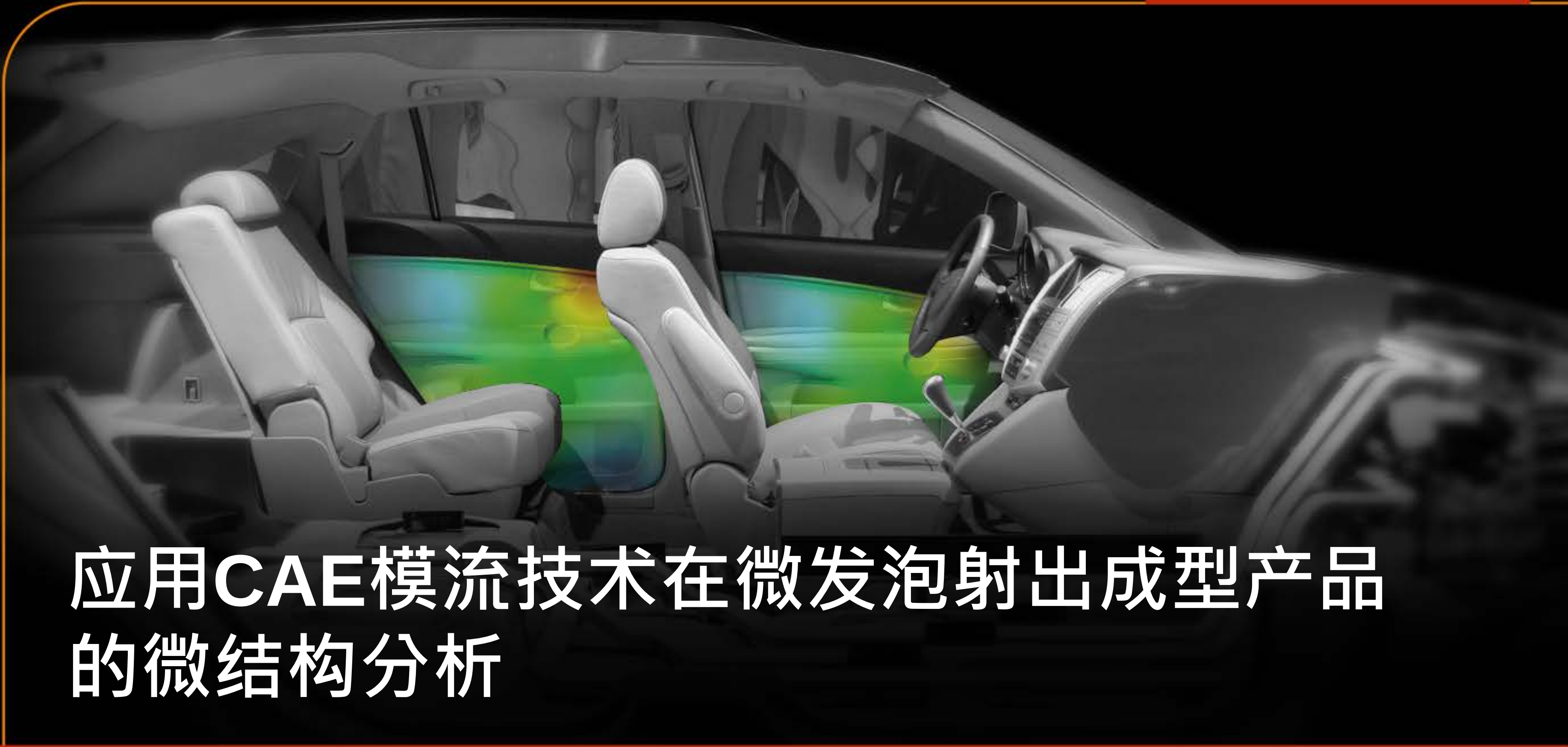


应用CAE模流技术在微发泡射出成型产品的微结构分析

科盛科技

CoreTech System Co., Ltd.
www.moldex3d.com

大纲

- 简介
  - 背景
  - MuCell®制程与应用
- 实验与模拟验证
  - 实验方法
  - 模拟验证
  - 传统塑料射出制程与微发泡射出制程比较
- 结论

简介

轻量化的技术

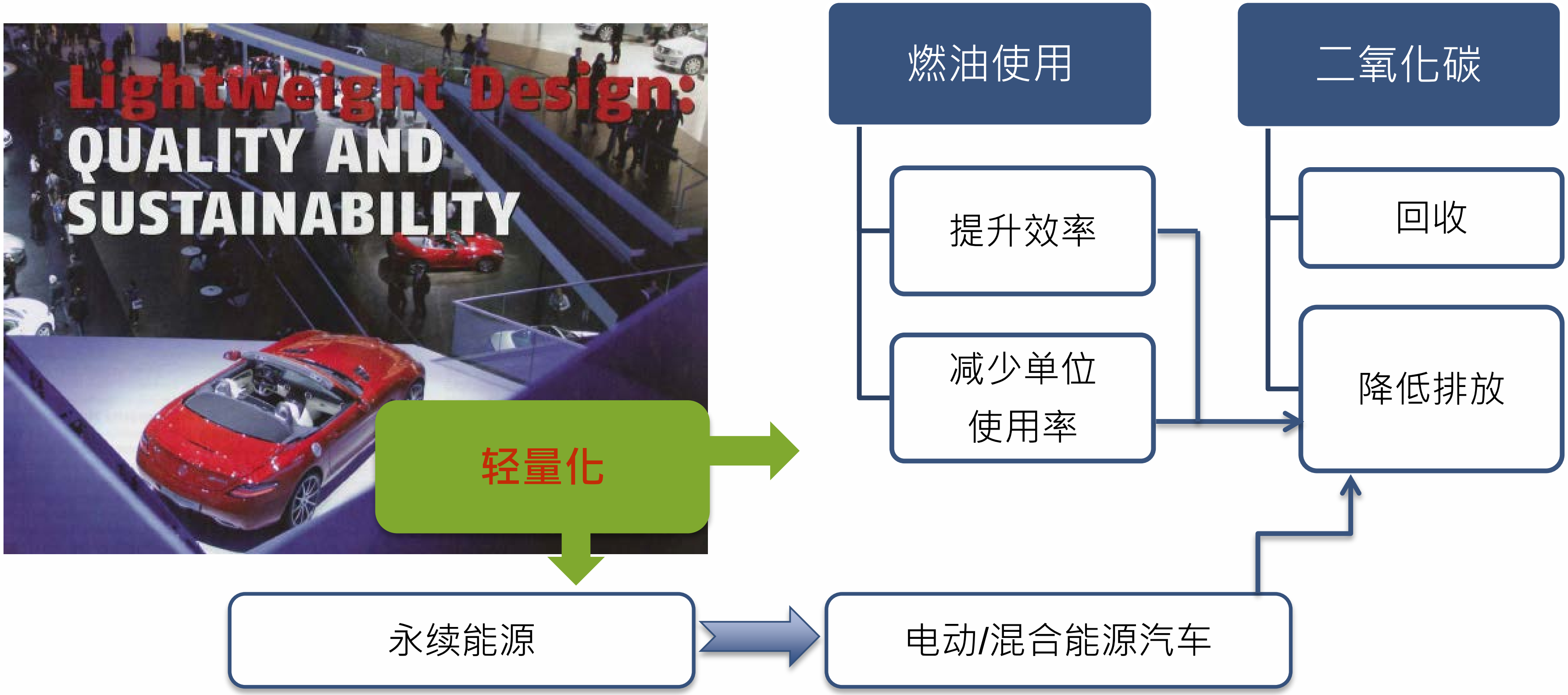

Autoevolution.com


perspectives.3ds.com


Compositesworld.com

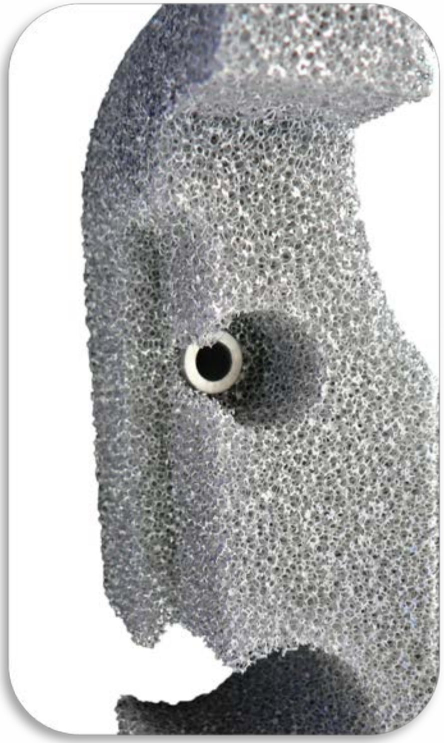
为何需要MuCell®

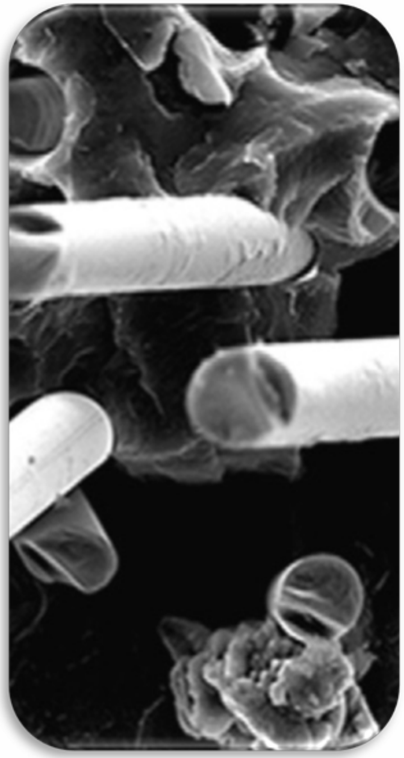
- 汽车产业轻量化需求
  - 轻量化可增加燃油运作效率与二氧化碳排放
  - MuCell 技术可显著地降低塑件产品重量，以及减少材料的使用量

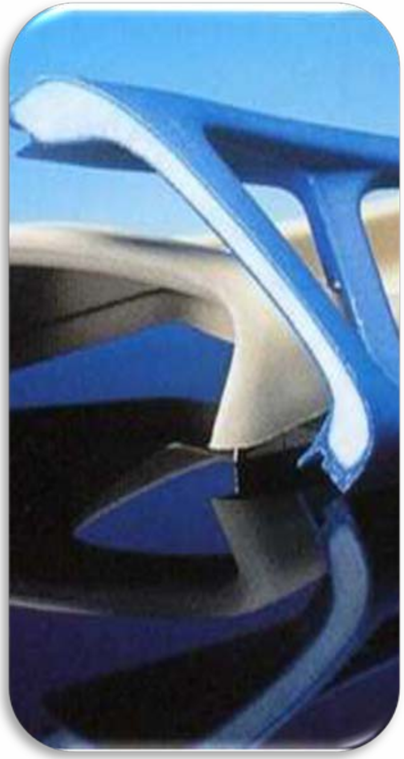


Moldex3D

Injection molding lightweight techniques


Foaming

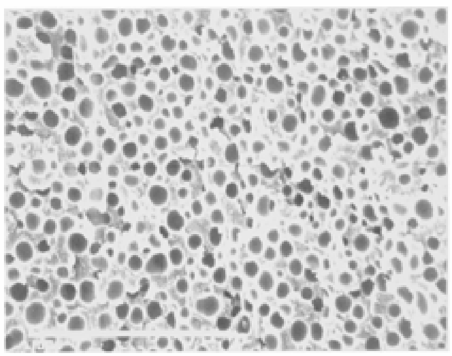

Fiber

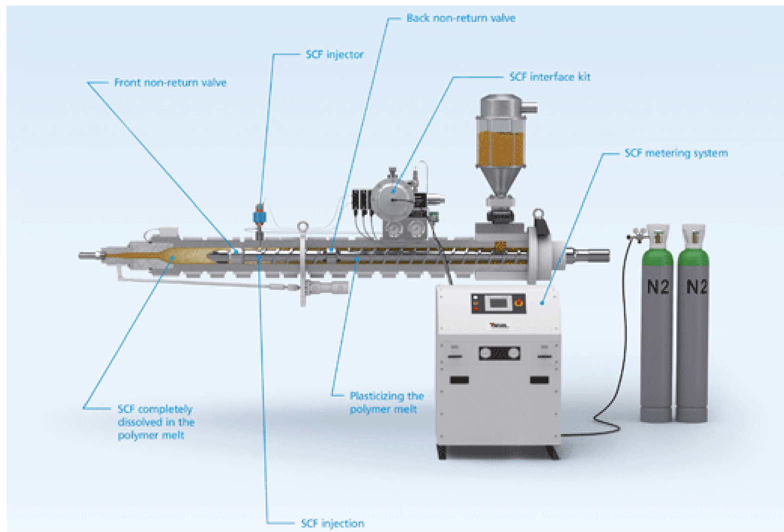

Co-injection


Gas-assisted

MuCell®操作原理

> MuCell®制程主要是在射出成型周期中去控制气体，让其保持在超临界流体的状态(SCF)，以产生数以百万计微米大小的气泡。



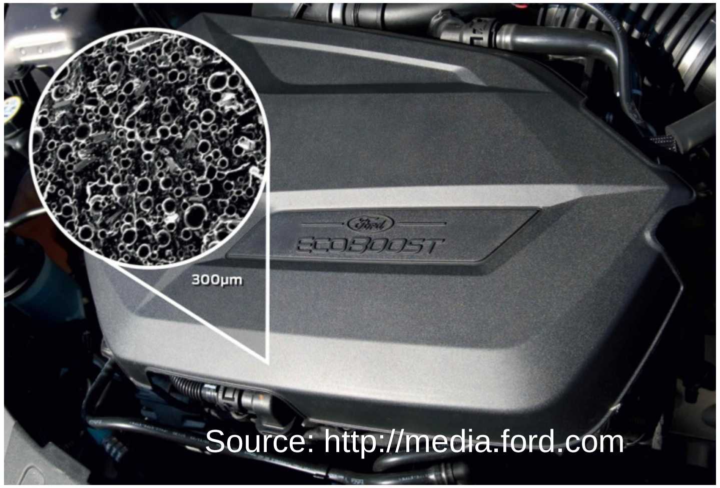


MuCell is a registered trademark of Trexel, Inc.

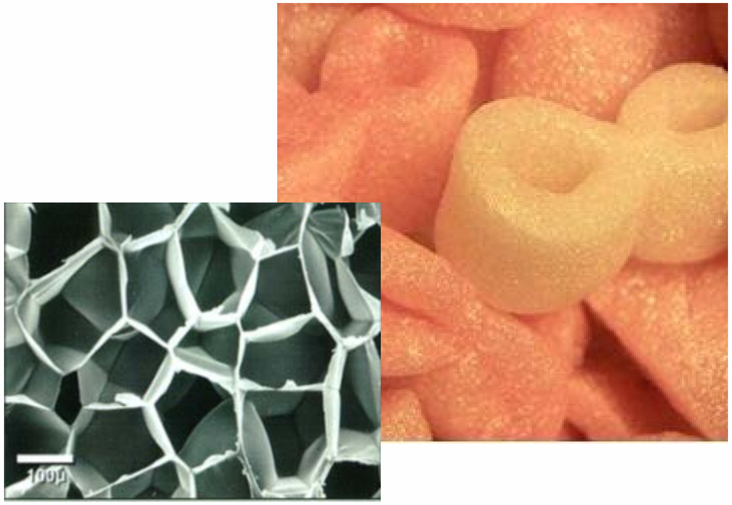
Moldex3D

微发泡制程特性

	微发泡	传统发泡
发泡形式	物理发泡	化学发泡
气泡尺寸	< 100 μm	> 100 μm
气泡密度	High	Low
机械性质	优	不好



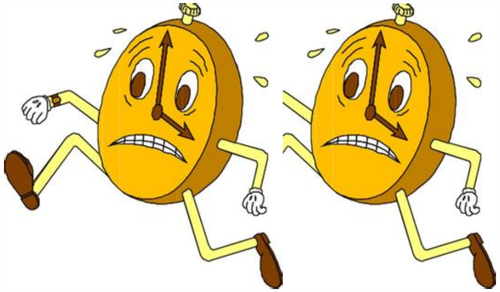
Source: http://media.ford.com



MuCell® 技術簡介

> 傳統注塑的限制
  - 尺寸精度不易控制
    - 塑料冷卻後體積收縮率不均
    - 體積收縮不均造成翹曲變形
  - 產品成本難以降低
    - 充填保壓需要足夠的鎖模力
    - 傳統成型製程不易節省塑料
  - 成型週期難以優化
    - 改善體積收縮增加保壓時間
    - 為改善變形而增加冷卻時間

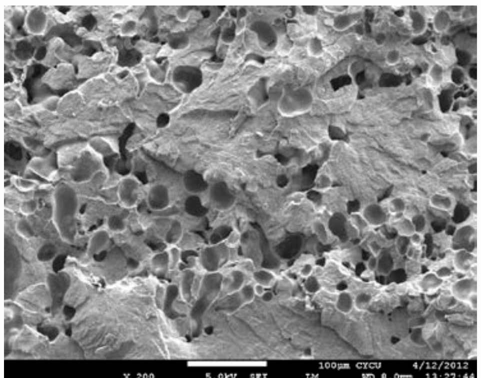
> 微發泡技術優勢
  - 大幅改善尺寸精度
  - 大幅降低鎖模成本
  - 大幅縮短成型週期

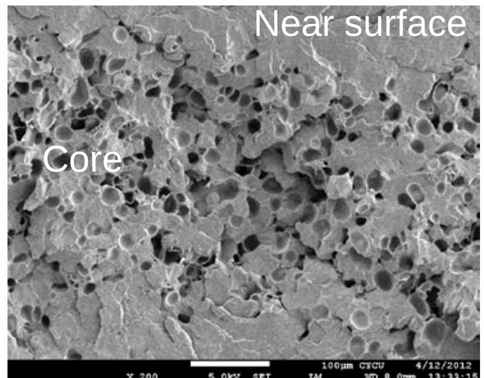


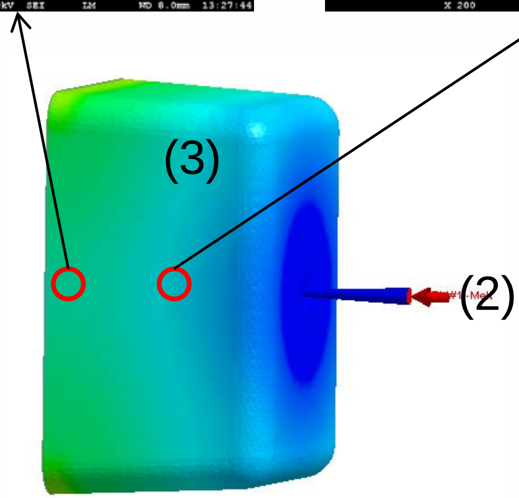
MuCell Processes TREXEL INC. Moldex3D

原理

三个主要步骤：(1) 气体和聚合物的单一相混合；
(2) 气泡成核；
(3) 气泡成长。

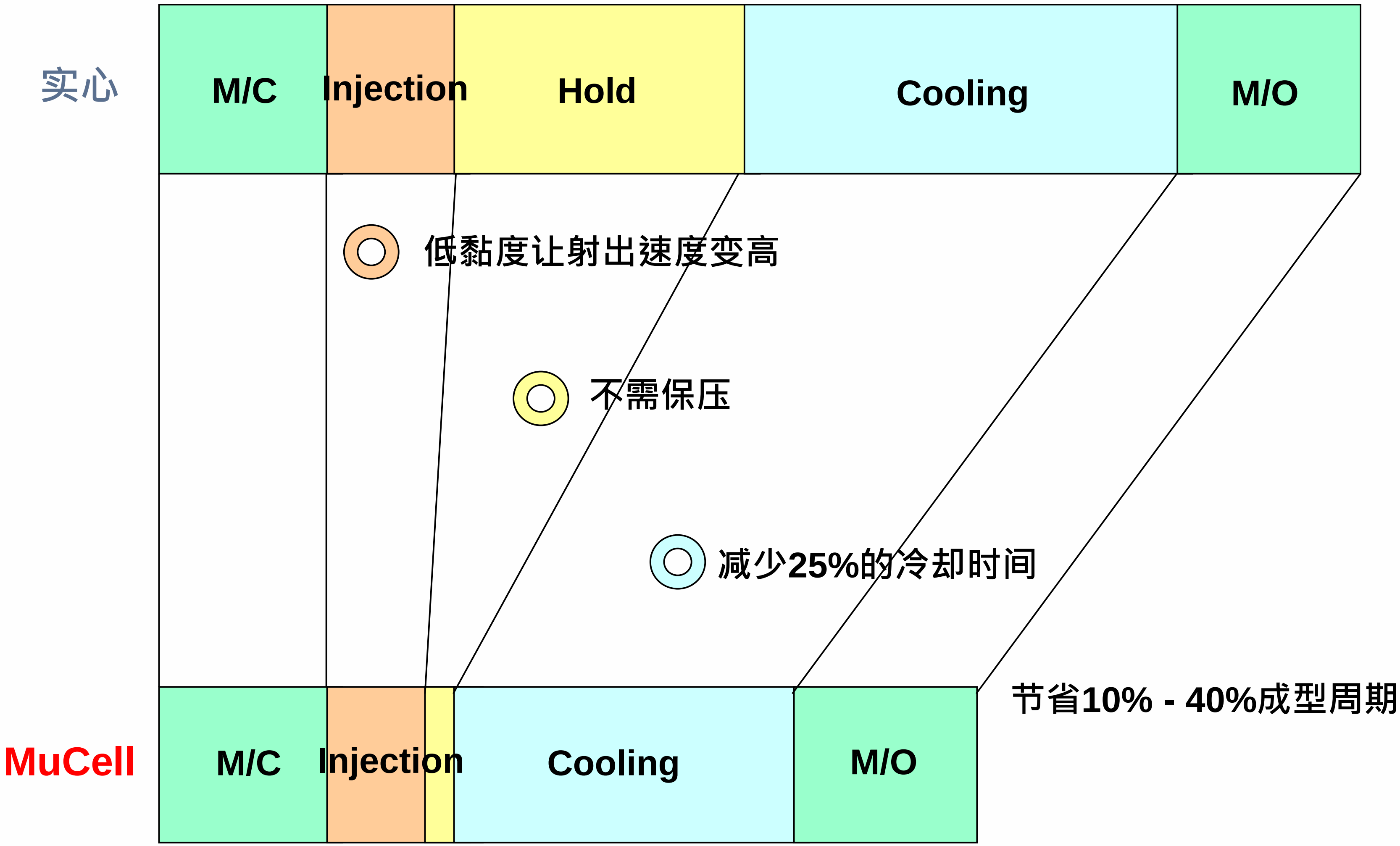






Moldex3D

特性与优点

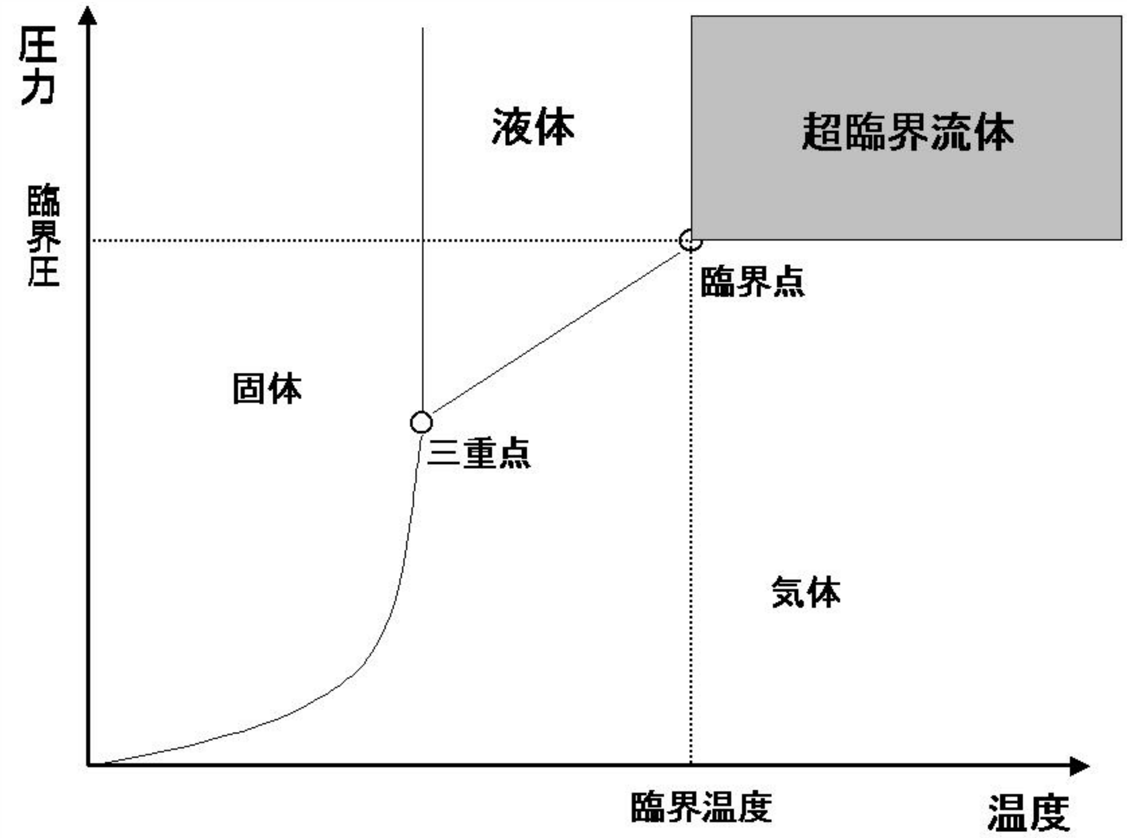


Moldex3D

MuCell® 技術簡介

> 超臨界流體特性

– 超臨界流體定義及特點



液體：分子運動小, 密度大

氣體：分子運動大, 密度小

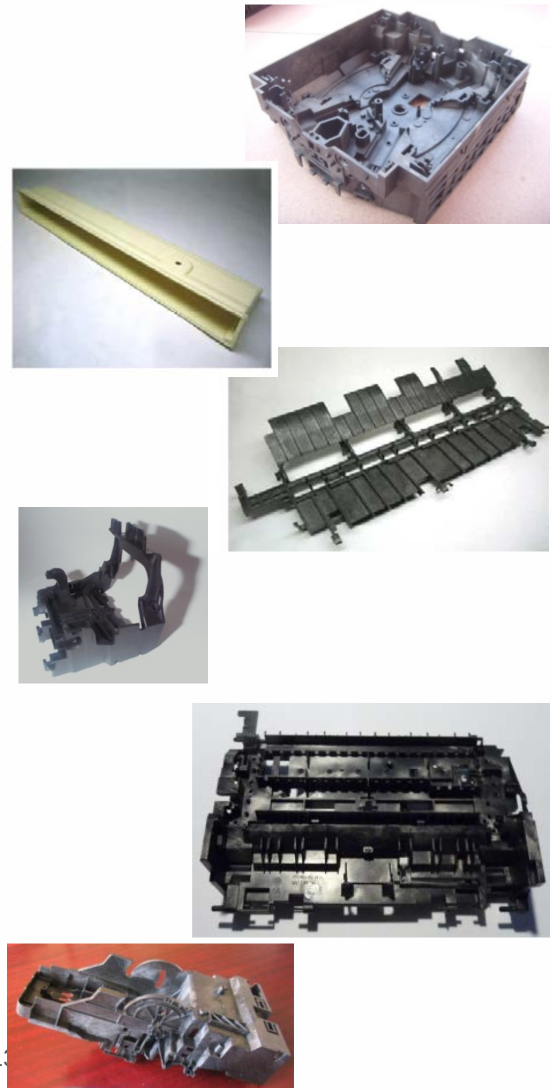
SCF：分子運動大, 密度大

超臨界流體特點：

- 擴散性強→易於混合
- 壓縮性低→精準計量

微细发泡射出成型的应用

商务设备



汽车业

工业与电子业

问题与挑战

> 成型过程难以控制 (热力学不稳定状态的控制)

> 未知的发泡过程 (温度与压力的变化)

> 表面质量的潜在问题

> 设计不同的高分子与发泡剂(SCFs)组合

> CAE技术的研发

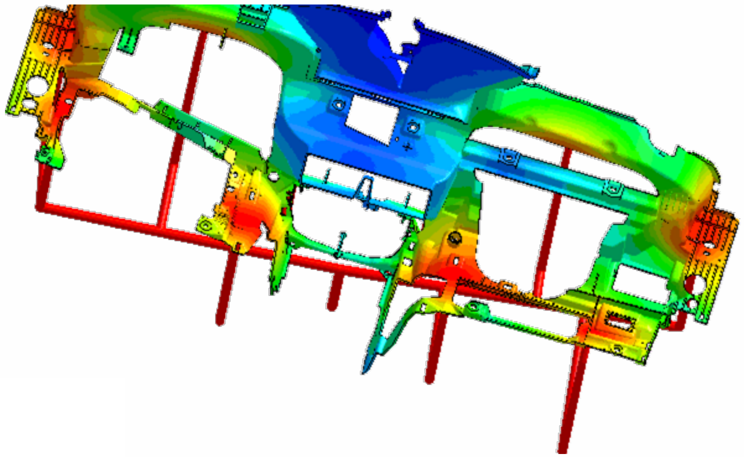
Moldex3D MuCell®成型模拟技术

> 真实三维技术提供更准确的微结构流体流动信息

> 同时考虑气泡成核与气泡成长，以预测气泡密度与气泡大小

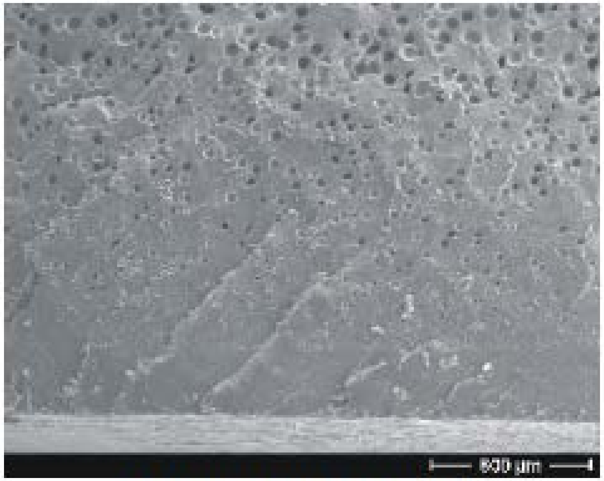
> 成型过程中考虑气泡发展与熔胶流动间的相互作用

> 考虑气泡结构对成品翘曲的影响，有效达到产品轻量化的目标

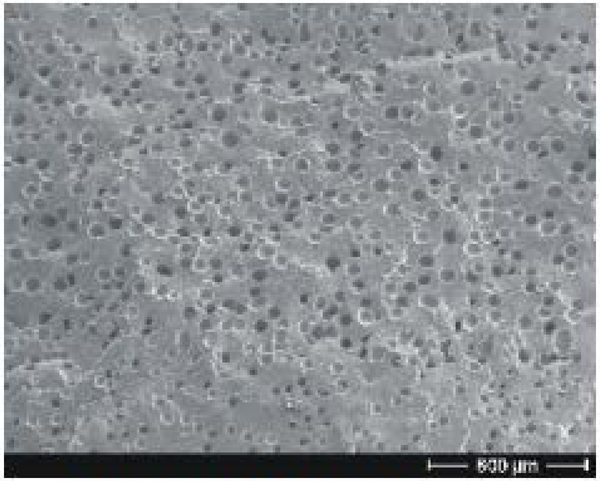


Moldex3D MuCell® 模拟结果输出

- 气泡半径分布 (一般约为5-100微米)
  - 表层 (半径愈小愈好)
  - 中心
- 气泡密度分布 (一般约为10^7-10^9 [cells/cm^3])
  - 表层 (密度越低越好)
  - 中心



Microstructure Near Surface



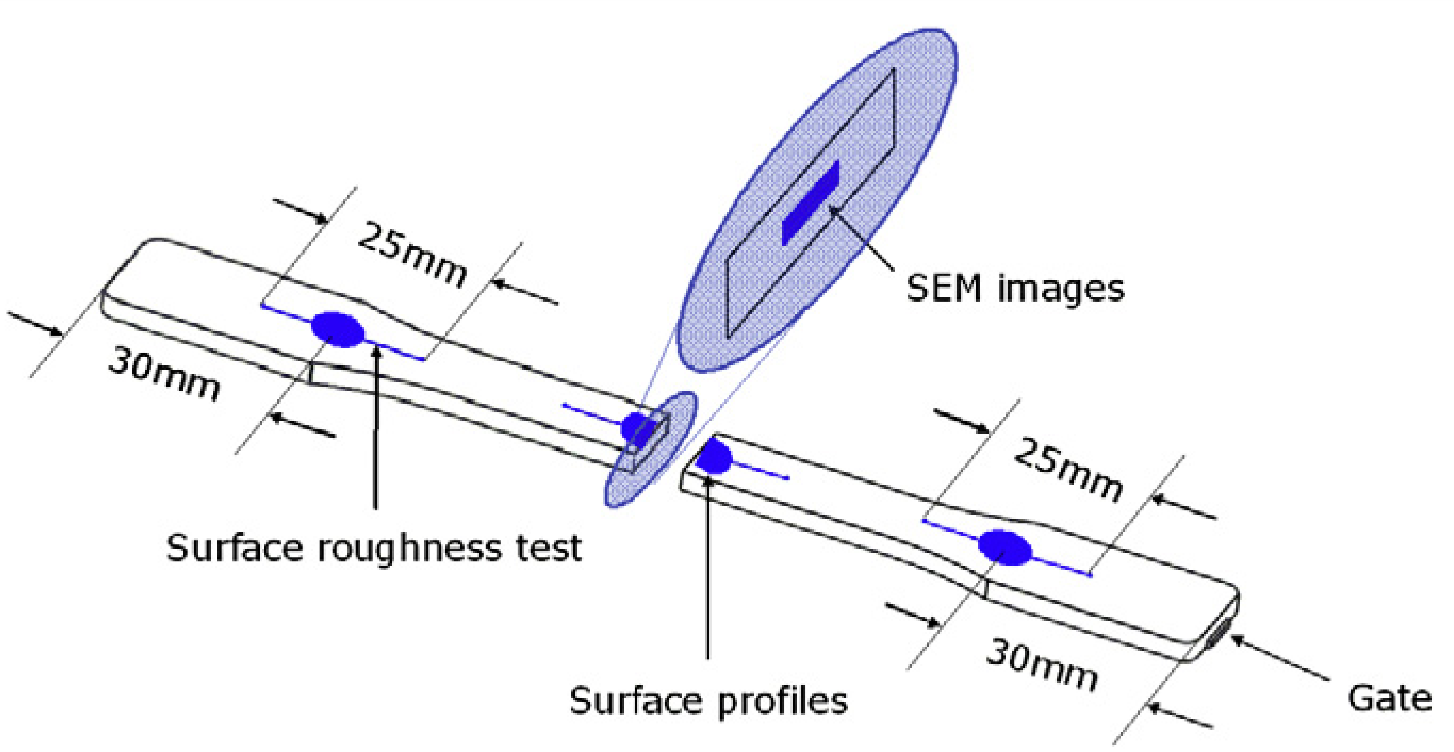
Microstructure Near Core

http://www.forestprod.org/composites09pilla.pdf /

实验与模拟验证

文献研究

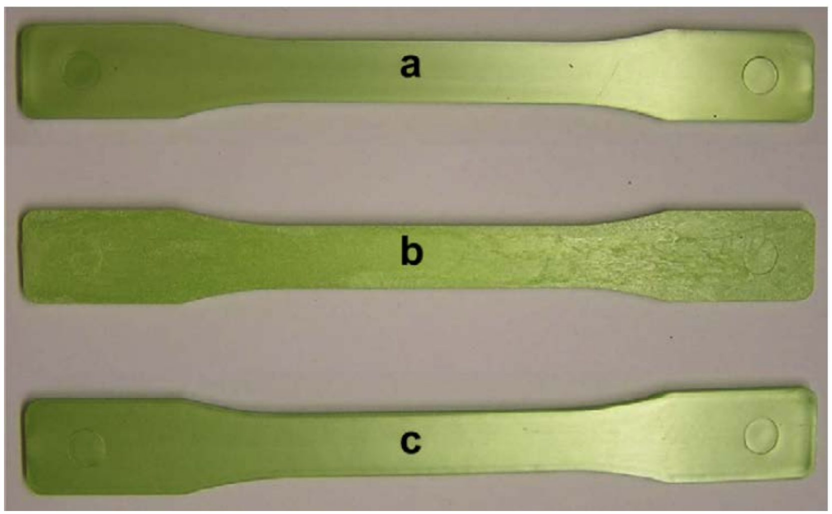
> 表面粗糙度与SEM量测

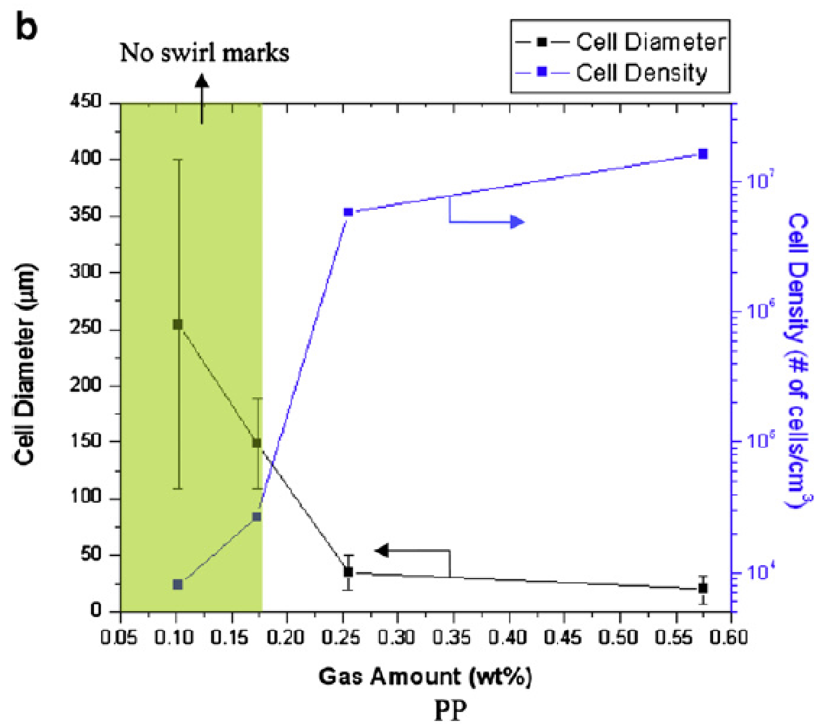


Ref: Turng et al, A novel method for improving the surface quality of microcellular injection molded parts, Polymer 52 (2011) 1436e1446

文献研究

- a: 实心
- b: 高 SCF 浓度
- c: 低 SCF 浓度

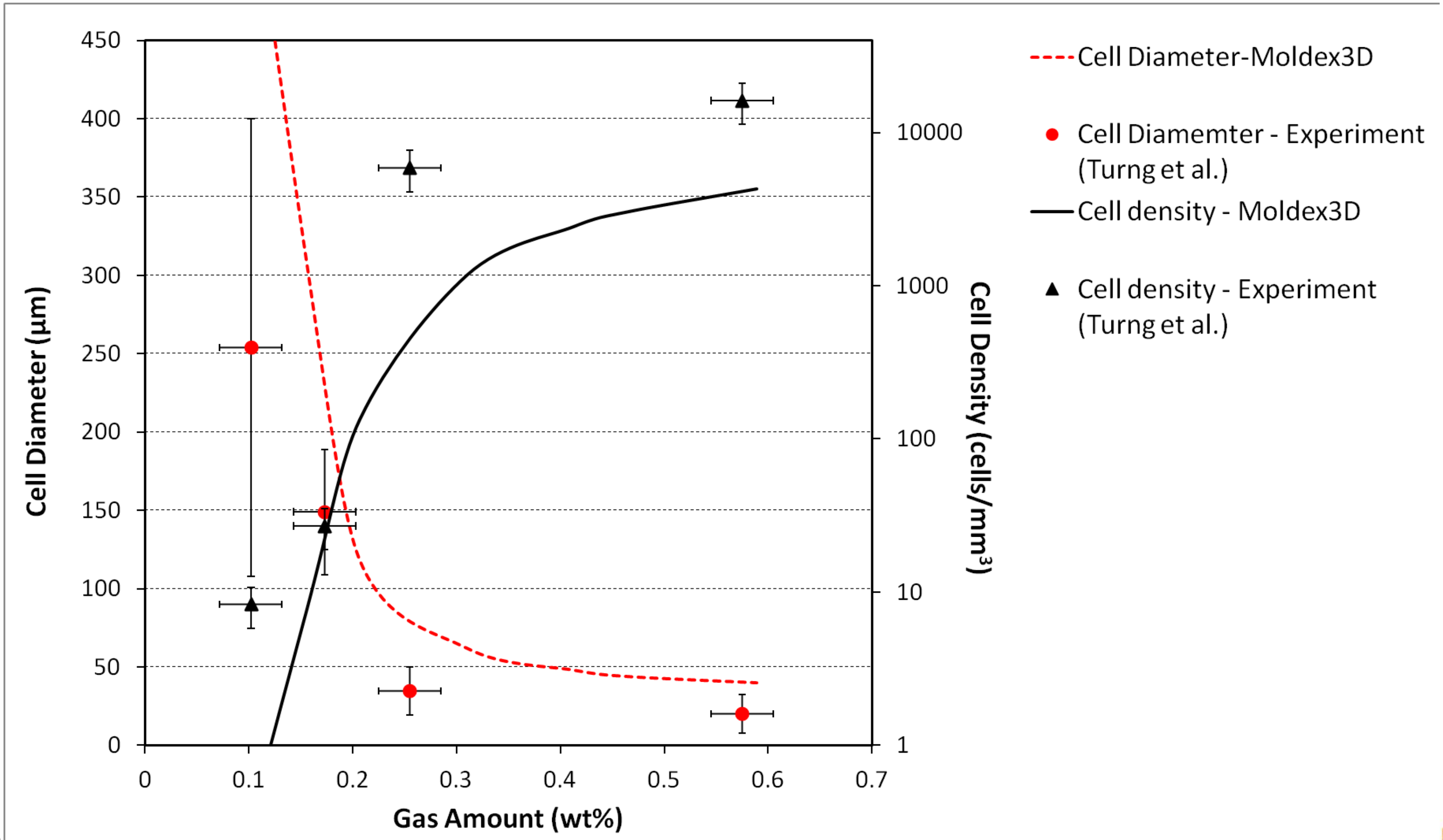




Ref: Turng et al, A novel method for improving the surface quality of microcellular injection molded parts, Polymer 52 (2011) 1436e1446

实验与模拟结果

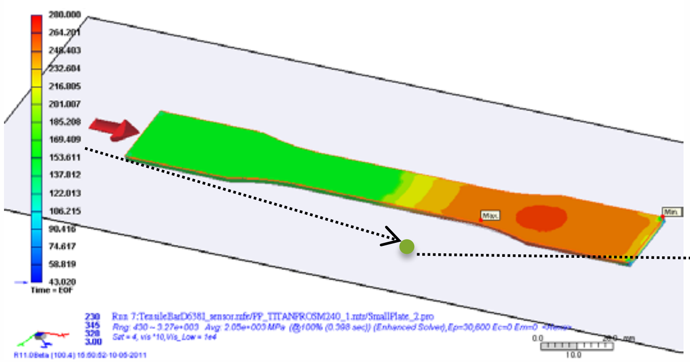
> N2/PP



N2/PP : Psat = 4MPa (Gas 0.48wt%)

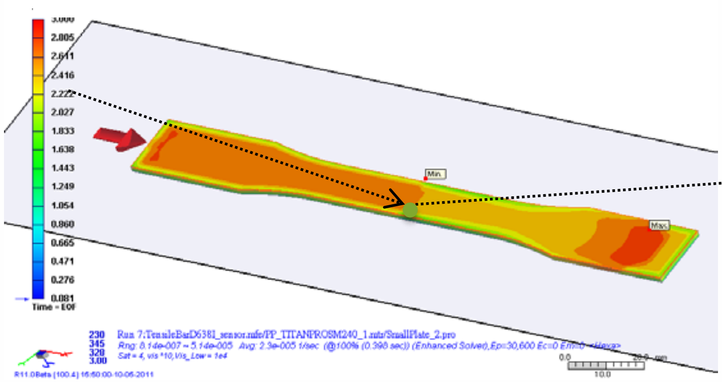
> 气泡密度 [Cells/mm³]

Cell Density
× 10¹ [1/mm³]

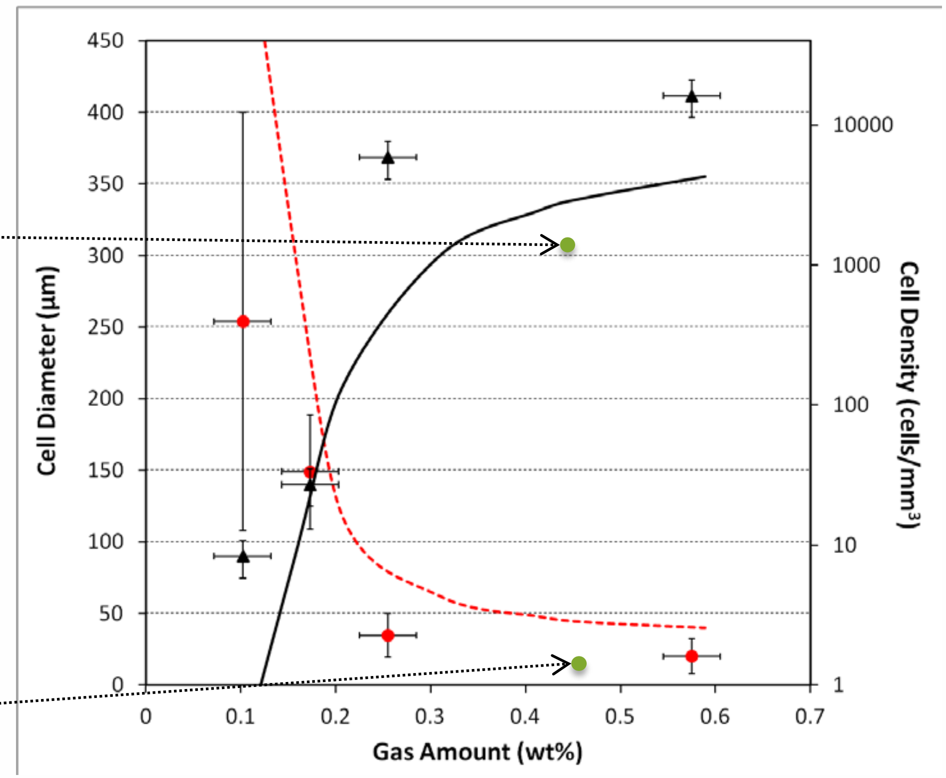


> 气泡半径 [e-5m]

Cell Radius
× 10⁻⁵ [m]



模拟量值，气泡密度为2300 Cells/mm3，
气泡半径为25μm，与实验结果接近



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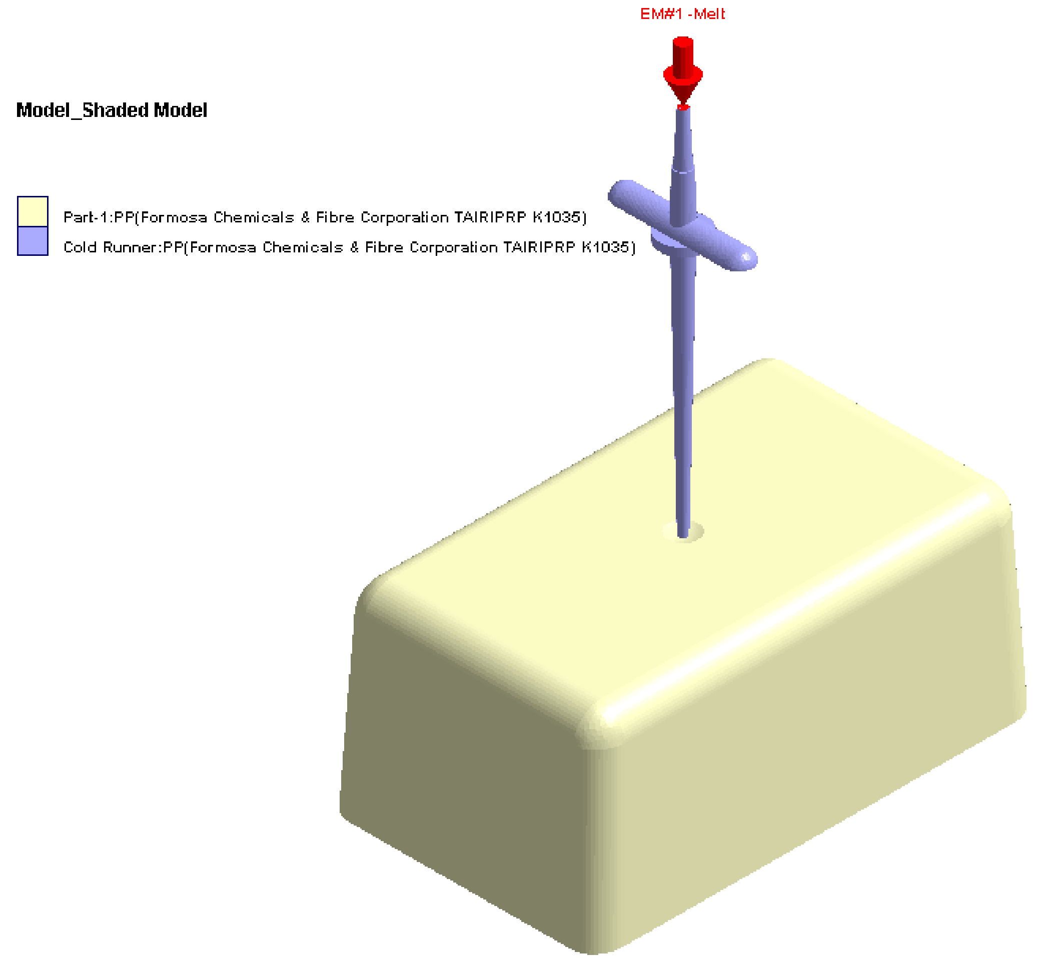
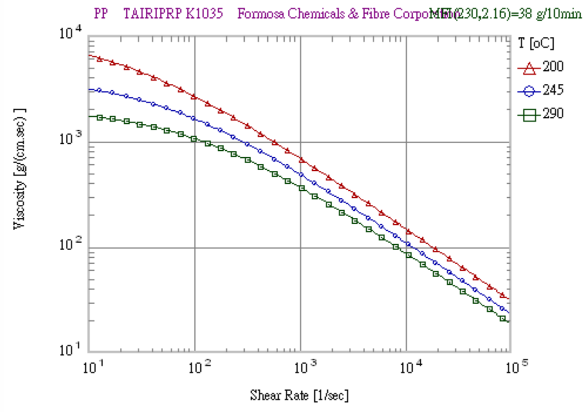
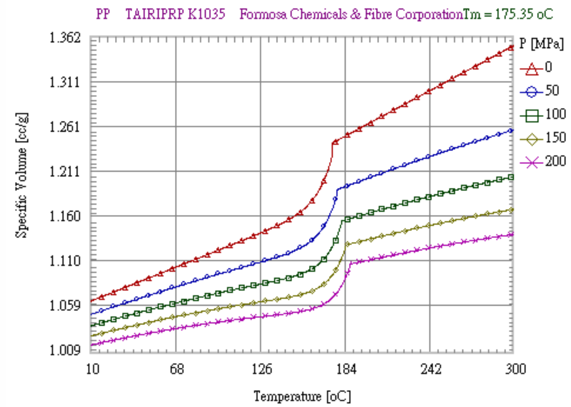
Validation – Thin Wall Container

实验与模拟验证

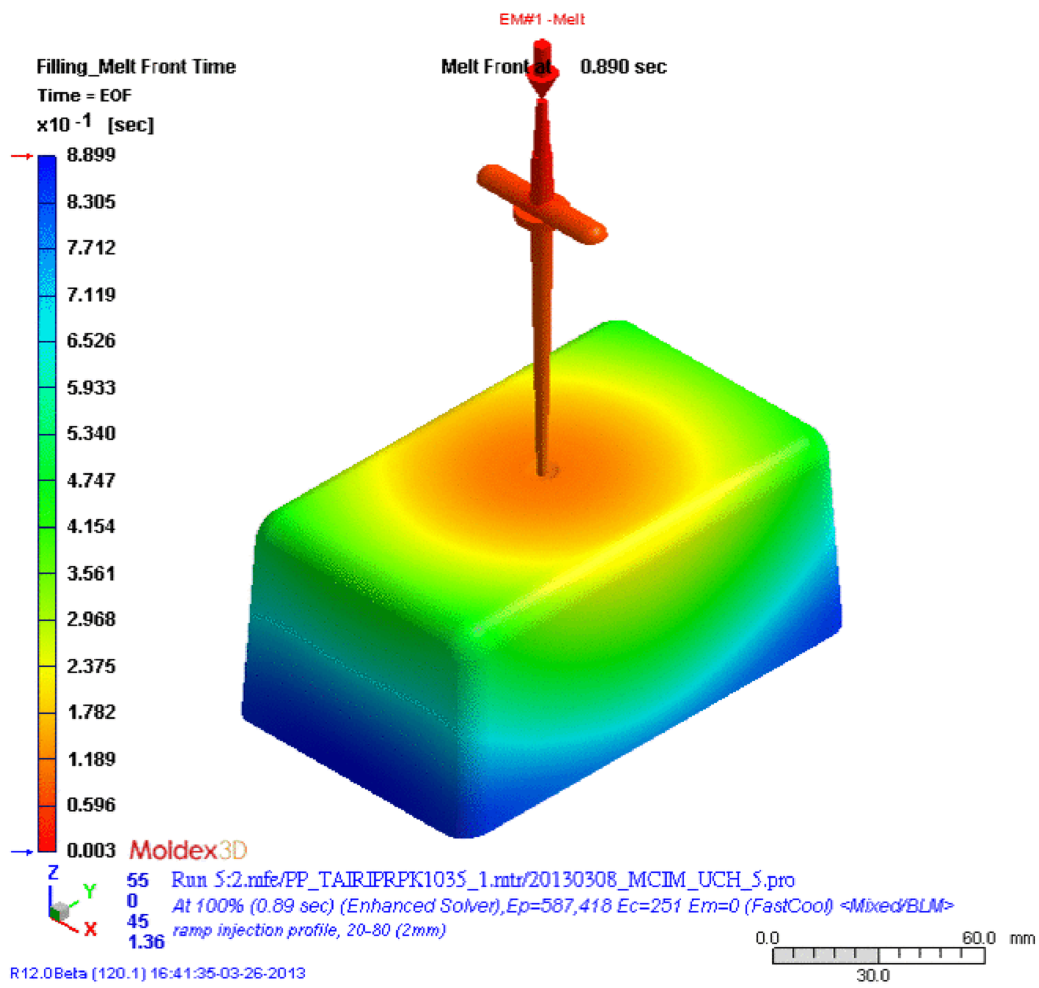






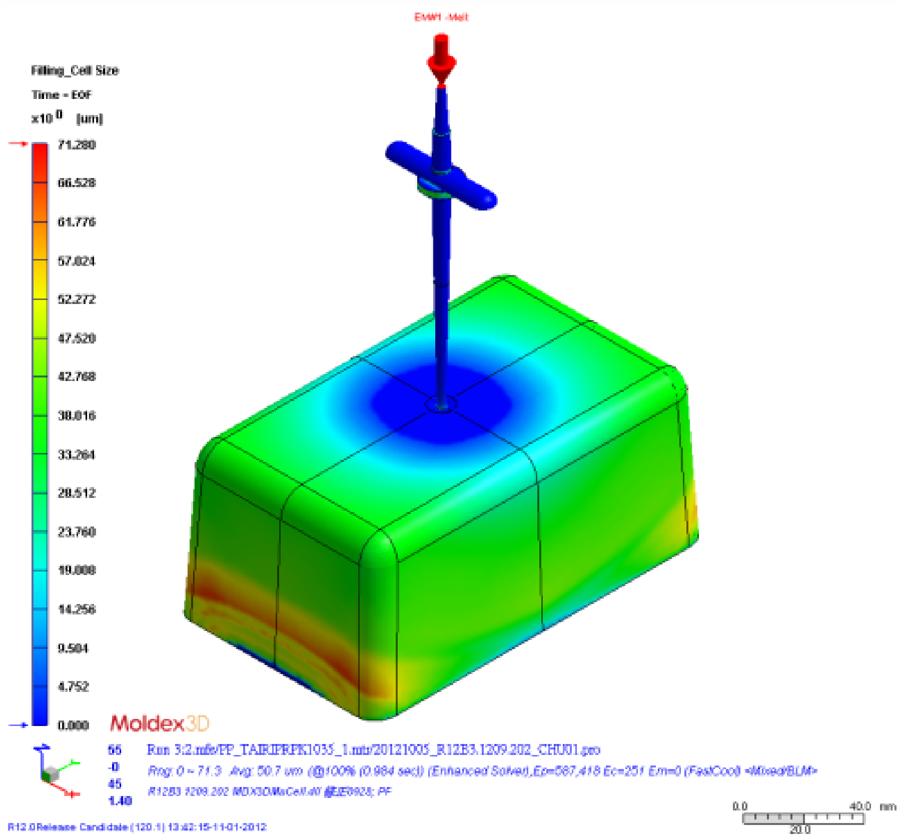
Moldex3D

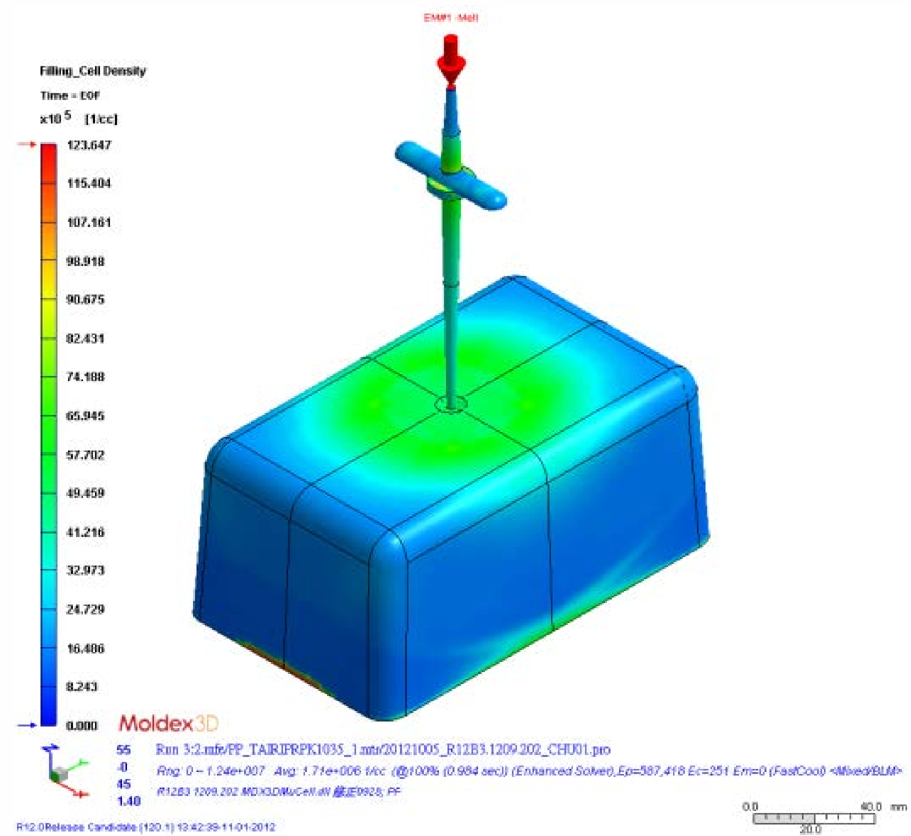
模拟与实验结果比较



Moldex3D

气泡大小 / 气泡密度结果

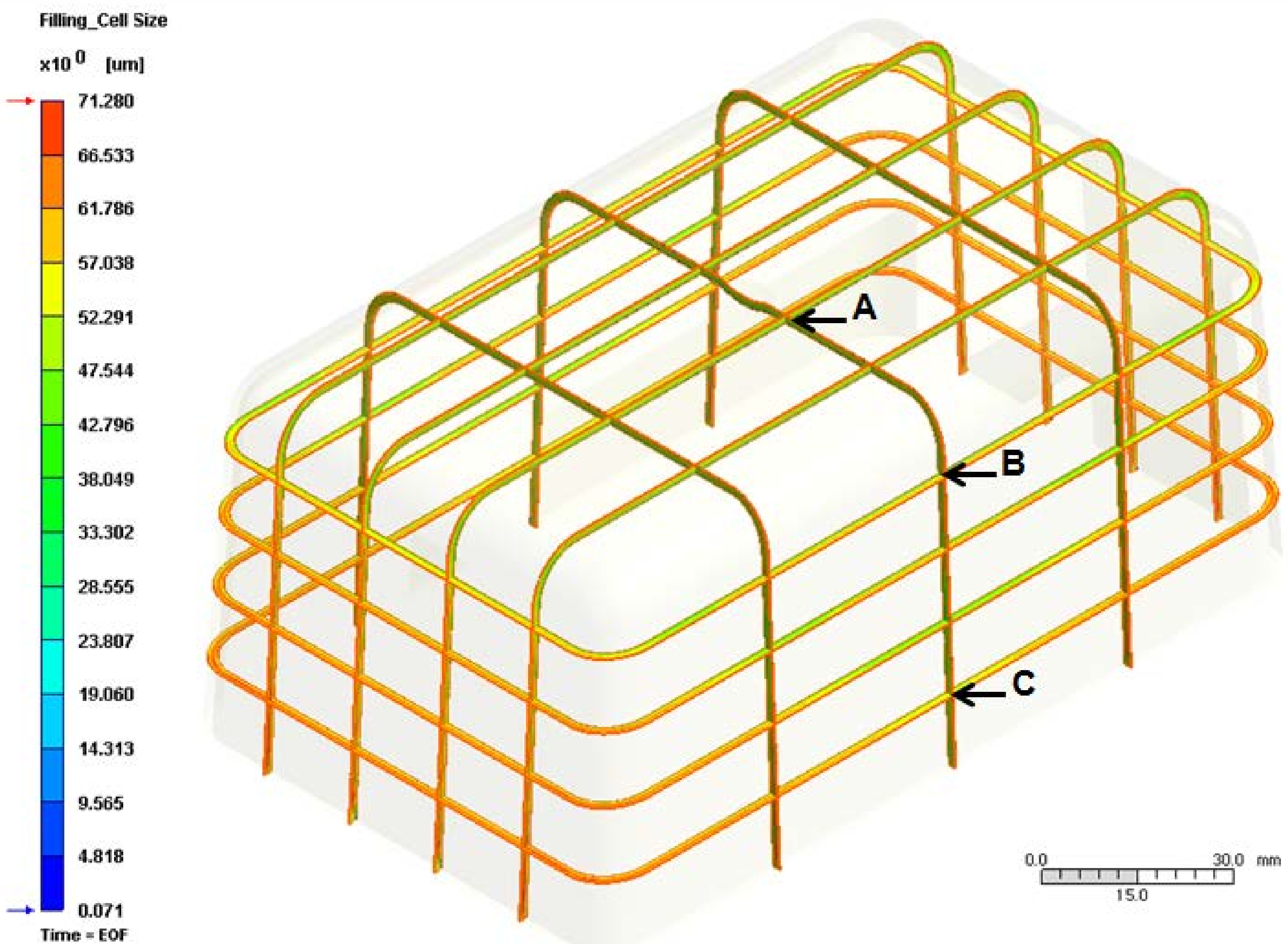




充填/保压结束的表面**气泡大小**与**气泡密度**结果

Moldex3D

PP成型盒的气泡大小分布



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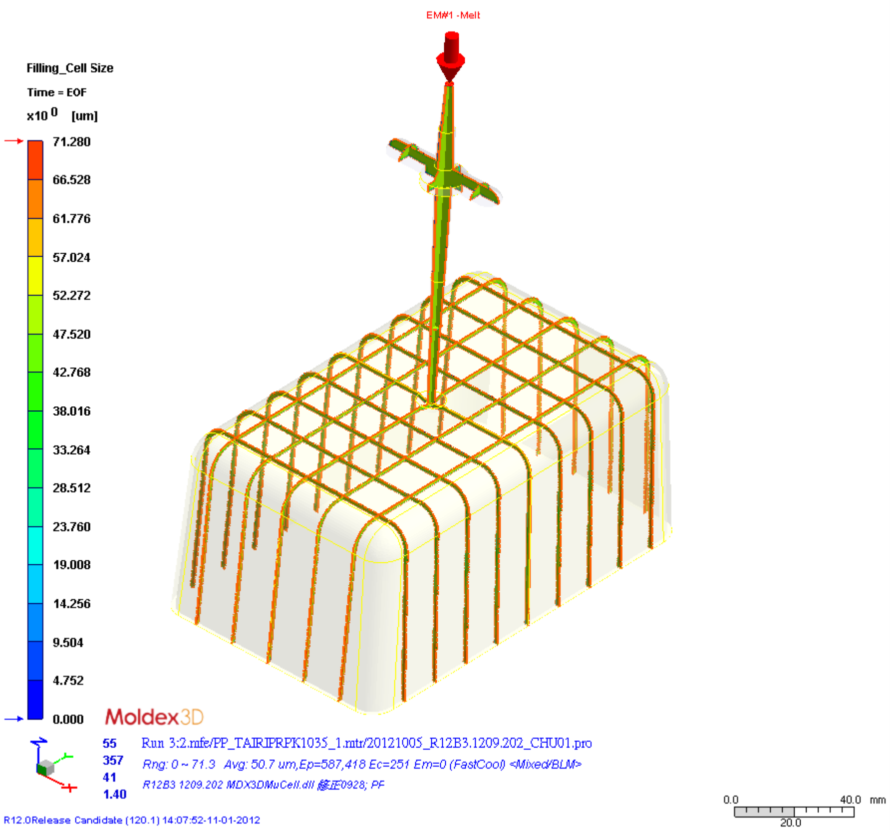
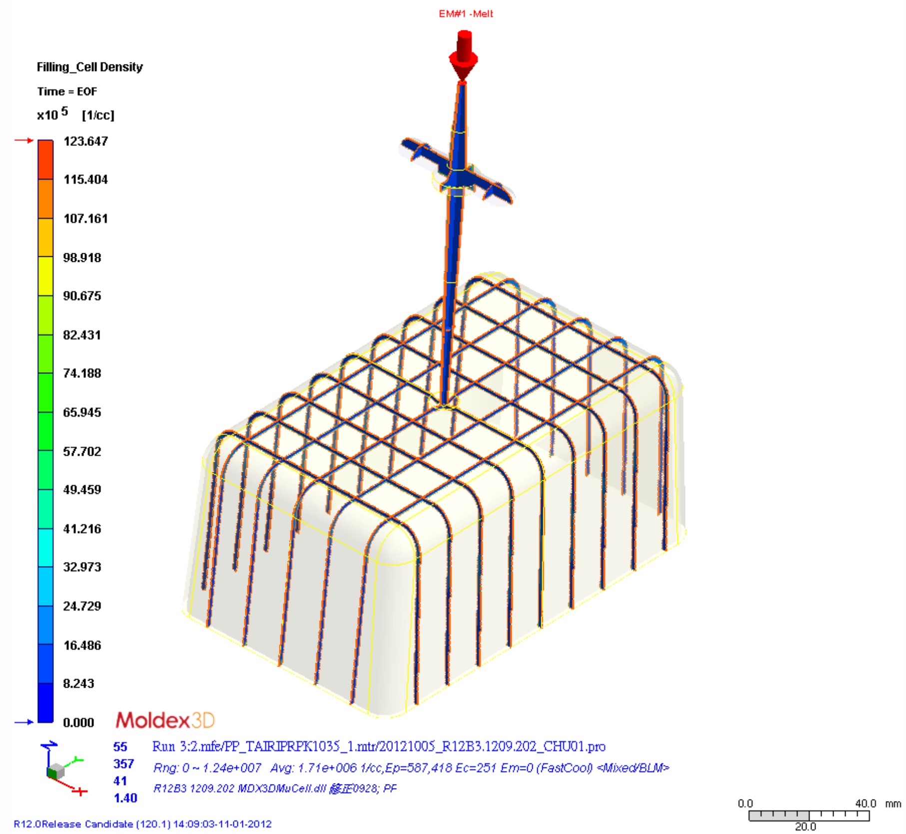
剖面功能显示

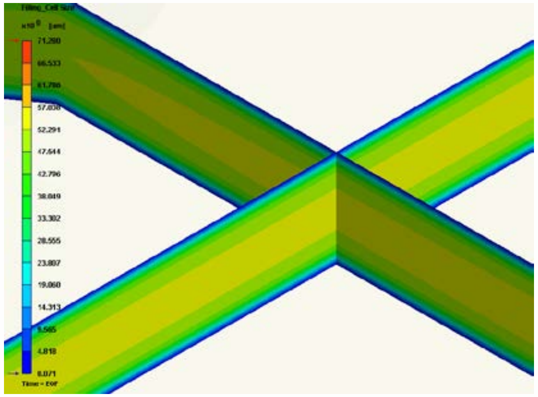


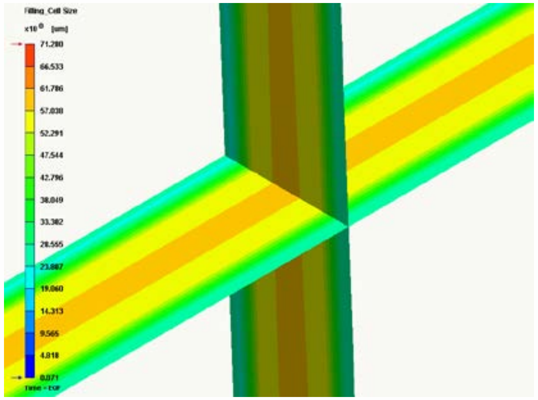


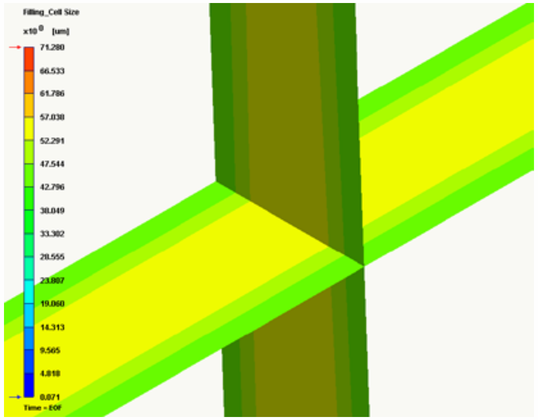
透过剖面功能，显示充填/保压结束的中央**气泡大小**与**气泡密度**结果

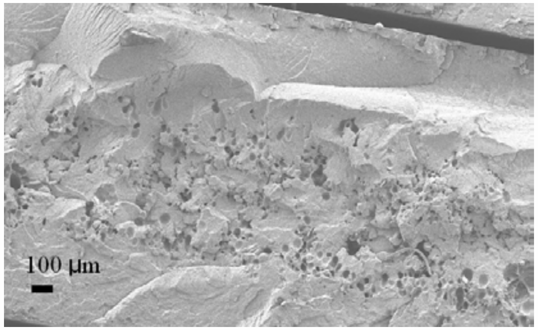
气泡大小分布比较

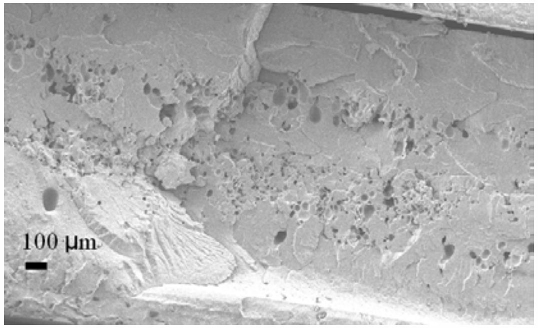
> 0.5 wt% N_2 SCF, PP

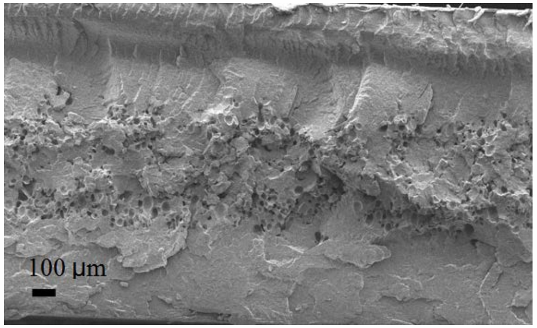




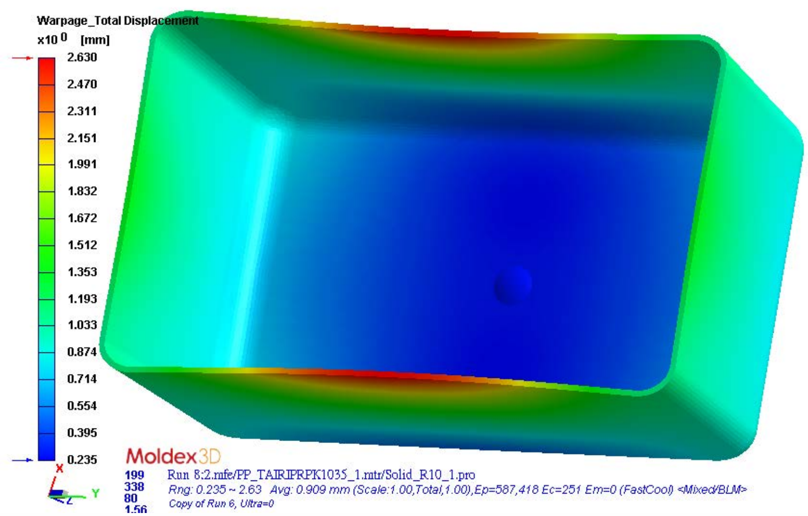




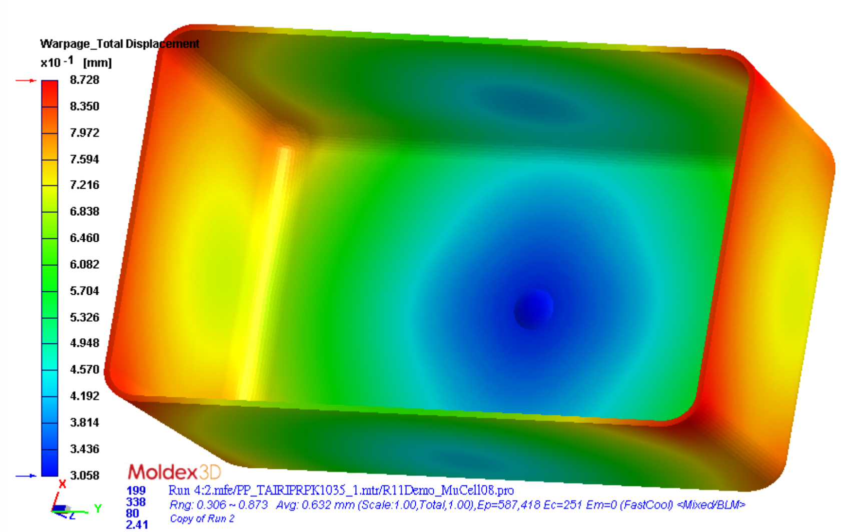




传统 vs 发泡制程的翘曲结果比较 (X1)



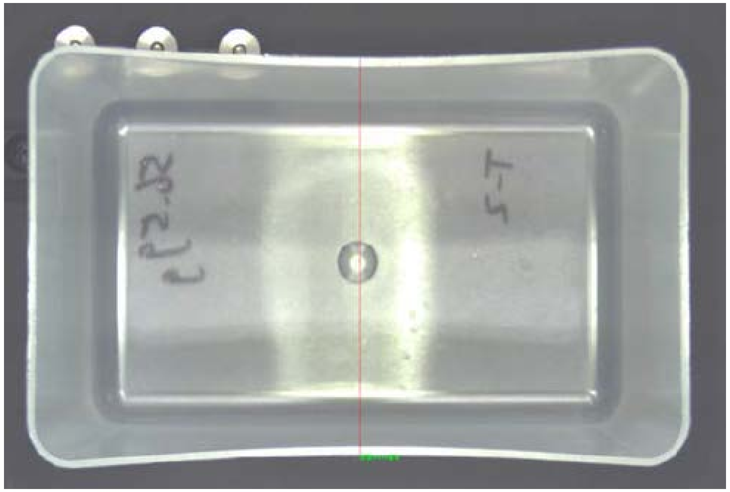
传统射出成型产品

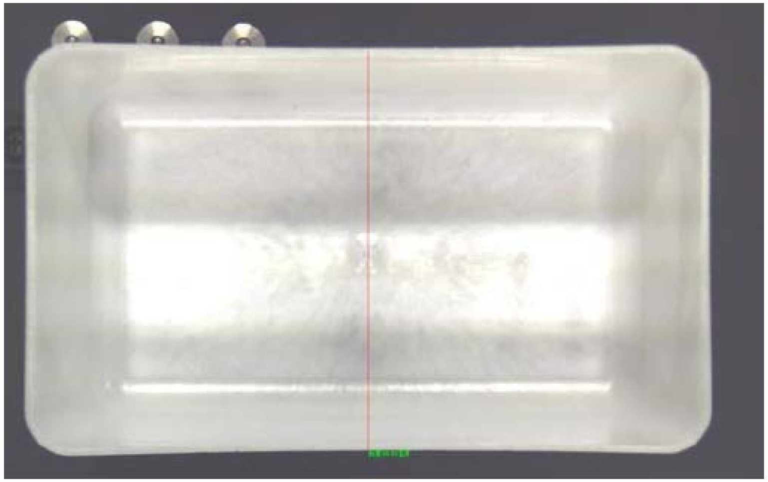


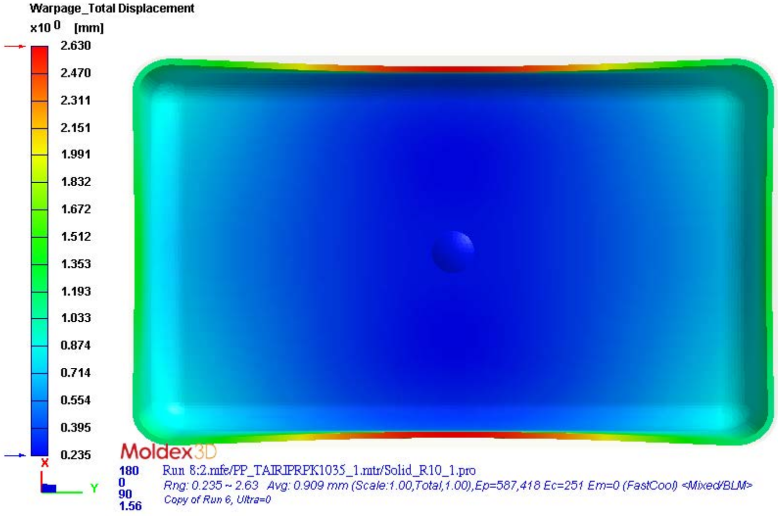
微细发泡成型(MuCell®)产品

Moldex3D

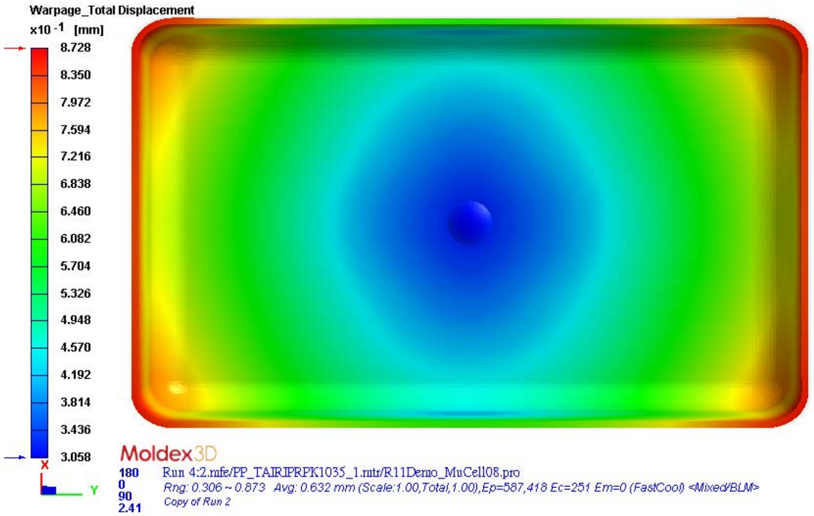
传统 vs 发泡制程的翘曲结果比较 (X1)







传统射出成型产品

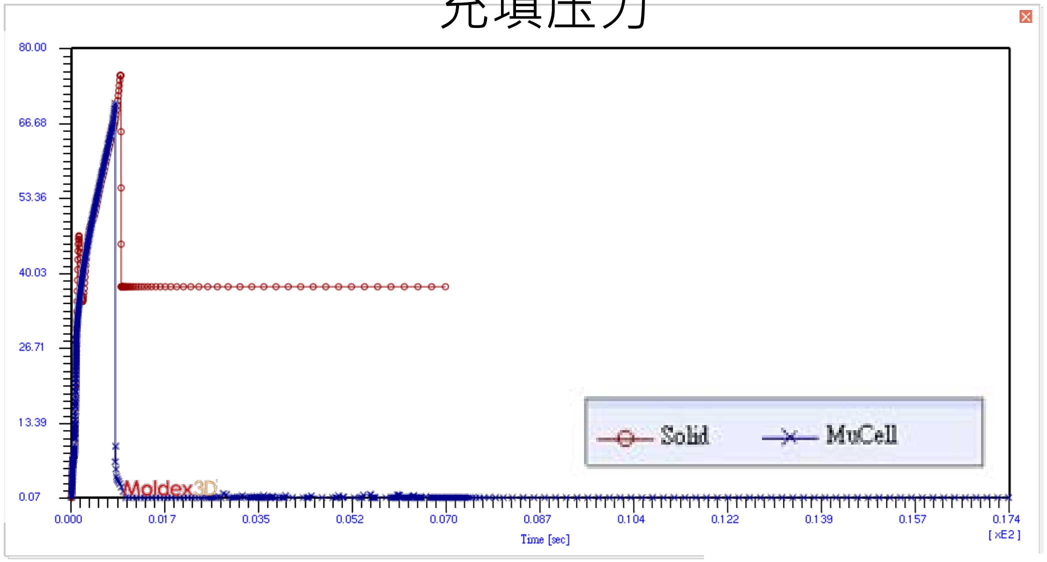


微细发泡成型(MuCell®)产品

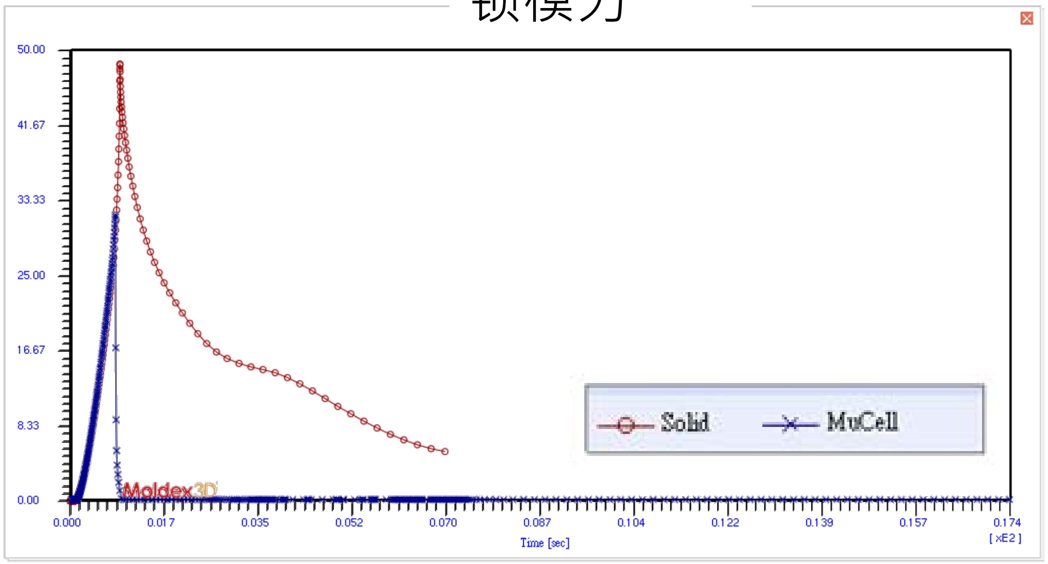
传统塑料射出制程与微发泡射出制程比较

压力随时间变化曲线

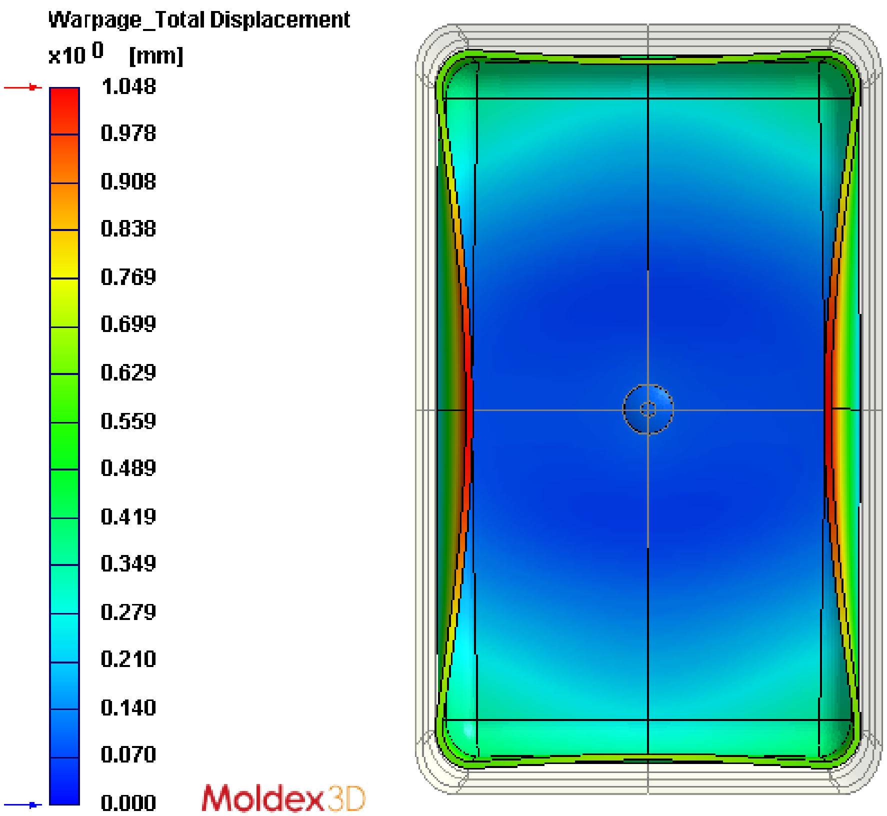
充填压力



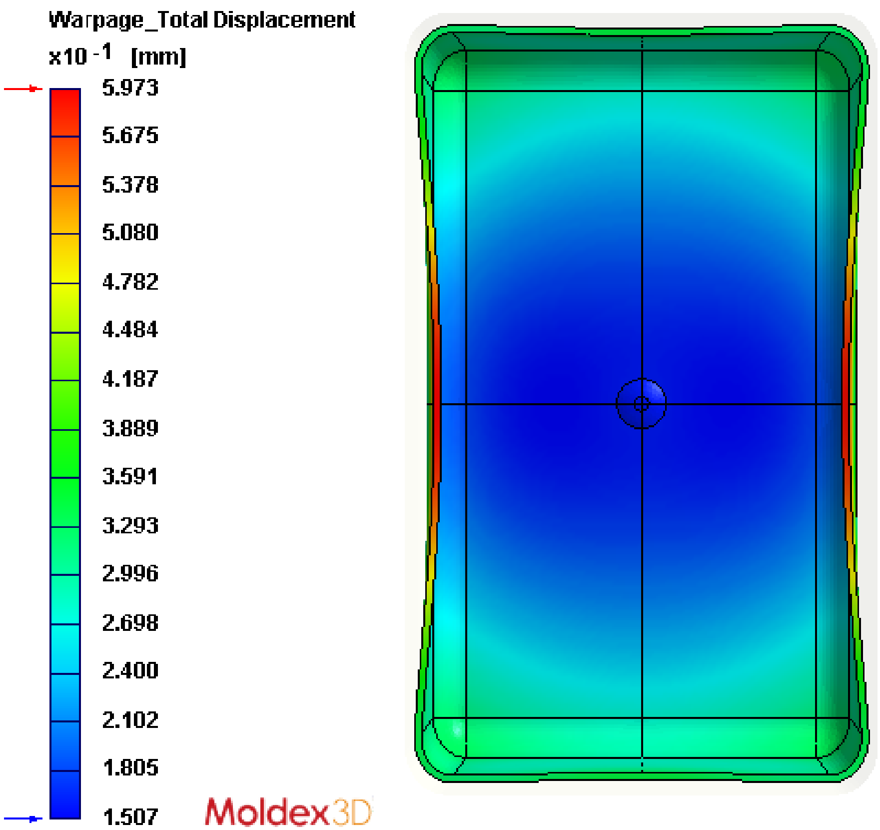
锁模力



翘曲结果比较



Solid part



MuCell® part

Moldex3D

传统射出成型与微发泡制程比较

	传统制程	微发泡制程	减少比率
最大充填压力 (MPa)	75.13	70.13	6.66%
最大锁模力 (Ton)	48.47	31.62	34.76%
成品重量 (g)	64.79	56.59	12.66%
最大翘曲位移量 (mm)	1.048	0.597	43.03%

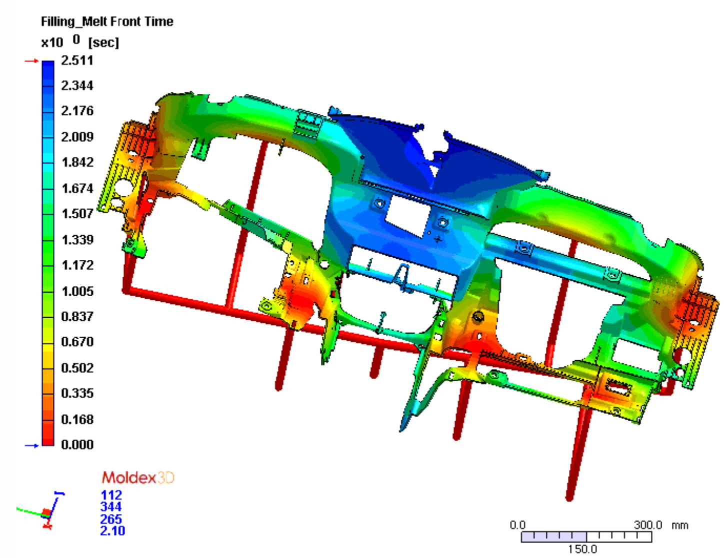
案例研究

汽车仪控台案例验证

MuCell® + 长玻璃纤维PP仪表板

> Ford 导入微细发泡射出成型制程结合长玻璃纤维材料来降低材料的使用与相关成型成本

MuCell Technology Helps Ford Win the Grand Award at the 41st SPE Automotive Innovation Awards

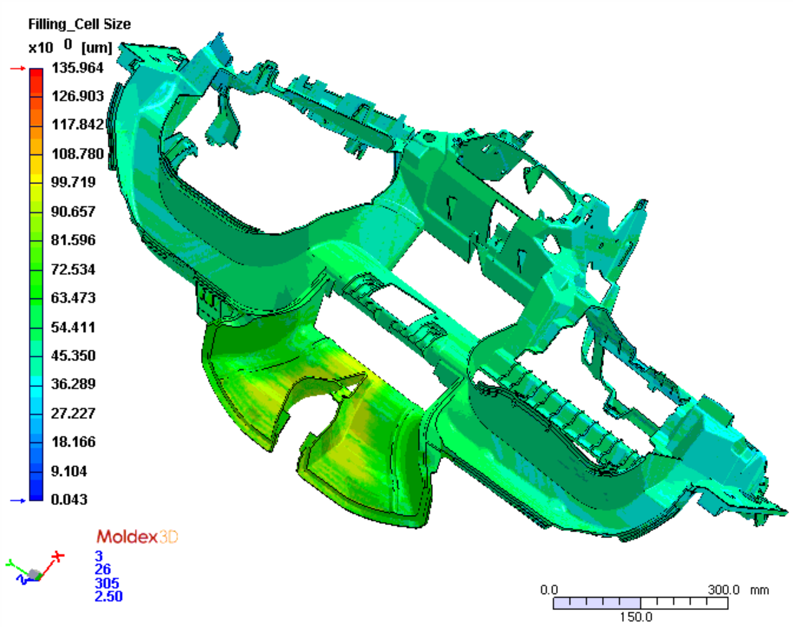


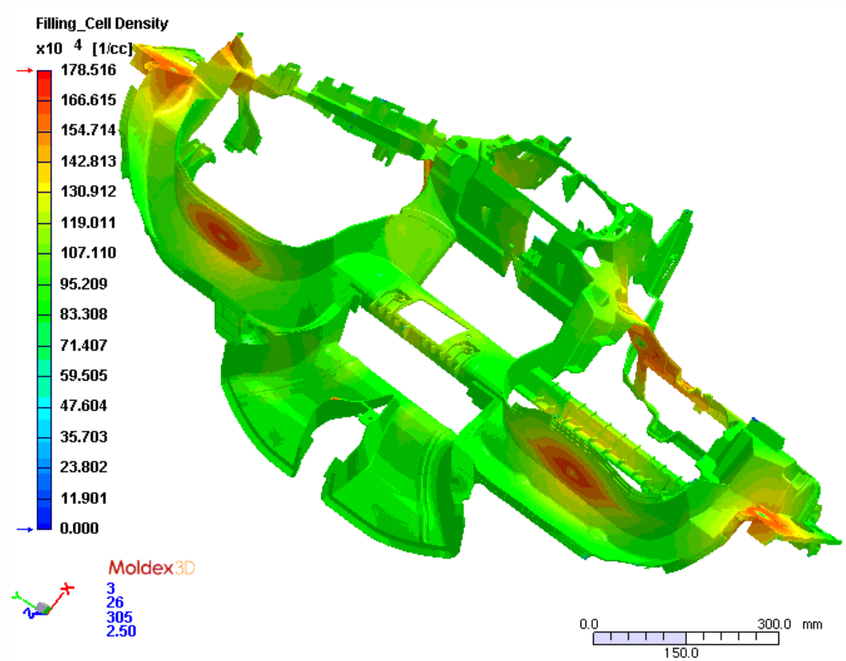
Livonia, MI & Wilmington, MA, Nov. 9, 2011 – The Society of Plastics Engineers awarded Ford's use of the MuCell process the Grand Award at the association's 41st Auto Innovation Awards Competition, held November 9th at the Burton Manner, in Livonia, MI. The instrument panel was originally entered in the Process/Assembly/Enabling Technologies category. By creating the instrument panel structure for the new Ford Escape in microcellular foam, weight is reduced more than 1 lb, mechanical properties are improved, molding cycle time is reduced 15%, and molding clamp tonnage is reduced 45%, saving an estimated $3 US / vehicle vs. solid injection molding.

MuCell® + 长玻璃纤维PP仪表板

> 气泡结构

– 参照真实现场的成型条件，执行微细发泡射出成型模拟可以得到相同的气泡大小与密度分布的趋势





$PP+N_2$

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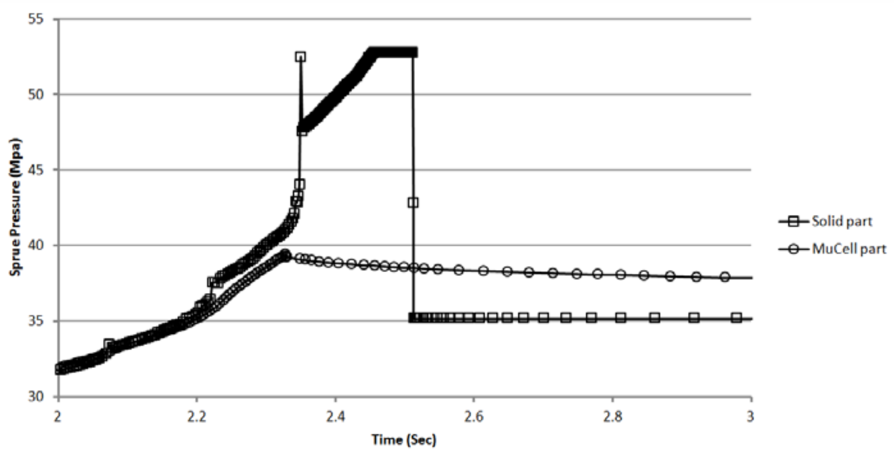
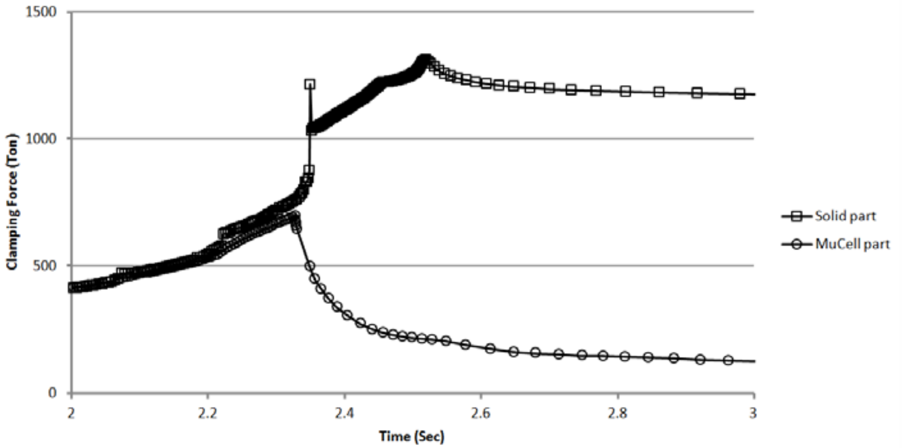
> 从这些结果显示使用微细发泡射出成型，可以降低原始一半以上的成型压力与锁模力，减少系统所需能源



进胶点压力



锁模力

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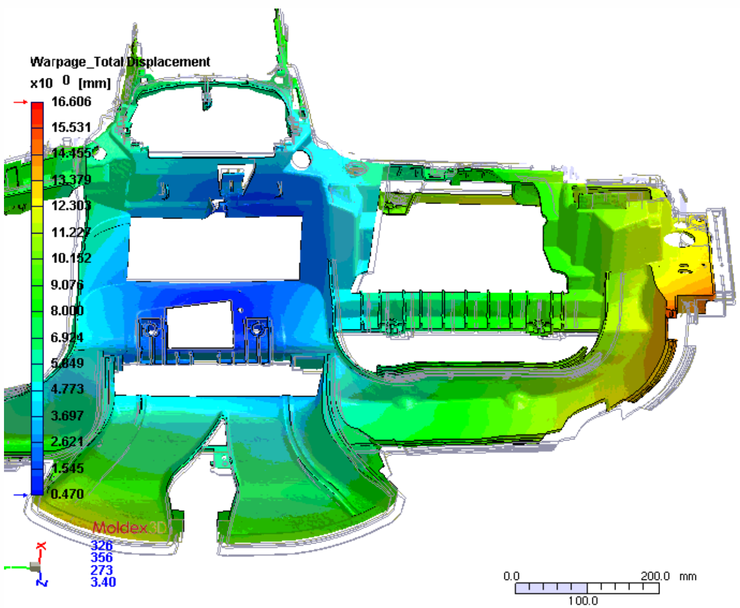
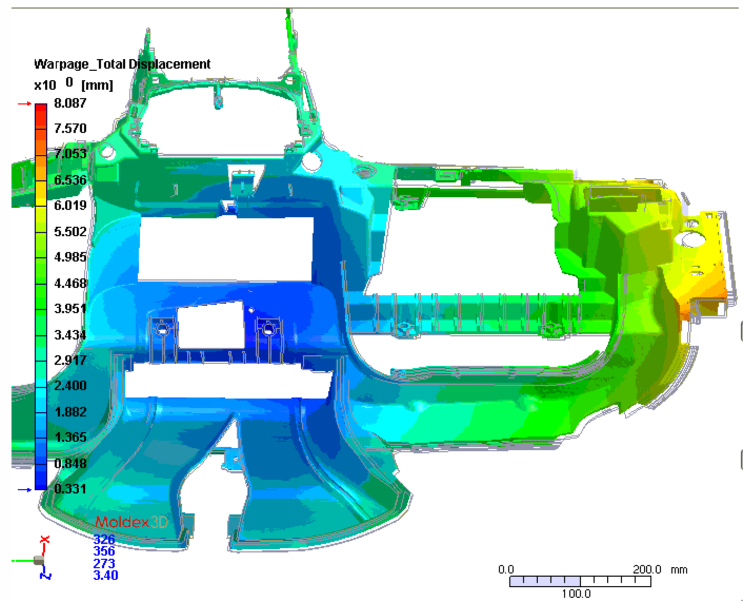
> 翘曲比较

– 微细发泡射出成型可以有效控制产品尺寸与降低翘曲



传统射出成型产品，16.6毫米



微细发泡成型(MuCell®)产品，8.08毫米

Moldex3D

MuCell® + LGFPP仪表板

> 总结

	传统制程产品	微细发泡制程产品	
产品重量 [g]	2724.2	2446.9	重量减少10%
最大锁模力 [Ton (m)]	1579	699.5	锁模力减少55%
x方向位移 [mm]	11.37	3.81	
y方向位移 [mm]	15.69	6.87	
z方向位移 [mm]	8.27	3.32	

产品尺寸：644.5*1415.8*562.4 (mm)

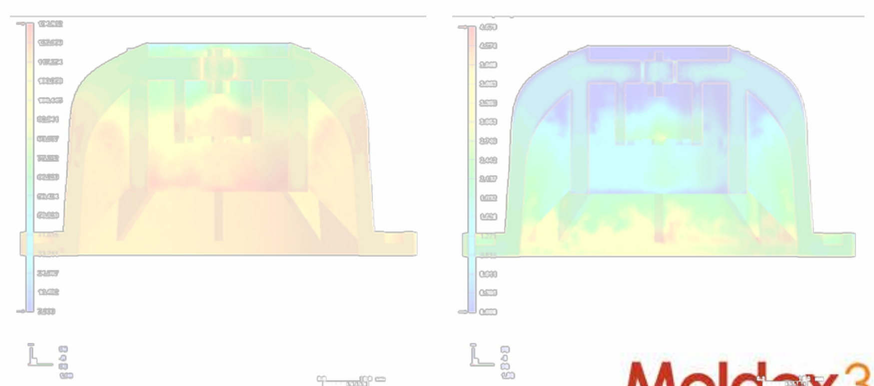
表1是来自传统射出成型及微细发泡射出成型的模拟结果比较。
产品重量减轻10.18%。

结论

> Moldex3D的真实三维技术同时考虑气泡成核与成长情形，提供最佳的MuCell®制程模拟。透过实验证实模拟与结果有很高的一致性。

> 藉由Moldex3D比较微细发泡与传统射出成型的分析结果，了解微细发泡射出成型的优点：
>
> – 减少锁模吨数
>
> – 减重
>
> – 尺寸稳定性更好

> 协助产品设计者在设计产品时就能评估“减重”、“减少锁模吨数” 、“减少体缩率”等，达到最终设计目标。



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