Simulation and Design of an Oven for PET Blow Molding Machines

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smigroup

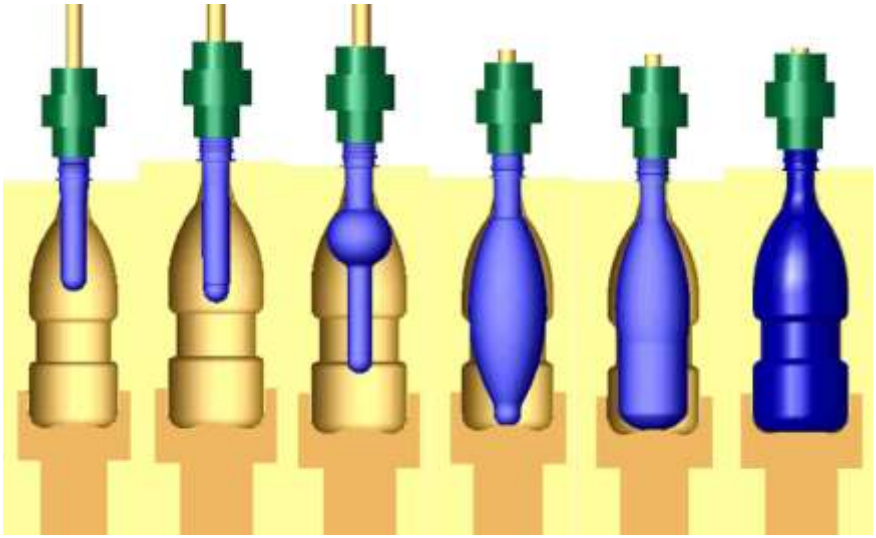
101.2 m€ sales volume
638 employees
130 nations served
4300 Smiflexi automatic packaging machines installed
313 Smiform rotary stretch-blow molders installed
34000 Smipack packaging machines installed
www.smigroup.it

poliBrixia

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

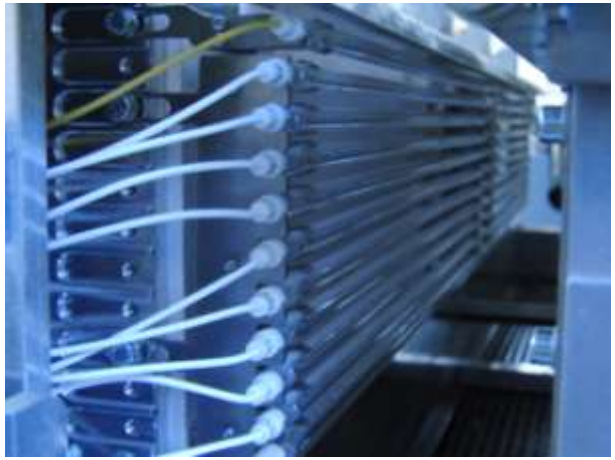
TRANSFORMATION PROCESS:

- Preforms production
- Preforms heating
- Preforms blow-streching

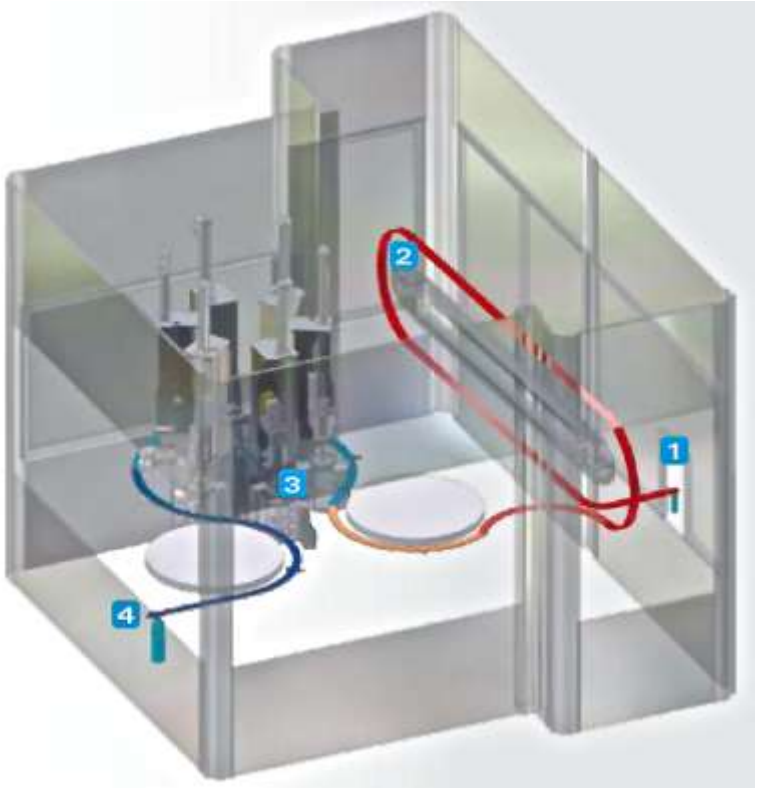


INDUSTRIAL PRACTICE:

- [1] Oven entrance
- [2] Oven tunnel
- [3] Rotating molds
- [4] Machine exit



[1]

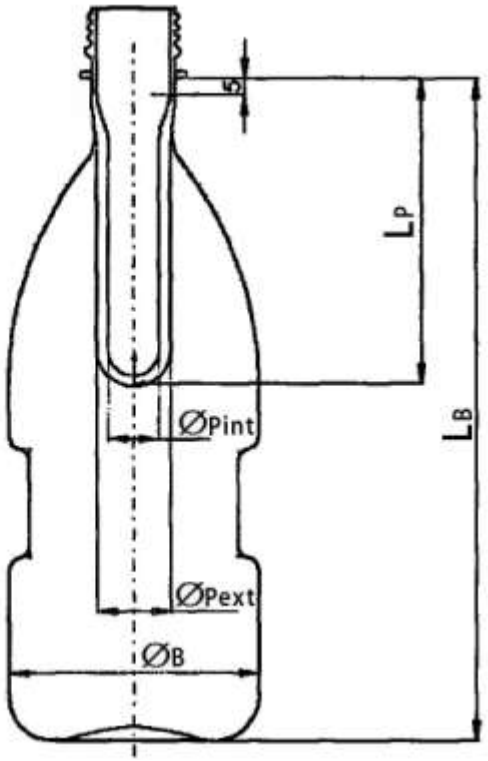


STRETCHING RATIOS:

$$SR_A = \frac{L_B - 5}{L_P - 5} \qquad \text{(Axial)}$$

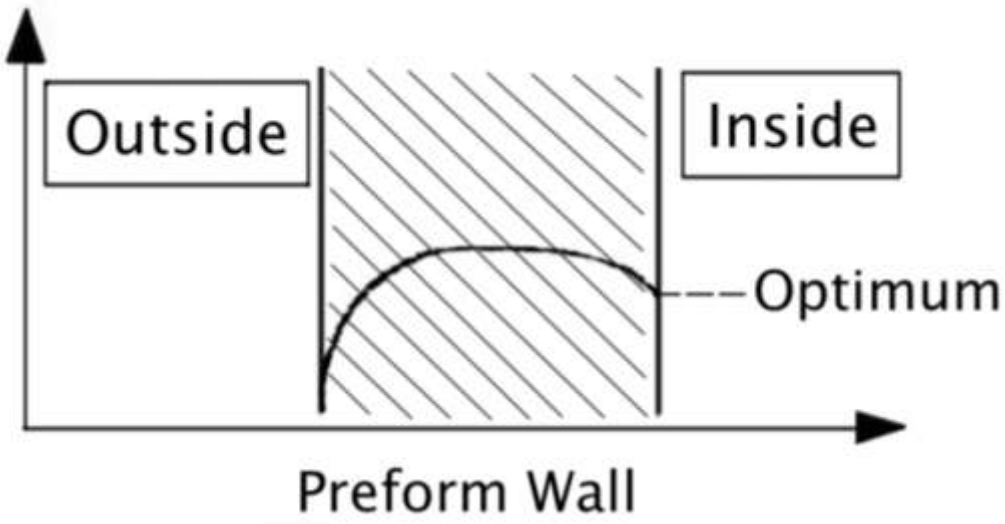
$$SR_H = \frac{\emptyset_B}{\emptyset_P} \qquad \text{(Hoop)}$$

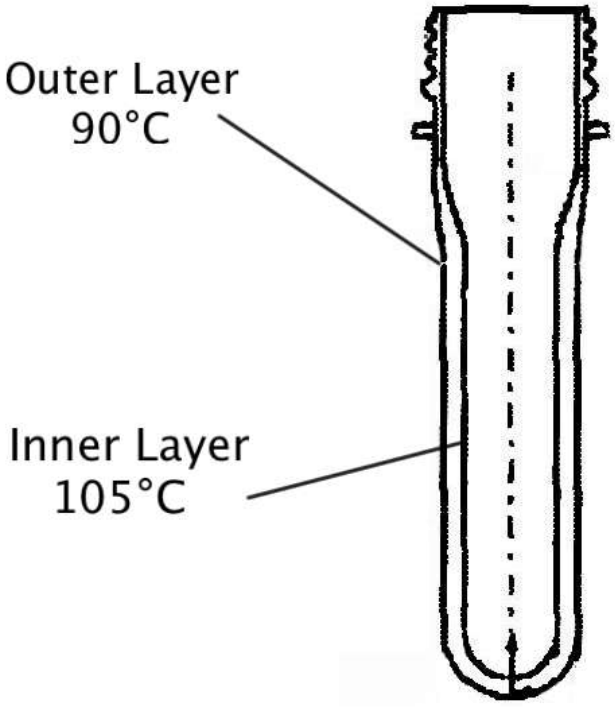
$$SR_{BU} = SR_A \times SR_H \qquad \text{(Blow-Up)}$$



[2]

IDEAL TEMP. DISTRIBUTION:

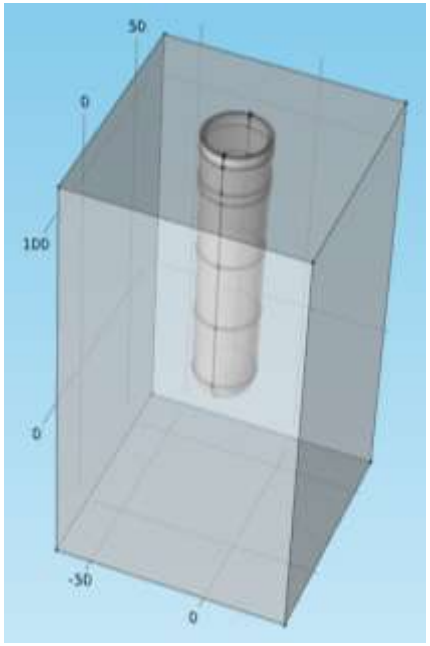




[2]

MODEL DEFINITION:

PET Properties		
Density [3]	1,370	g/cm^3
Heat Capacity [3]	1000	J/(kg·K)
Thermal Conductivity [4]	0.15	W/(m·K)

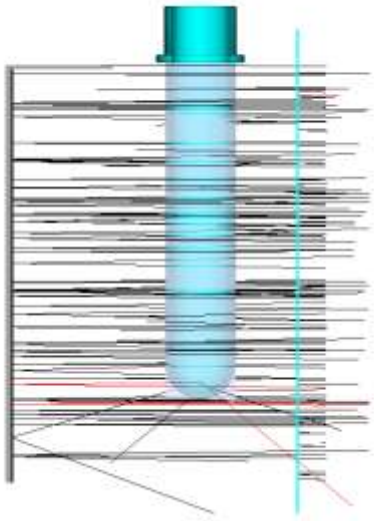


Assumptions:

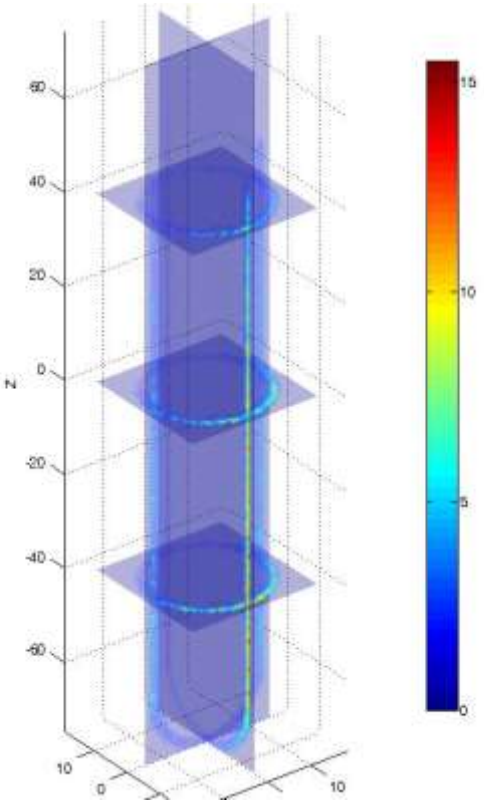
- Turbulent air flow inside the oven cavity.
- Thermal absorption dynamics very fast

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

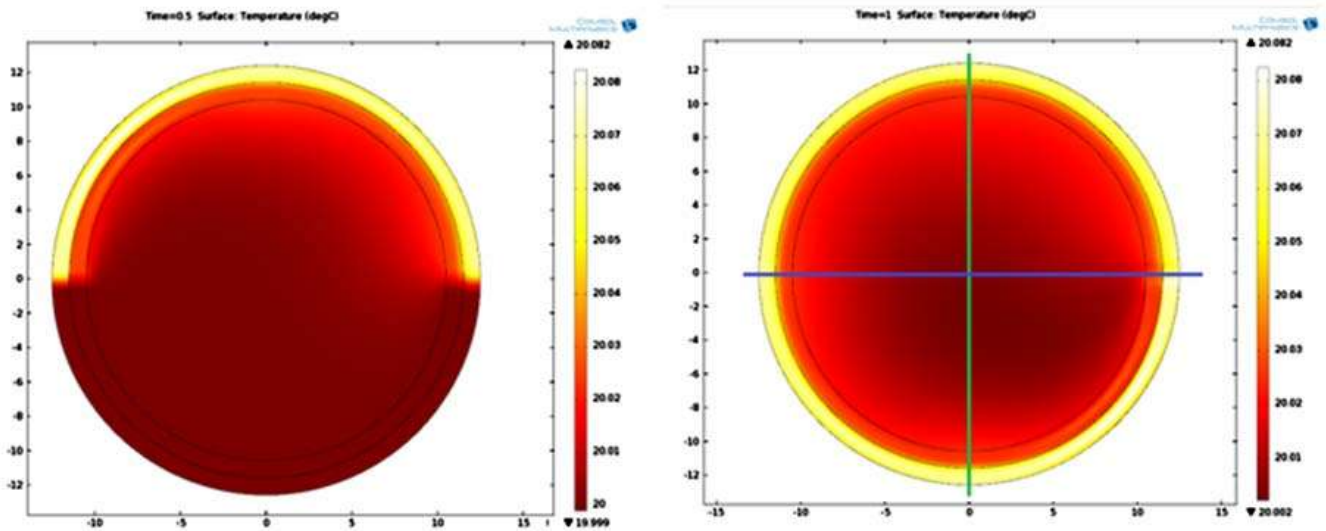


[5]



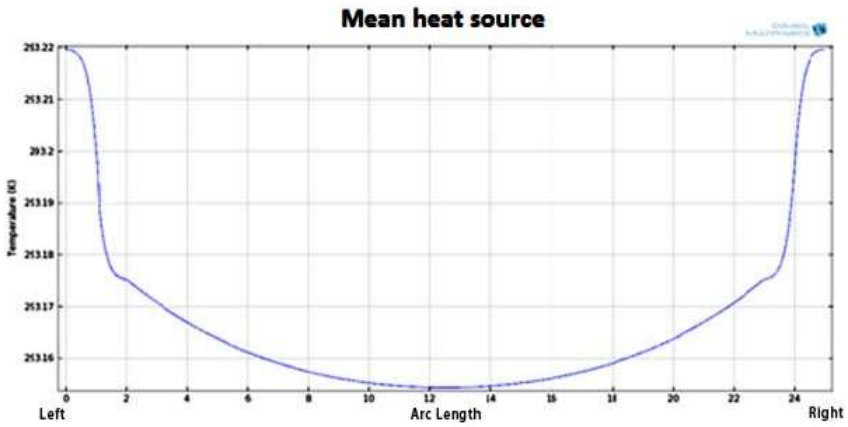
STUDY OF THE THERMAL SOURCE:

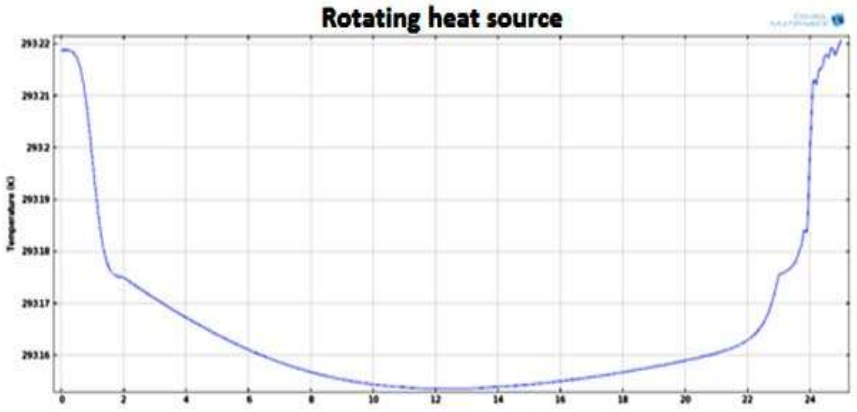
- Rotating external heat source 9mW
- Rotating internal heat source 3mW
- Heat sources surface 1mm^2



STUDY OF THE THERMAL SOURCE:

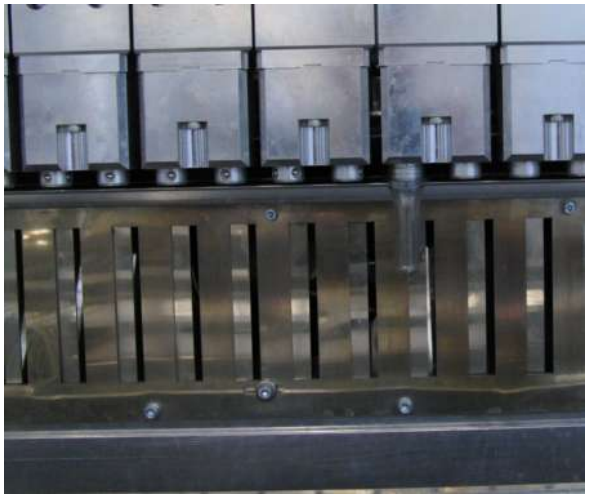
- No relevant difference between the cases
- Possibility to implement mean heat source
- Reduced model complexity

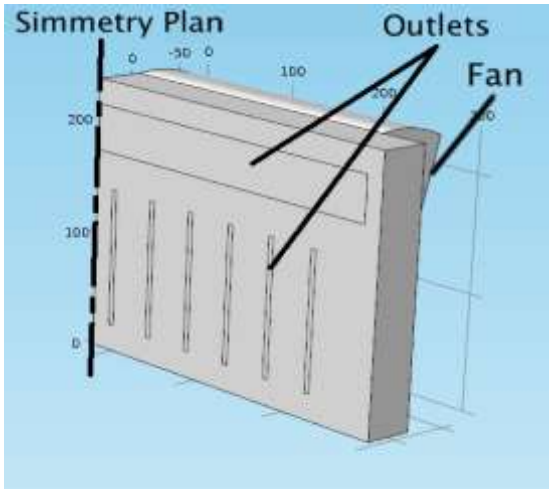


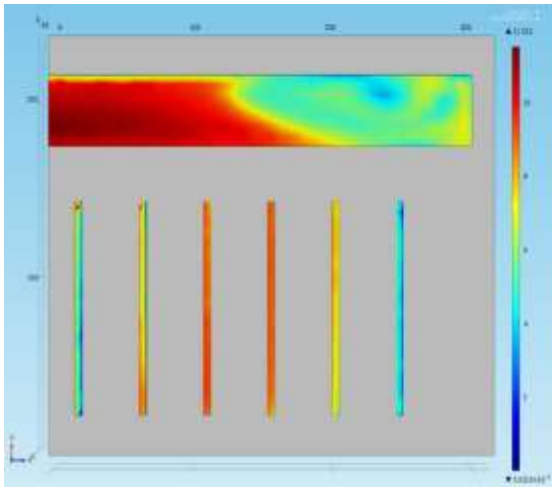


STUDY OF THE FLUID DYNAMICS:

- 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

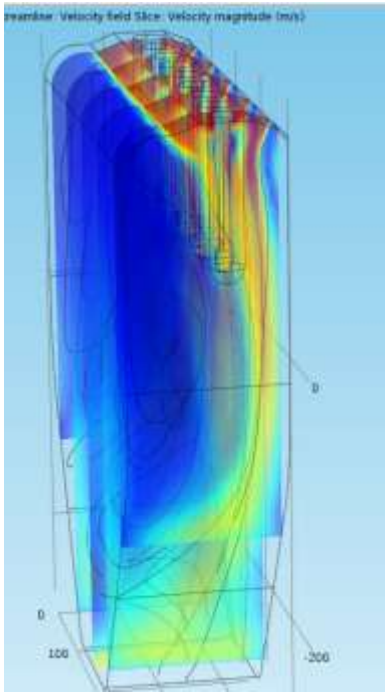


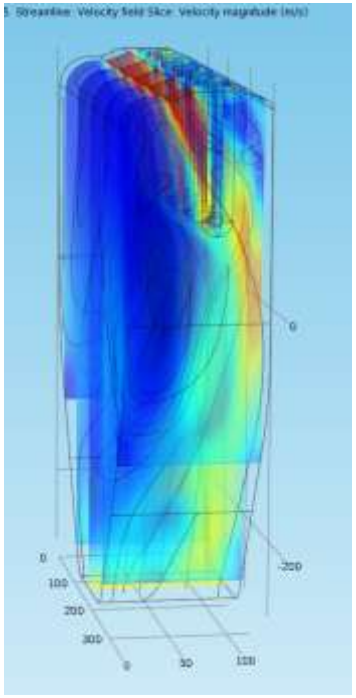


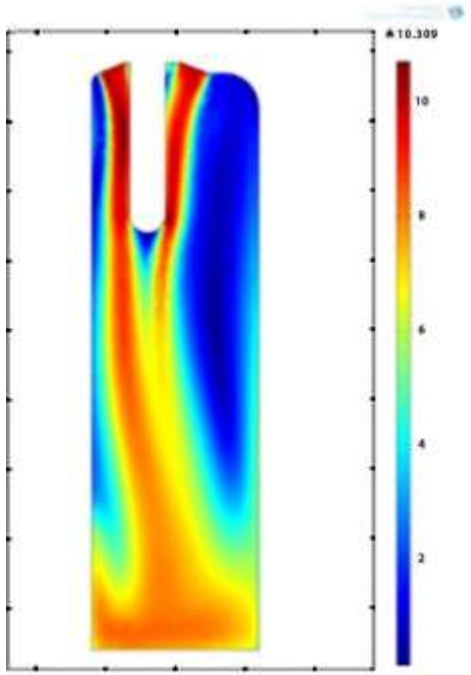


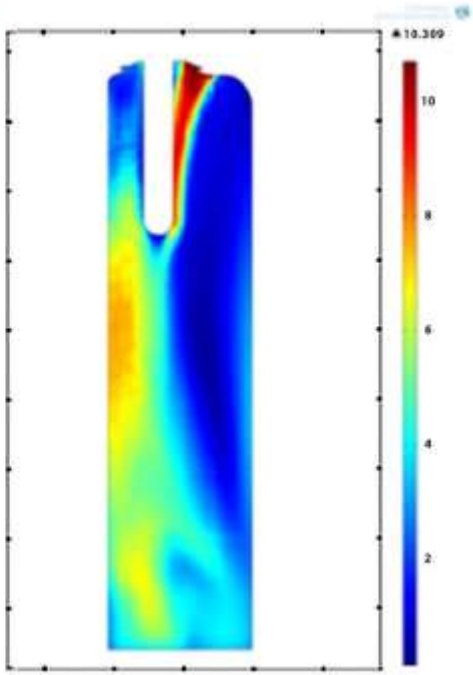
STUDY OF THE FLUID DYNAMICS:

- Definition of the blowing strategy: symmetric or asymmetric
- Mean aspiration rate 300m^3/h





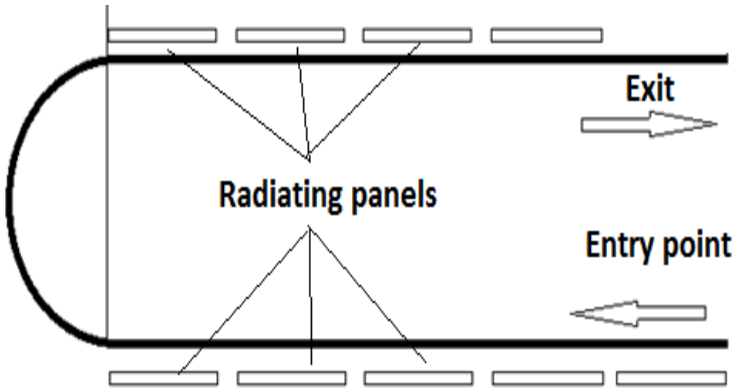


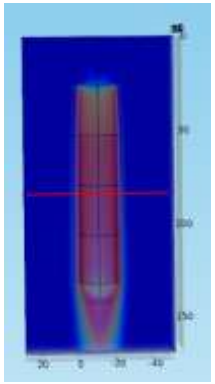


COMBINED STUDY:

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

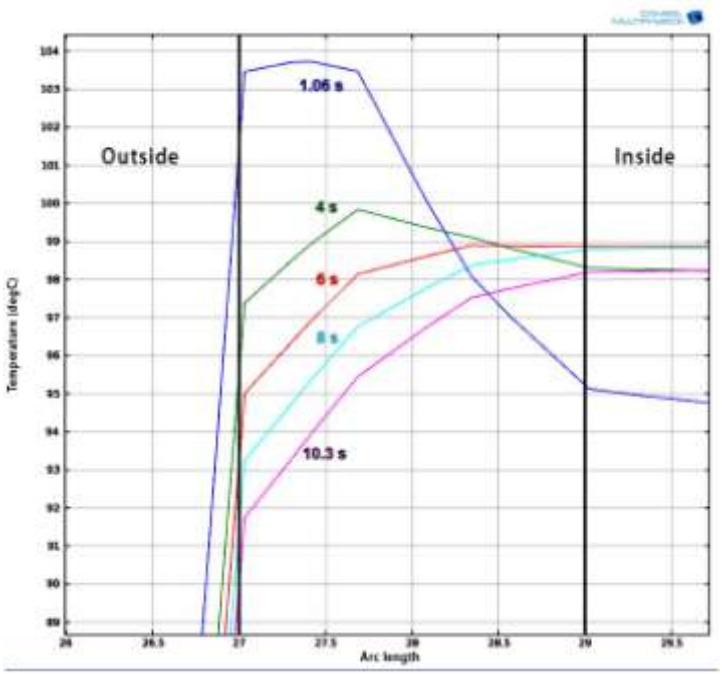
Phase Number	Absorbed Heating Power	Physics
Heating 1	290 W	Heating
Cooling 1	0 W	Diffusion
Heating 2	290 W	Heating
Cooling 2	0 W	Diffusion
Heating 3	290 W	Heating
Cooling 3	0 W	Ther.Inver.
Heating 4	290 W	Heating
Cooling 4	0 W	Diffusion

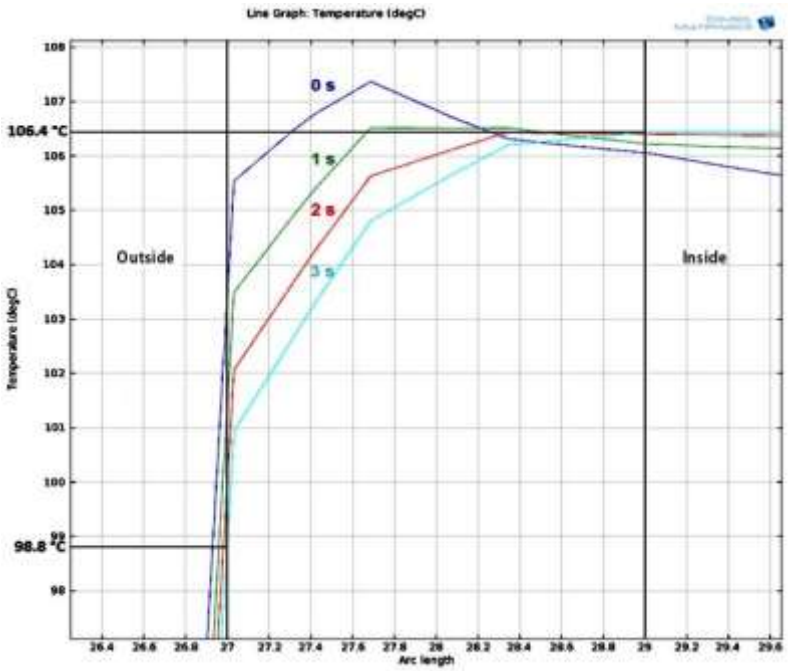




COMBINED STUDY:

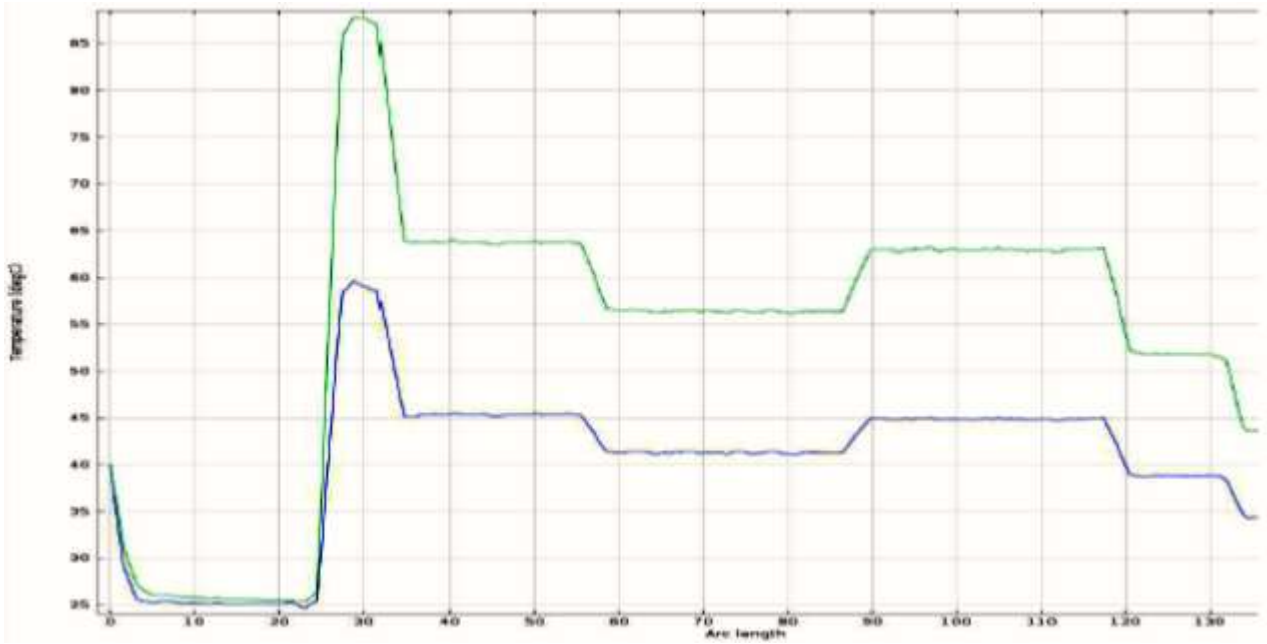
- Wall temperature measured at half the length
- Temperature measured during cooling phases 3 (left) and 4 (right)





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.



Top **Bottom**

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:

[1] SMI Stretch-Blow Molding Machine Series: SR8.
[2] O. Brandau, Stretch Blow Molding, Elsevier (2012).
[3] A.K. van der Vegt & L.E. Govaert, Polymeren, van keten tot kunstof, (2005).
[4] J. G. Speight, McGraw-Hill. ed. Lange's handbook of chemistry (2005).
[5] Zemax 12, Optical and Illumination Design Software.

THANKS FOR THE ATTENTION

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