Effect of Co-Extrusion Die Design on Overall Equipment Effectiveness (OEE)

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Commercial Director – North & Latin America
BRAMPTON ENGINEERING

An innovator in multi-layer blown film extrusion since 1973, with over 250 lines with 5 to 11 layers installed worldwide.
BRAMPTON ENGINEERING
Breakthroughs

- Introduced SCD® - modular dies with streamlined channels
- Sold 1st Water-Quench line AquaFrost® in the world
- Unveiled the revolutionary Single Inlet Air Ring Technology Vector®
- Production of 1st 5-Layer co-extrusion line.
- Produced IsoTherm SCD®, installed 1st 9-Layer line & developed AquaFrost®
- Installed first 11-Layer commercial line in the world
effectiveness
iˈfektɪvnəs/
noun

the degree to which something* is successful in producing a desired result

* Process or equipment
OEE is a score that measures how effectively a manufacturing operation or equipment is utilized. It identifies the percentage of manufacturing time that is truly productive.

An OEE score of 100% means you are making no scrap, at the ideal output rate, with no Downtime.
CALCULATING OEE

Quality Score – Yield (%)
Determines the amount of good product as a ratio of total production

Availability Score – Productive time (%)
Measures the total productive time divided by the duration of the manufacturing cycle

Performance Ratio - Capacity (%)
Indicates the actual process or equipment output as a ratio of the ideal output
What period of time should I use for my OEE calculation?

• Choose the time period that is most meaningful for your process or plant: shift, job (part run), hour, day, year.

• Use **ideal cycle time**, which represents the maximum theoretical speed that the process can run.

• Ideal cycle does not include allocations for typical losses such as planned or unplanned downtime, process slowdown, slow cycles, and defects.
EFFECT OF DIE DESIGN ON
OVERALL BLOWN FILM EXTRUSION
EFFECTIVENESS

STREAMLINED
CO-EXTRUSION DIE
SCD®

CONVENTIONAL
CYLINDRICAL
DIE
STREAMLINED CO-EXTRUSION DIES – SCD®

FEATURES
• Modular design
• Stackable
• Streamlined channels
• No hang-up points
• Easy access for cleaning
• Lower wetted surface
• Multiple options for temperature control
SCD® - Temperature Isolation

Thermal Conductivity at 200° C:
Air: 0.0386 W/m K
Steel: 54 W/m K
SCD® - Flow Channel Geometry

ADVANTAGES

• Lowest flow resistance
• Fast purging
• Minimizes carbon buildup and gel generation
• Quick cleaning
Cylindrical Dies - Flow Channel Geometry

“D” Shaped Distribution Channels
Slow flow areas create stagnation and poor purge areas, causing resin degradation and carbon buildup.

Sharp Turns in Distribution Channels
Abrupt changes in flow direction create stagnation and poor purge areas, causing resin degradation and carbon buildup.

“U” Shaped Spirals
Deep “U” shaped spirals will not flush as well as the shallow “O” shaped SCD® spirals. They create stagnation and poor purge areas that will cause degradation and carbon buildup.
# OEE – PROCESS INPUTS

<table>
<thead>
<tr>
<th>EQUIPMENT &amp; PROCESS SPECS</th>
<th>SCD®</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIE SIZE (mm)</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>AVERAGE OUTPUT (Kg/h)</td>
<td>445</td>
<td>467</td>
</tr>
<tr>
<td>DAILY MAINTENANCE (h)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>WEEKLY MAINTENANCE (h)</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>DIE CLEAN DURATION</td>
<td>4 Days</td>
<td>10 Days</td>
</tr>
<tr>
<td>DIE CLEAN INTERVAL</td>
<td>18 Months</td>
<td>12 Months</td>
</tr>
</tbody>
</table>
## OEE Inputs
### Production Plan

<table>
<thead>
<tr>
<th>Equipment &amp; Process Specs</th>
<th>SCD®</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Run Size (Kg)</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Film Structures</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Changeovers</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Trim Per Side (mm)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Average Off-Spec (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Working Days (days/year)</td>
<td>350</td>
<td>350</td>
</tr>
</tbody>
</table>
### OEE - PURGING CONDITIONS

<table>
<thead>
<tr>
<th>EQUIPMENT &amp; PROCESS SPECS</th>
<th>SCD®</th>
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</thead>
<tbody>
<tr>
<td>PURGE TIME – SIMILAR RESINS (min)</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>PURGE TIME – PURGE RESINS (min)</td>
<td>45</td>
<td>120</td>
</tr>
<tr>
<td>CHANGEOVER on GAUGE (min)</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

* Purge time refers to changing the resin in one of more layers of the die, i.e., PE to Nylon.
## OEE – PRODUCT PORTFOLIO

<table>
<thead>
<tr>
<th>FILM TYPE</th>
<th>RATIO</th>
<th>LAYFLAT (mm)</th>
<th>BLOW-UP RATIO</th>
<th>PURGE RESIN</th>
<th>FILM COST</th>
<th>RUN SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARRIER/7LAYERS/50µ</td>
<td>10 %</td>
<td>1600</td>
<td>2.26</td>
<td>Similar</td>
<td>1.60 $/lb</td>
<td>10,000 Kg</td>
</tr>
<tr>
<td>BARRIER/7LAYERS/80µ</td>
<td>30 %</td>
<td>1600</td>
<td>2.26</td>
<td>Purge</td>
<td>1.75 $/lb</td>
<td>30,000 Kg</td>
</tr>
<tr>
<td>POD/4LAYERS/80µ</td>
<td>20 %</td>
<td>1580</td>
<td>2.24</td>
<td>Similar</td>
<td>1.10 $/lb</td>
<td>20,000 Kg</td>
</tr>
<tr>
<td>POD/3LAYERS/50µ</td>
<td>40 %</td>
<td>1600</td>
<td>2.29</td>
<td>Purge</td>
<td>1.13 $/lb</td>
<td>40,000 Kg</td>
</tr>
</tbody>
</table>
KEY PERFORMANCE INDICATORS

- HIGH YIELD
- RAPID CHANGEOVERS
- EASY TO CLEAN
- LOW CLEANING FREQUENCY

ANNUAL YIELD
- SCD®: 8.06M lb
- Other: 7.99M lb

ANNUAL SCRAP
- SCD®: 334,500 lb
- Other: 420,600 lb

CHANGEOVERS
- SCD®: 128 hr
- Other: 230 hr

CLEANING TIME
- SCD®: 80 hr
- Other: 480 hr
**PROCESSING TEMPERATURE SENSITIVE RESINS?**

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<td>10 Days</td>
</tr>
<tr>
<td>DIE CLEAN INTERVAL</td>
<td>18 Months</td>
<td>6 Months</td>
</tr>
</tbody>
</table>
KEY PERFORMANCE INDICATORS

ANNUAL YIELD
8.06M lb
7.61M lb
334,500 lb
400,600 lb
128 hr
230 hr
80 hr
960 hr

LOSS OF 300,000 lb OF CAPACITY PER YEAR

ANNUAL SCRAP

CHANGEOVERS

CLEANING TIME

SCD®
Other

SCD® DIES DO NOT REQUIRE ADDITIONAL CLEANING TIME WHEN PROCESSING HEAT SENSITIVE MATERIALS DUE TEMPERATURE ISOLATION.
OEE COMPARISON
TEMPERATURE SENSITIVE MATERIALS

SCD®
- Quality: 96%
- Performance: 95%
- Availability: 93%
- OEE: 85%

OTHER
- Quality: 92%
- Performance: 95%
- Availability: 84%
- OEE: 73%

LOWER AVAILABILITY RESULTED IN OEE REDUCTION OF 3%
FINANCIAL IMPLICATIONS

OPERATIONAL COSTS

- **REVENUE LOSS**
  Opportunity loss due to lower yield from inefficient operations.

- **LABOR & UTILITIES**
  Cost of labor and utilities (excluding energy).

- **ENERGY**
  Annual cost of energy based on equipment energy factor.

- **RESIN**
  Based on annual yield – the cost of making good film.

- **ANNUAL SCRAP**
  The cost of resin that ends in scrap due to purge, trim and off-spec.

- **DOWNTIME**
  Opportunity loss due to equipment not available for production.

- **DIE CLEANING**
  Costs incurred when an oven is not available. This is an external cost.

- **EQUIPMENT**
  Cost of capital equipment on an annual basis – linear amortization over 5 years.

* Other costs include inventory cost and holding costs.
LINE COSTS BREAKDOWN (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>SCD® 71%</th>
<th>OTHER 70%</th>
<th>LABOR &amp; UTILITIES 24%</th>
<th>SCRAP 2.8%</th>
<th>ENERGY 1.8%</th>
<th>EQUIPMENT* 0.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resins</td>
<td>71%</td>
<td>70%</td>
<td>24%</td>
<td>3.8%</td>
<td>1.8%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Labor &amp; Utilities</td>
<td>24%</td>
<td>24%</td>
<td>24%</td>
<td>3.8%</td>
<td>1.8%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Scrap</td>
<td>2.8%</td>
<td>2.8%</td>
<td></td>
<td>2.8%</td>
<td>2.8%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Energy</td>
<td>1.8%</td>
<td>1.8%</td>
<td></td>
<td>1.8%</td>
<td>1.8%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Equipment*</td>
<td>0.5%</td>
<td>0.5%</td>
<td></td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

* Equipment costs represent yearly amortization cost.
ANNUAL COSTS & OPPORTUNITY LOSS
(WHY OEE IS IMPORTANT)

<table>
<thead>
<tr>
<th>Category</th>
<th>SCD®</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrap Cost</td>
<td>US$ 534,000</td>
<td>US$ 671,000</td>
</tr>
<tr>
<td>Downtime</td>
<td>US$ 207,000</td>
<td>US$ 516,000</td>
</tr>
<tr>
<td>Die Cleaning</td>
<td>ZERO</td>
<td>US$ 40,000</td>
</tr>
<tr>
<td>Revenue Loss</td>
<td>ZERO</td>
<td>US$ 122,000</td>
</tr>
</tbody>
</table>

- Scrap Cost: Resin - Material
- Downtime: Opportunity cost
- Die Cleaning: External/Oven cost
- Revenue Loss: Opportunity cost

![Diagram showing cost breakdown with SCD® and Other categories.](image-url)
OEE & YIELD vs. Minimum Run Size

Minimum Run Size (Kg)

<table>
<thead>
<tr>
<th>Minimum Run Size</th>
<th>OEE</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.12M Lbs</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>8.05M Lbs</td>
<td>79%</td>
<td></td>
</tr>
<tr>
<td>8.06M Lbs</td>
<td>84%</td>
<td></td>
</tr>
<tr>
<td>7.93M Lbs</td>
<td>76%</td>
<td></td>
</tr>
<tr>
<td>7.99M Lbs</td>
<td>82%</td>
<td></td>
</tr>
<tr>
<td>7.71M Lbs</td>
<td>71%</td>
<td></td>
</tr>
</tbody>
</table>

SCD® Other
FINAL REMARKS

OEE enable operations managers to identify and address losses in the process that limit effectiveness.

Improving OEE results in cost reductions and increased yield – more revenue potential and profitability.

The SCD® advantage is to reduce set-up and changeover time, and to maximize line availability (reduce cleaning time and frequency) – reliability is key.

Further reducing minimum run size will negatively impact OEE (lower yield) – need to make decision based on inventory and holding costs.
What’s your OEE?

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