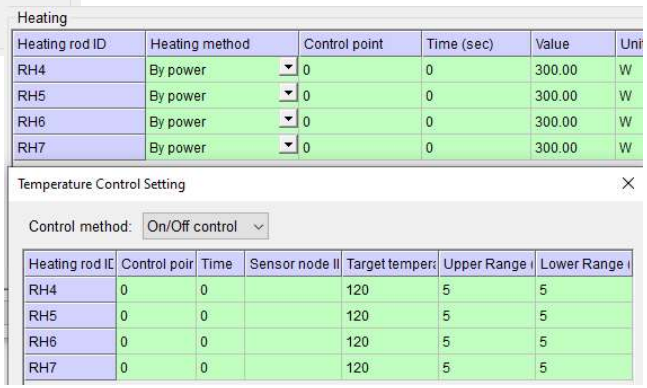


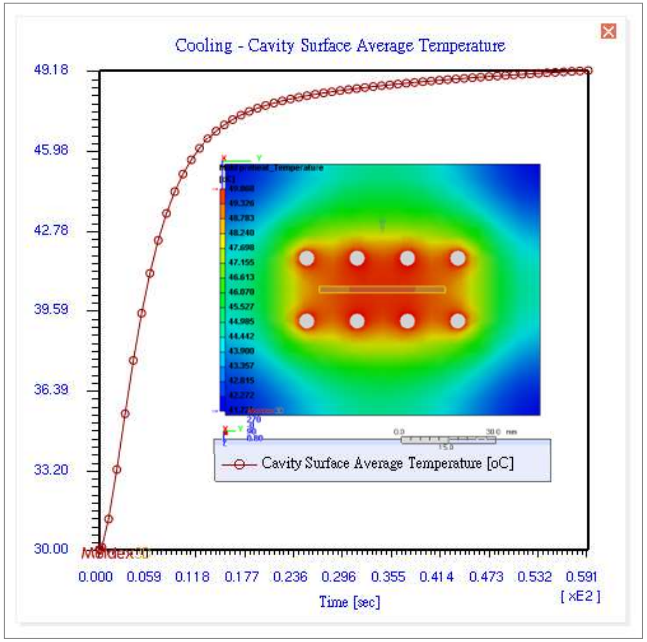
Funzionalità avanzate

- Simulazione dello stampo e analisi di preheat
  - Per ottenere una temperatura dello stampo più stabile, il preriscaldamento dello stampo è una tecnica comune utilizzata per riscaldare la base dello stampo prima dell'inizio di un ciclo di stampaggio.









Caso di studio – Frigel Syncro

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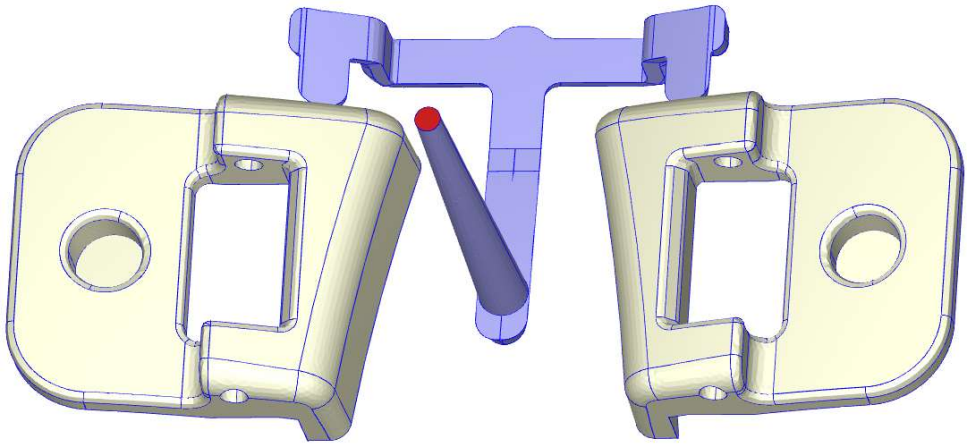
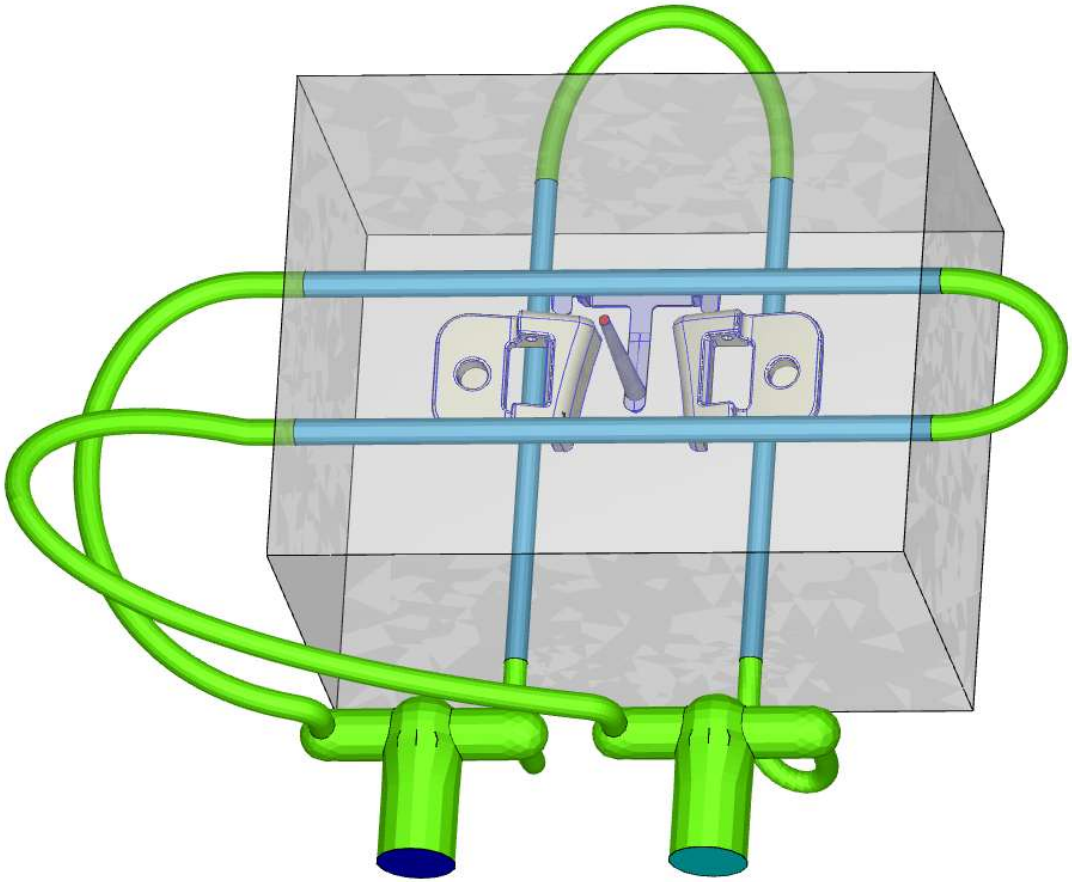
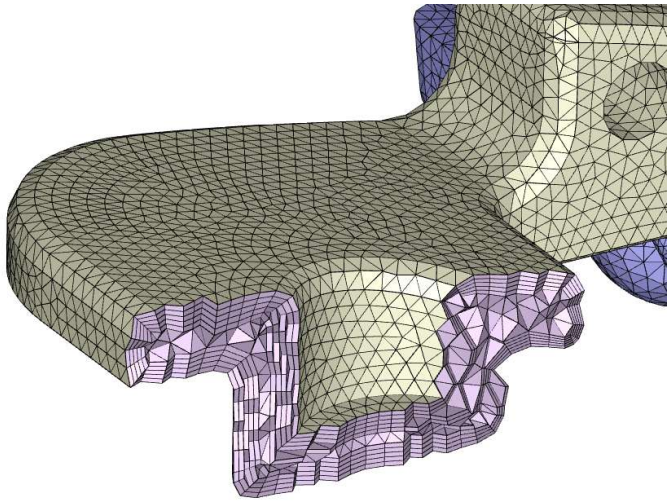
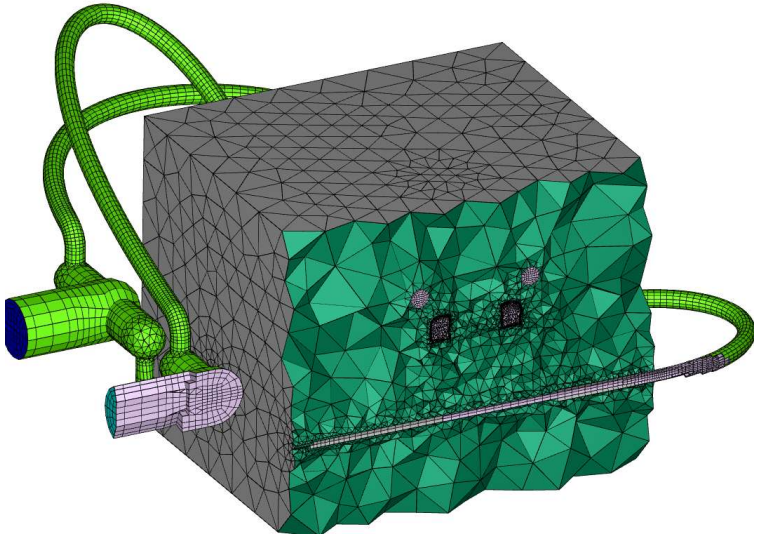
Modello





Mesh





Model Details	
Mesh Type	Solid
Solid Mesh Element Count	**805,942**
Part	355,044
Cold Runner	87,163
Moldbase	303,276
Cooling Channel	60,459
Surface Mesh Element Count	**54,340**
Part	41,544
Runner	12,796
Dimension	**mm**
Part	39.74x22.44x118.35
Mold	156.00x128.60x195.00
Projection Area	**cm²**
In Parting Direction (Z)	34.895
Volume	**cc**
Part	18.40
Cold Runner	3.42

Mesh solida BLM di tutto il modello.
Parte, materozza, raffreddamenti, distributore e stampo.
Totale elementi 0.8M.
Parte di piccole dimensioni: 40x45 mm circa.

Materiale

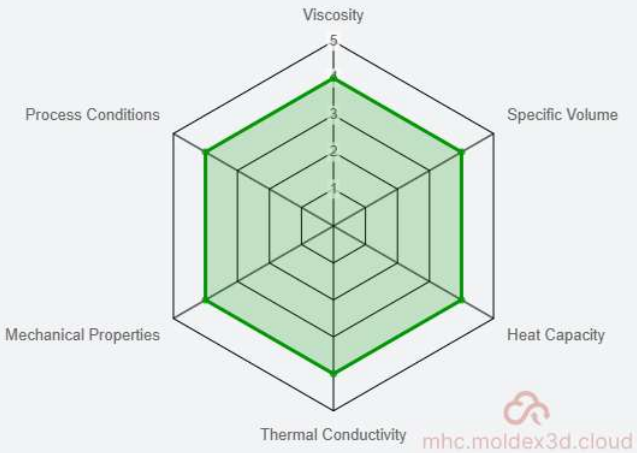
SCHULABLEND (ABS-PA) M-MK NC800 | ABS+PA | A. Schulman

Material File Version - 1.1.0

Overview | Viscosity | PVT | Heat Capacity | Thermal Conductivity | Mechanical Properties | Process Conditions

Quality Index Analysis

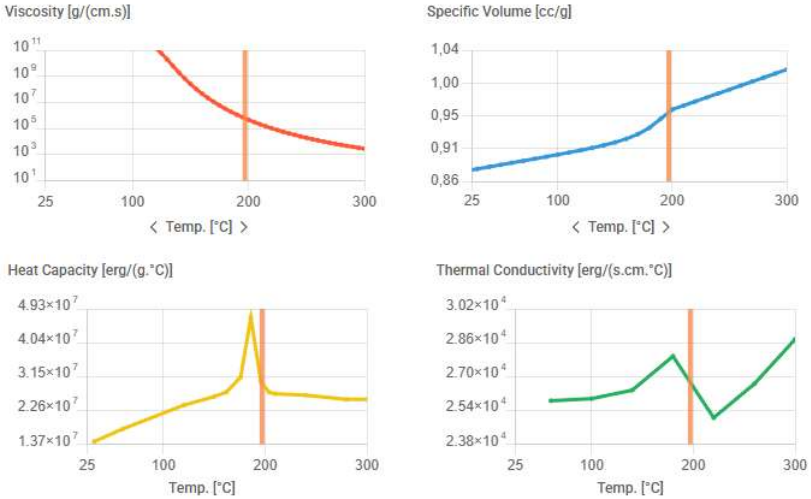
Quality Level : ☆☆☆



Mechanical Properties

Elastic Modulus 2.29E+010 [dyne/cm²]	Poisson's Ratio 0.390 [-]
CLTE 7.40E-005 [1/°C]	Filler Content None

Processing Curves

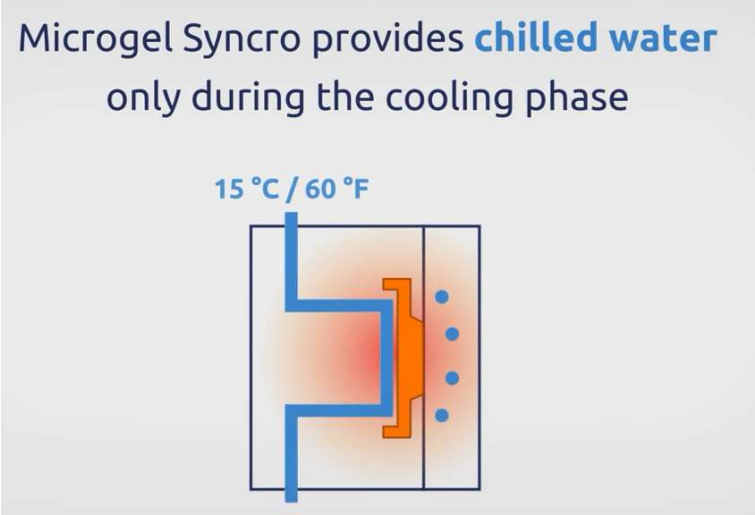


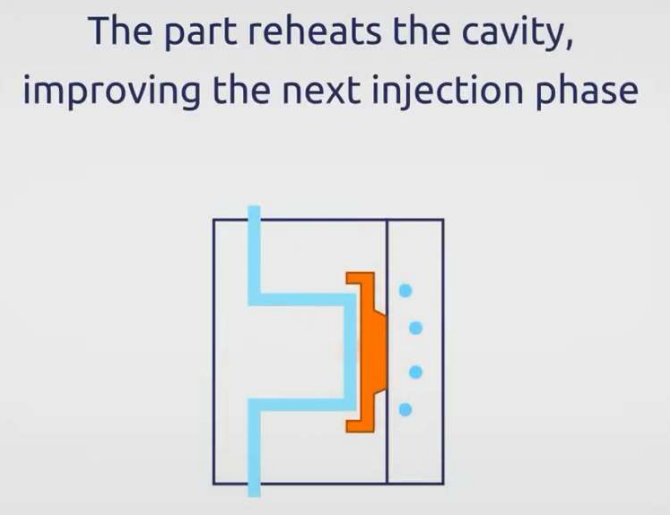
Process Conditions [Show Bar in Charts]

Transition Temp.	Melt Temp.	Freeze Temp.	Ejection Temp.	Mold Temp.	User Def. Temp.
197 [°C]	240 [°C]	196 [°C]	176 [°C]	60 [°C]	25 [°C]

Frigel Syncro

La *tecnologia Syncro* di Frigel consiste in una centralina brevettata che consente una **significativa riduzione del tempo ciclo (fino al 40%).**
Sincronizzata digitalmente con lo stampo, l'unità *Microgel Syncro* eroga acqua fredda solo durante la fase di raffreddamento, riducendo drasticamente i tempi di raffreddamento e mantenendo calde le cavità dello stampo durante la fase di iniezione.





Dati processo Syncro

Frigel
Intelligent Process Cooling

SYNCRO Test - Process Data and Test Result - R.201001

** Mandatory fields*

Date*	
Company name*	
Address	
City	
Country	
Web-site	
Contact name*	
Mobile phone*	
E-Mail*	
IMM - Machine ID - Model /TON*	engel 80
Available Mold open/closed signal - Digital OUTPUT? *	yes

Mold ID (name)*	Z0014A	
Part name and/or description (**add photos**)*	**Cerniera**	
Material (**resin**)*	**P.C. Sabic 223 R**	
Part maximum thickness	mm	2
Part minimum thickness	mm	3
Part weight	gr	
Number of cavities	n	2
Cold runners total weight (if any)	gr	
Hot runners (if any)*	kW	0
Total injection weight*	gr	20

Notes: The best solution is the E1 both for quality and for the reduction of cycle time. The customer believes that in order to improve the loose pin hole problem (not serious problem), he can reduce the die pin diameter by a few cents. After the machine has been stopped due to various problems, it is necessary to restart with the mold at about 70 ° C and then re-enter the syncro mode. The waiting time from machine stop to ok to restart is about 13-14 minutes. All this if the break is longer than about 5 minutes.

Test name (Recipe name)	**Traditional**													
Total Cycle Time*	sec	**31,6**									sec		sec	
Injection	sec	1									sec		sec	
Post-injection (holding)	sec	7									sec		sec	
Dosing time	sec	8,3									sec		sec	
Cooling time*	sec	18									sec		sec	
Open mold /part extraction/close mold	sec	5,5									sec		sec	
Actual dosing speed	rpm	45									rpm		rpm	
Maximum dosing speed	rpm										rpm		rpm	
Total throughput	kg/hr	2,28									kg/hr	#DIV/0!	kg/hr	#DIV/0!
Production rate	parts/hr	**114**									parts/hr	**#DIV/0!**	parts/hr	**#DIV/0!**

Syncro	
All circuits	
Not connected	
°C	20
%	100
%	0
Sec/10	0
Sec/10	
Sec	

Processo

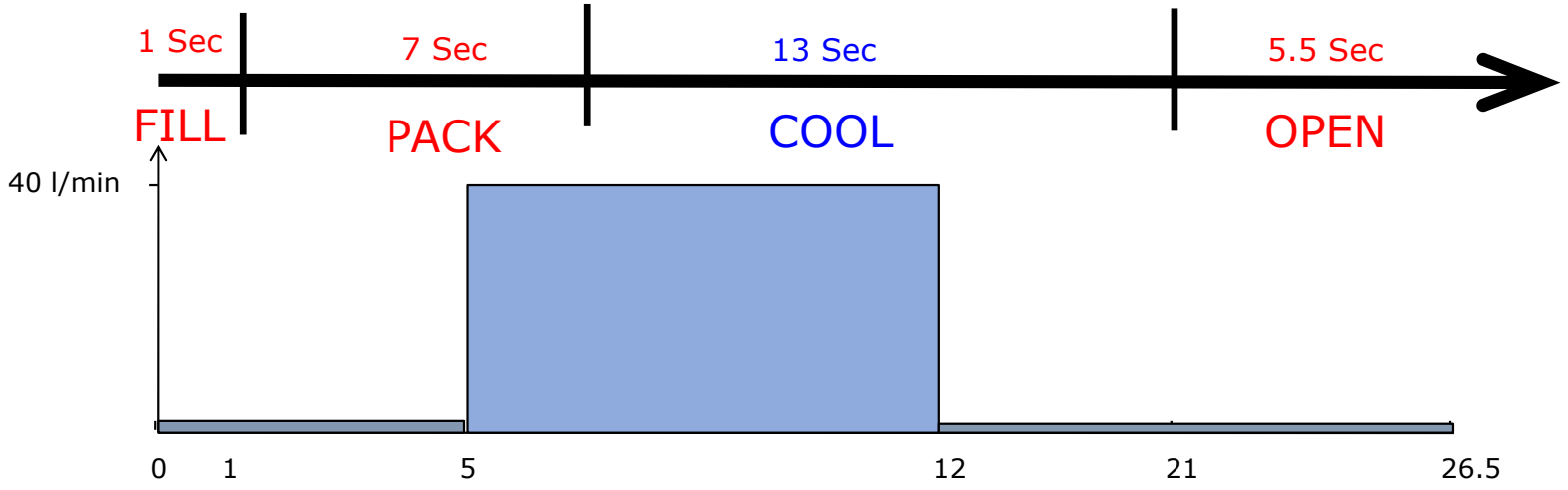
[Filling]	
Filling time (sec)	1
Melt Temperature (oC)	250
Mold Temperature (oC)	70
Maximum injection pressure (MP...	250
Injection volume (cm^3)	21.8267
[Packing]	
Packing time (sec)	7
Maximum packing pressure (MPa)	250
[Cooling]	
Cooling Time (sec)	13
Mold-Open Time (sec)	5.5
Eject Temperature (oC)	176
Air Temperature (oC)	18
[Miscellaneous]	
Cycle time (sec)	26.5

Cooling

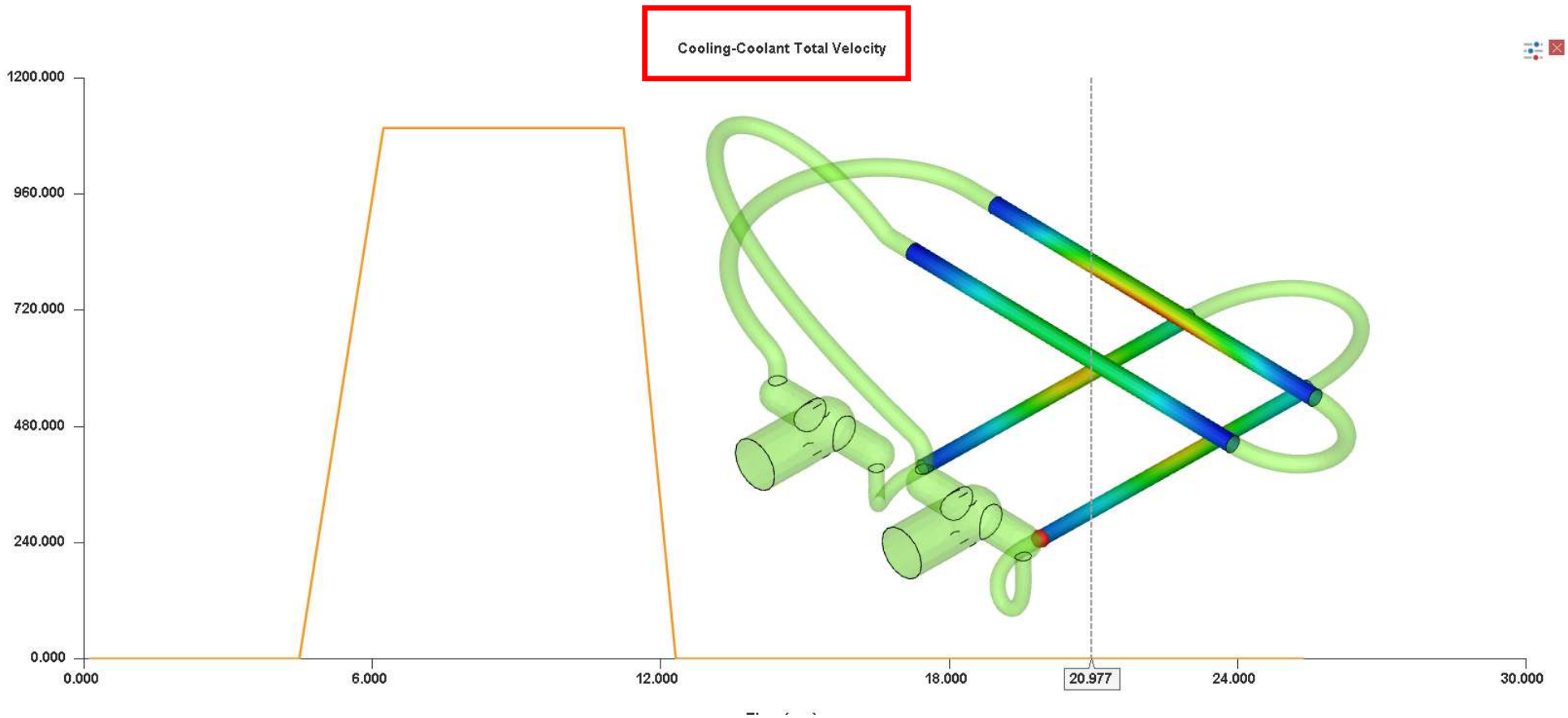
Setting : By flow rate

Coolant Inlet ID	Control point	Time (sec)	T (oC)	Q (l/min)	Coolant	D (mm)	Re
EC1 (Group 1)	2	0	20	0	Water	24	0
	1-1	5	20	40	Water	24	35177.5
	1-2	12	20	0	Water	24	0

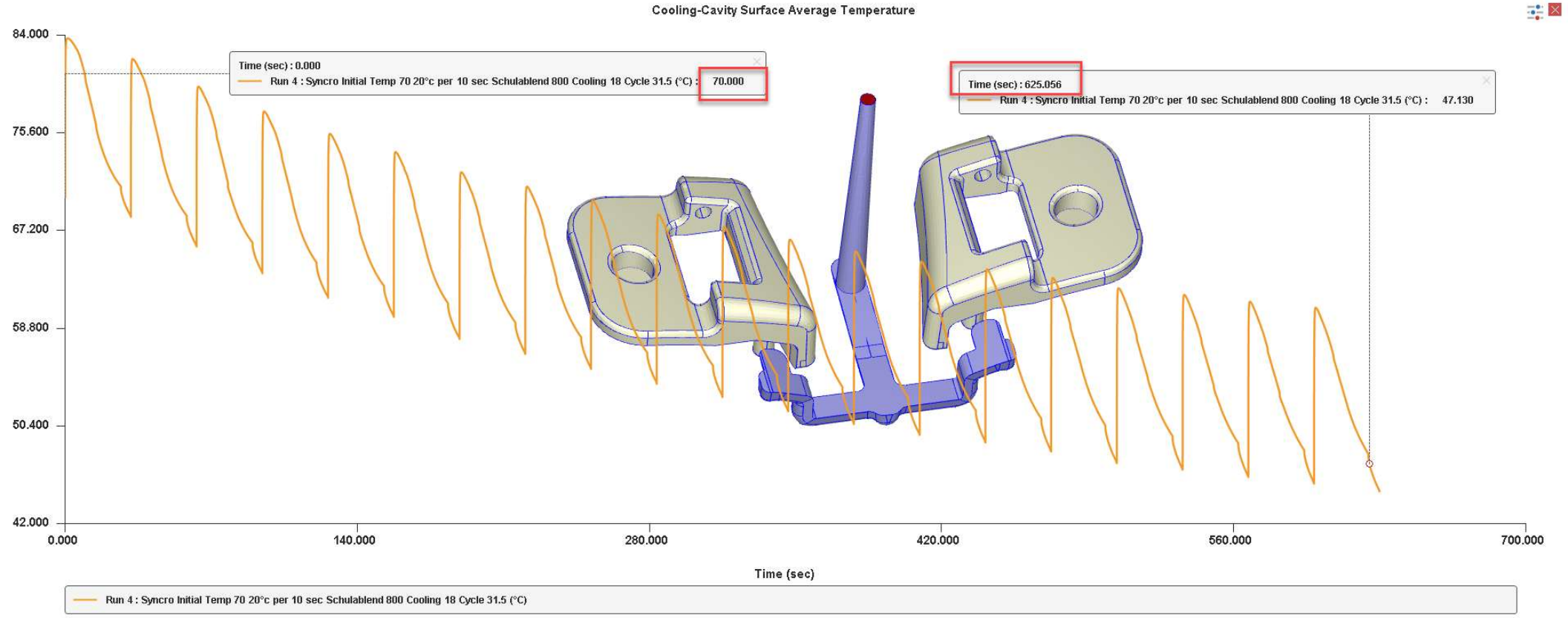
```
<Prediction of Gate-Freeze Time>
    Freeze Time of Gate #1      = 4.496 sec

    Freeze Time of Gate #2      = 4.496 sec
```



Velocità refrigerante

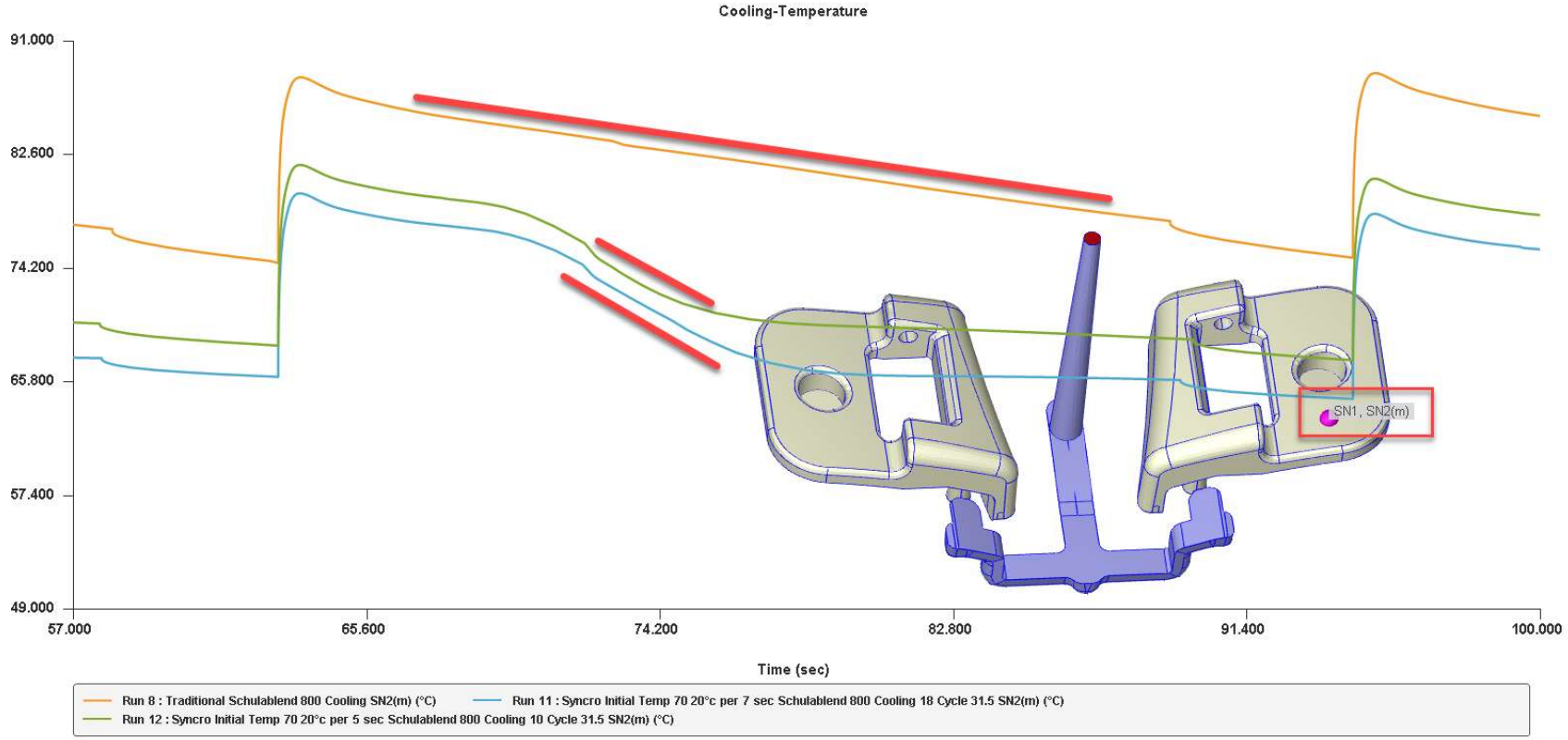


Cicli transitori



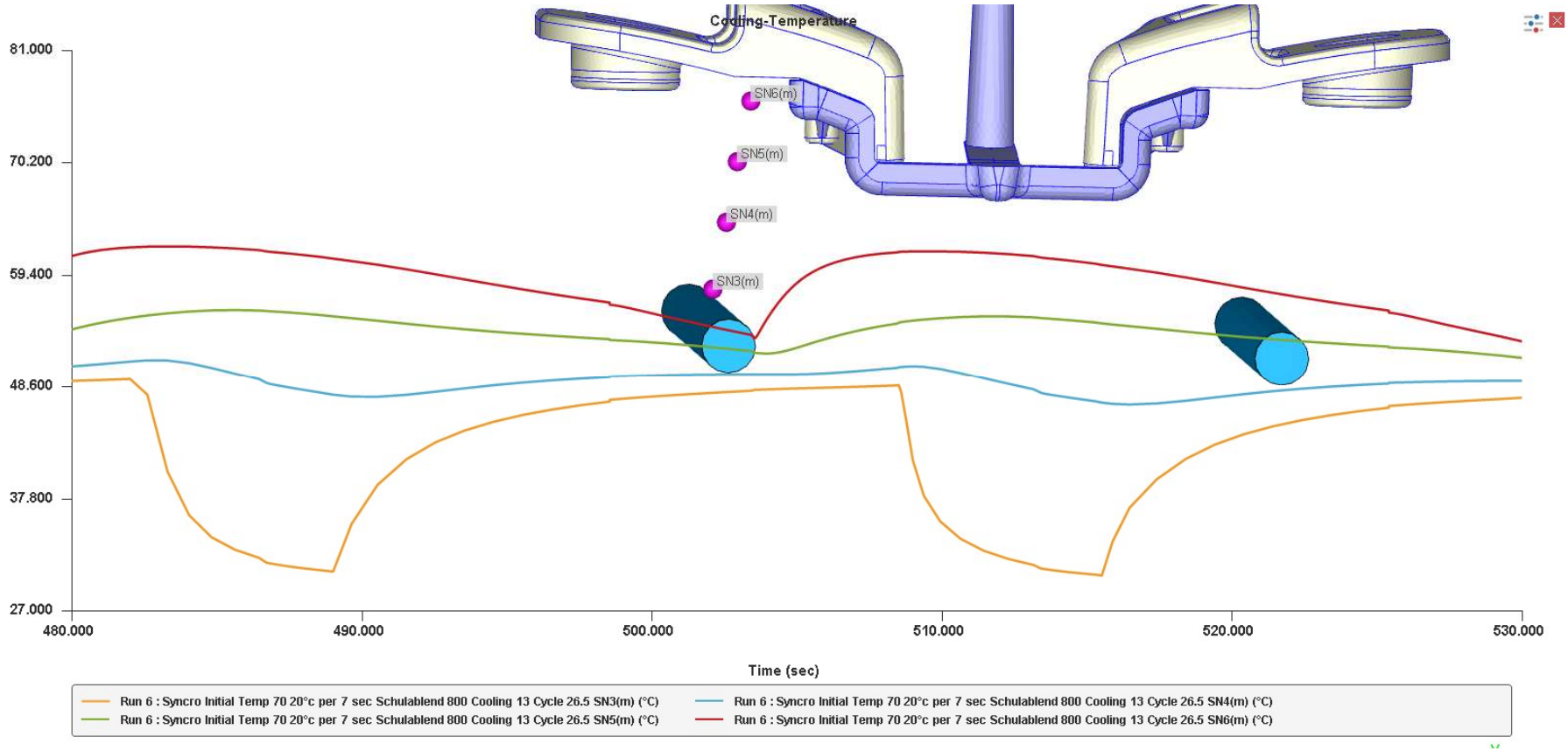
Cicli Syncro

La temperatura superficiale della cavità nei raffreddamenti con attivo il SYNCRO si abbassa più velocemente rispetto ad un raffreddamento tradizionale e la durata del SYNCRO determina a che range di temperatura lavorerà lo stampo.



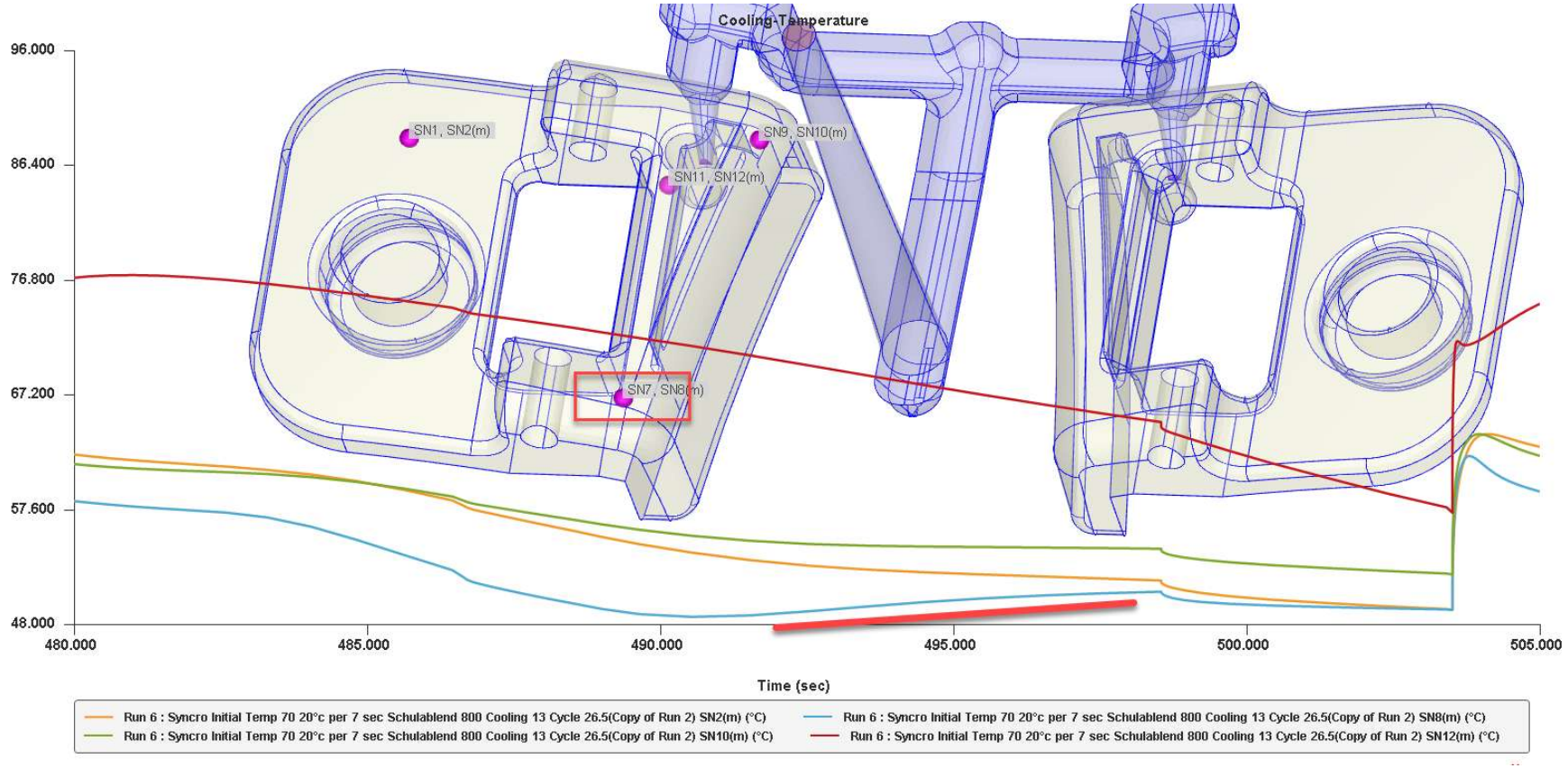
Cicli Syncro

Le temperature dello stampo appena ci allontaniamo dal foro di raffreddamento sono meno sensibili al processo di accensione e spegnimento dell'acqua nei circuiti



Cicli Syncro

Aumento della temperatura stampo finita la fase di raffreddamento



Confronto ciclo Syncro Vs ciclo tradizionale

Ciclo 31.5 «Tradizionale»

[Filling]	
Filling time (sec)	1
Melt Temperature (oC)	250
Mold Temperature (oC)	70
Maximum injection pressure (bar)	2500
Injection volume (cm^3)	21.8267
[Packing]	
Packing time (sec)	7
Maximum packing pressure (bar)	2500
[Cooling]	
Cooling Time (sec)	18
Mold-Open Time (sec)	5.5
Eject Temperature (oC)	176
Air Temperature (oC)	18
[Miscellaneous]	
Cycle time (sec)	31.5

Cooling

Setting : By flow rate

Coolant Inlet ID	T (oC)	Q (l/min)	Coolant	D (mm)	Re
EC1 (Group 1)	Refer to Mold Temperature	20	Water	24	43163.4

Ciclo 26.5 7 sec. cooling 20°C

[Filling]	
Filling time (sec)	1
Melt Temperature (oC)	250
Mold Temperature (oC)	70
Maximum injection pressure (bar)	2500
Injection volume (cm^3)	21.8267
[Packing]	
Packing time (sec)	7
Maximum packing pressure (bar)	2500
[Cooling]	
Cooling Time (sec)	13
Mold-Open Time (sec)	5.5
Eject Temperature (oC)	176
Air Temperature (oC)	18
[Miscellaneous]	
Cycle time (sec)	26.5

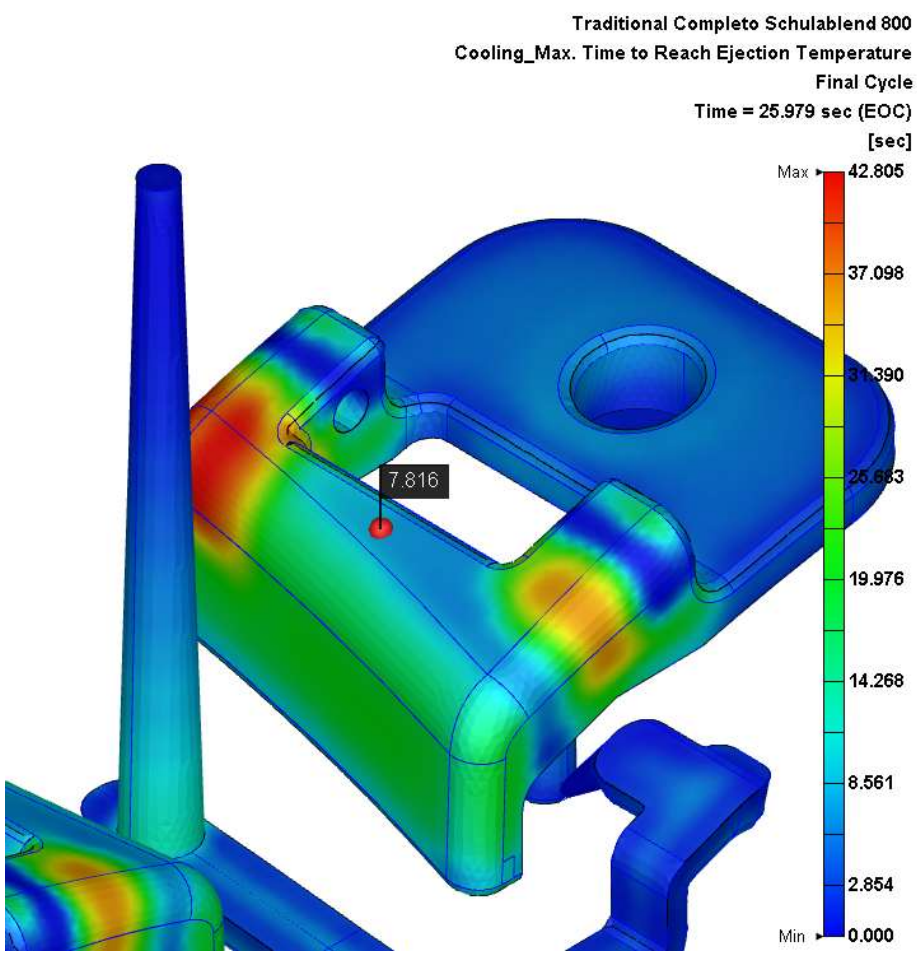
Cooling

Setting : By flow rate

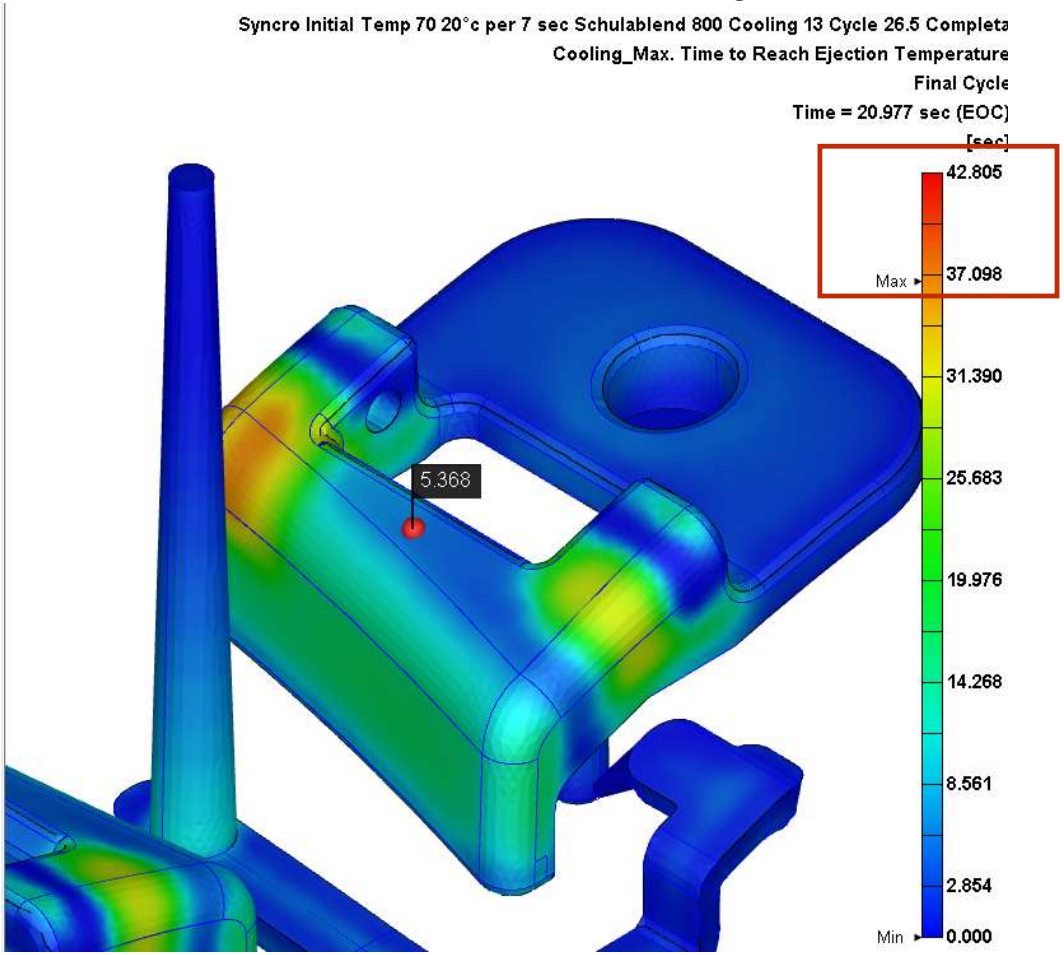
Coolant Inlet ID	Control point	Time (sec)	T (oC)	Q (l/min)	Coolant	D (mm)	Re
EC1 (Group 1)	2	0	20	0	Water	24	0
	1-1	5	20	40	Water	24	35177.5
	1-2	12	20	0	Water	24	0

Confronto ciclo Syncro Vs ciclo tradizionale

Ciclo 31.5 «Tradizionale»

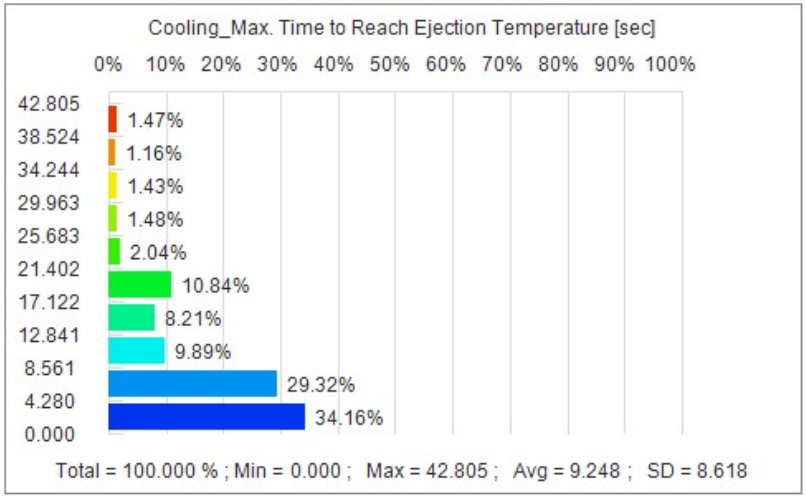


Ciclo 26.5 7 sec. cooling 20°C

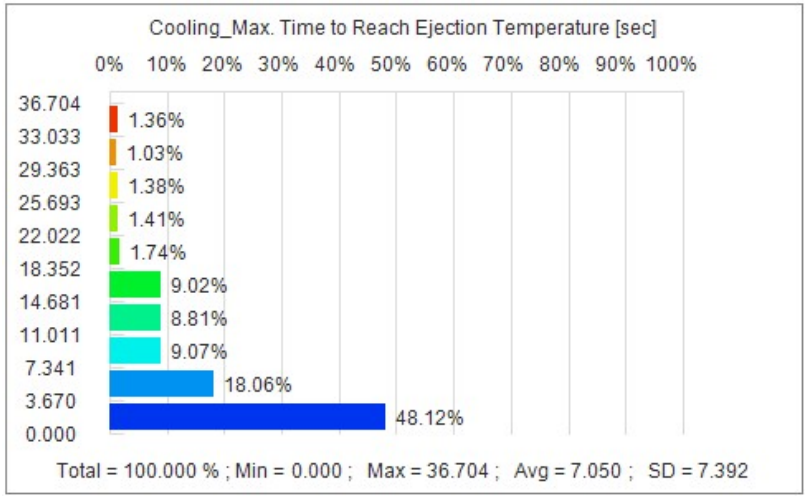


Confronto ciclo Syncro Vs ciclo tradizionale

Ciclo 31.5 «Tradizionale»

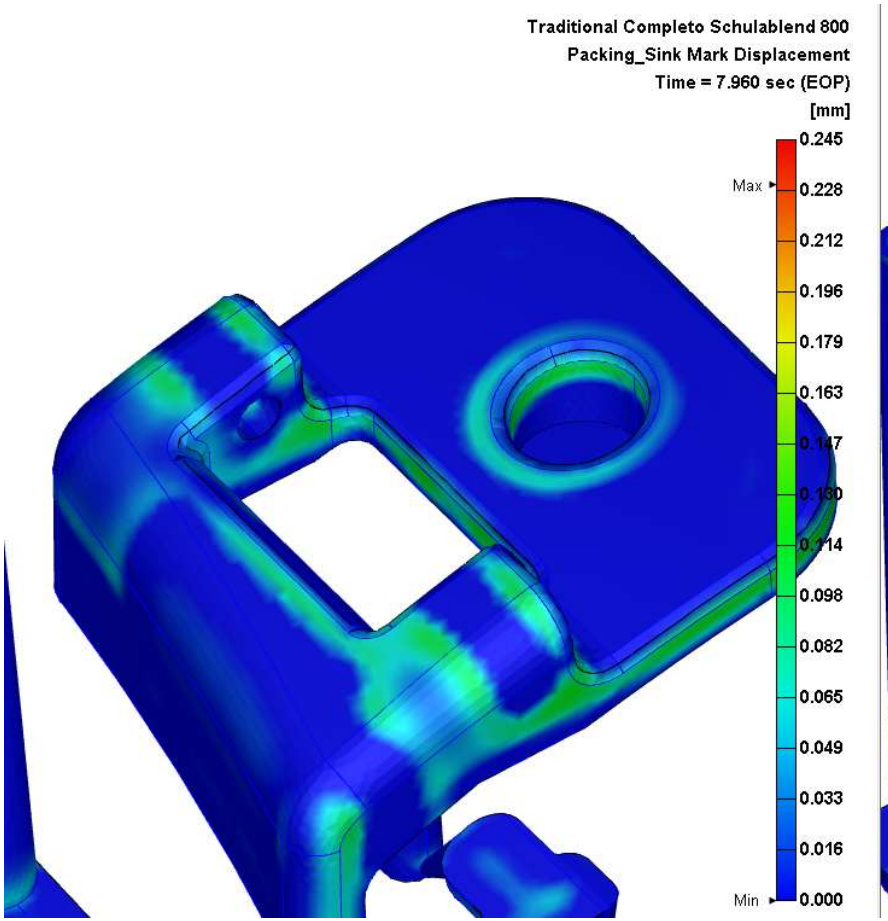


Ciclo 26.5 7 sec. cooling 20°C

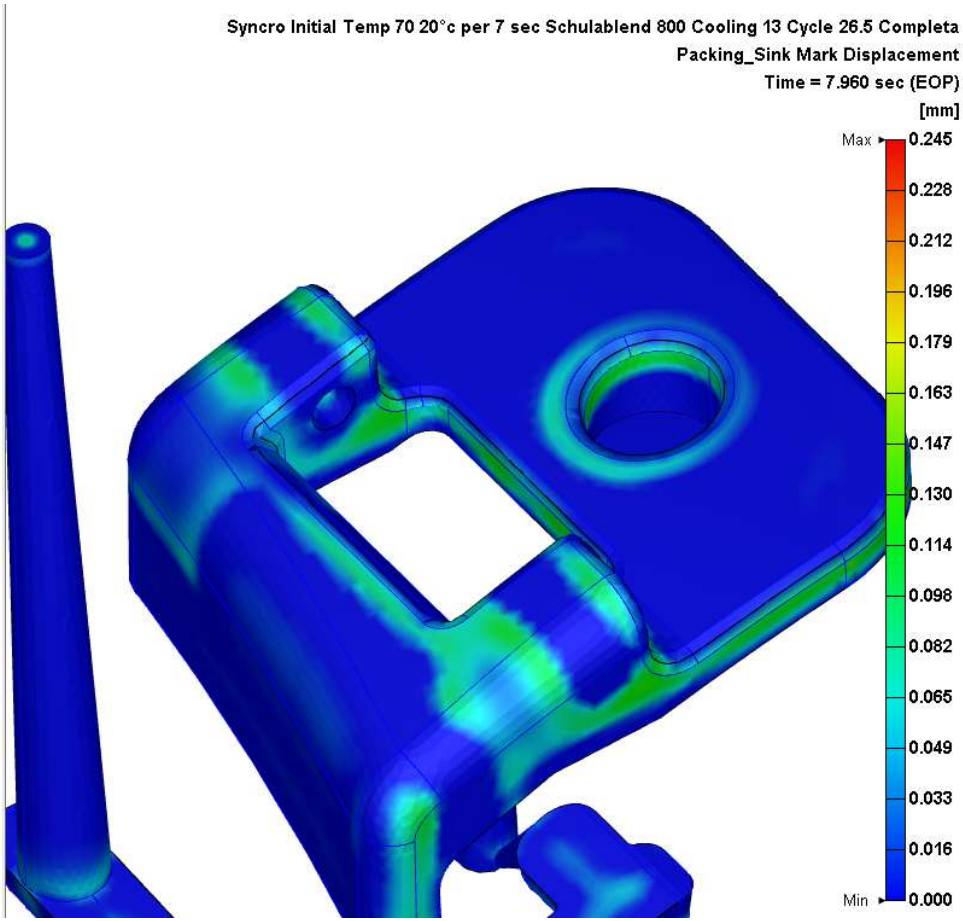


Confronto ciclo Syncro Vs ciclo tradizionale

Ciclo 31.5 «Tradizionale»

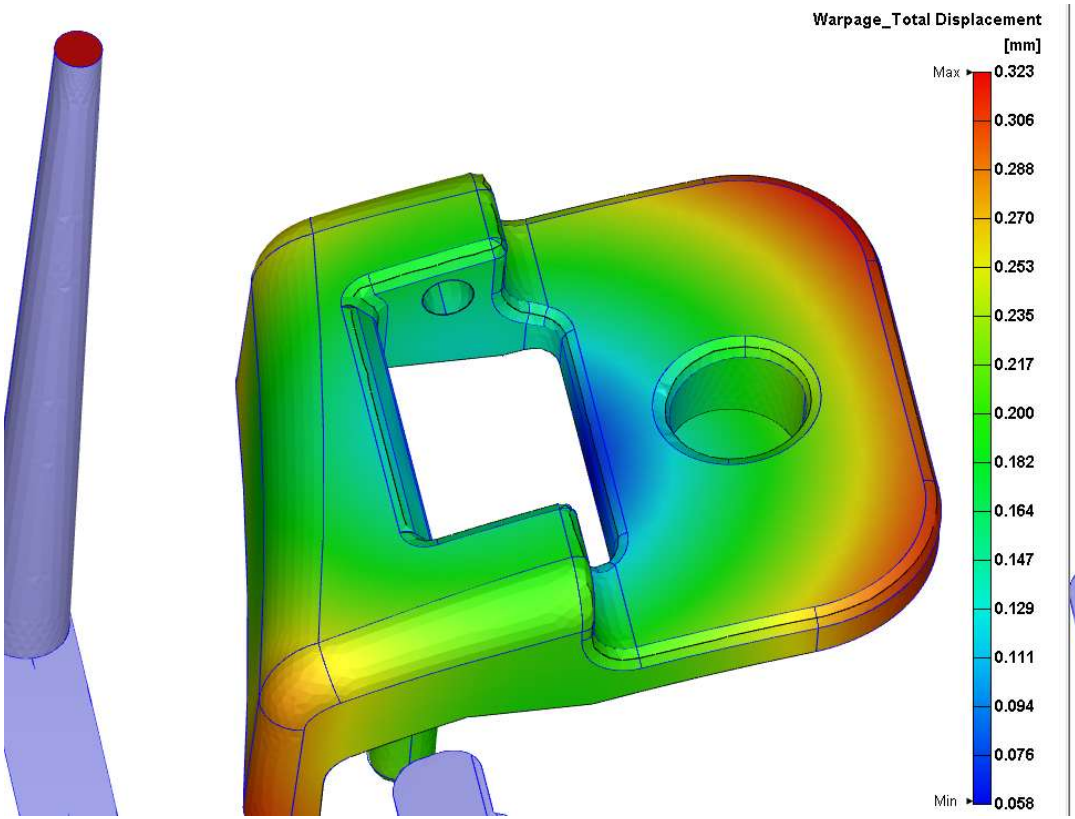


Ciclo 26.5 7 sec. cooling 20°C

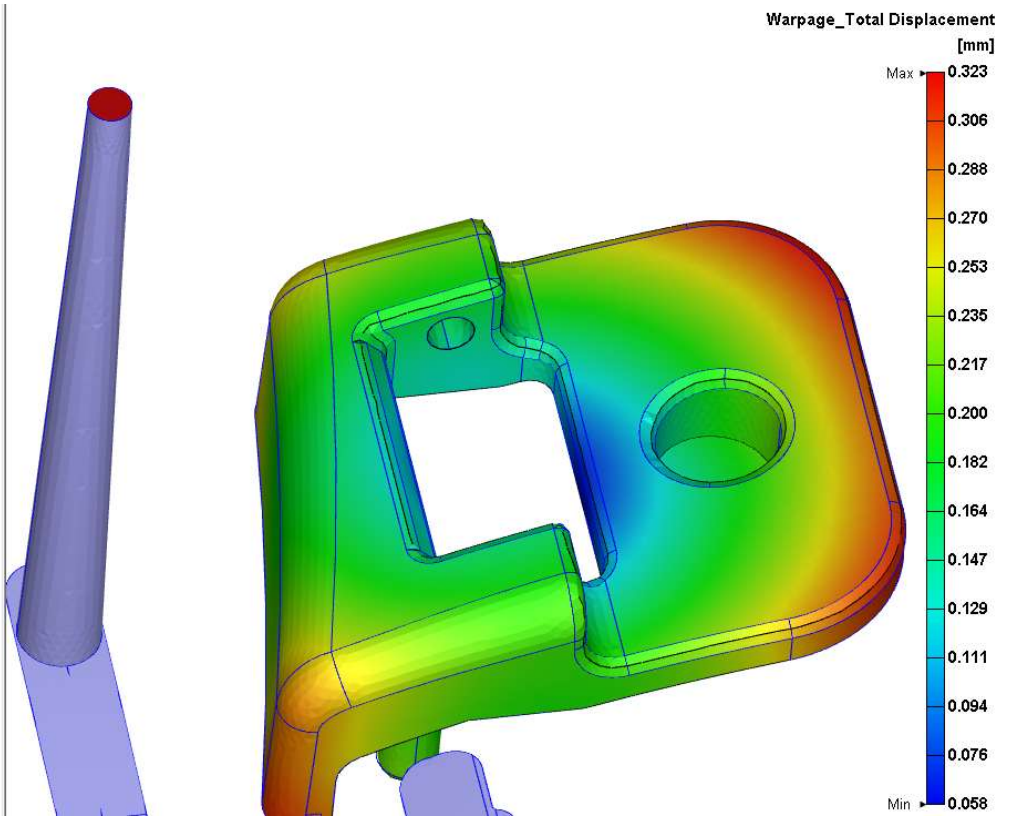


Confronto ciclo Syncro Vs ciclo tradizionale

Ciclo 31.5 «Tradizionale»



Ciclo 26.5 7 sec. cooling 20°C



Conclusioni

Tutto lo studio riguardante l'implementazione di un sistema di raffreddamento come il Syncro di Frigel può essere supportato da Moldex3D grazie alla simulazione termica utilizzando le seguenti funzioni:

- Analisi dei transitori termici nel ciclo (in questo caso variazione di portata)

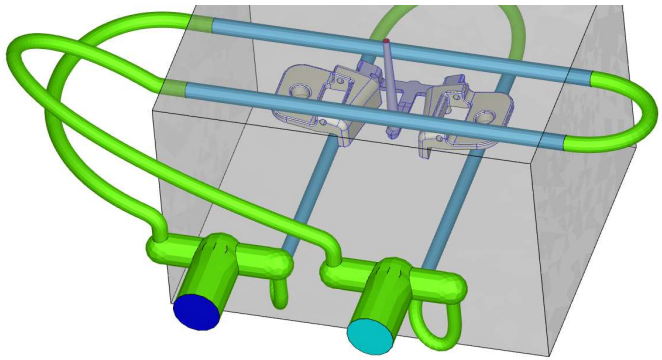
Item	Value	Unit
Cooling method	Transient	-
Initial Mold Temperature	70	oC
Air Temperature	18	oC
Eject Temperature	176	oC
Cooling Time	13	sec
Mold-Open Time	5.5	sec
Ejection Timing After Mold Open	0	sec
Mold preheat	Setting	

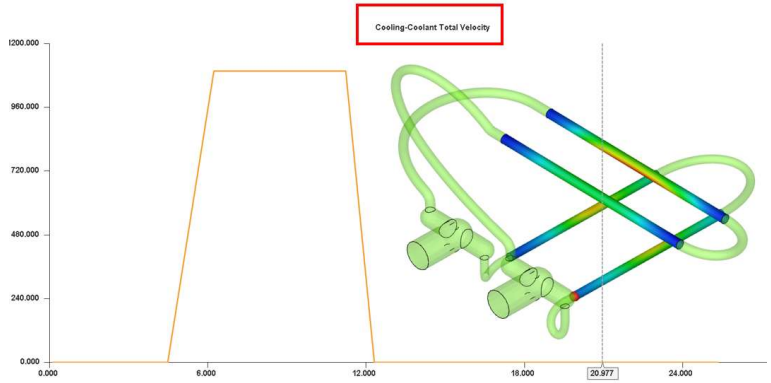
Cooling

Setting : By flow rate

Coolant Inlet ID	Control point	Time (sec)	T (oC)	Q (l/min)	Coolant	D (mm)	Re
EC1 (Group 1)	2	0	20	0	Water	24	0
	1-1	5	20	40	Water	24	35177.5
	1-2	12	20	0	Water	24	0

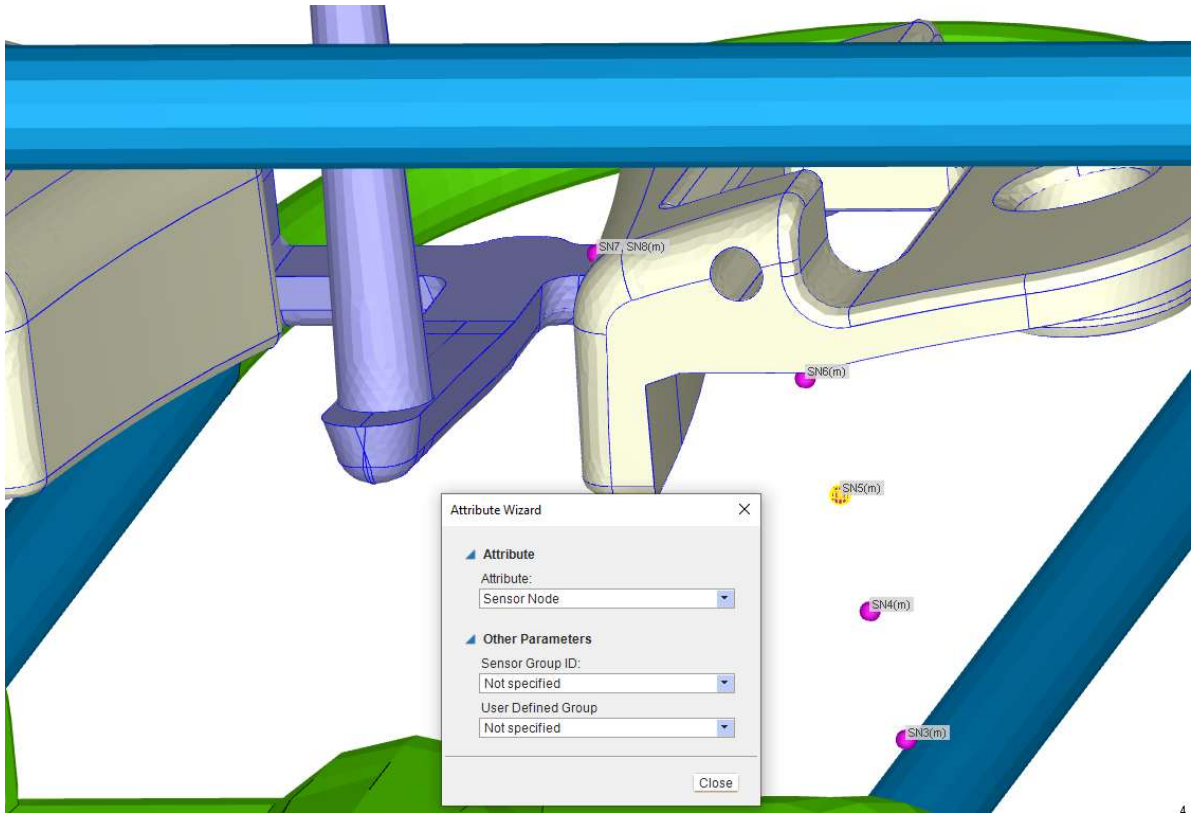
- Realistica rappresentazione del distributore

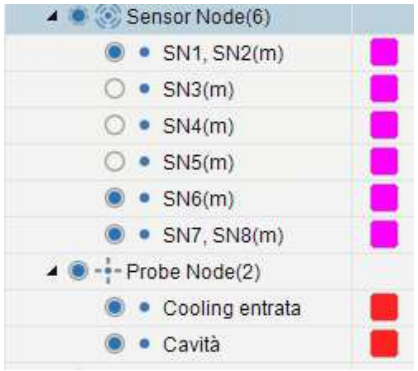




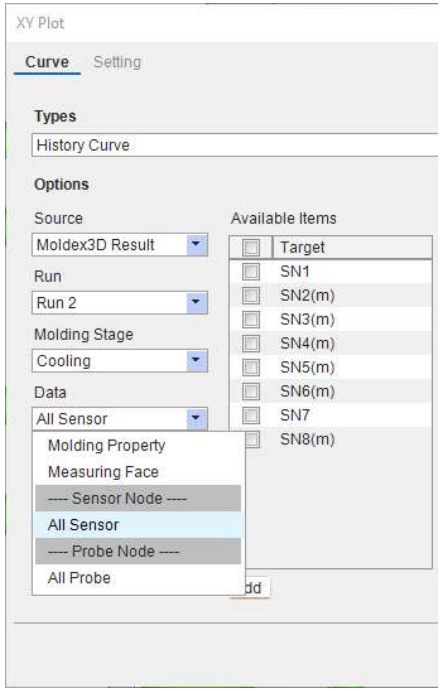
Conclusioni

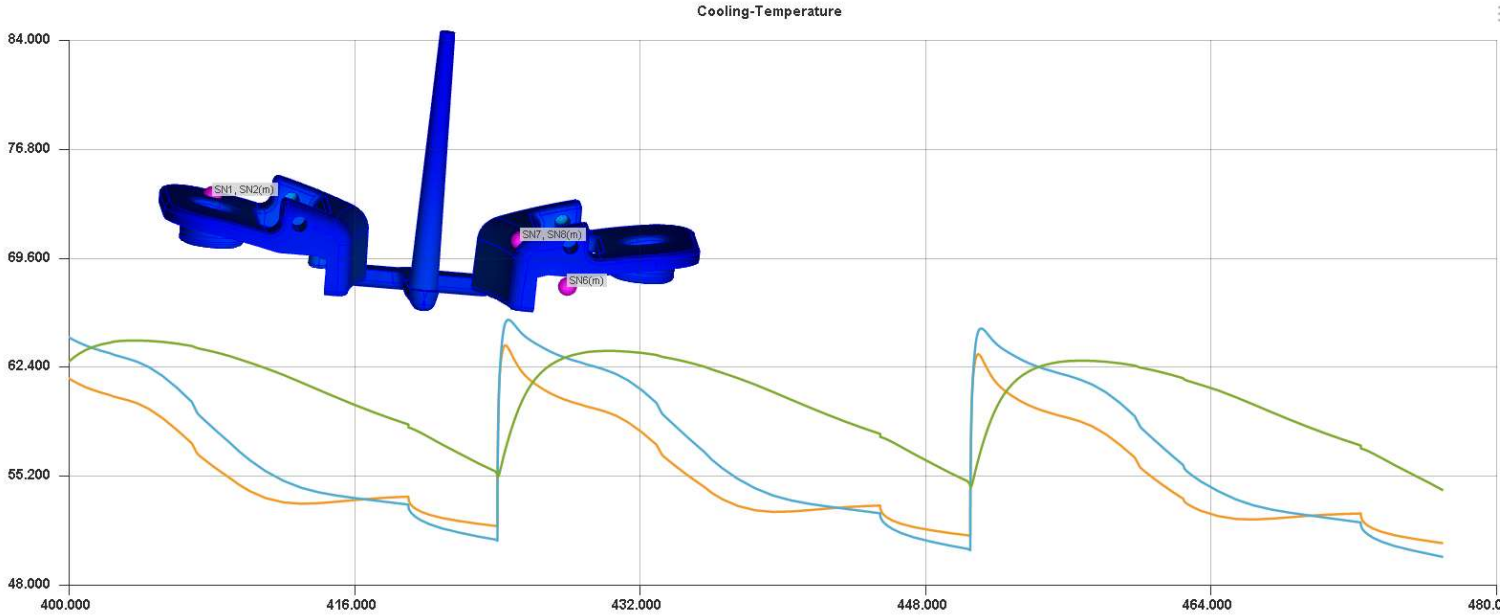
- Utilizzo di due tipologie di sensori sulla cavità e nello stampo (sensor e probe node)

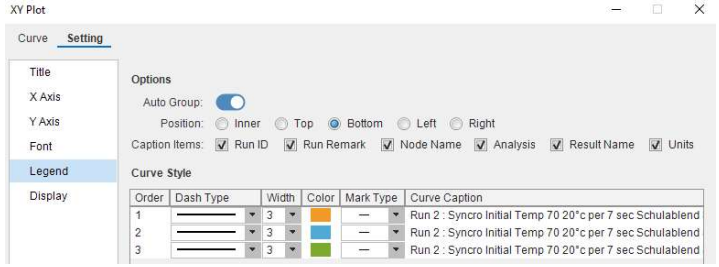




Conclusioni








Grazie per l’attenzione