塑料光學組件射出成型之殘留應力與光彈分析

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CoreTech System Co., Ltd
www.moldex3D.com

大綱

- 光學產業所面臨的機會與挑戰
- 塑料光學產品須歷經那些內在機理粹煉?
- 如何掌握塑膠特性
  - 有效應用科學技術
  - 實際案例分享
- 結語

精密光學元件之應用

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- 應用範疇廣、種類繁多
- 因應各項用途所需特性與規格不同，設計要點不同
  - 一般非常大量需求之 3C 產業
  - 各項電子產業之顯示器
  - 近年來推動之綠能產業: LED and 太陽能
  - Bio-application

最熱門產品之一
iPhone

> **Total iPhones Sold Worldwide**
> **Nov. 2013:** 421 million
> **March 2011:** 108 million
> **April 2010:** 50 million
> **January 2010:** 42.4 million
> **January 2009:** 17.3 million
> **January 2008:** 3.7 million

Source:
http://ipod.about.com/od/glossary/f/how-many-iphones-sold.htm

塑膠光學元件的技術挑戰

- 供需問題
  - 看起來好像機會很大
- 從產品面
  - 存在於內在與外在
- 從製程面
  - 不易診斷與掌握 但確主導品質

塑膠光學元件的技術挑戰
供需問題

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- 量產需求非常大
  - 3C產品大量生產與應用需求
  - Display 產業之大量擴增
  - 機構與光學零件構成之sub-components

塑膠光學元件的技術挑戰
從產品面: 存在於隱性與顯性問題

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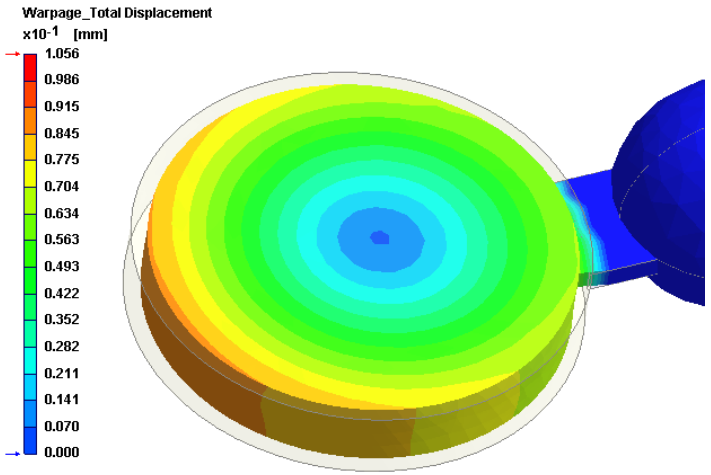
- 塑膠光學元件之品質取決於
  - 外在之幾何精度之掌握
    - 塑膠具有shrinkage and warpage
  - 材料內部因製程所引導之變異
    - 分子排列現象引起在光主軸之折射率變化?
    - 引發之殘留應力影響光學特性
    - 其他



形狀 與 應力！

塑膠光學元件的技術挑戰
從產品面

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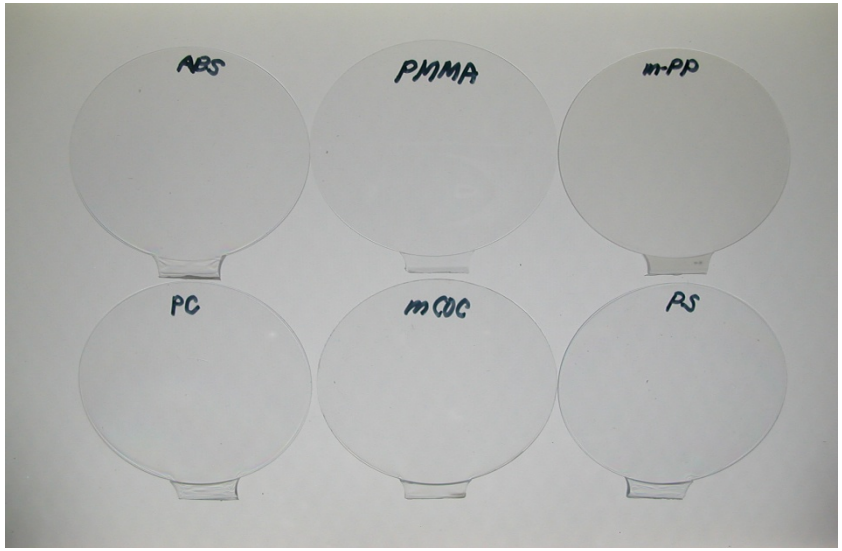
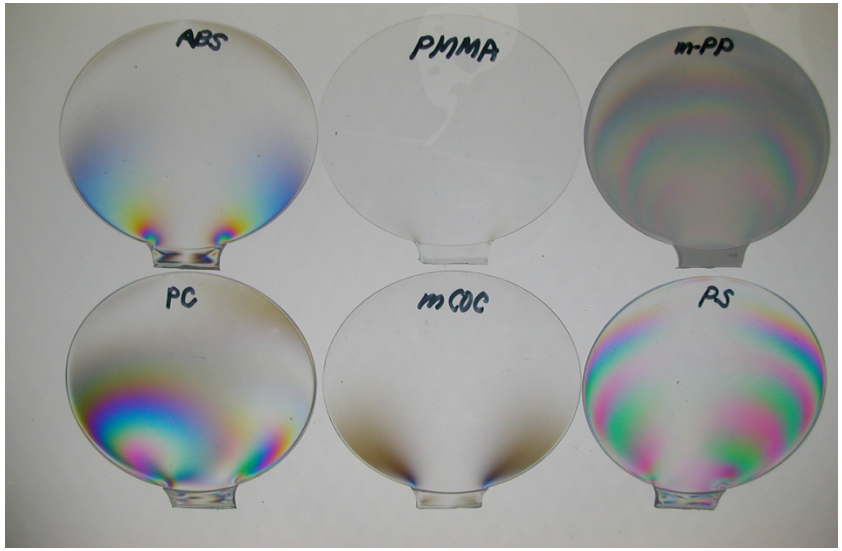
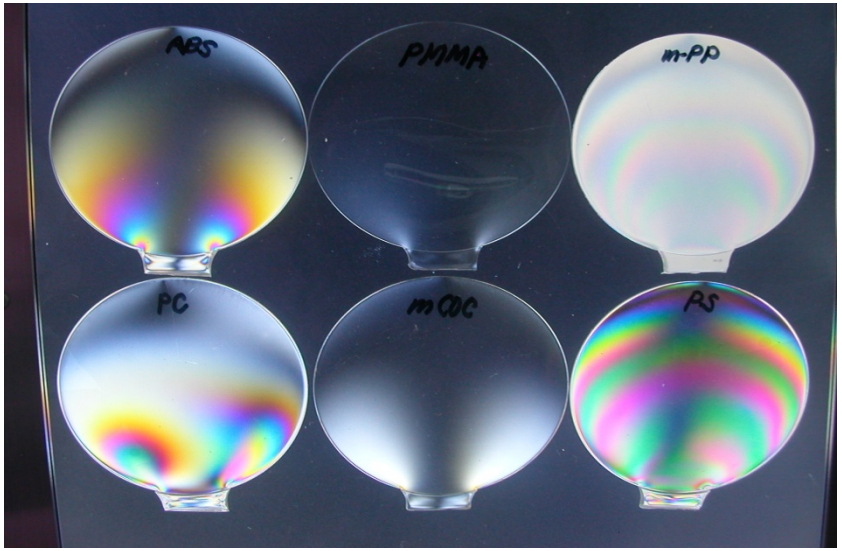


Polarizer // 0°



Polarizer ⊥ 90°



塑膠光學元件的技術挑戰
從製程面: 不易診斷與掌握 但確主導品質

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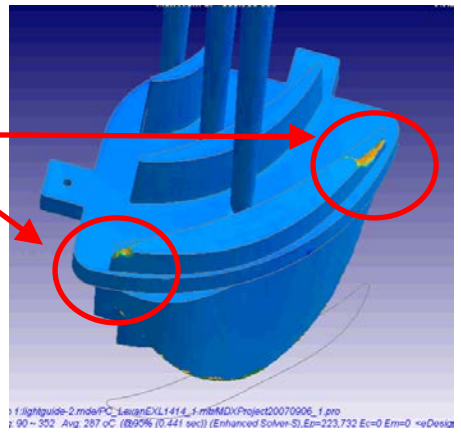
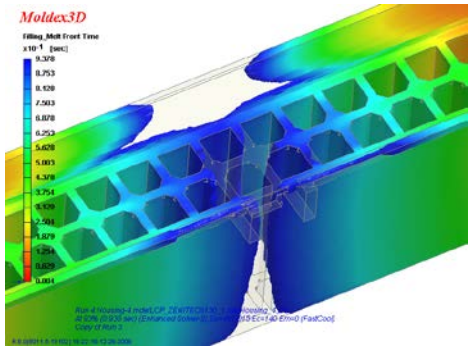
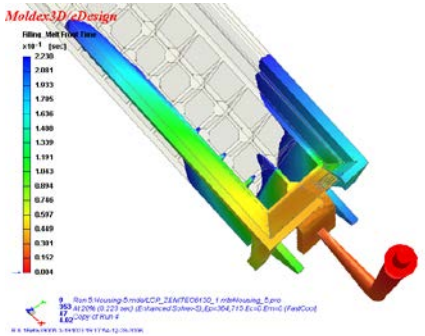
> 常見之產品缺陷及品質不佳 量產受阻 仍不斷上演
  - 短射 (short shot)
  - 燒焦 (burning)
  - 縫合線 (weldlines)
  - 凹痕 (sink mark)
  - 翹曲變形 (Warpage)
  - 毛邊 (Flash)
  - Many others

包封







> Why ??
  - 因為沒有真正了解及掌握製程及其機構

傳統上 我們是這樣做

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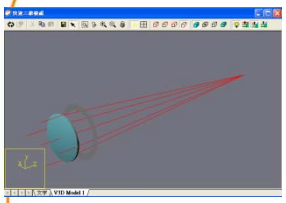

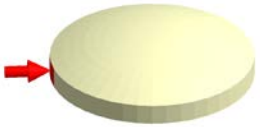

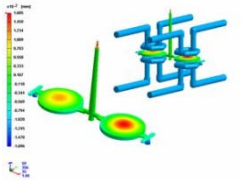

光學設計 → 產品設計 → 模具設計 → 模具製作

實體試模驗證

進行實體試模及修模

量產

- 試模及修模於真實模具製作完成後才進行
- 試模及修模乃根基於真實之模具雛型進行
- 許多內含因素一般人並無法了解

問題是: 如何與 “時間&品質” 競賽

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> 塑膠光學元件開發

塑料 → 光學產品
歷經那些內在機理粹鍊?

塑膠歷經內在機理粹鍊

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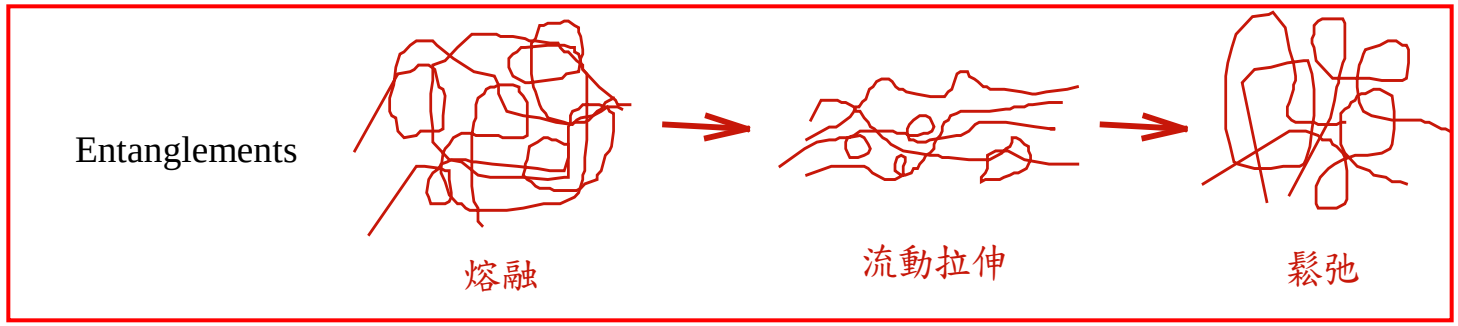

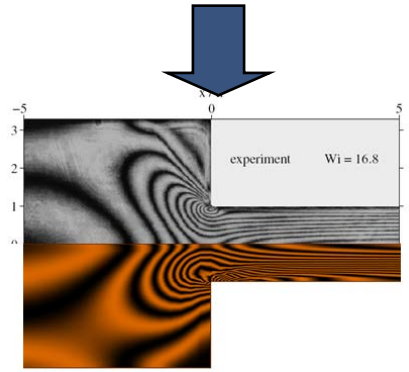

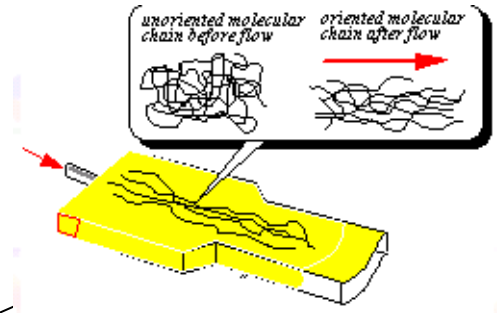

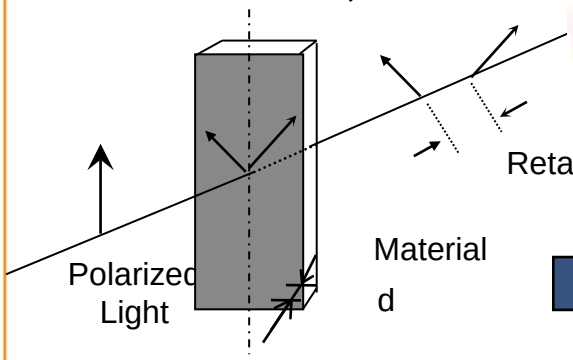

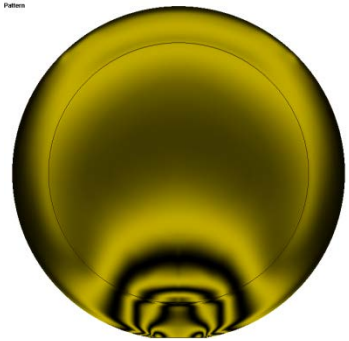

Ref: 科盛 黃招財博士, 精密光學研討會 (2009)

精密光學元件之應用

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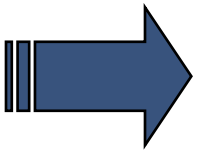
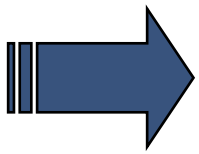
> 因應各項需求 所須建立之核心技術不盡相同 但是
  - 因應大量需求量產：採用塑膠射出成型技術
  - 塑膠產品之精度與品質，決定重要參數
    - 產品設計：因應不同之需求
    - 製程條件與操作控制：非常敏感
    - 塑膠材料之選定
    - …

- ❑ 產品設計
- ❑ 模具設計
- ❑ 材料
- ❑ 製程操作



塑膠內在機理

- ❑ 到底發生什麼?
- ❑ 對光學性質影響?



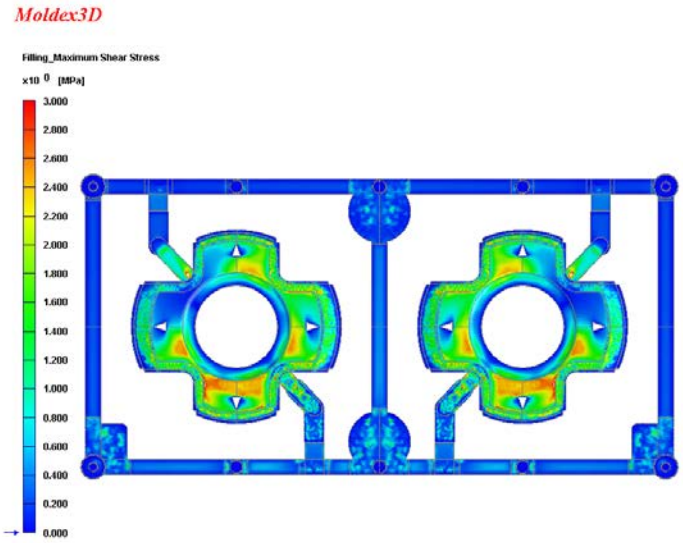
掌握與控制

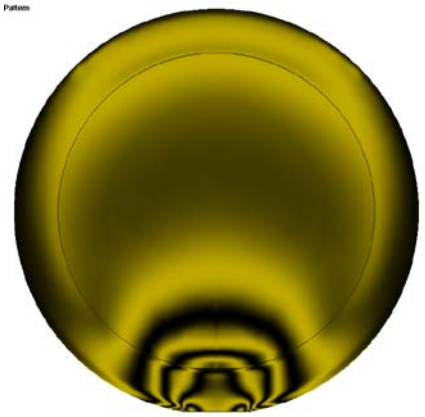
- ❑ 光學特性及品質
- ❑ 消弭問題
- ❑ 提昇競爭力

從塑膠材料特性進行深入之探究

從產品面

- 光學品質
  - 外在特徵
    - 表面精度與平坦度
    - 真圓度
  - 內在特徵
    - 雙折射
    - 殘留應力





供需問題

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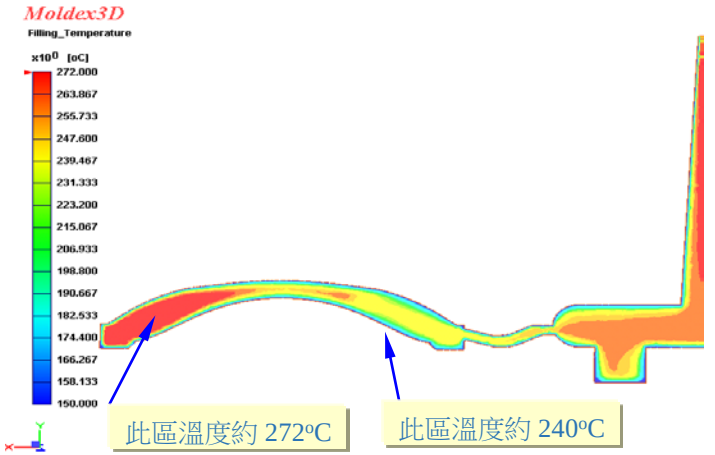
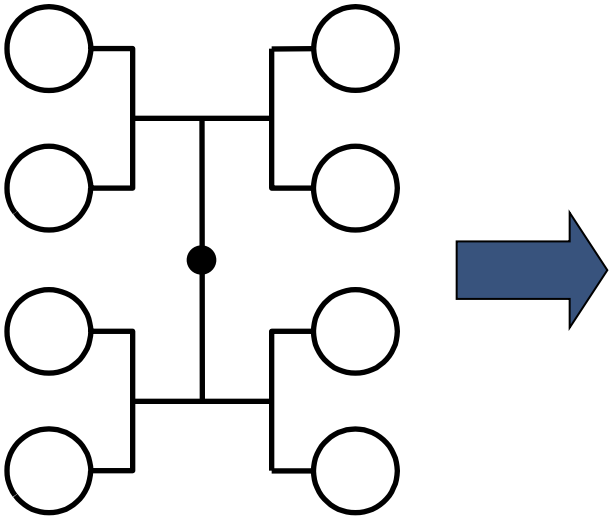
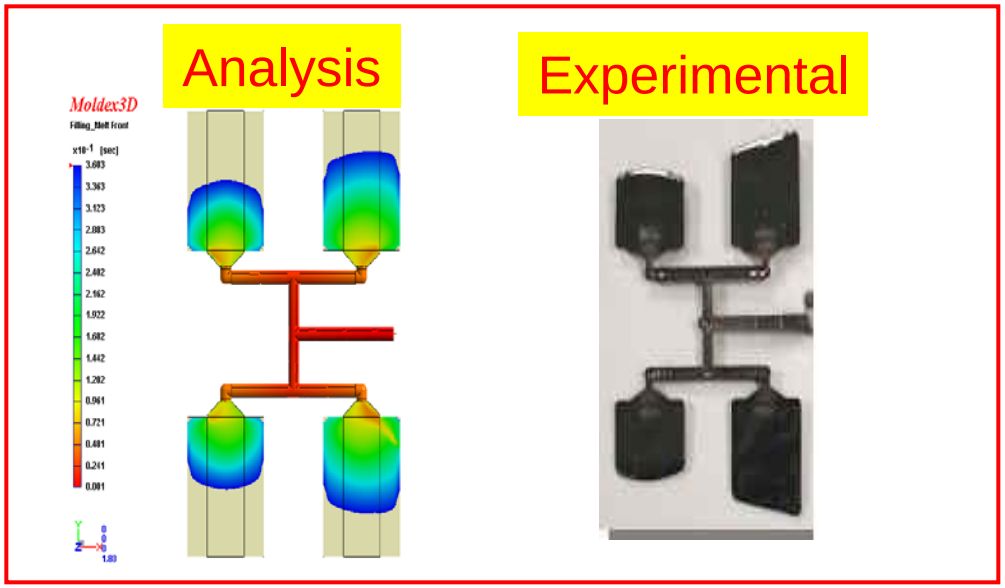
- 良率與產量
  - 確認品質提昇良率
  - 改善製程提昇效率
  - 更新製程設計 導入多模穴技術







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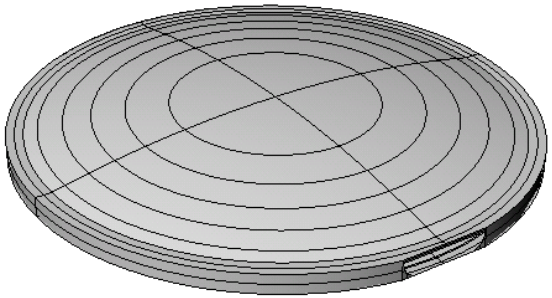
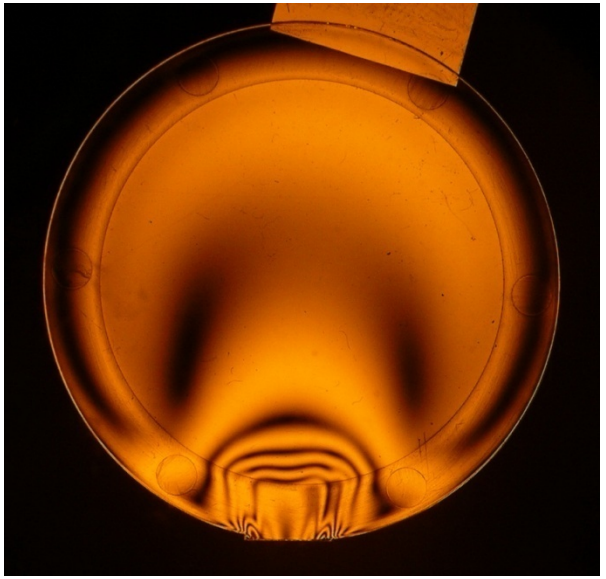
應用科學技術 CAE 掌握塑膠特性

案例 1: 如何掌握肉眼看不到之光學品質

問題與挑戰

- 塑膠光學產品開發：品質一直都是要求非常嚴苛
- 幾何精度問題：屬於外顯性問題 利用實驗法
- 雙折射或殘留應力問題
  - 如何理解成因
  - 如何量化與掌握





問題診斷與科學化技術之應用

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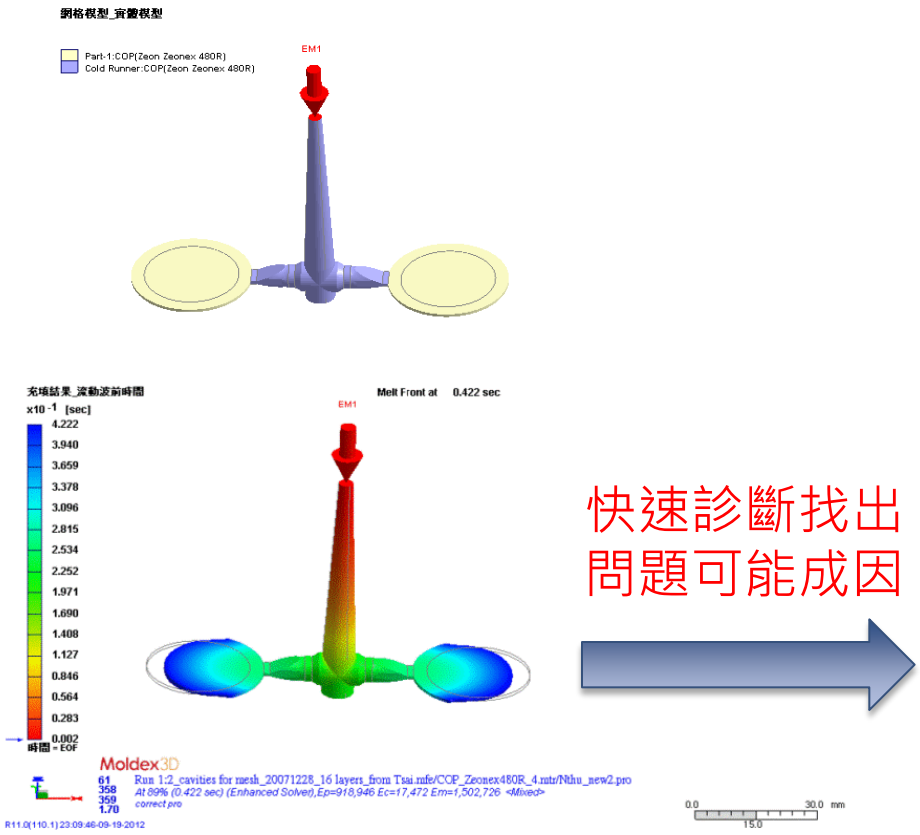
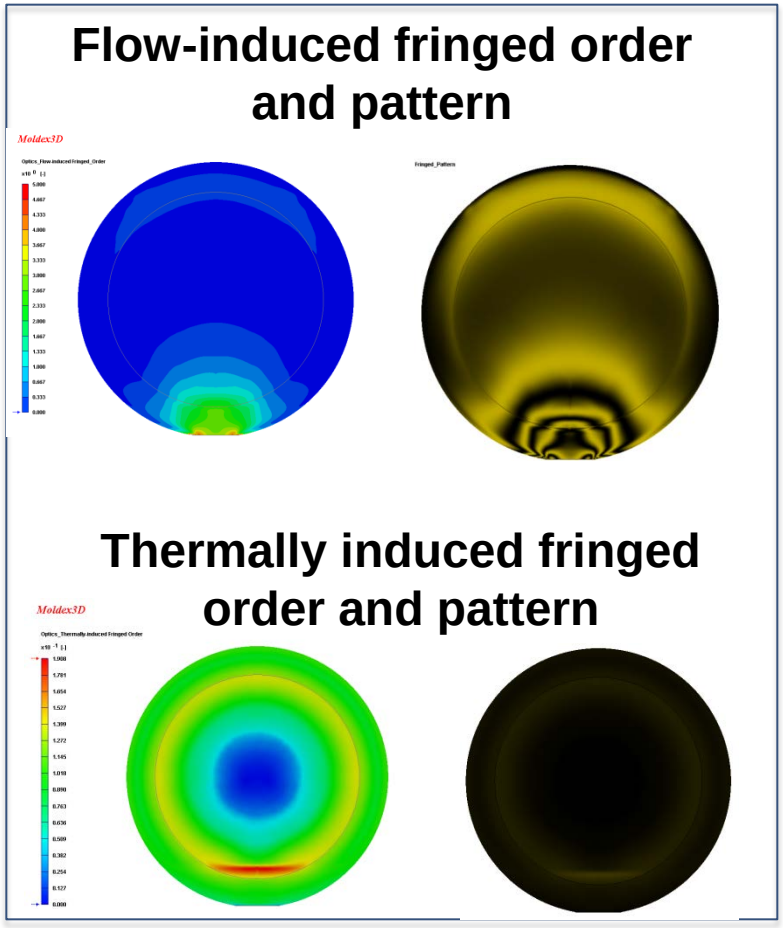
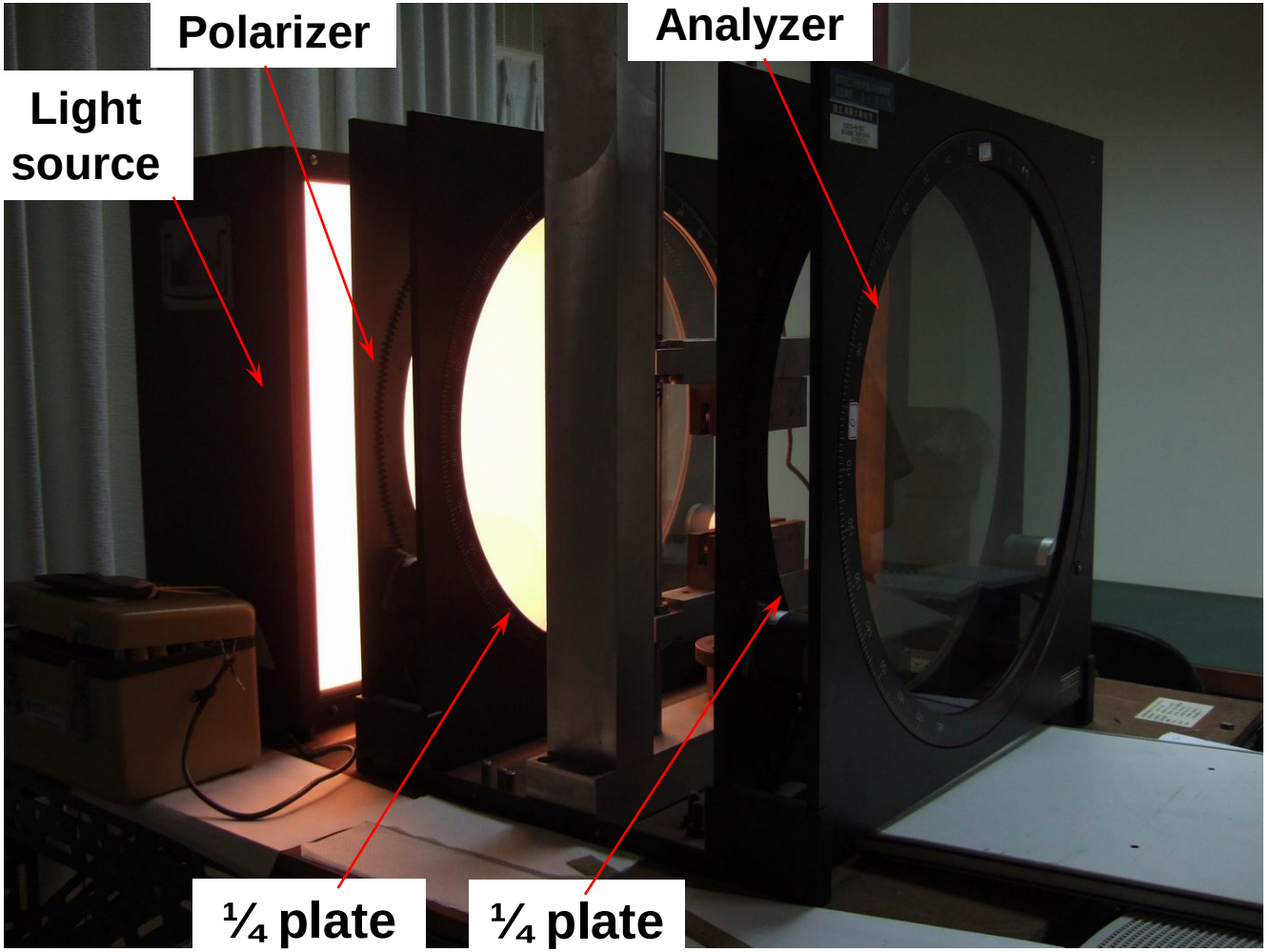
- 應用CAE模流分析
  - 應用科學技術 CAE 掌握塑膠特性



快速診斷找出
問題可能成因



Photoelasticity Measurements



Source:
Huai-En Lai and Pei-Jen Wang, National Tsing-Hua University

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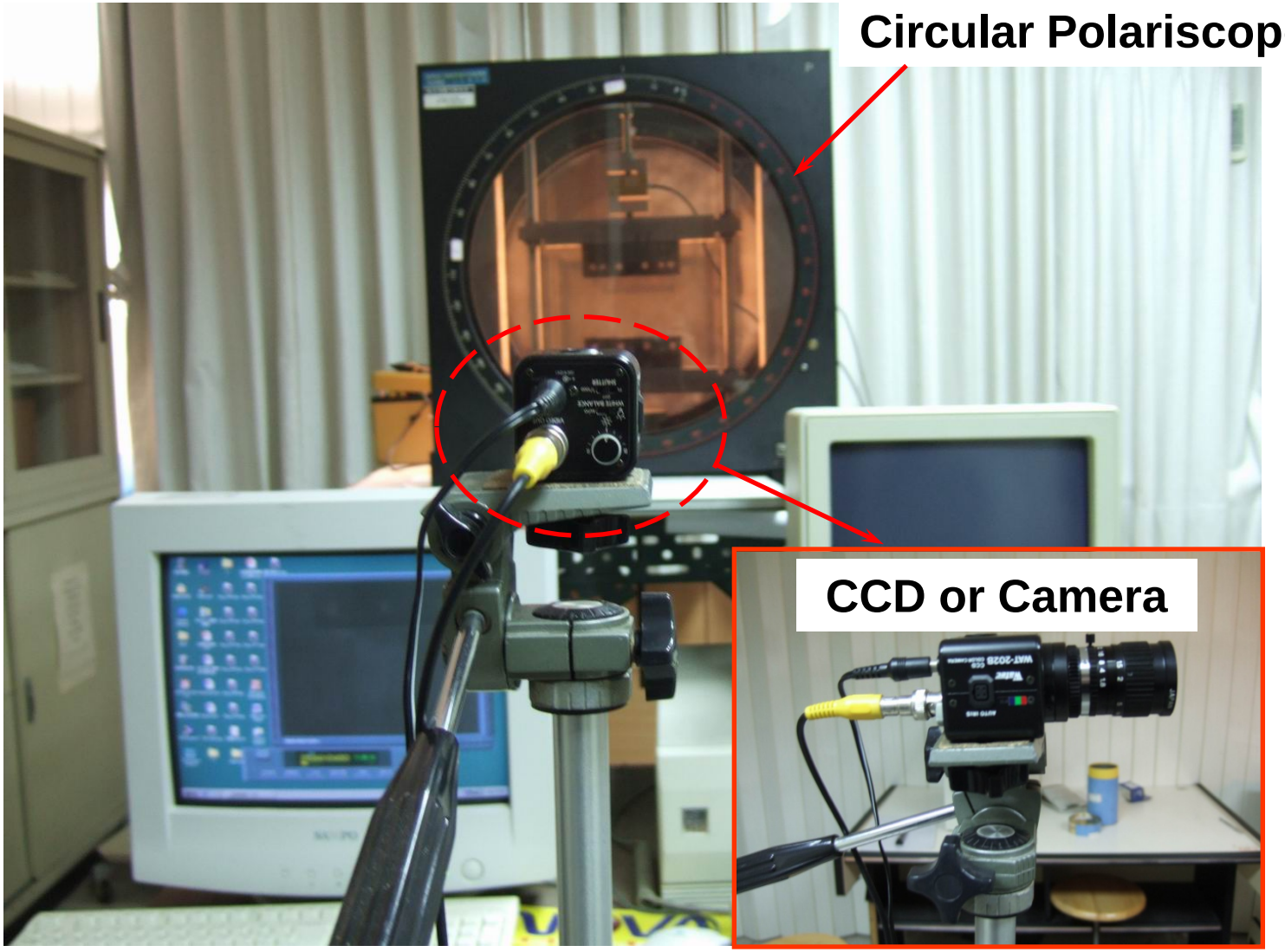
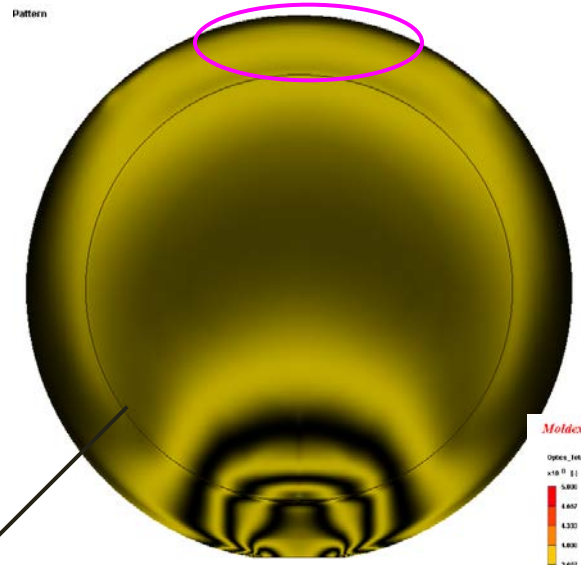
Photoelasticity Measurements (cont.)



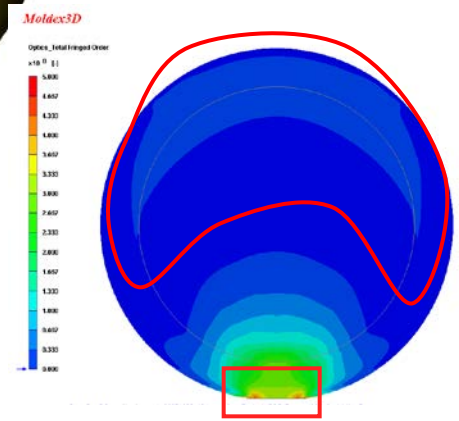
Source:
Huai-En Lai and Pei-Jen Wang, National Tsing-Hua University

Comparison of final fringed pattern

> Increase in birefringence at the cross-sectional area with abrupt change in thickness circled in the figure

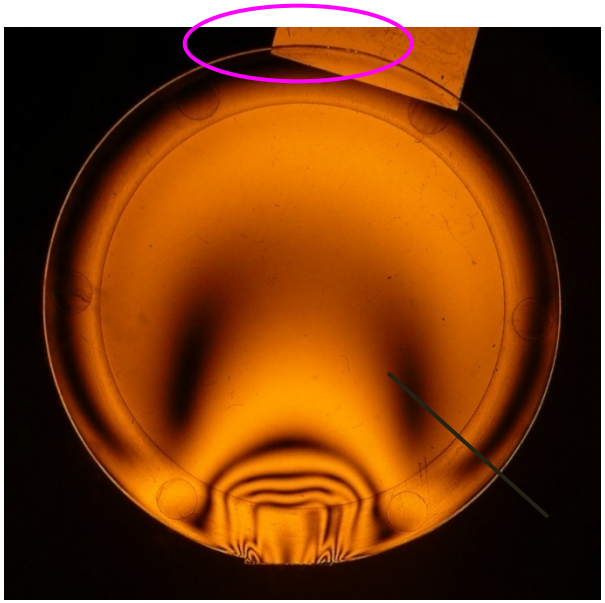


Simulation



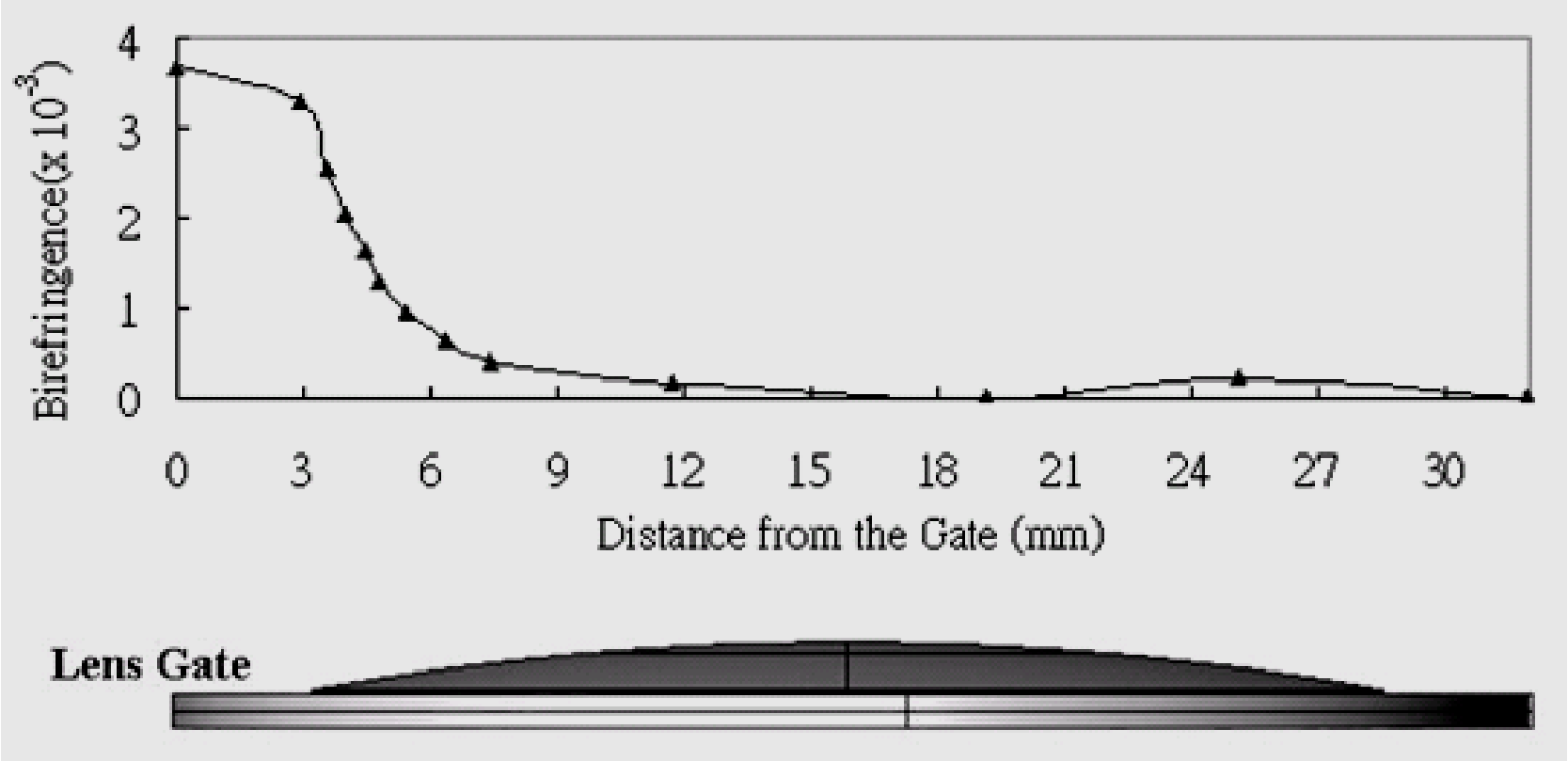
Gate corner effect

The same fringed order



Experiments

Profile Measurements of Birefringence



Gap-wise Birefringence Distributions

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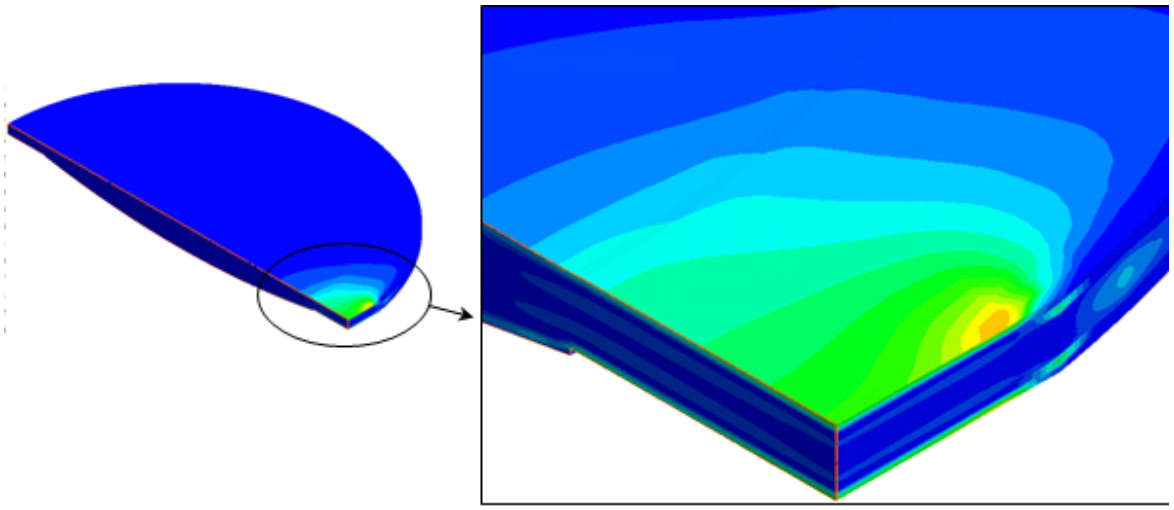
> **Most residual birefringence occur near the mold wall and at gate area.**



Verifications of Gap-wise Birefringence

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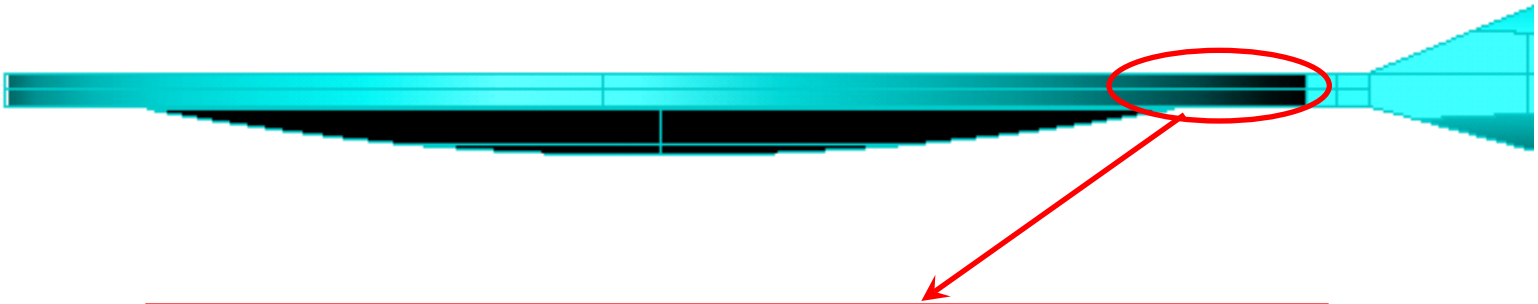
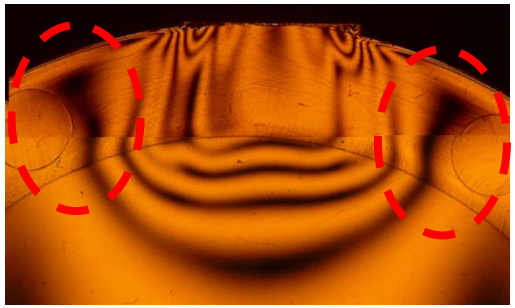
> To confirm that most birefringence would occur near the mold wall, a portion of molded lenses near the gate were removed layer by layer at 0.1 mm, 0.2 mm, 0.3 mm and 0.4 mm respectively with high speed diamond turning.

The thickness of gate is 0.8 mm

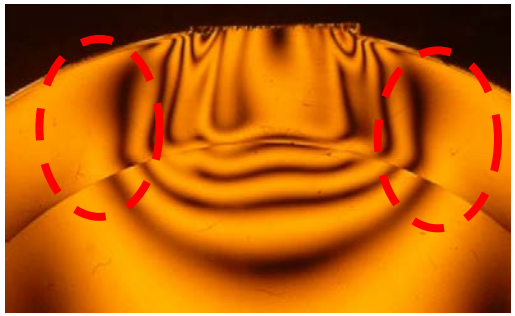


Removed for 0.1 mm, 0.2 mm, 0.3 mm and 0.4 mm

Verifications of Gap-wise Birefringence (cont.)

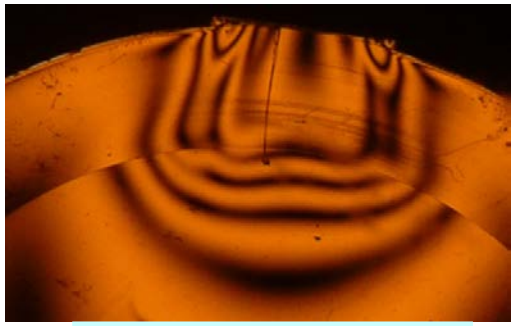


Origin



0.1 mm (12.5%)

0.2 mm (25%)



0.3 mm (37.5%)

0.4 mm (50%)

From the measurements under Circular Polariscope, most birefringence exists near the mold wall which agrees well to simulation results.

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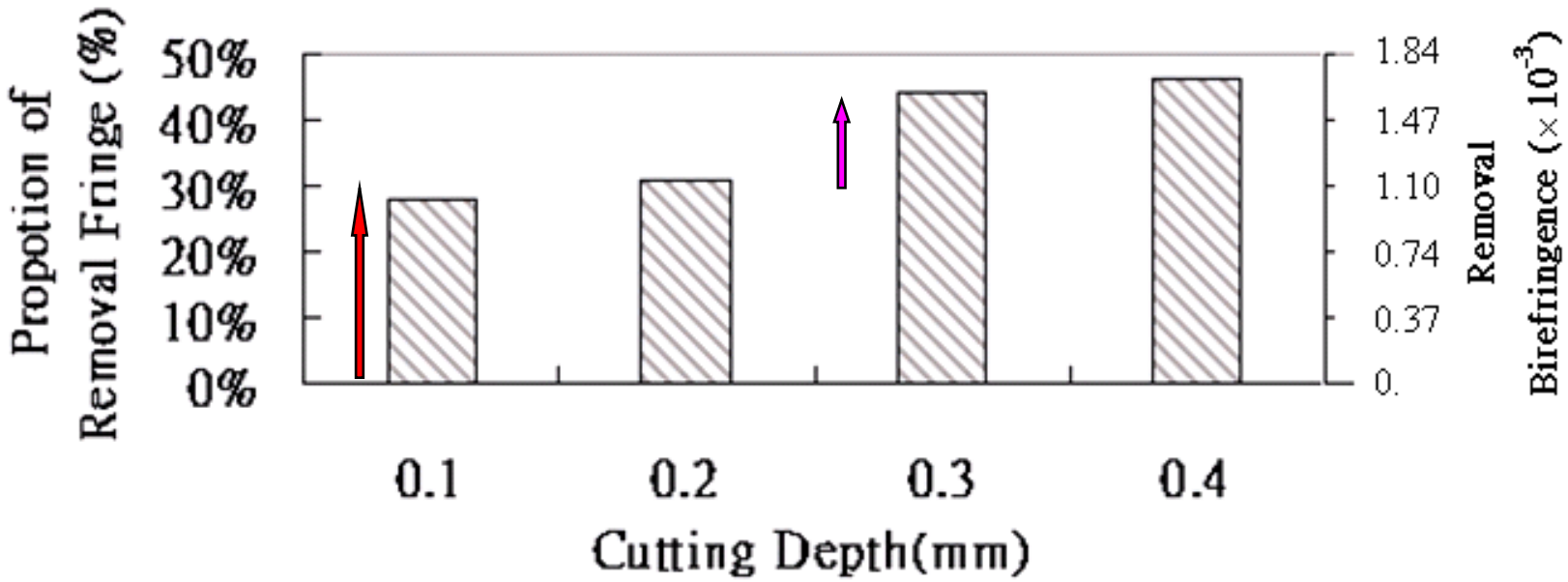
Verifications of Gap-wise Birefringence (cont.)



Nearly 30% of residual birefringence in gap-wise direction was removed on the first layer; and, the second peak of residual birefringence may occur between 0.2 mm and 0.3 mm of the removed layers.

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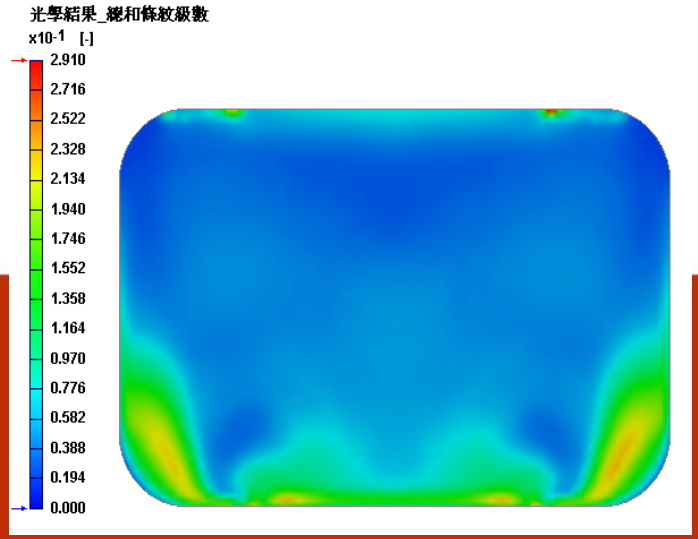
應用科學技術 CAE 掌握塑膠特性

案例 2: 薄件射出殘留應力與雙折射特性探討



問題與挑戰

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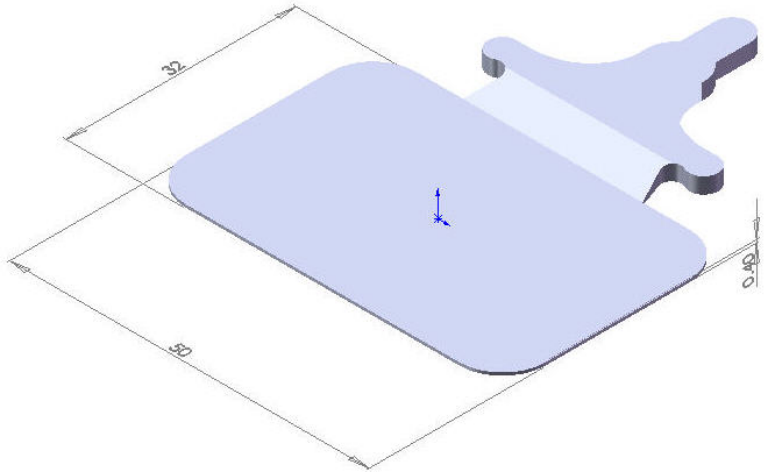
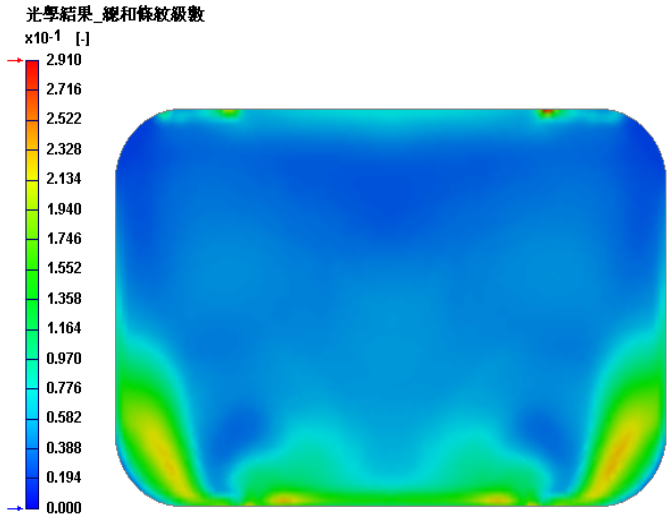
- 光學元件設計固定 射出製程影響為何?
  - 如何理解成因:
    - Flow-induced?
    - Thermally induced?





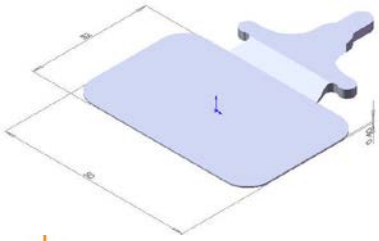
Geometry of a thin wall plate (Case A) **unit: mm**

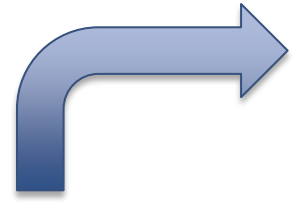
Source: 雲科大曾世昌院長

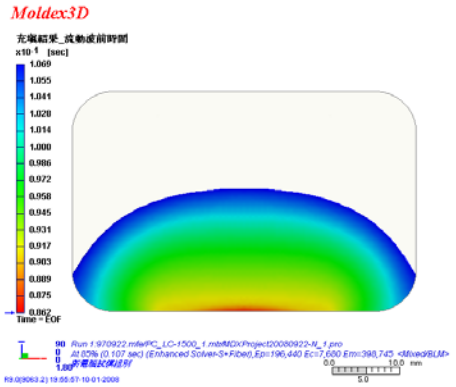
問題診斷與科學化技術之應用

Moldex3D

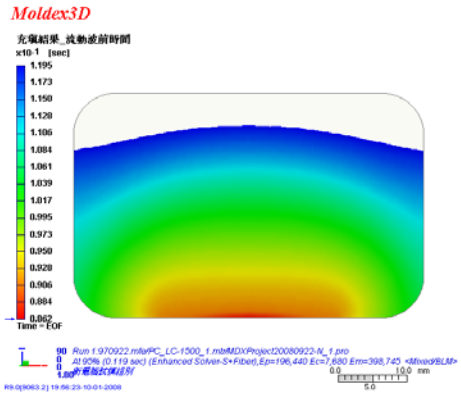
V= 70 mm/sec



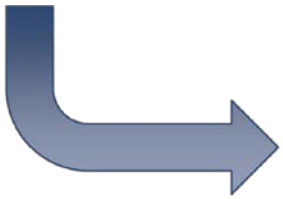




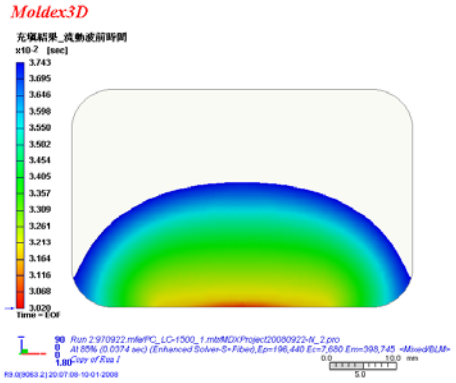
Fill 85%



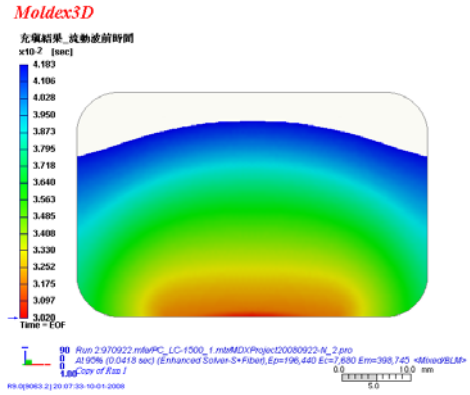
Fill 95%



V= 120 mm/sec



Fill 85%



Fill 95%

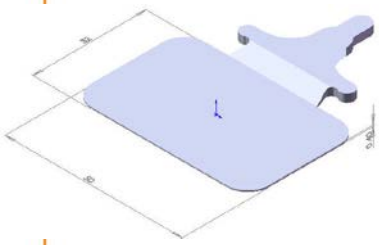
Source: 雲科大曾世昌院長

問題診斷與科學化技術之應用

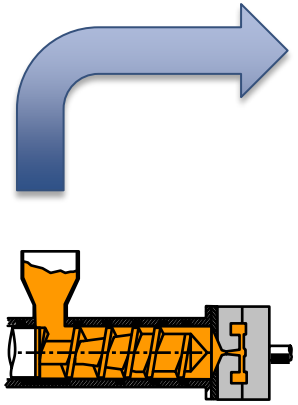
Moldex3D

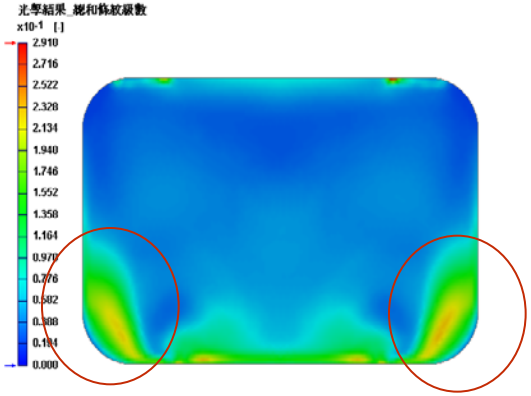
Simulation

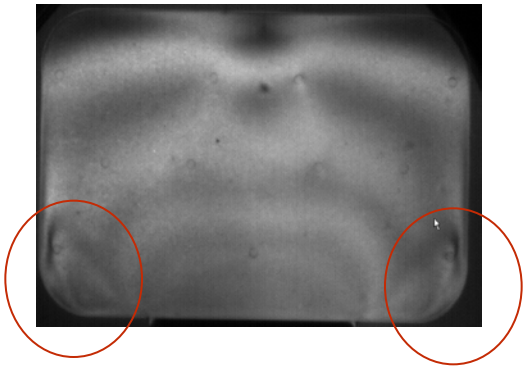
Experiment



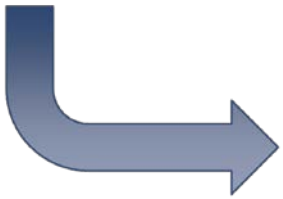
V= 70 mm/sec

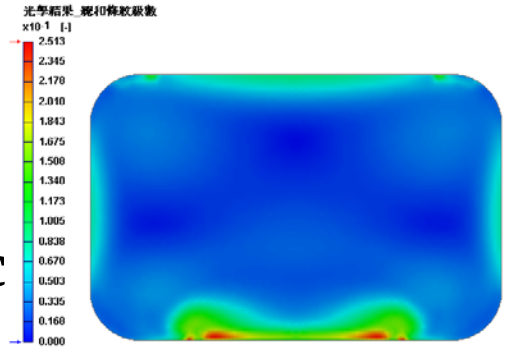


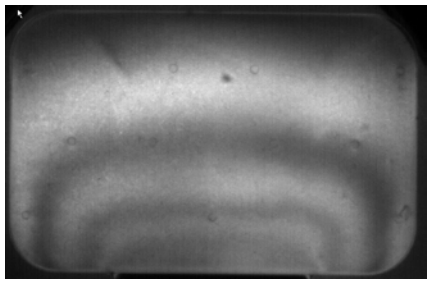




V= 200 mm/sec



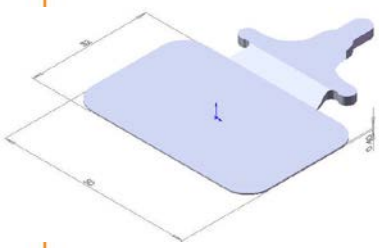




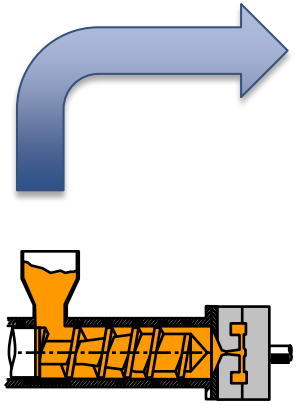
Source: 雲科大曾世昌院長

問題診斷與科學化技術之應用

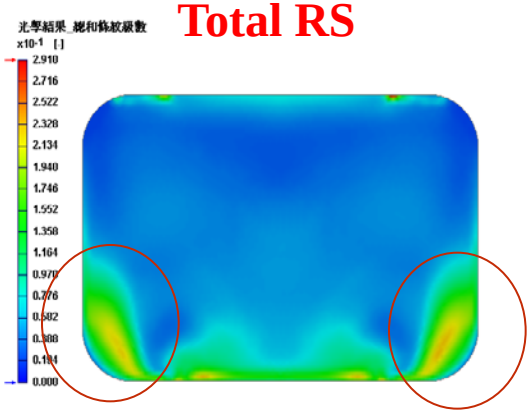
Moldex3D

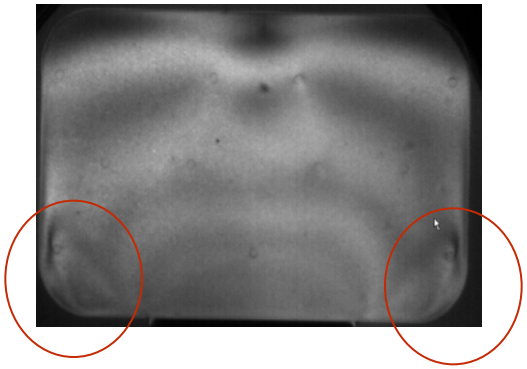


V= 70 mm/sec

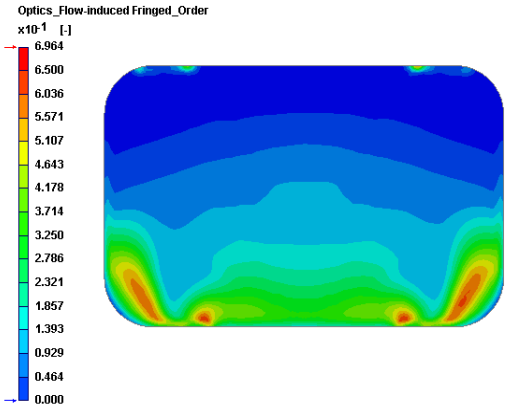


Total RS

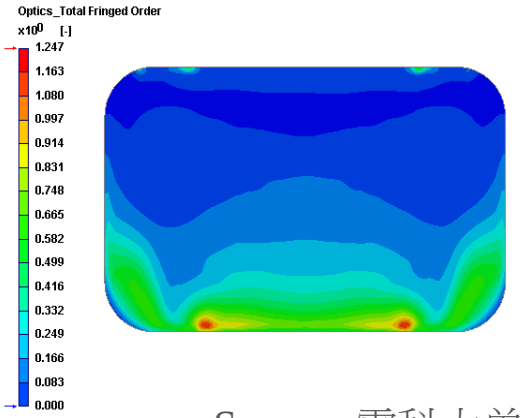




Moldex3D **Flow induced RS**



Moldex3D **Thermal RS**



Simulated fringe pattern

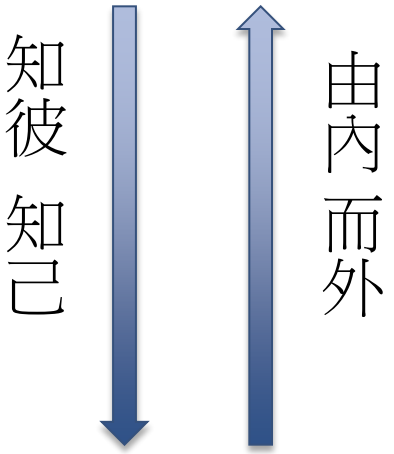
Source: 雲科大曾世昌院長

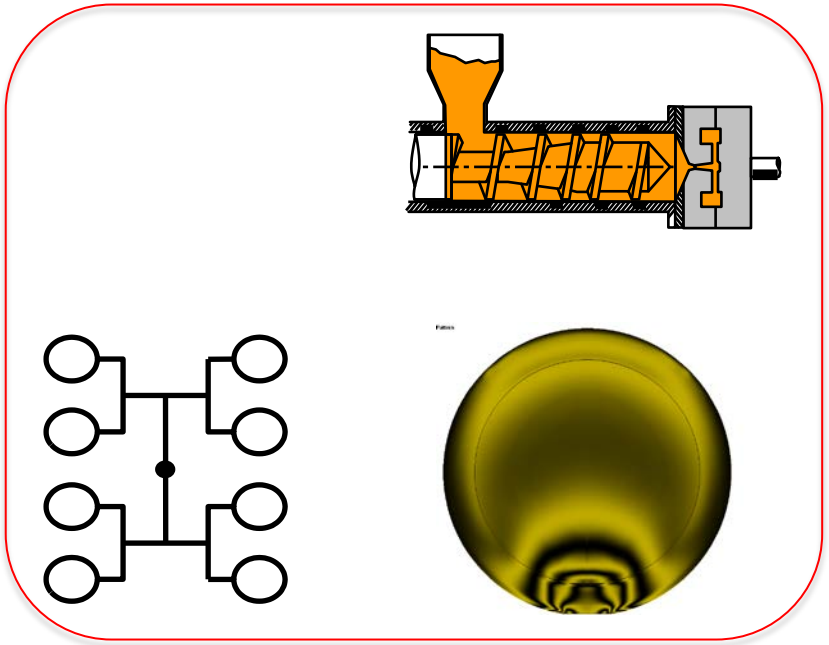
結語

CAE 效益

Moldex3D

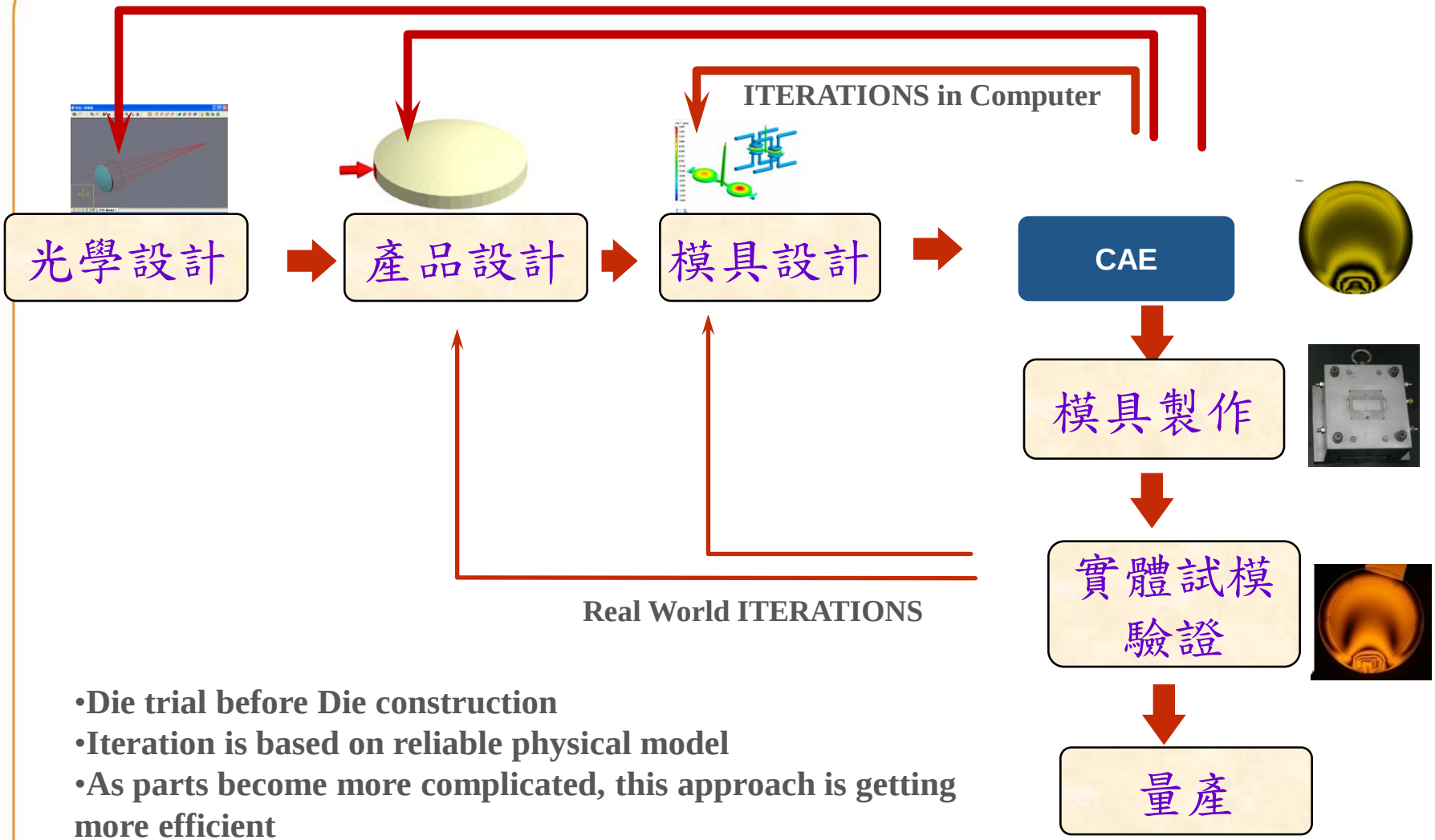
- 品質與製程提昇
  - 量化外在特徵(幾何精度)及內在特徵(雙折射)
  - 貫穿製程與產品
- 良率與產能提昇
  - 製程優化效能提昇
  - 從單穴到多穴
- Know-how 及智權
  - 從設計到製程
  - 累積能量拓展出更大更廣之天空
- 接單效應
  - 原廠要求
  - 競爭力提昇後自然而生





CAE 技術整合: 同步開發流程技術

Moldex3D



- Die trial before Die construction
- Iteration is based on reliable physical model
- As parts become more complicated, this approach is getting more efficient

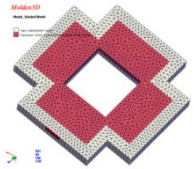
執行虛擬產品開發 建立產品設計驗證

Moldex3D

網格

- 塑件與嵌件
- 流道配置
- 模座與水路

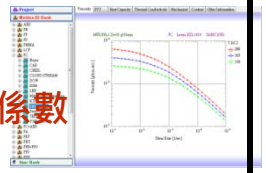
：



材料

- PVT
- 黏度
- 比熱與熱傳導係數

：



成型條件

- 射出時間
- 融膠溫度
- 模具溫度

：

Moldex3D

Thank you for your attention!

CoreTech System Co., Ltd
www.moldex3D.com