Simulation and Design of an Oven for PET Blow Molding Machines

Carlo A. Seneci
101.2 m€ sales volume
638 employees
130 nations served
4300 Smiflexi automatic packaging machines installed
313 Smiform rotary stretch-blown blow molders installed
34000 Smipack packaging machines installed

www.smigroup.it

Academic start-up company of University of Brescia
Industrial automation and mechanical design
Multi-disciplinary approach to non-conventional problems

www.polibrixia.it
TRANSFORMATION PROCESS:
- Preforms production
- Preforms heating
- Preforms blow-streching
INDUSTRIAL PRACTICE:
- [1] Oven entrance
- [2] Oven tunnel
- [3] Rotating molds
STRETCHING RATIOS:

\[ SR_A = \frac{L_B - 5}{L_P - 5} \]  
(Axial)

\[ SR_H = \frac{\phi_B}{\phi_P} \]  
(Hoop)

\[ SR_{BU} = SR_A \times SR_H \]  
(Blow-Up)
IDEAL TEMP. DISTRIBUTION:

- Outer Layer 90°C
- Inner Layer 105°C
**MODEL DEFINITION:**

<table>
<thead>
<tr>
<th>PET Properties</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density [3]</td>
<td>1,370</td>
<td>g/cm³</td>
</tr>
<tr>
<td>Heat Capacity [3]</td>
<td>1000</td>
<td>J/(kg·K)</td>
</tr>
<tr>
<td>Thermal Conductivity [4]</td>
<td>0.15</td>
<td>W/(m·K)</td>
</tr>
</tbody>
</table>

Assumptions:

- Turbulent air flow inside the oven cavity.
- Thermal absorption dynamics very fast
STUDY OF THE THERMAL SOURCE:
- Simulation of IR heating with Zemax
- Preform: 125,000 voxels
- Mean heating on one preform turn
- IR Lamps USHIO QIH400-2500/ZH
STUDY OF THE THERMAL SOURCE:

- Rotating external heat source 9mW
- Rotating internal heat source 3mW
- Heat sources surface 1mm²
STUDY OF THE THERMAL SOURCE:

- No relevant difference between the cases
- Possibility to implement mean heat source
- Reduced model complexity
STUDY OF THE FLUID DYNAMICS:

- Study of the state of the art [1]
- Evaluation of the boundary effects (i.e. preforms translation and rotation, IR lamps cooling fans...)
- Definition of the oven module’s geometry
STUDY OF THE FLUID DYNAMICS:

- Definition of the blowing strategy: symmetric or asymmetric
- Mean aspiration rate 300 m³/h
**COMBINED STUDY:**

- Series of heating and cooling phases.
- 5 IR Lamps combined with mirrors

<table>
<thead>
<tr>
<th>Phase Number</th>
<th>Absorbed Heating Power</th>
<th>Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating 1</td>
<td>290 W</td>
<td>Heating</td>
</tr>
<tr>
<td>Cooling 1</td>
<td>0 W</td>
<td>Diffusion</td>
</tr>
<tr>
<td>Heating 2</td>
<td>290 W</td>
<td>Heating</td>
</tr>
<tr>
<td>Cooling 2</td>
<td>0 W</td>
<td>Diffusion</td>
</tr>
<tr>
<td>Heating 3</td>
<td>290 W</td>
<td>Heating</td>
</tr>
<tr>
<td>Cooling 3</td>
<td>0 W</td>
<td>Ther.Inver.</td>
</tr>
<tr>
<td>Heating 4</td>
<td>290 W</td>
<td>Heating</td>
</tr>
<tr>
<td>Cooling 4</td>
<td>0 W</td>
<td>Diffusion</td>
</tr>
</tbody>
</table>
COMBINED STUDY:
- Wall temperature measured at half the length
- Temperature measured during cooling phases 3 (left) and 4 (right)
COMBINED STUDY:

- Modularity in controlling longitudinal temperature distribution.
- IR lamps alternatively used at 50% of the power (Heating phase 2 & 3).
- Possibility to control critical areas.
RESULTS:

- Energy consumption efficiency increased to 24.1% from 10.5% of the state of the art (mirrors and thermal exchanger).
- Customizable longitudinal and radial temperature distributions.
- Higher depth of thermal absorbion
- Good uniformity in temperature distribution.
- Reduced reciprocal influence between adjacent lamps.
- Increased distance between lamps and preforms.
- Increased uniformity in air flow.
- Reduced the number of components, lamp heads cooled with the main flow.
- Possibility to control each oven module separately.
- Possibility to define consistent recipes due to enviromental insulation.
REFERENCES:

THANKS FOR THE ATTENTION

poliBrixia S.r.l.
Via Branze 45, 25123 - Brescia, Italy
(+39) 030 6595051
info@polibrixia.it