

mid Moulding
Innovation
Day 2024

Simulazioni Moldex3D

Applicazioni innovative e non convenzionali

Proplast
Andrea Romeo
Marta Palenzona

Moldex3D

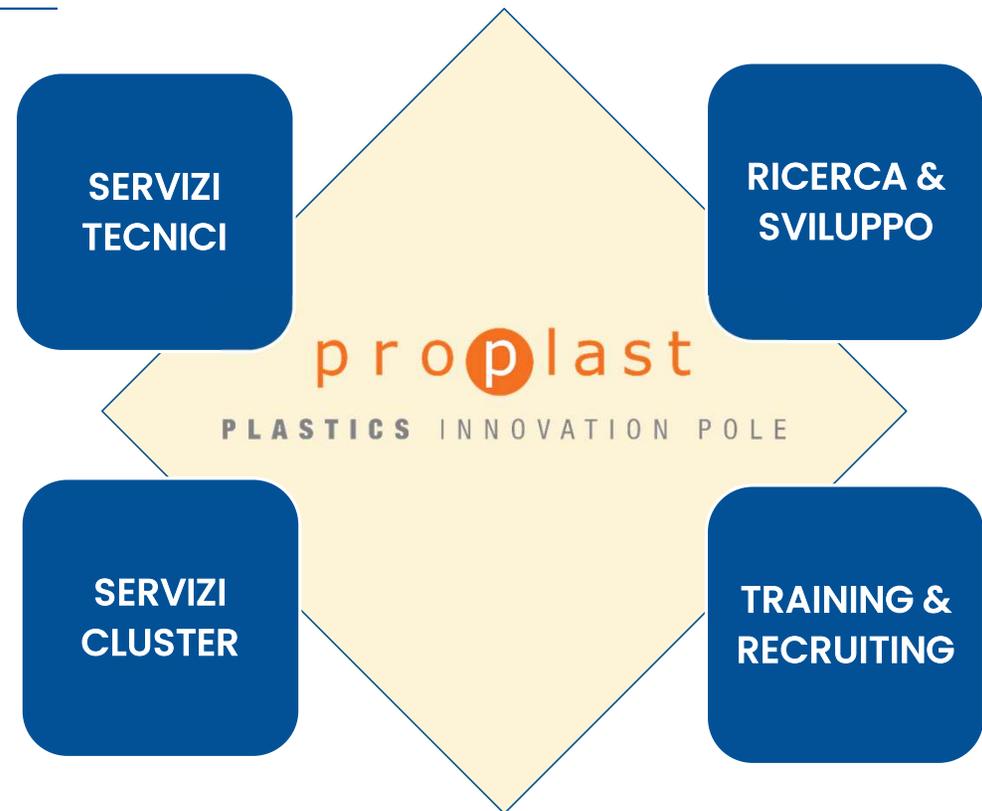


Proplast è un centro R&D privato, riconosciuto anche come cluster, le cui aziende associate appartengono alla filiera industriale dei **polimeri** e dei **compositi**. È Co-gestore del Polo di Innovazione Regione Piemonte.



La nostra strategia

Creare un **rapporto di fiducia** con il mondo industriale, offrendo una gamma completa di servizi per migliorare la loro competitività.



I nostri servizi



INGEGNERIA DEI MATERIALI

Selezione materiali e fornitori in base all'applicazione, compounding, analisi di laboratorio (caratterizzazione termica, fisica chimica, meccanica, ecc.).



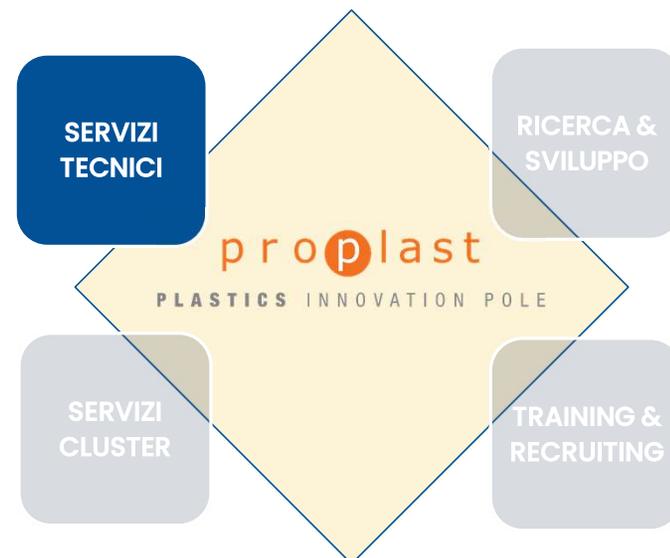
INGEGNERIA DI PROCESSO

Stampaggio a iniezione, tradizionale e con tecnologie innovative (Mucell®, Roctool®, Heat&Cool mediante acqua/olio), filmatura, termoformatura, trasformazione di compositi termoindurenti, stampa 3D.



INGEGNERIA DI PRODOTTO

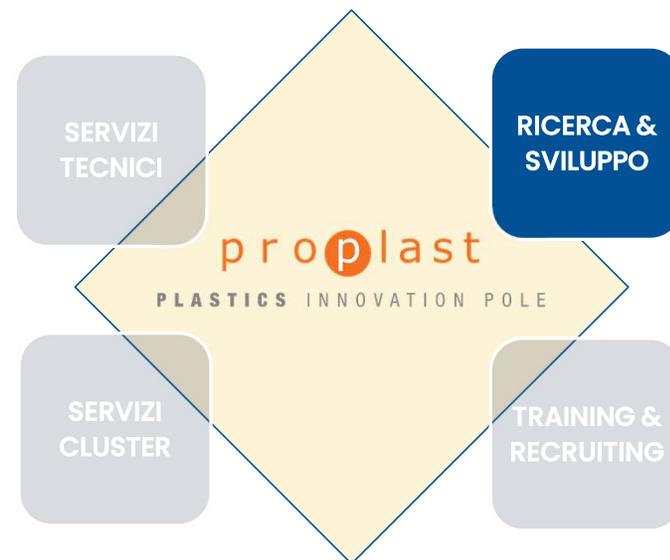
Progettazione stampi e manufatti, realizzazione stampi per stampaggio a iniezione, stampaggio preserie, rapid prototyping, calcoli strutturali, simulazioni di processo e di flusso.



I nostri servizi

Competenza nel R&D per i materiali polimerici e compositi per lo sviluppo di soluzioni più adatte in ambito tecnico, formativo e amministrativo.

Collaborazione con il proprio network di aziende, enti di ricerca internazionali e università e partecipazione attiva a progetti di ricerca finanziati da fondi Regionali, Nazionali ed Europei



P.Ri.S.Ma. MED2



FRONTSHIP



RIVAL
Rilevazione Virale rApida
tramite Lab on a chip



I nostri servizi

RICERCA E SELEZIONE

ORIENTAMENTO E FORMAZIONE

FORMAZIONE AZIENDALE

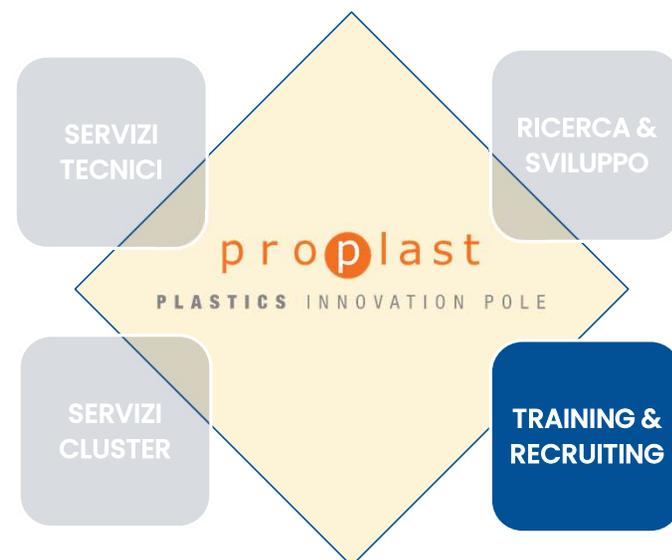
PERCORSI FORMATIVI CUSTOMIZZATI

PERCORSI DI COACHING

WEBINAR



CALENDARIO
CORSI 2023



I nostri servizi

NETWORKING

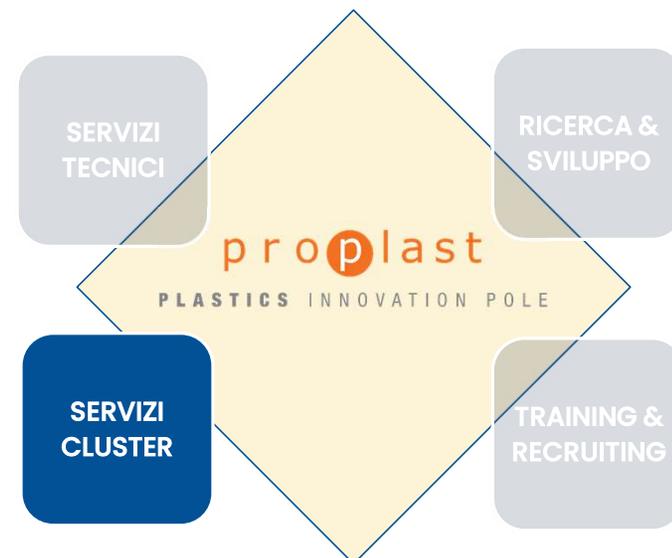
BANDI DI FINANZIAMENTO

INTERNAZIONALIZZAZIONE

PROGETTI FINANZIATI DALLA EU

POLO CGREEN

ORGANIZZAZIONE EVENTI – WORKSHOP – TAVOLI TECNICI

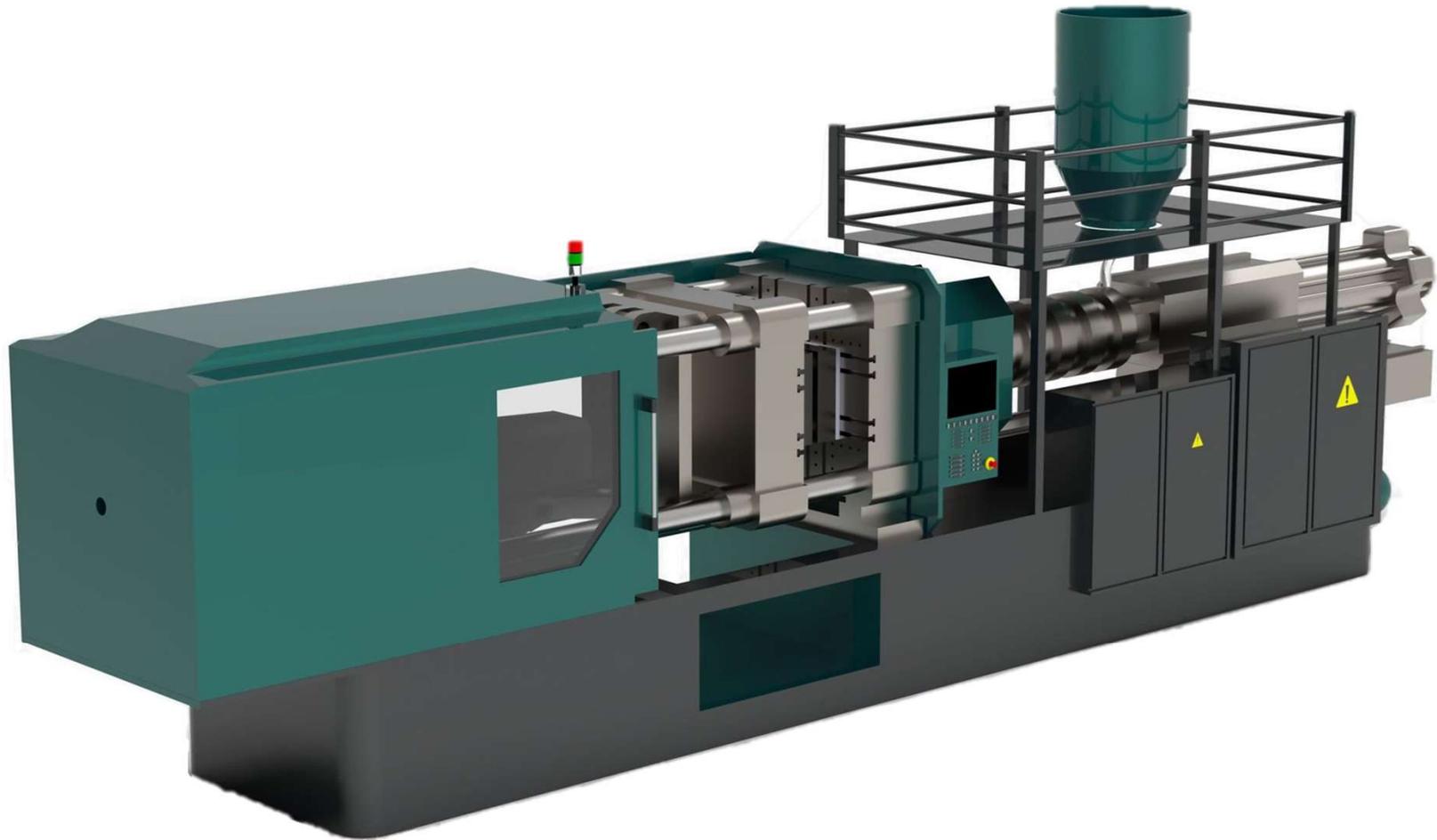




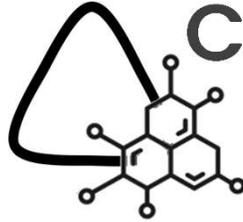
Applicazioni innovative e non convenzionali delle simulazioni Moldex3D

Casi di successo

Quando i materiali e le tecnologie divergono dalla
tradizionalità dello stampaggio a iniezione
gli strumenti di predizione diventano
il braccio destro di una
progettazione
efficace



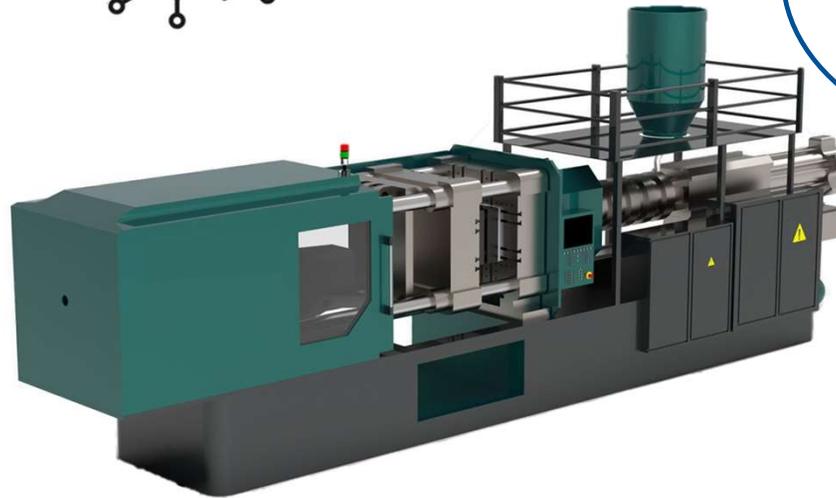
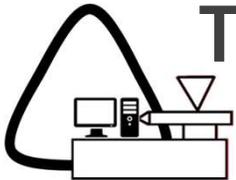
MATERIALI CONDUTTIVI



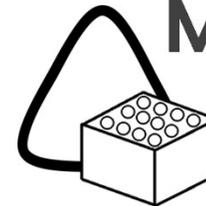
STAMPI FAMIGLIA



DIGITAL TWIN



MUCELL

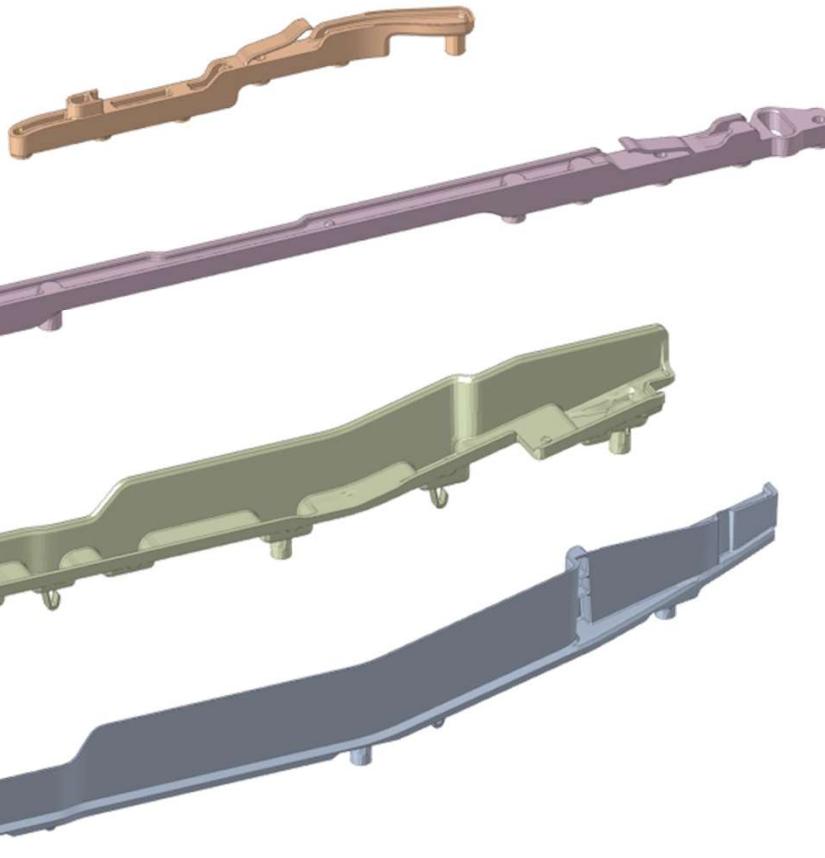
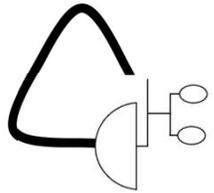


HEAT & COOL



Bilanciamento stampo famiglia

IL PROGETTO



13.5 cc

A

39.2 cc

B

42.4 cc

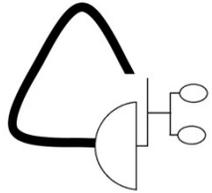
C

48 cc

D

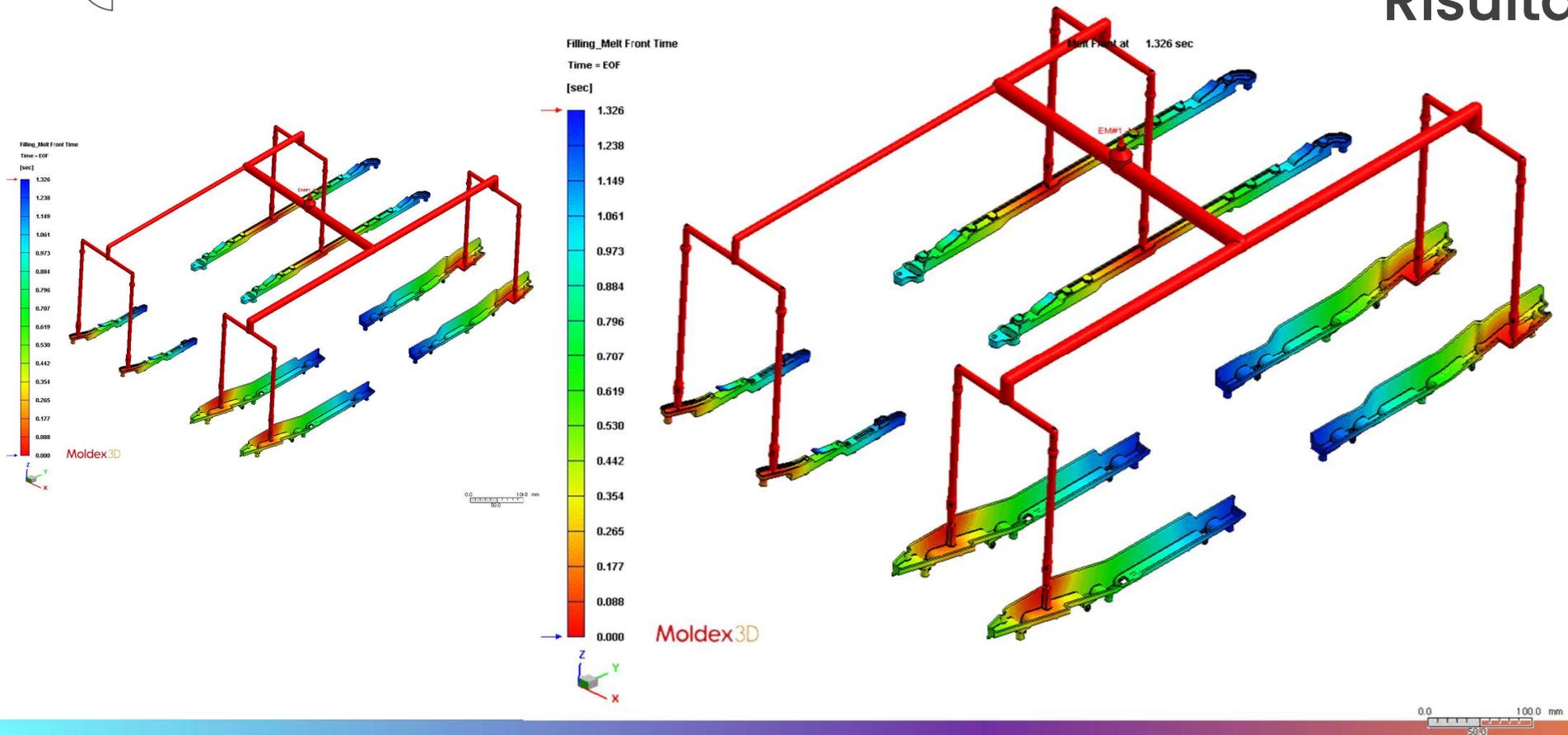
Riempimento simultaneo

- ✓ 8 cavità
- ✓ camera calda
- ✓ senza iniezione sequenziale
- ✓ singolo gate per figura
- ✓ PP + 30 GF



Bilanciamento stampa famiglia

Risultato

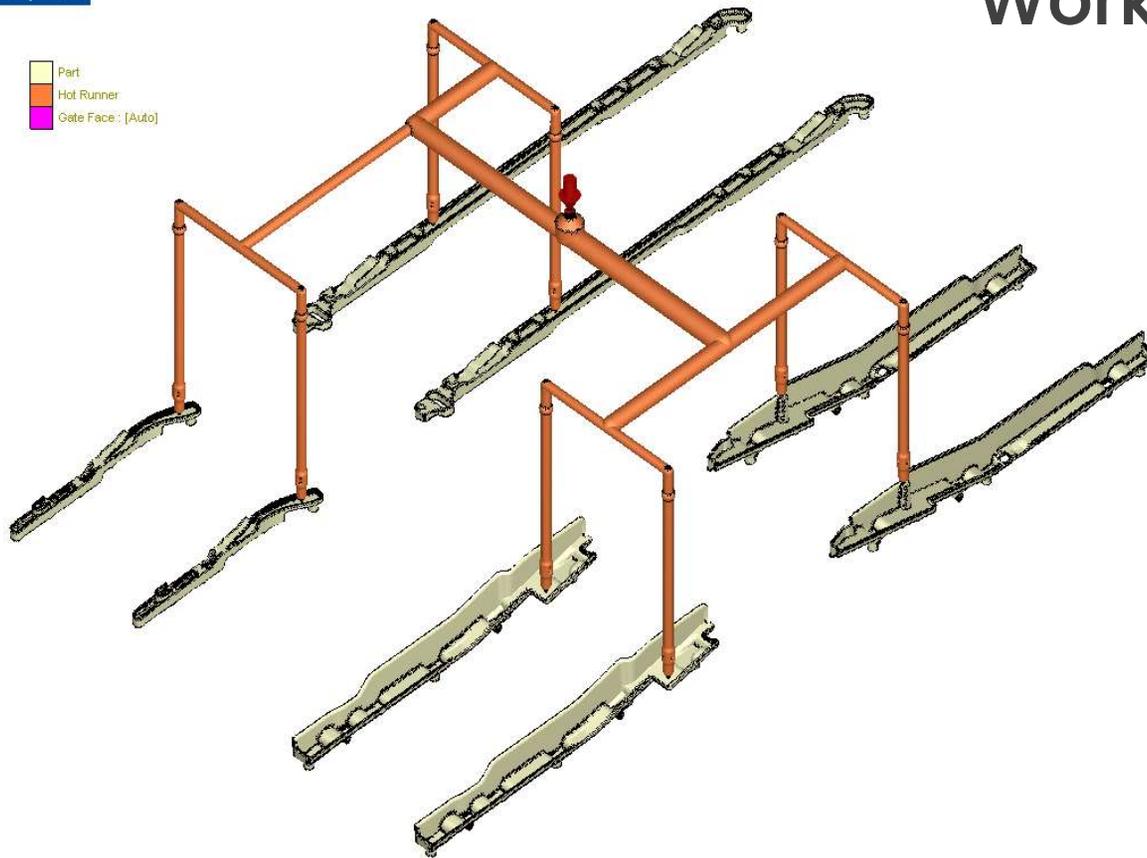


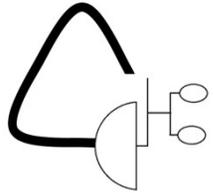
Bilanciamento stampo famiglia

Workflow: Step I

Perspective

- Part
- Hot Runner
- Gate Face: [Auto]

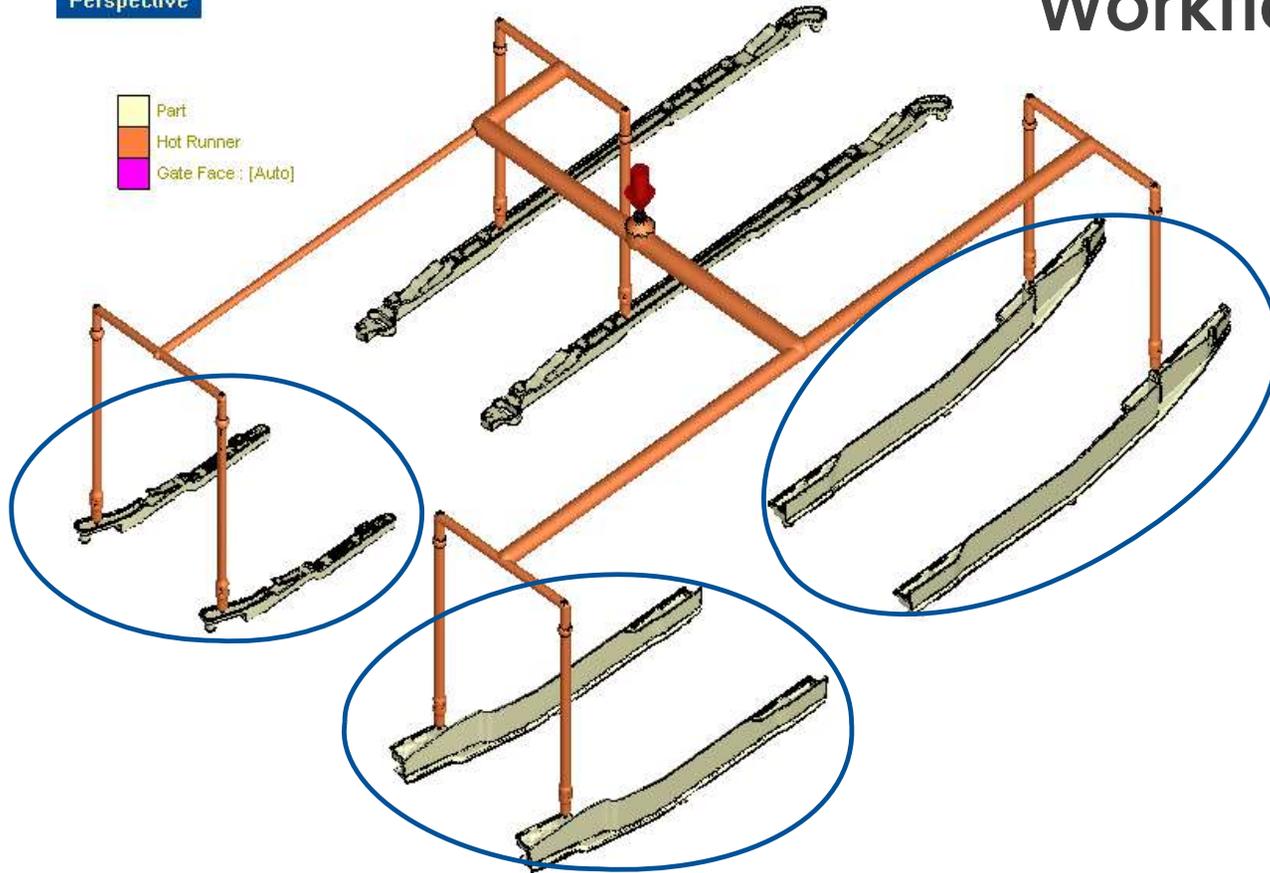




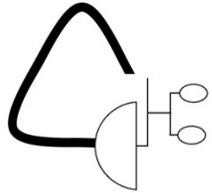
Bilanciamento stampo famiglia

Workflow: Step II

Perspective



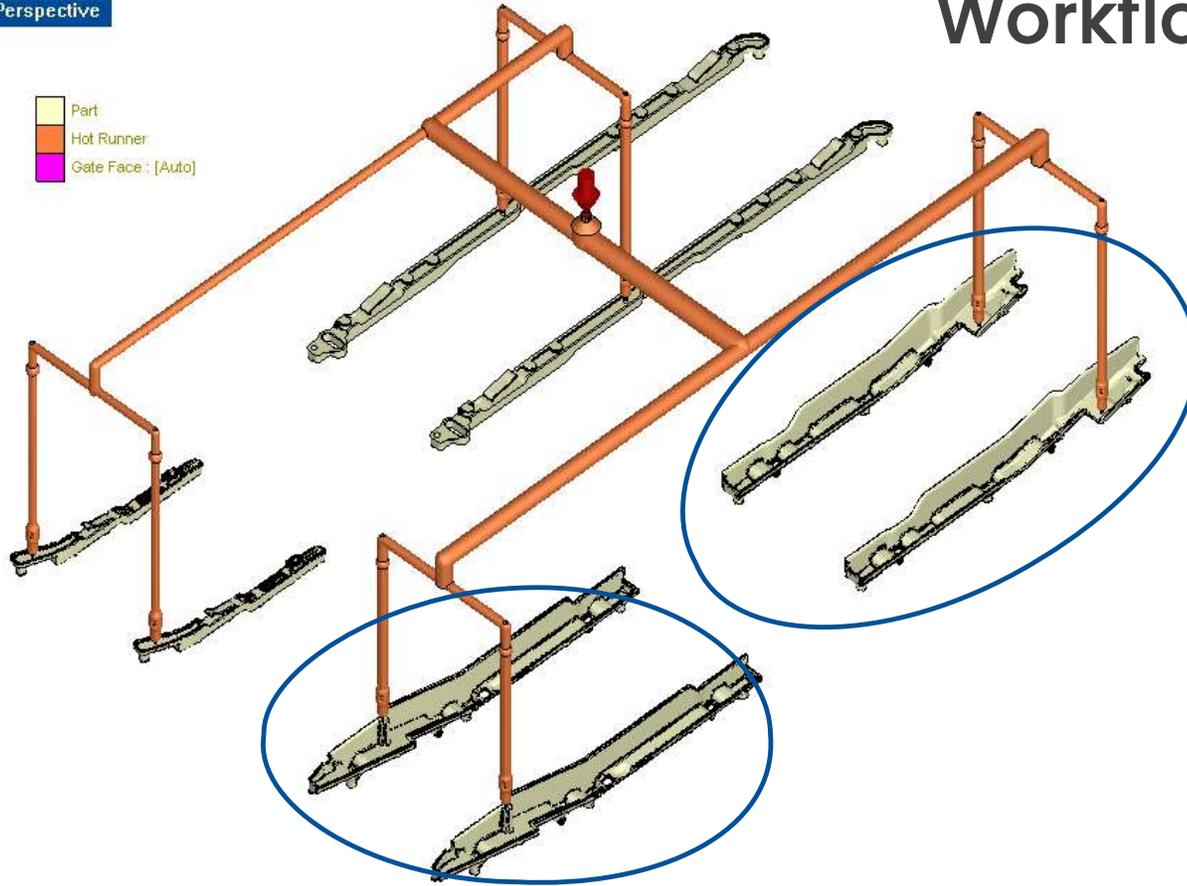
Bilanciamento stampo famiglia



Perspective

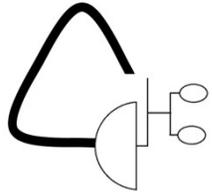
Workflow: Step III

- Part
- Hot Runner
- Gate Face: [Auto]

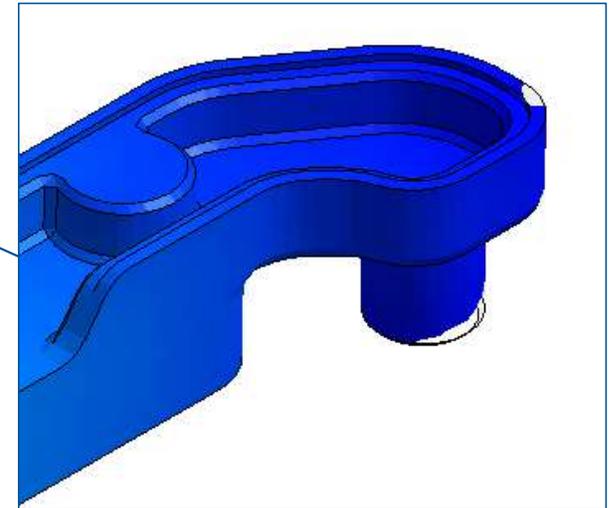
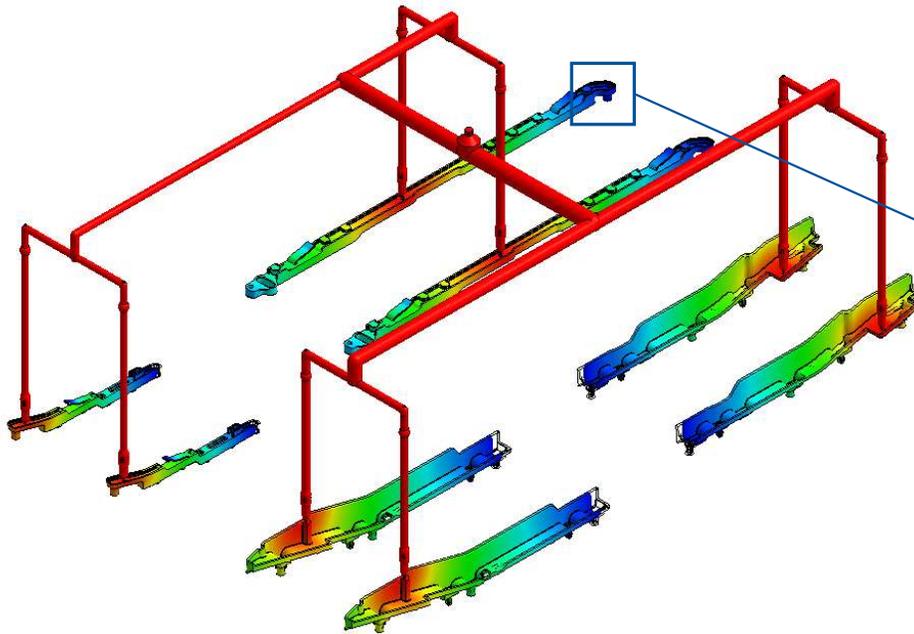
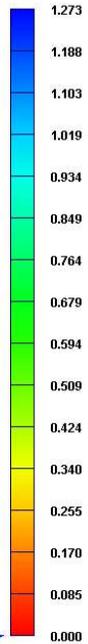


Bilanciamento stampo famiglia

Riempimento simultaneo

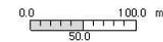


Filling_Melt Front Time
Time = EOF
[sec]



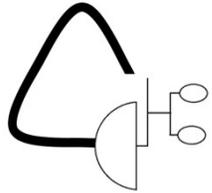
Moldex3D

Istante: 96 % del riempimento totale

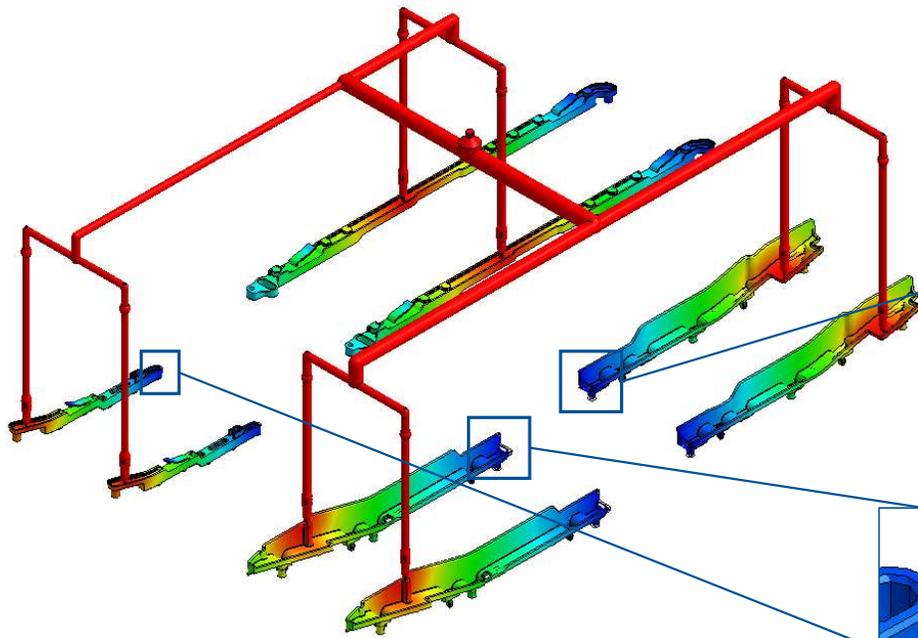
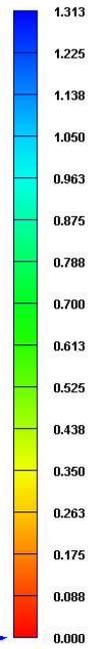


Bilanciamento stampo famiglia

Riempimento simultaneo

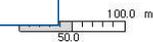
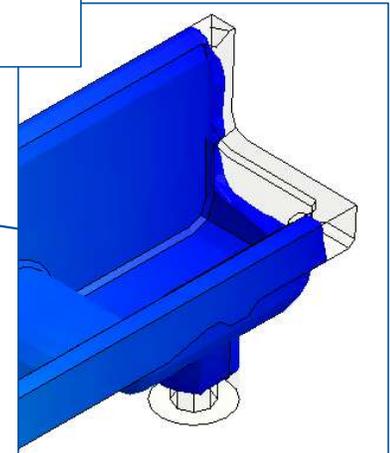
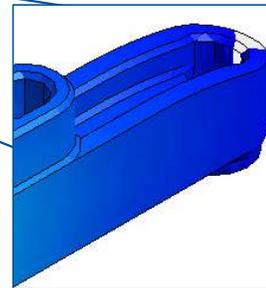
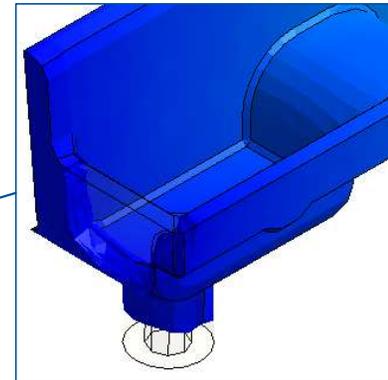


Filling_Melt Front Time
Time = EOF
[sec]



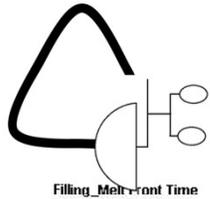
Moldex3D

Istante: 99 % del riempimento totale



Bilanciamento stampo famiglia

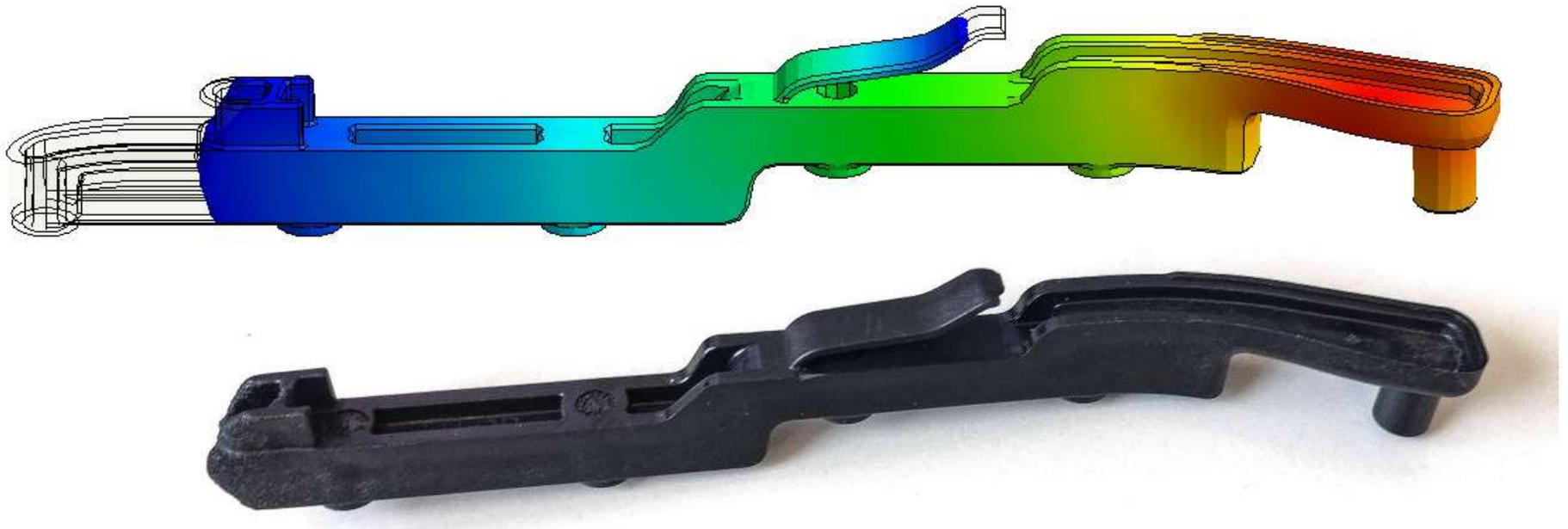
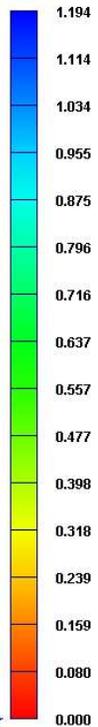
Risultati a confronto



Filling_Melt-front Time

Time = EOF

[sec]

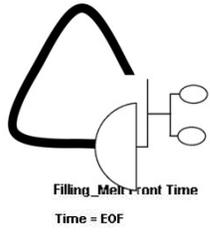


Moldex3D

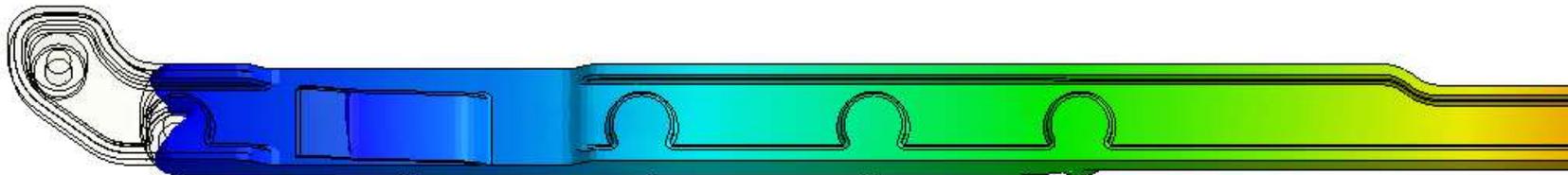
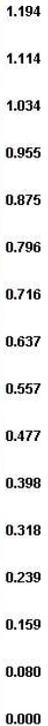
Istante: 90 % del riempimento totale

Bilanciamento stampo famiglia

Risultati a confronto



[sec]

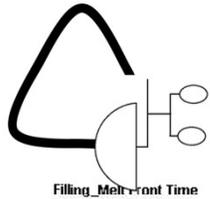


Moldex3D

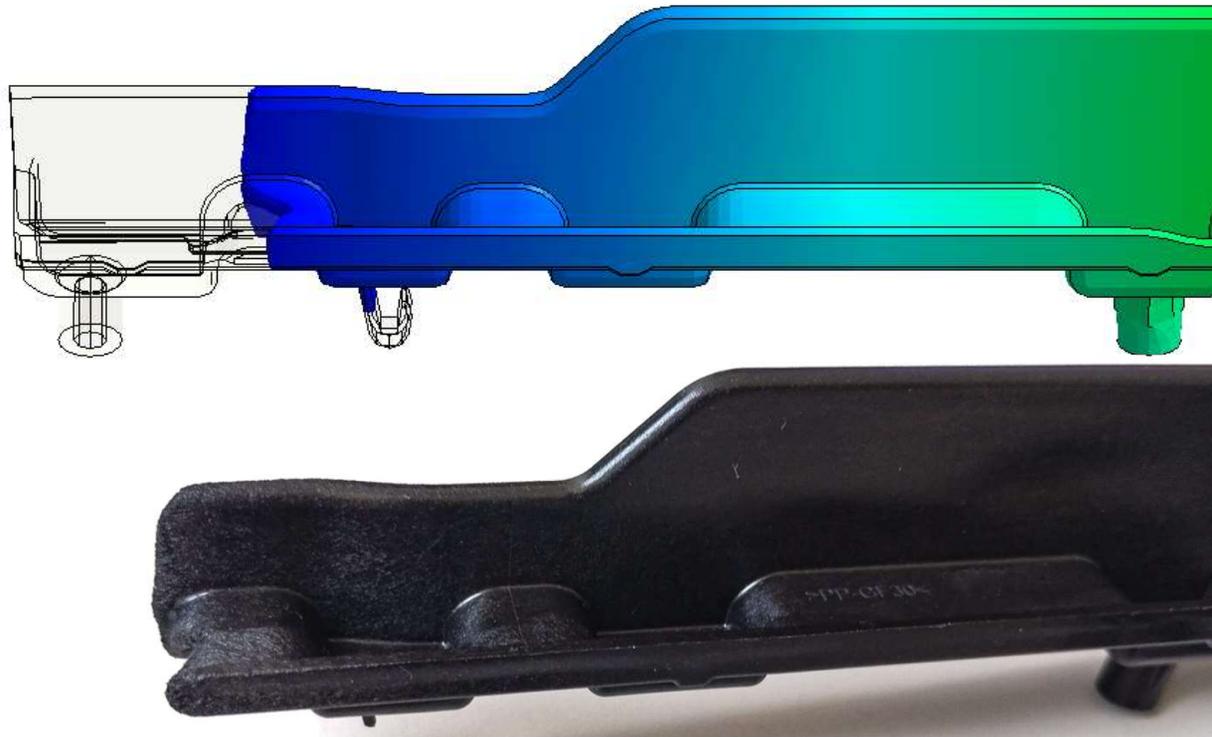
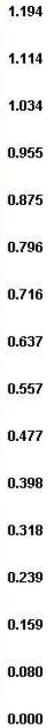
Istante: 90 % del riempimento totale

Bilanciamento stampo famiglia

Risultati a confronto



[sec]

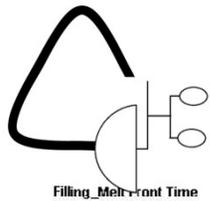


Moldex3D

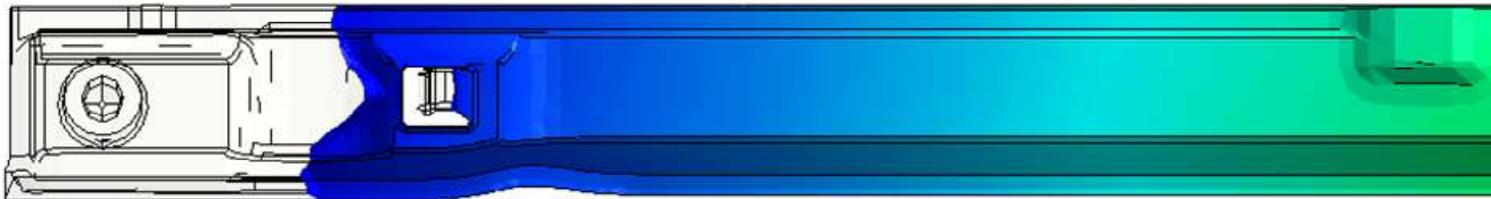
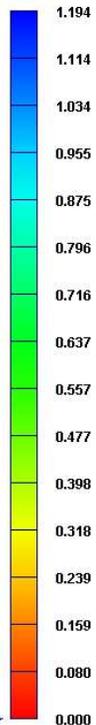
Istante: 90 % del riempimento totale

Bilanciamento stampo famiglia

Risultati a confronto



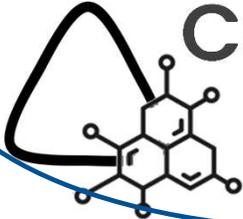
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Moldex3D

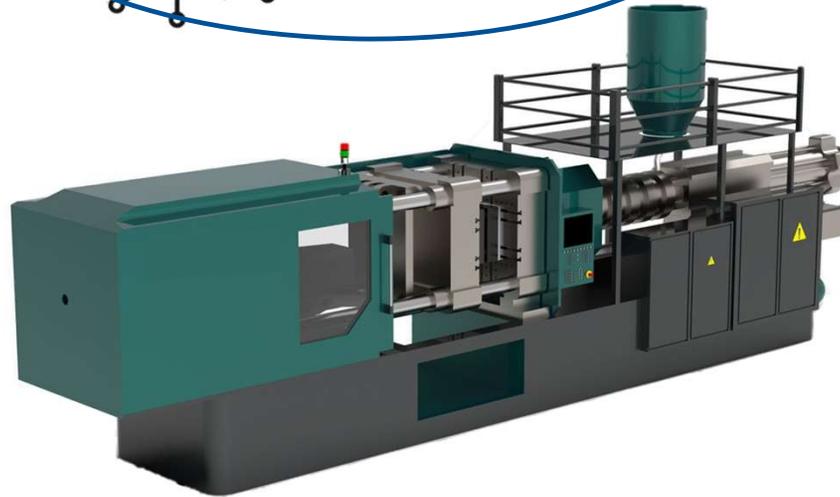
Istante: 90 % del riempimento totale

MATERIALI CONDUTTIVI



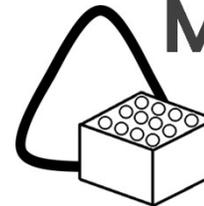
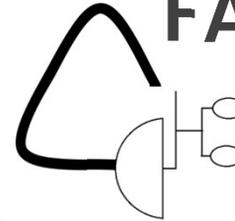
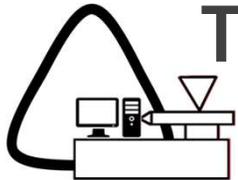
STAMPI FAMIGLIA

DIGITAL TWIN



MUCELL

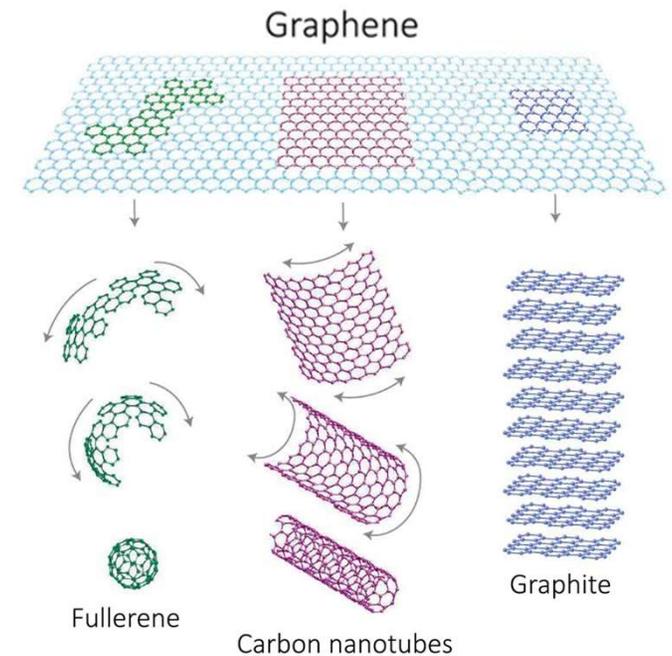
HEAT & COOL



Materiali elettricamente conduttivi

Il grafene

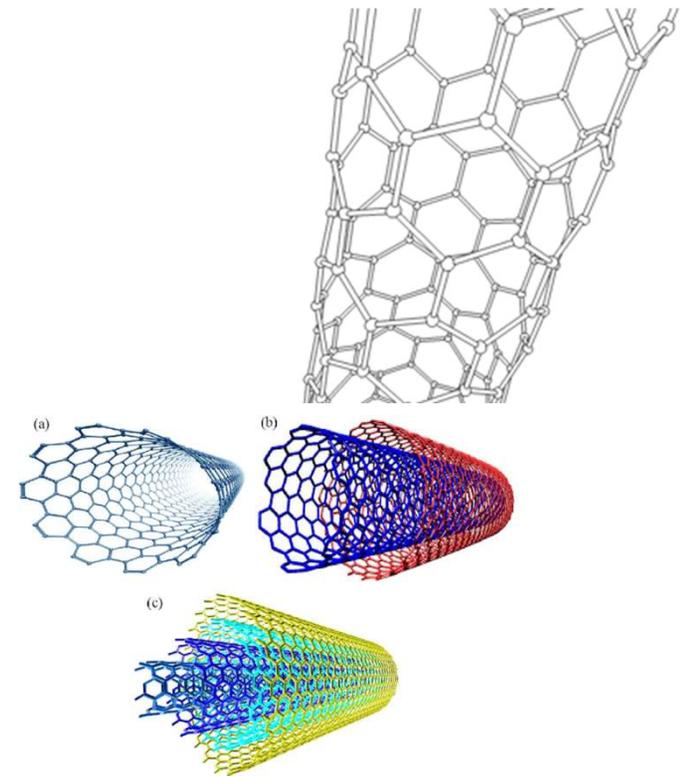
- ❑ Scoperto nel 2004 vince il Nobel per la fisica nel 2010
- ❑ Un foglio di spessore di un solo atomo
- ❑ Quasi trasparente
- ❑ 200 volte più forte dell'acciaio
- ❑ Madre di tutte le nanostrutture grafitiche

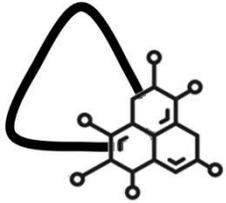


Materiali elettricamente conduttivi

I nanotubi di carbonio

- ❑ Strutture cilindriche dalla forma tubolare con diametro di pochi nanometri (0.7 nm ÷ 10 nm) e lunghi quanto il diametro di un capello, chiusi alle estremità.
- ❑ Classificati in base al numero di fogli di grafene arrotolati
 - CNT a parete singola (SWCNT)
 - CNT a doppia parete (DWCNT)
 - CNT a parete multipla (MWCNT)





Materiali elettricamente conduttivi

IL PROGETTO



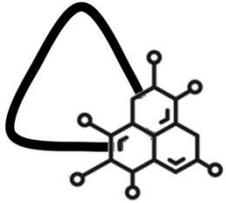
PP + 3% CNTs = FORMULAZIONE ELETTRICAMENTE CONDUTTIVA

Matrice: PP Moplen RP 348 R prodotto da Lyondell Basell,

Filler: multi-walled carbon nanotubes (MWCNTs), diametro 10 nm, lunghezza 1.5 μm , percentuale di carbonio del 90%.

Pressa a iniezione: Engel VC 500/120, con diametro della vite di 40 mm

Dimensioni del provino: 100x140x2 mm



Materiali elettricamente conduttivi

IL PROGETTO



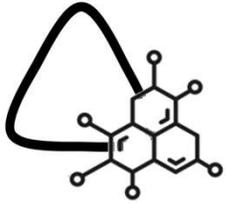
PROVE IN
CORRENTE CONTINUA

— Resistività
elettrica

— Resistenza
elettrica

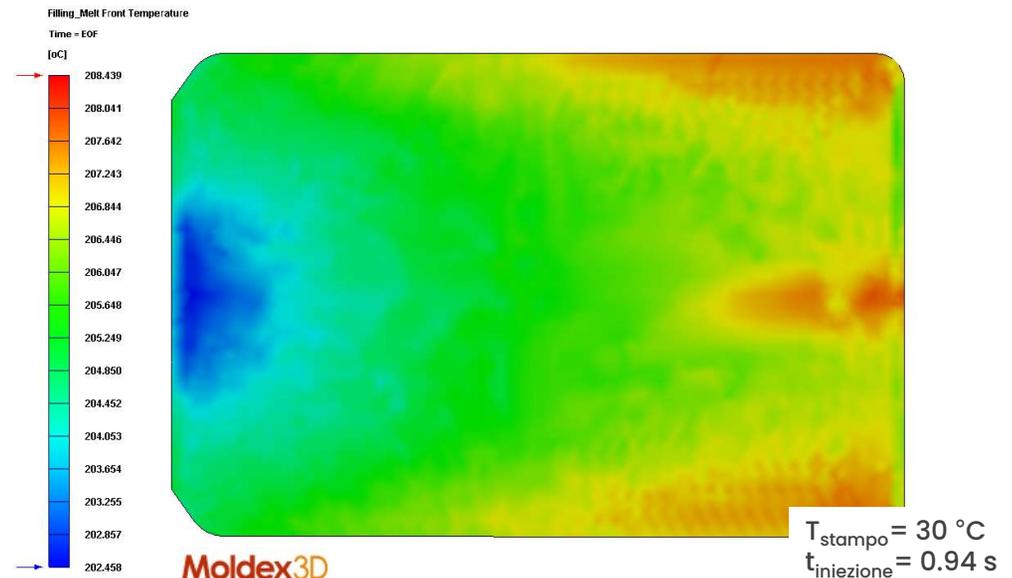
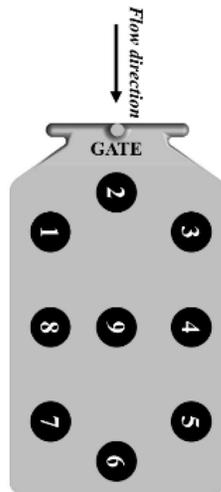
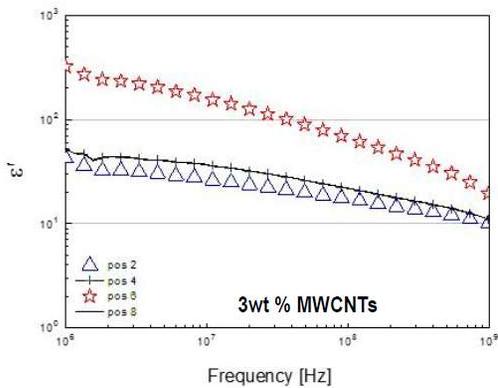
PROVE IN
CORRENTE ALTERNATA

— Permittività
elettrica



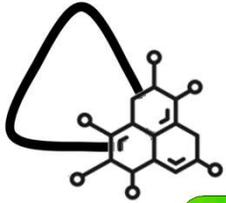
Materiali elettricamente conduttivi

Risultati



- Il punto più vicino al gate (2) è il meno conduttivo mentre, alla massima distanza dall'iniezione (6) si ha conduttività più alta.

La maggior conduttività del punto 6 rispetto al punto 2 corrisponde ad una temperatura del fronte di flusso più elevata nel punto con risposta elettrica migliore.



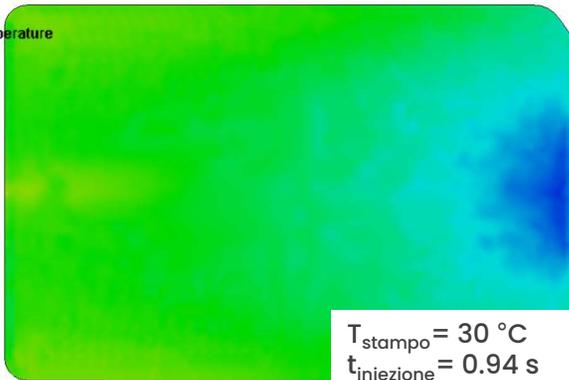
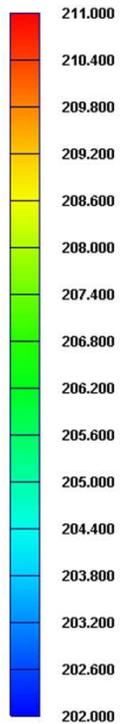
Materiali elettricamente conduttivi

Risultati

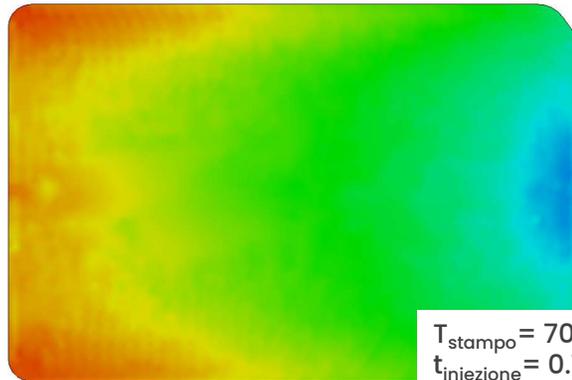
Filling_Melt Front Temperature

Time = EOF

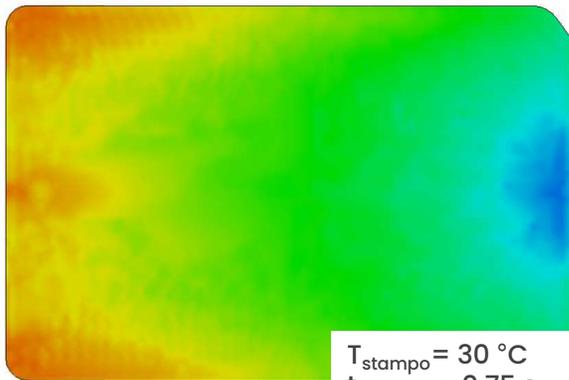
[°C]



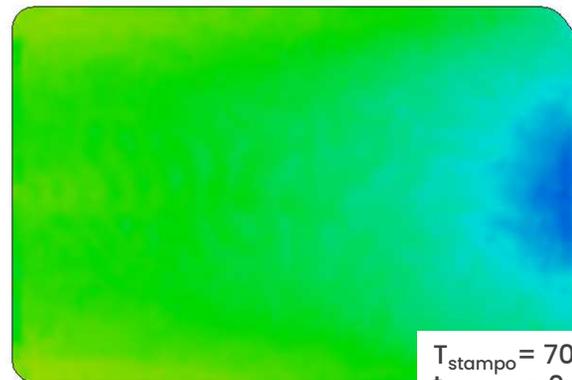
$T_{\text{stampo}} = 30\text{ °C}$
 $t_{\text{iniezione}} = 0.94\text{ s}$



$T_{\text{stampo}} = 70\text{ °C}$
 $t_{\text{iniezione}} = 0.75\text{ s}$



$T_{\text{stampo}} = 30\text{ °C}$
 $t_{\text{iniezione}} = 0.75\text{ s}$

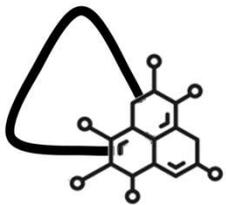


$T_{\text{stampo}} = 70\text{ °C}$
 $t_{\text{iniezione}} = 0.94\text{ s}$

Moldex3D

Secondo i precetti dello stampaggio a iniezione:

temperature elevate & alte velocità di iniezione
materiale più fluido

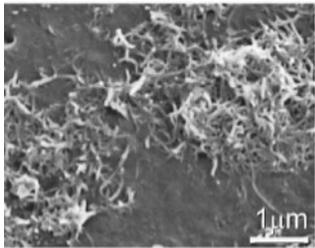


Materiali elettricamente conduttivi

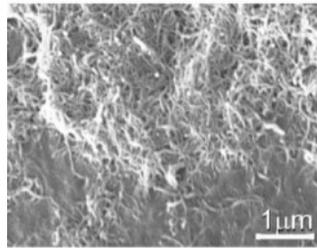
- Il comportamento elettrico finale è legato alla dispersione e distribuzione dei nanoriempitivi

MWCNTs (%)

3wt%



Pelli



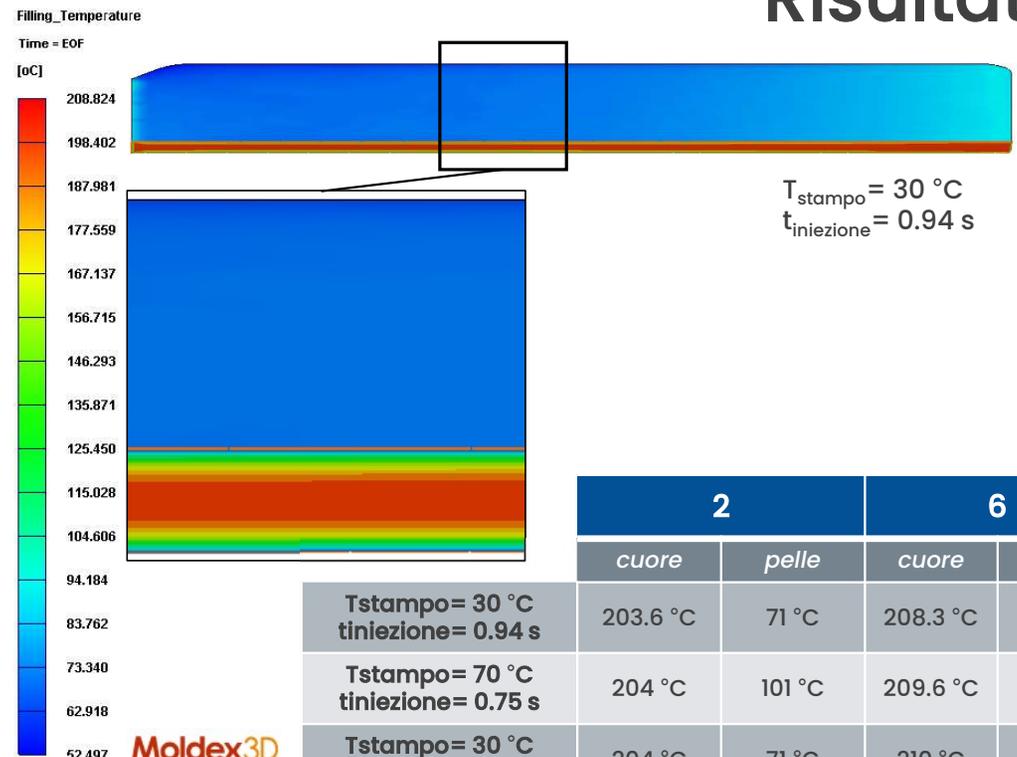
Cuore

- Distribuzione non omogenea dei MWCNTs lungo lo spessore:

al cuore → area ricca di fibre, con agglomerati ben impregnati dalla matrice polimerica

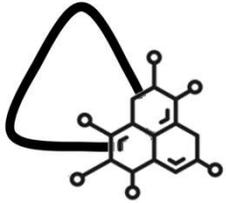
sulle pelli → concentrazione di fibra minore

Risultati



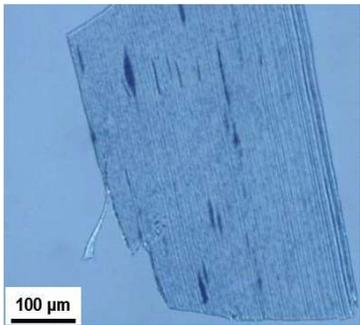
| | 2 | | 6 | |
|--------------------------------------|----------|--------|----------|----------|
| | cuore | pelle | cuore | pelle |
| Tstampo= 30 °C tiniezione= 0.94 s | 203.6 °C | 71 °C | 208.3 °C | 87 °C |
| Tstampo= 70 °C tiniezione= 0.75 s | 204 °C | 101 °C | 209.6 °C | 113 °C |
| Tstampo= 30 °C tiniezione= 0.75 s | 204 °C | 71 °C | 210 °C | 86 °C |
| Tstampo= 70 °C tiniezione= 0.94 s | 203.8 °C | 101 °C | 207.6 °C | 113.5 °C |

Moldex3D

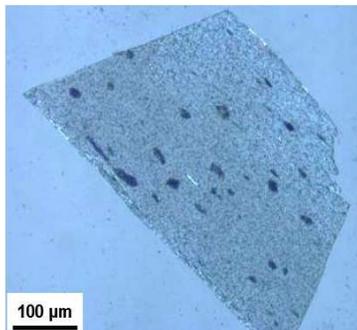


Materiali elettricamente conduttivi

Risultati



Pelli

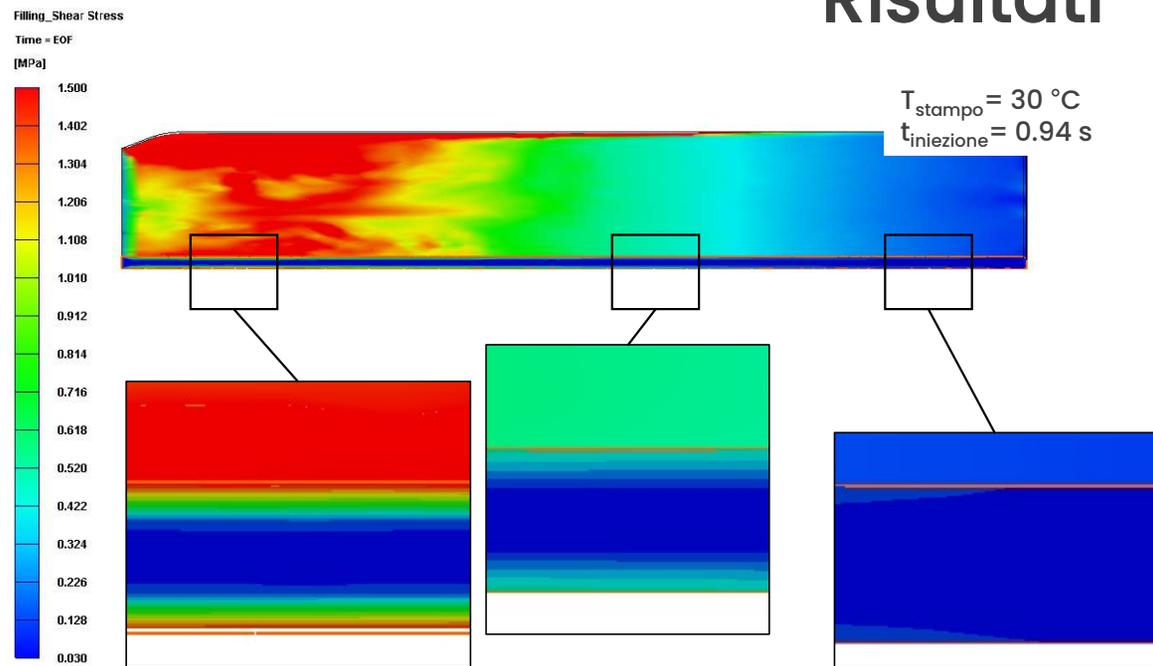


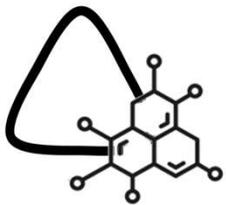
Cuore

- Diversa morfologia degli agglomerati:

sulle pelli → MWCNTs dalla forma allungata e orientata rispetto al flusso

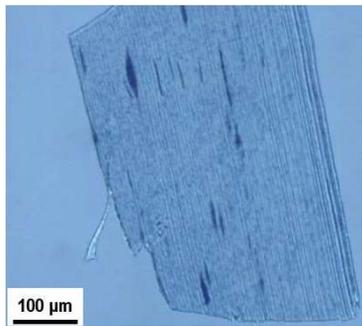
al cuore → MWCNTs organizzati in aggregati non orientati dalla forma sferica.



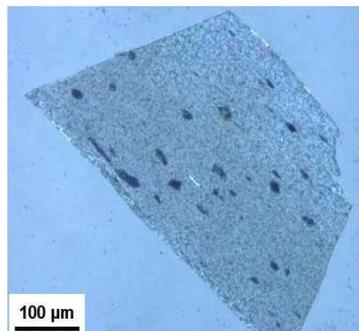


Materiali elettricamente conduttivi

Risultati



Pelli

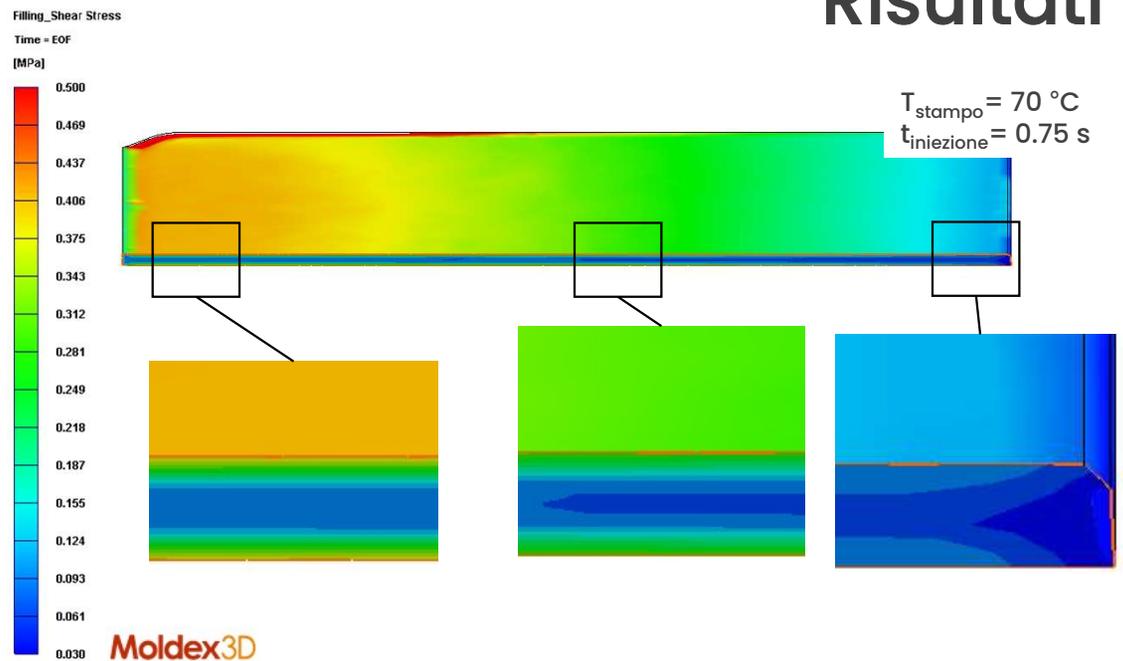


Cuore

□ Diversa morfologia degli agglomerati:

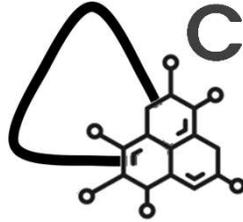
sulle pelli → MWCNTs dalla forma allungata e orientata rispetto al flusso

al cuore → MWCNTs organizzati in aggregati non orientati dalla forma sferica.

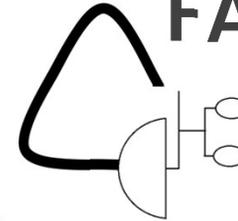


Gli shear stress sono responsabili della morfologia degli agglomerati. Temperature stampo elevate migliorano gli stress totali.

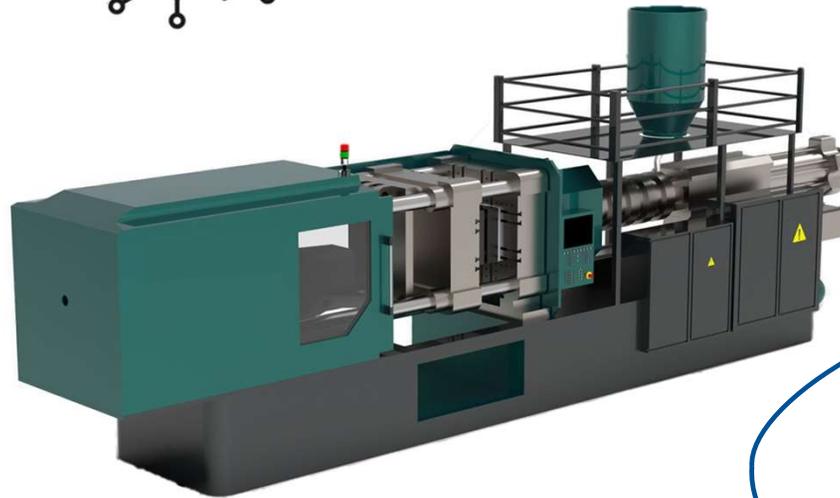
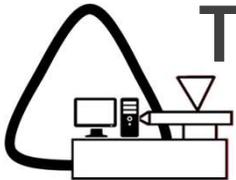
MATERIALI CONDUTTIVI



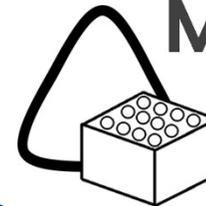
STAMPI FAMIGLIA



DIGITAL TWIN

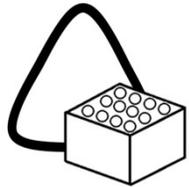


MUCELL



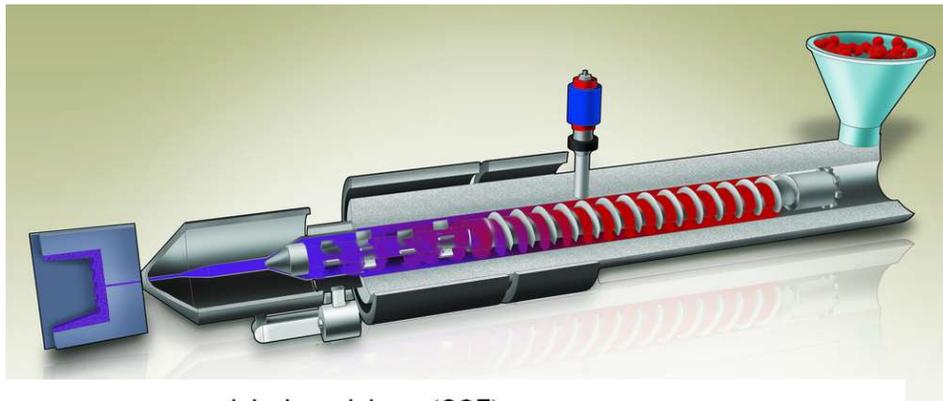
HEAT & COOL



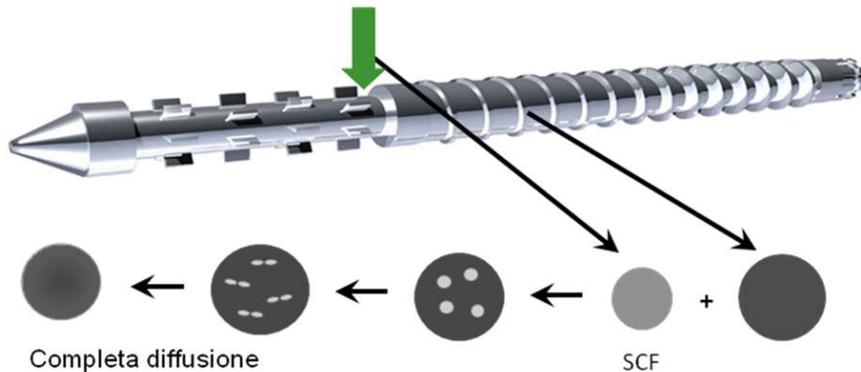


Stampaggio a iniezione Mucell

Stato dell'arte



Iniezione del gas (SCF)



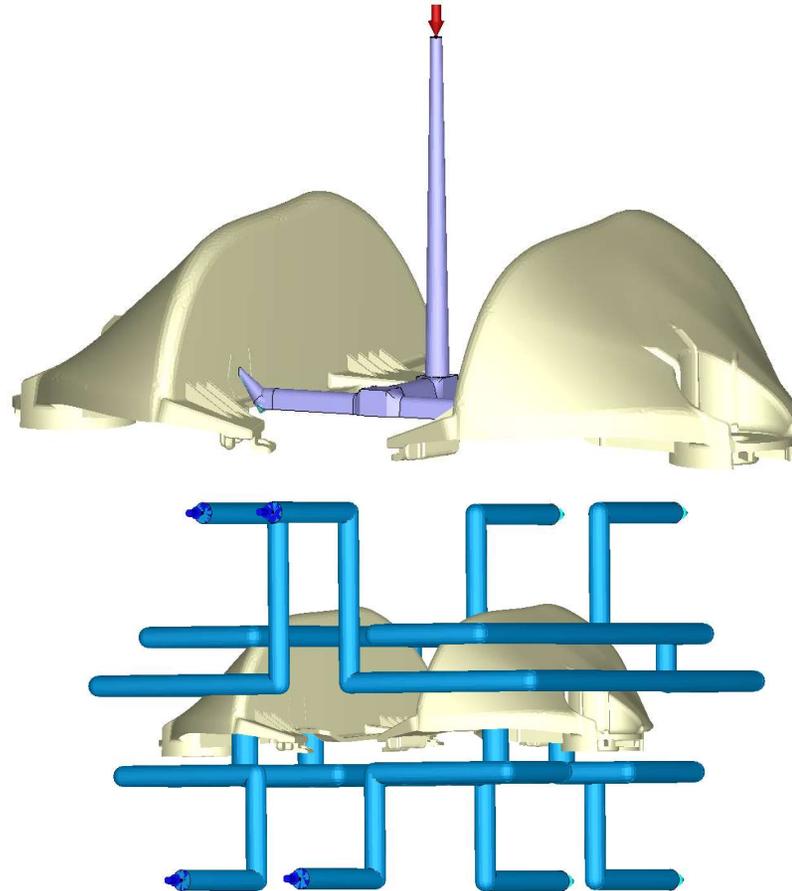
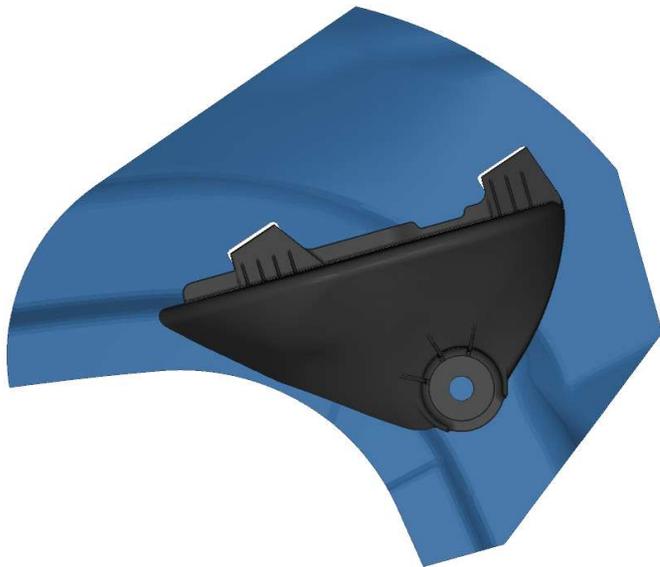
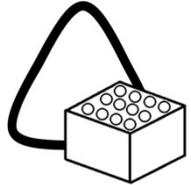
SCF

Fonte: Trexel

La tecnologia di espansione microcellulare MuCell permette di realizzare componenti plastici espansi fisicamente, e quindi alleggeriti.

Offre numerosi vantaggi in termini di performance del processo e del prodotto.

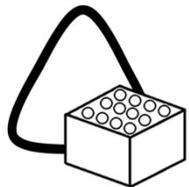
Stampaggio a iniezione Mucell



IL PROGETTO

*Ottimizzazione e
alleggerimento*

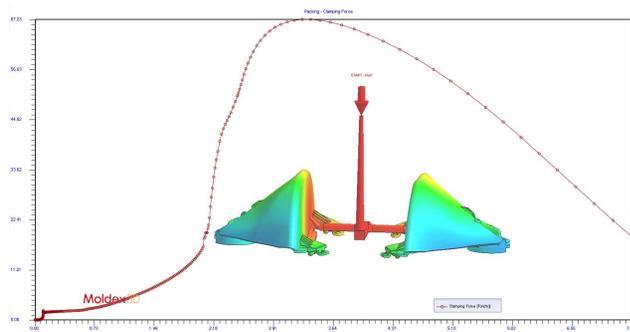
- ✓ 2 cavità
- ✓ materozza con
iniezione
sottomarina
- ✓ Condizionamento
da layout stampo
- ✓ PC+ABS



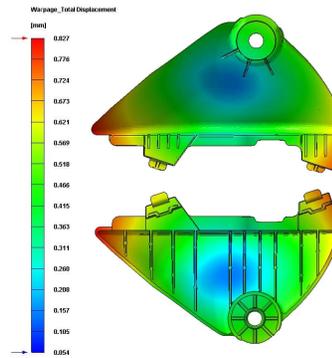
Stampaggio a iniezione Mucell

Risultati

COMPATTO

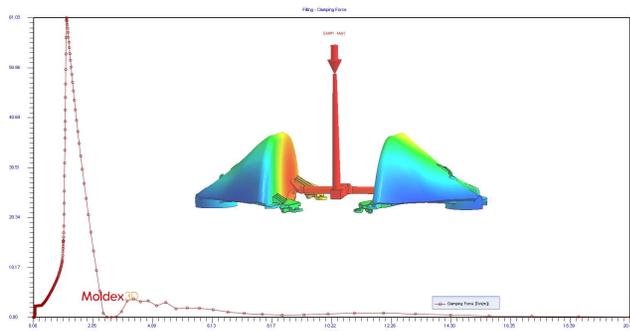


Forza di chiusura massima = 67.2 ton

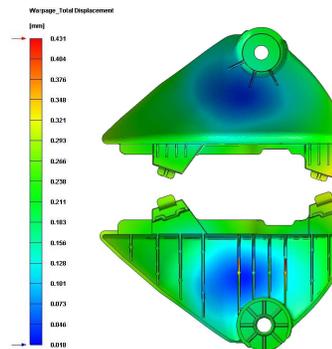


Deformazione massima = 0.83 mm

MUCELL



Forza di chiusura massima = 61 ton



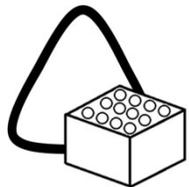
Deformazione massima = 0.43 mm

| | |
|---------------------------|-------------|
| Tempo d'iniezione | 2.12 s |
| Tempo di mantenimento | 5 S |
| Tempo di raffreddamento | 28 s |
| Tempo ciclo totale | 40 s |

| | |
|---------------------------|-------------|
| Tempo d'iniezione | 1.1 s |
| Tempo di mantenimento | - |
| Tempo di raffreddamento | 1.6 s |
| Tempo ciclo totale | 26 s |

Stampaggio a iniezione Mucell

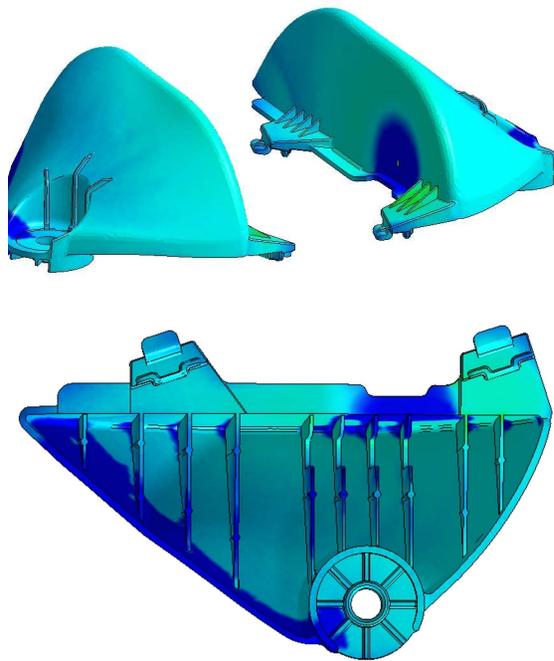
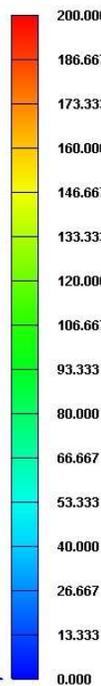
Risultati



Filling_Cell Density

Time = EOF

$\times 10^4$ [1/cc]

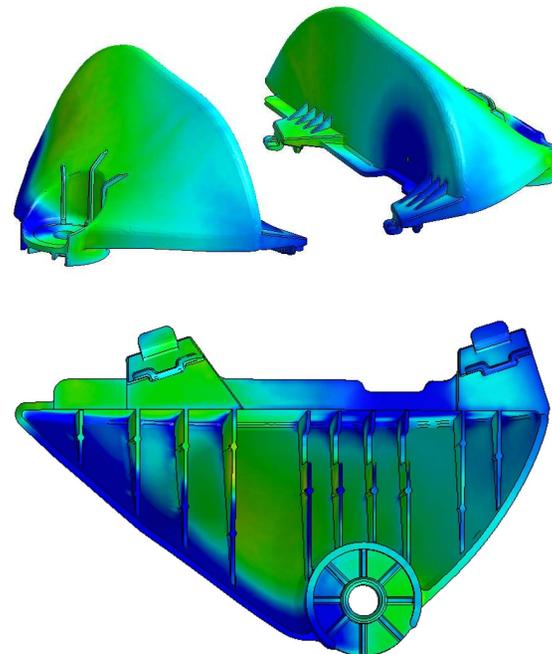
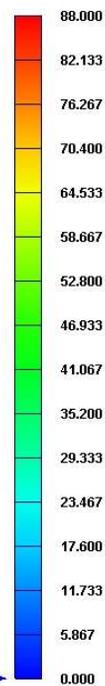


Densità delle celle

Filling_Cell Size

Time = EOF

[um]

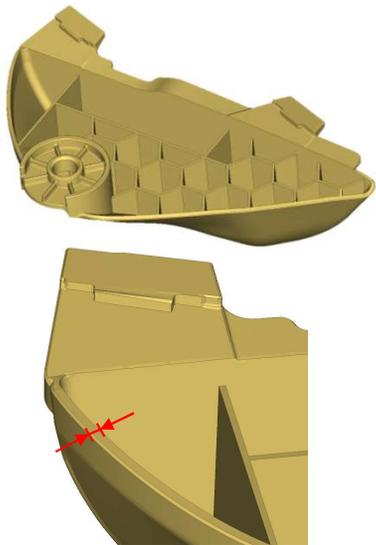
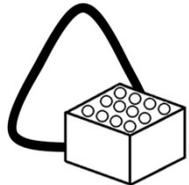


Taglia delle celle

Il gas si espande per una riduzione di peso del 7.9%

Stampaggio a iniezione Mucell

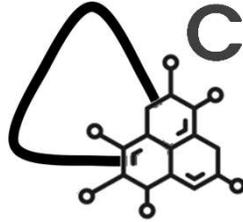
Risultati



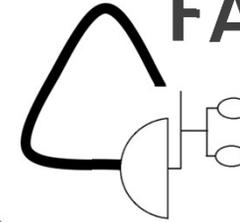
Modifiche CAD

| | | peso (g) | RIDUZIONE (%) | t ciclo (s) | RIDUZIONE (%) | F chiusura (ton) | RIDUZIONE % | warpage (mm) | RIDUZIONE % |
|------------|----------|----------|----------------|-------------|----------------|------------------|----------------|--------------|-----------------|
| ORIGINALE | COMPATTO | 49.4 g | - | 40.12 s | - | 67.2 ton | - | 0.8 mm | - |
| | MUCELL | 45.5 g | -7.9 % | 26 s | -35.2 % | 61 ton | -9.2 % | 0.3 mm | -62.5 % |
| MODIFICATO | COMPATTO | 42.3 g | -14.4 % | 36.3 s | -9.5 % | 140 ton | +108,3% | 0.35 mm | -56.25 % |
| | MUCELL | 39.2 g | -20.6% | 25.9 s | -35.4 % | 74 ton | +10.1% | 0.4 mm | -50 % |

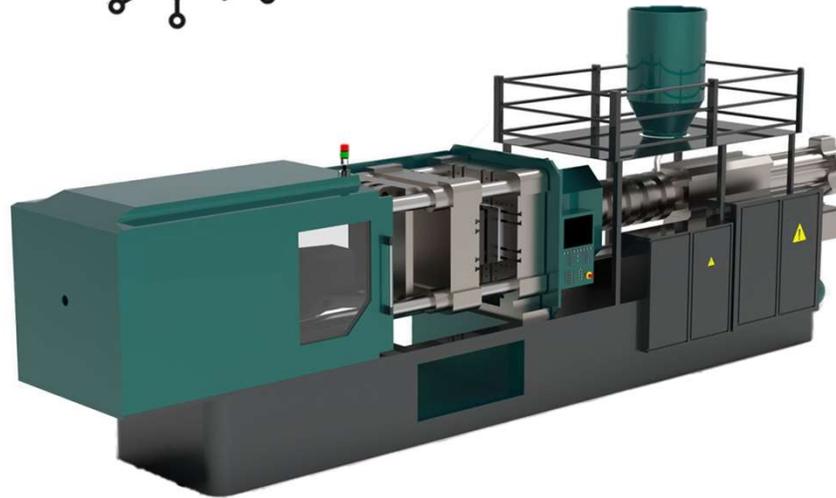
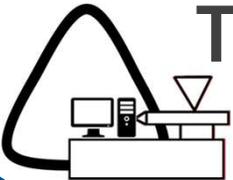
MATERIALI CONDUTTIVI



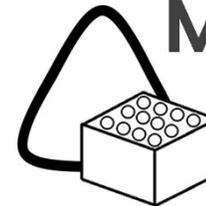
STAMPI FAMIGLIA



DIGITAL TWIN

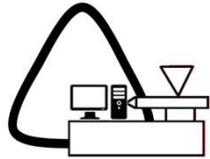


MUCELL



HEAT & COOL





Digital Twin

Engel - SimLink

Step I

Simulazione iniziale, Machine Mode

Moldex3D

ENGEL sim link

Step II

Simulazione modificata, con Sim Link

Moldex3D

ENGEL sim link

INJECTION

MOLDING

PROCESS

Fase iniziale di produzione, Sim Link esporta i parametri di processo, basati sui risultati della simulazione

Ottimizzazione del processo produttivo

ENGEL

Step III

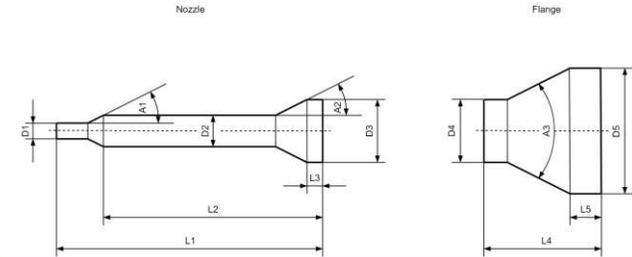
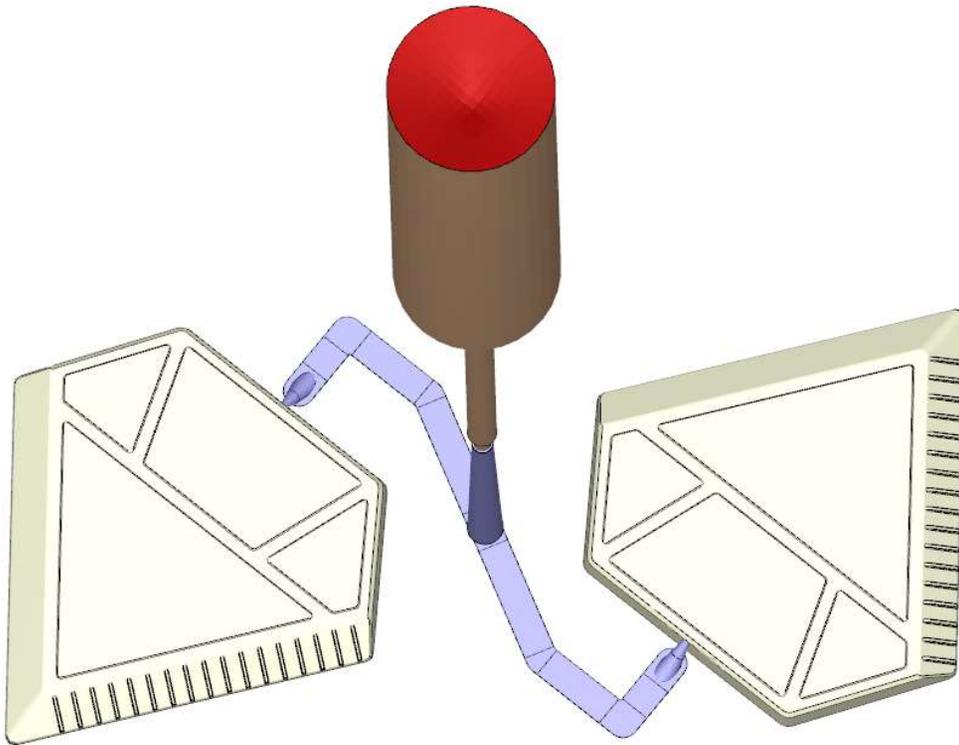
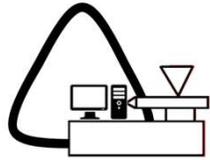
Simulazione conclusiva, con i parametri reali estrapolati dalla pressa mediante Sim Link

ENGEL sim link

Moldex3D

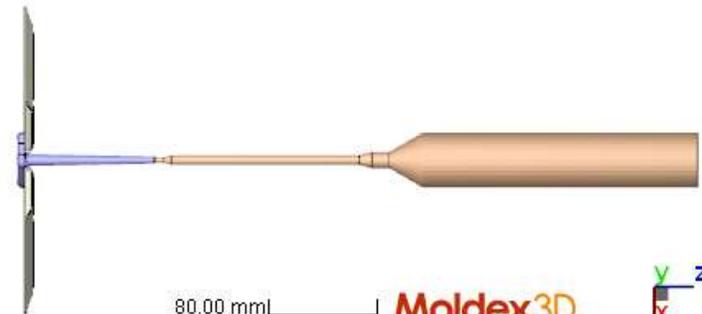
Digital Twin

IL PROGETTO



!!! ANGABEN FÜR ENGEL STANDARDDÜSEN OHNE GEWÄHR !!!

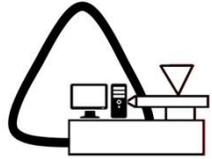
| FabNr | D1 [mm] | D2 [mm] | D3 [mm] | A1 [°] | A2 [°] | L1 [mm] | L2 [mm] | L3 [mm] | D4 [mm] | D5 [mm] | A3 [°] | L4 [mm] | L5 [mm] |
|--------|---------|---------|---------|--------|--------|---------|---------|---------|---------|---------|--------|---------|---------|
| 245053 | 4 | 7 | 12 | 15 | 15 | 163 | 151 | 5 | 12 | 40 | 60 | 35 | 3 |



80.00 mm

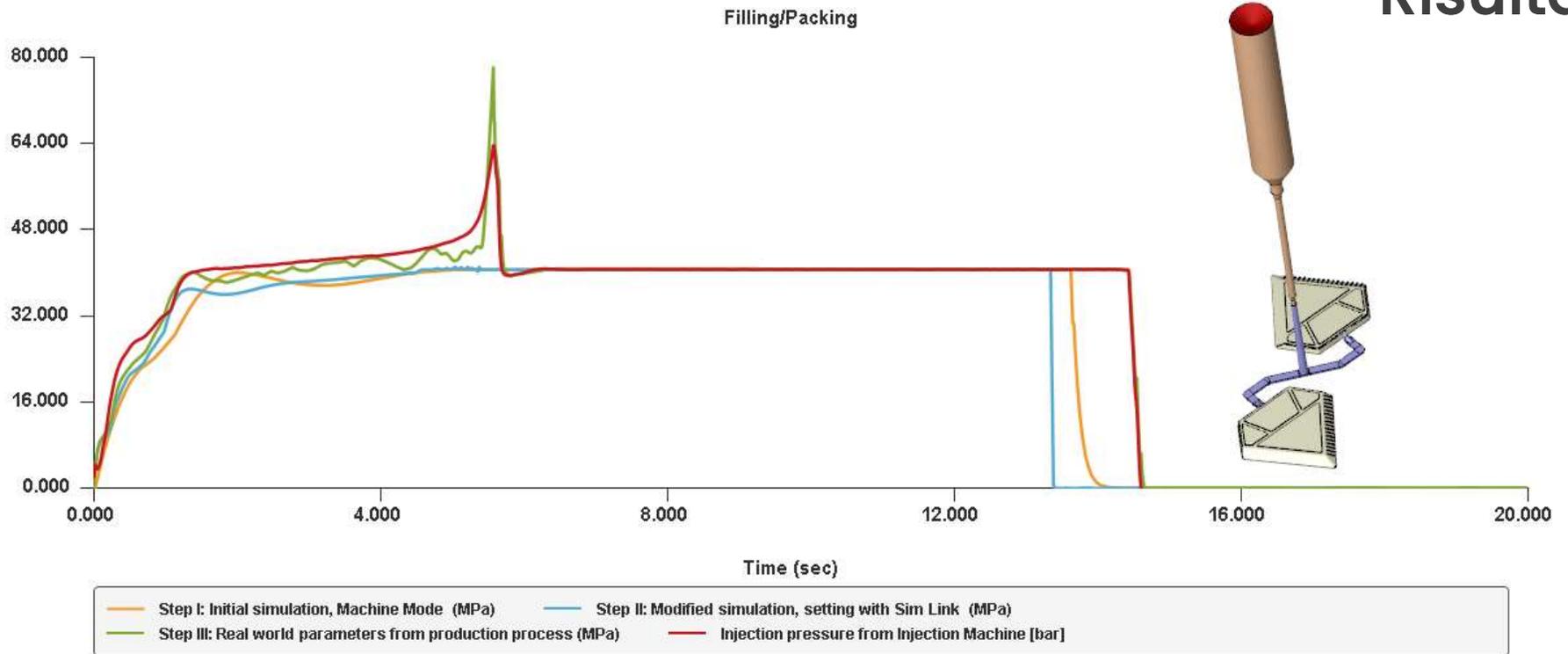
Moldex3D





Digital Twin

Risultati

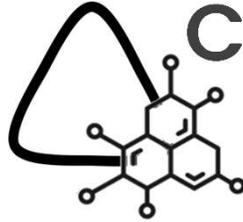


80.00 mm

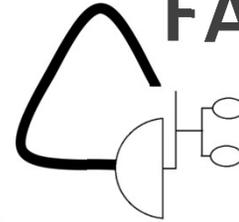
Moldex3D



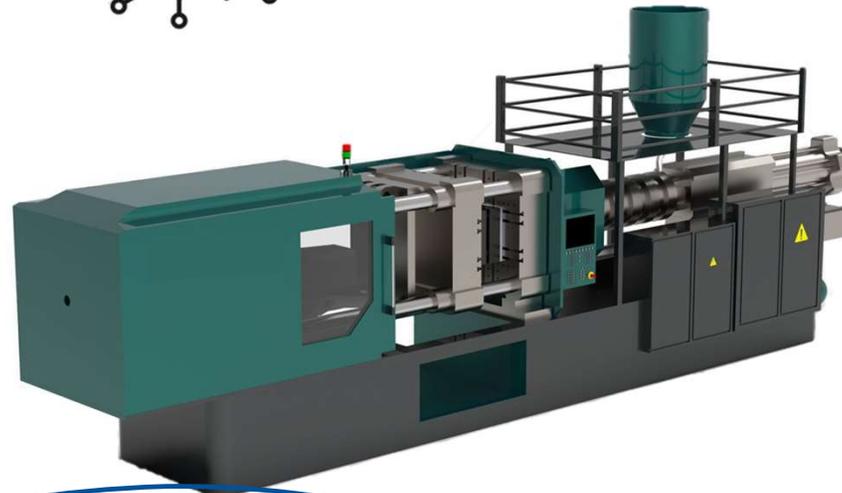
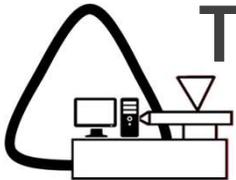
MATERIALI CONDUTTIVI



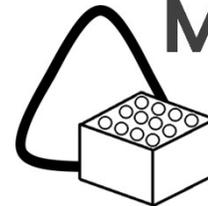
STAMPI FAMIGLIA



DIGITAL TWIN



MUCELL



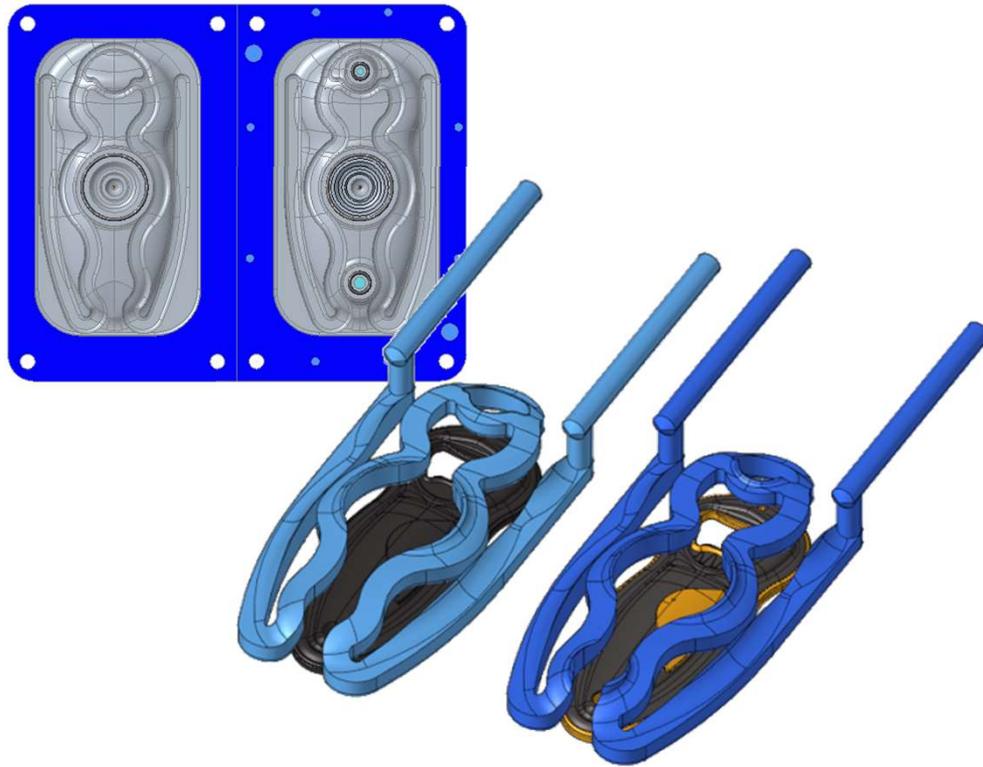
HEAT & COOL





Heat & Cool

Stato dell'arte



Canali conformali realizzati mediante lavorazioni CNC

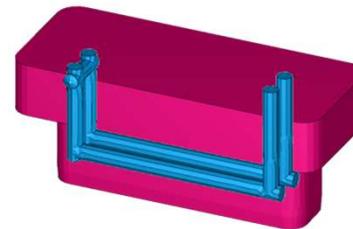
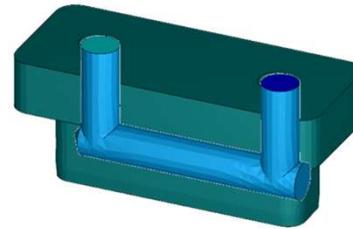
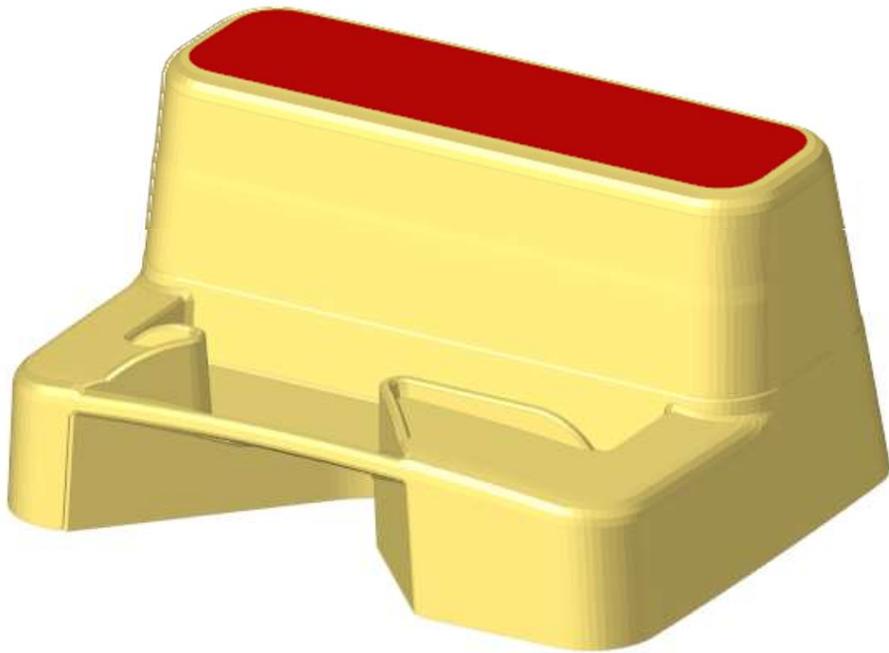


Fonte: Duleba, B.; Greskovic, F.
Conformal Cooling for Plastics in
Injection Moulding, Technical University
of Kosice, Letná

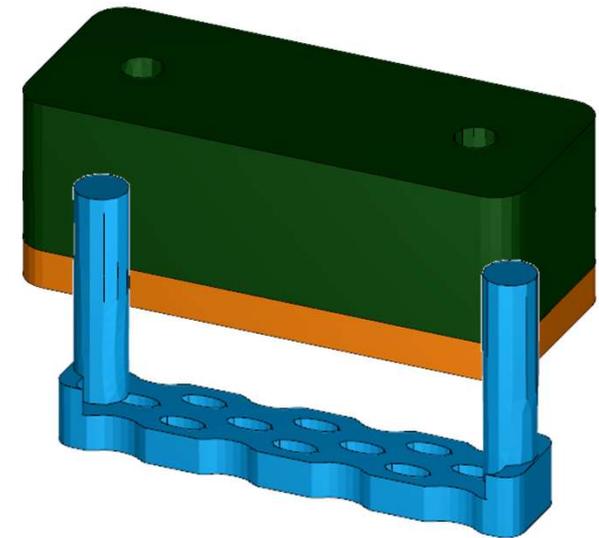
Canali conformali realizzati in DMLS, inserto in DMLS

Heat & Cool

IL PROGETTO



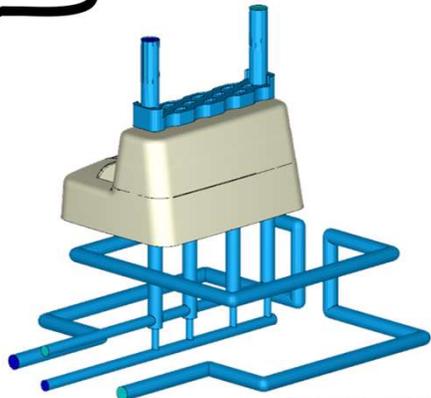
Condizionamento
tradizionale



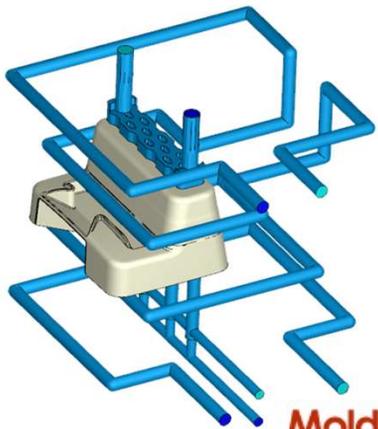
Condizionamento
conformale

Heat & Cool

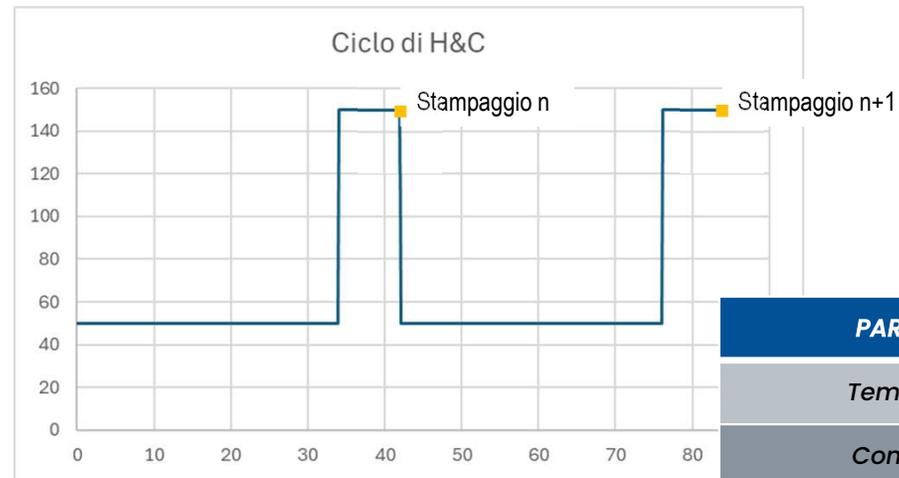
IL PROGETTO



Moldex3D



Moldex3D

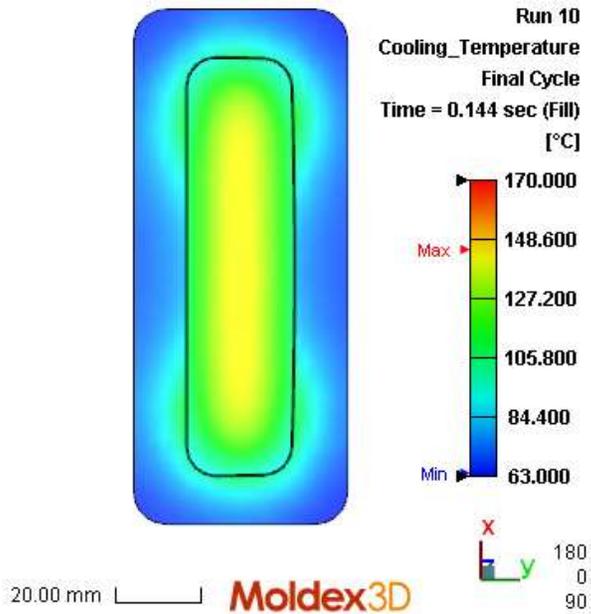


PARAMETRI DI PROCESSO OTTIMIZZATI

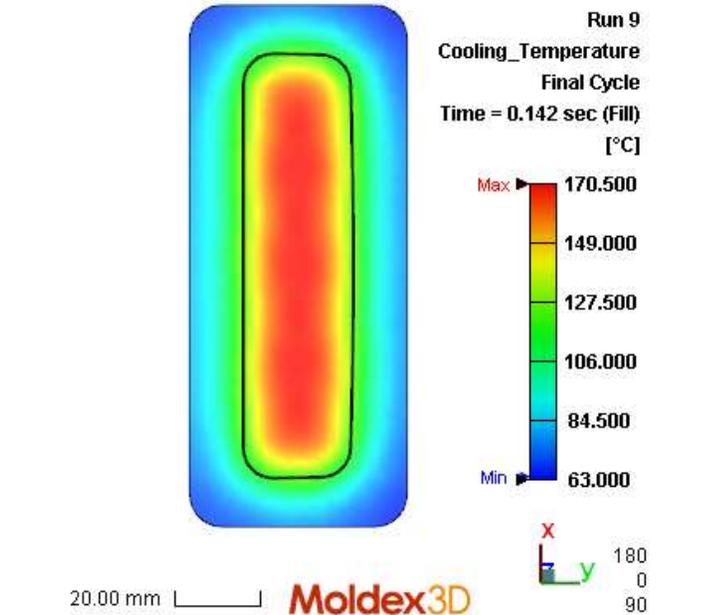
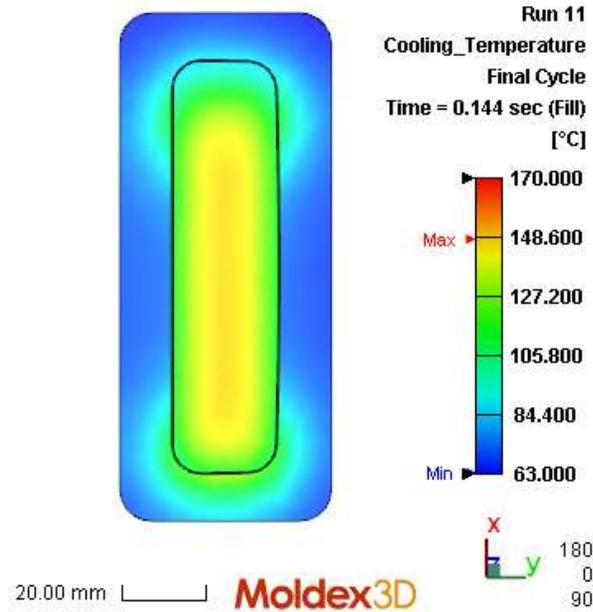
| | |
|-----------------------------|----------------|
| Tempo iniezione | 1.2 sec |
| Commutazione | 98.5 % |
| Tempo di mantenimento | 30 sec |
| Pressione di mantenimento | 60% picco inj. |
| Tempo di raffreddamento | 6 sec |
| Temperatura del fuso | 250 °C |
| Temperatura condizionamento | 50 °C |

Heat & Cool

Risultati

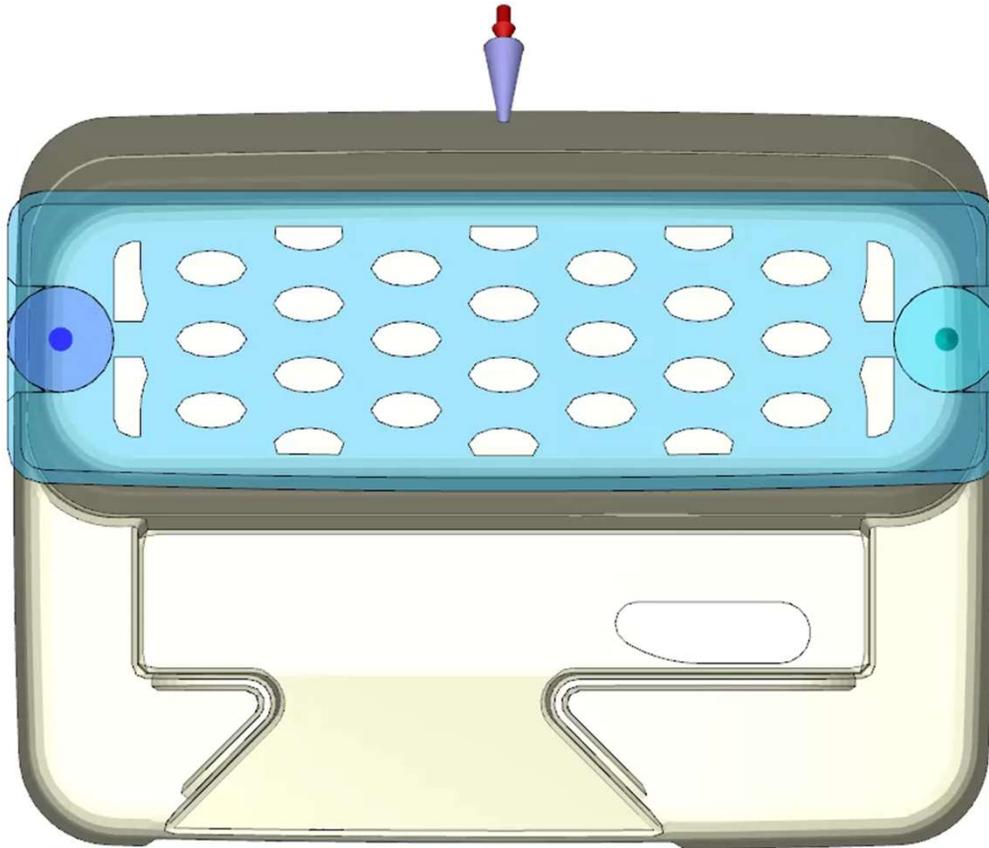


Condizionamento tradizionale



Condizionamento conformale – configurazione iniziale

Heat & Cool



Cooling_Stream Line_Flow Length
Final Cycle
Time = 37.200 sec (EOC)
[mm]
Max 237.111
Min 0.000

Risultati

Heat & Cool

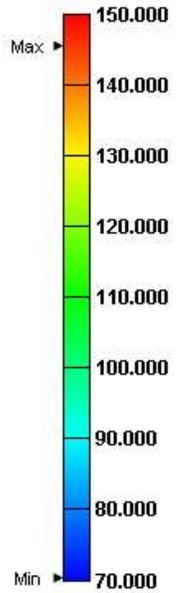
Risultati

Cooling_Temperature

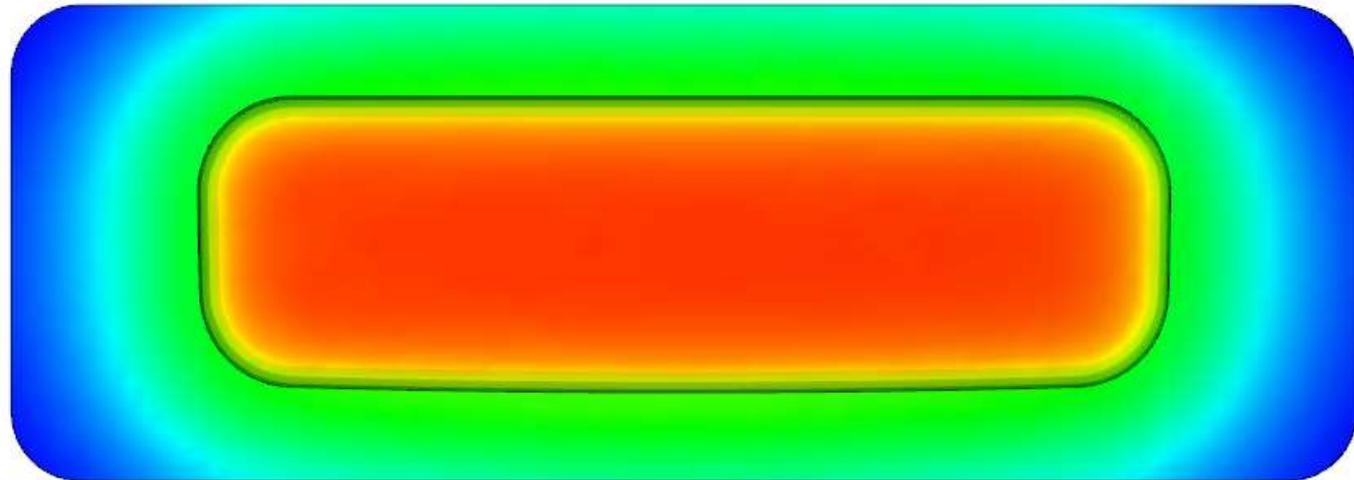
Final Cycle

Time = 0.125 sec (Fill)

[°C]



Condizionamento conformale – configurazione ottimizzata



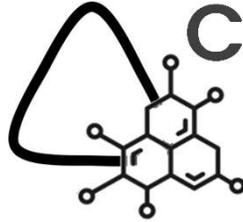
180
0
0



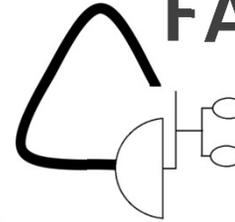
Moldex3D

10.00 mm

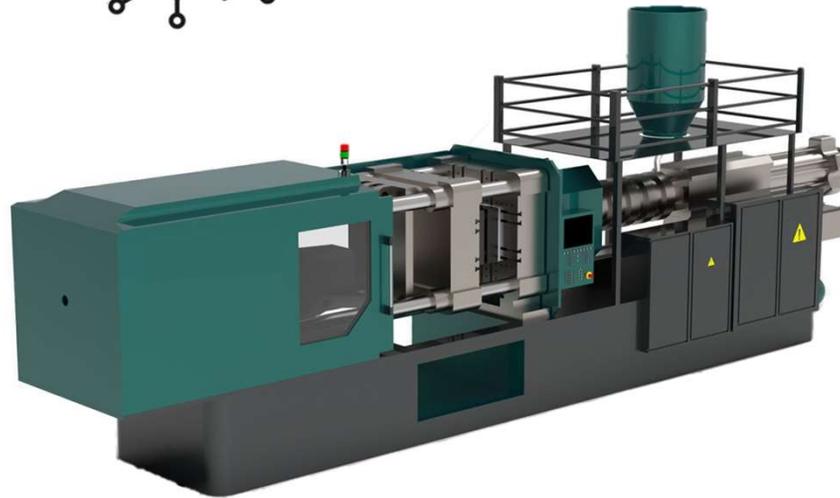
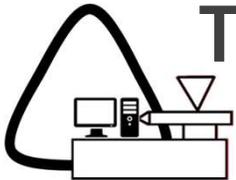
MATERIALI CONDUTTIVI



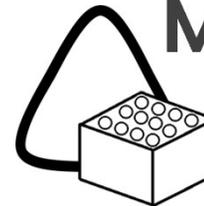
STAMPI FAMIGLIA



DIGITAL TWIN

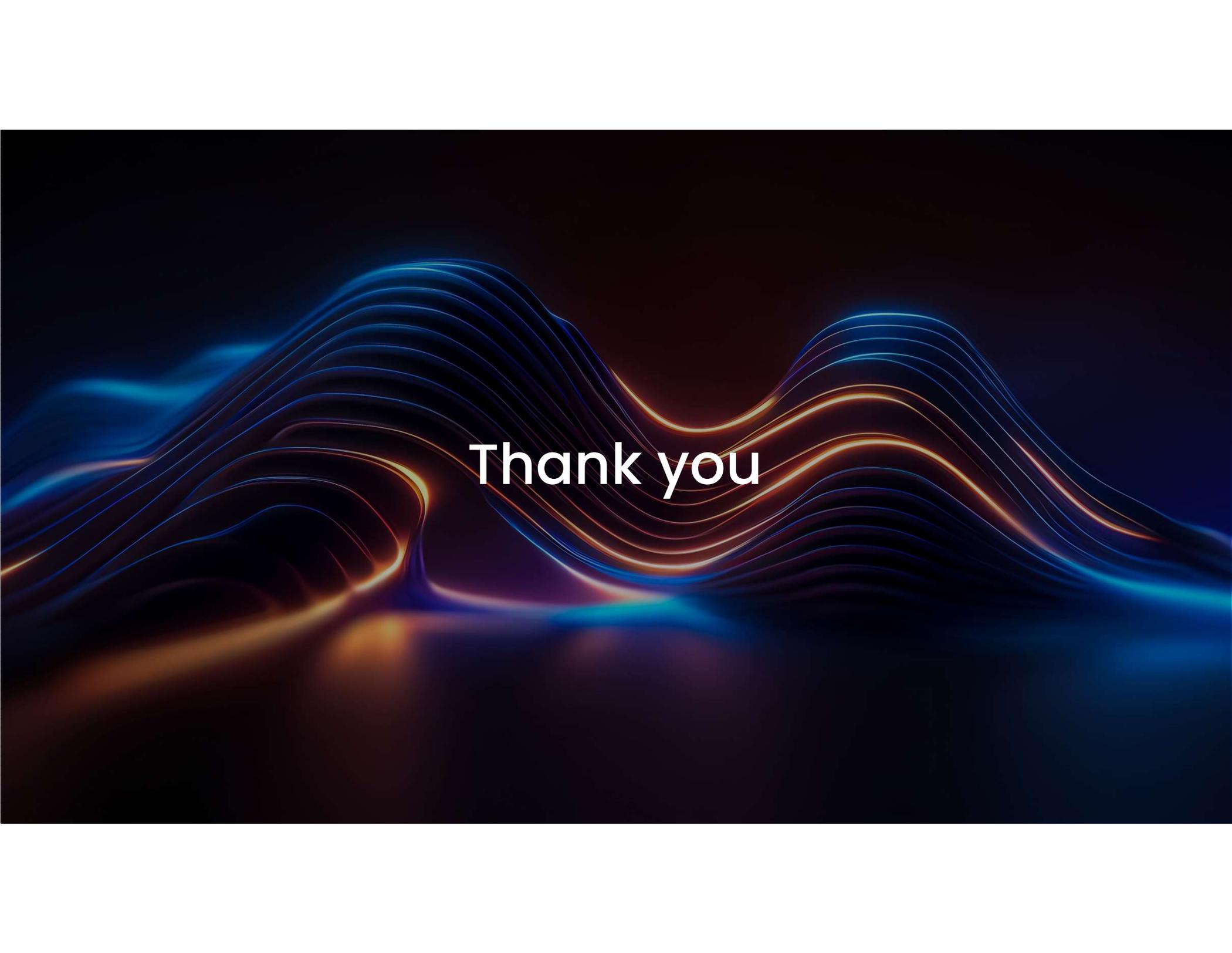


MUCELL



HEAT & COOL



The background features a series of flowing, wavy lines in shades of blue and orange, creating a sense of motion and depth. The lines are layered and have a soft, ethereal glow, set against a dark, almost black background. The overall effect is reminiscent of a digital or liquid landscape.

Thank you