A Multi-physical Approach of a Sterilization System for Aseptic Food Processing

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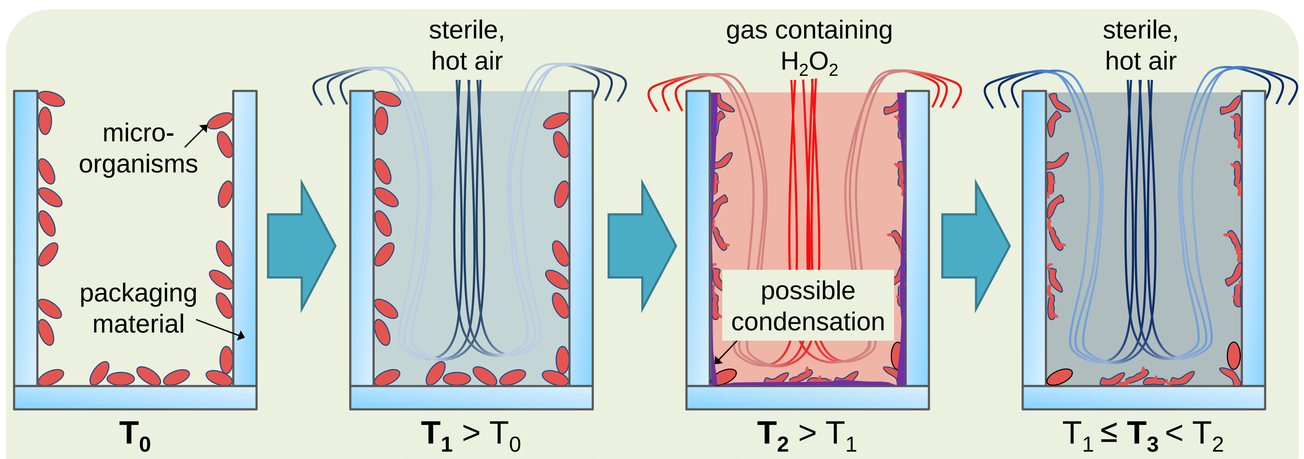
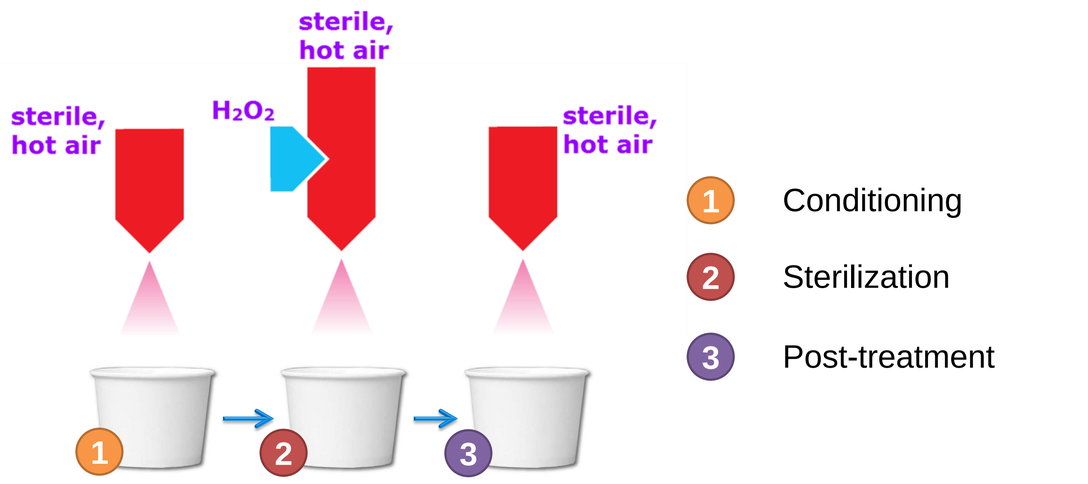
Introduction and motivation

- Package sterilization by a high temperature mixture containing H_2O_2 gas became the standard procedure in most food and pharmaceutical sectors
- Typical three-step sterilization procedure: preheating of packages, sterilization and post-heating



Detailed view of the sterilization procedure of a packaging material

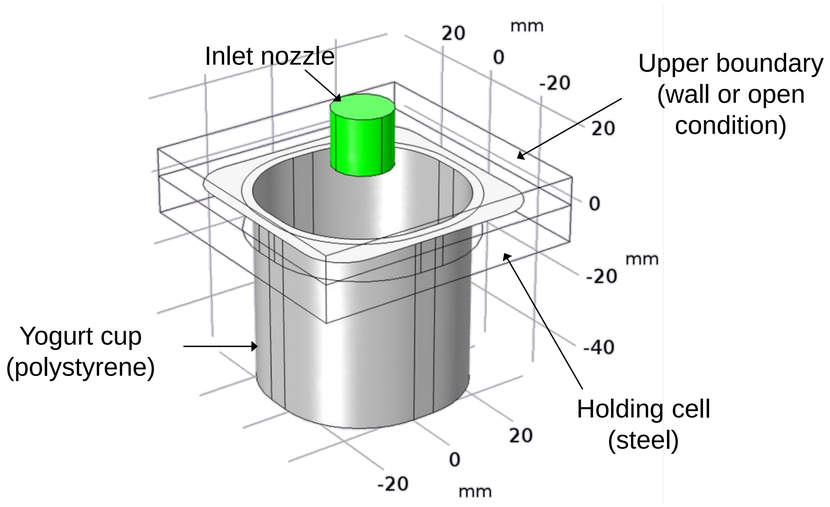


Schematic diagram of sterilization process in aseptic yogurt filling machines

- A competent design increases: reliability of the sterilization process, micro-biological stability and overall quality of the final packaged product
- **Design parameters** include: nozzle geometry and position, humidity levels, flow velocity and temperature

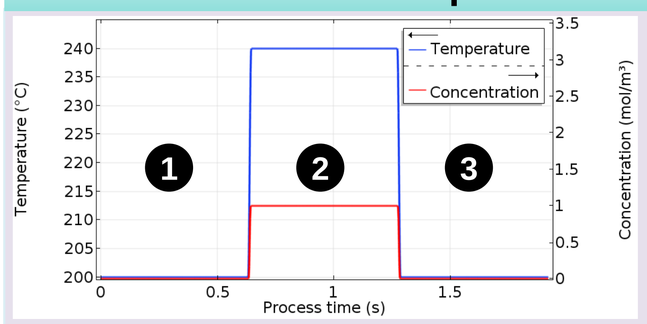
→ **Numerical modeling** is used to reduce the number of variables and experiments and predict design enhancements

Model design



Numerical model design of a yogurt cup

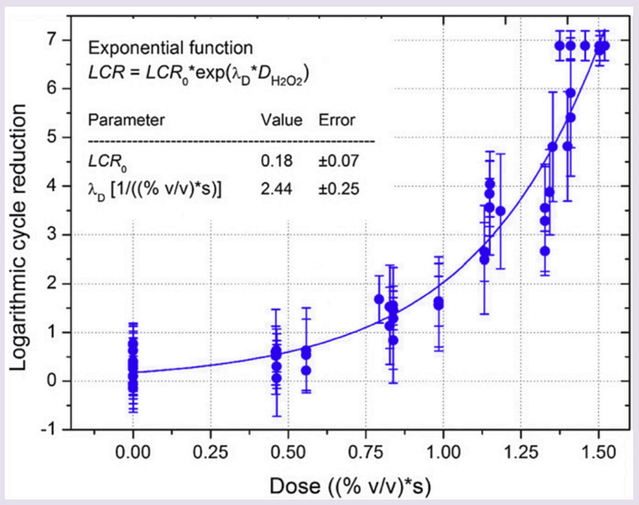
Process parameters



Process parameters:

$t_{process}$ = 0.64 s,
T_0 = 30 °C,
$T_1 = T_3$ = 200 °C,
T_2 = 240 °C

Result interpretation

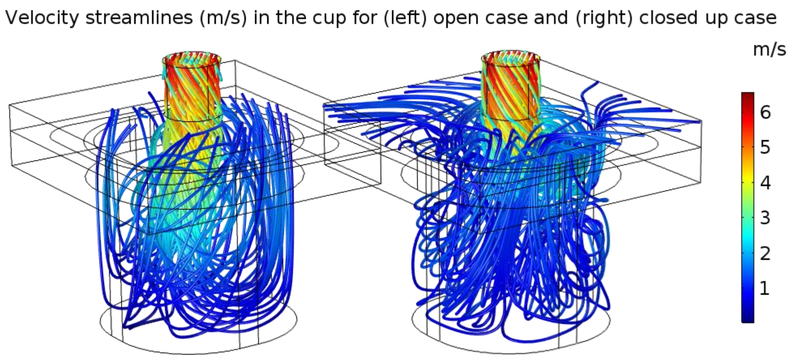


An increase in H_2O_2 leads to an increase in sterility assurance level

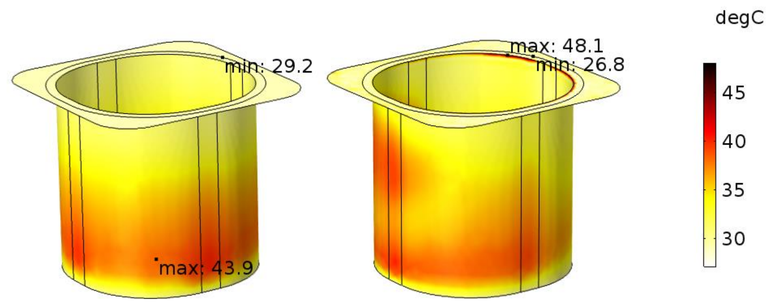
Kirchner et al, Food Control 31 (2013), 530-538

Results

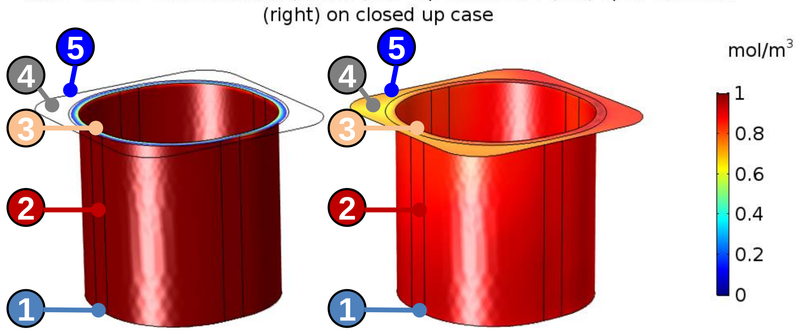
Velocity
Isothermal velocity streamlines show that a simple parameter variation enhances the distribution of flow

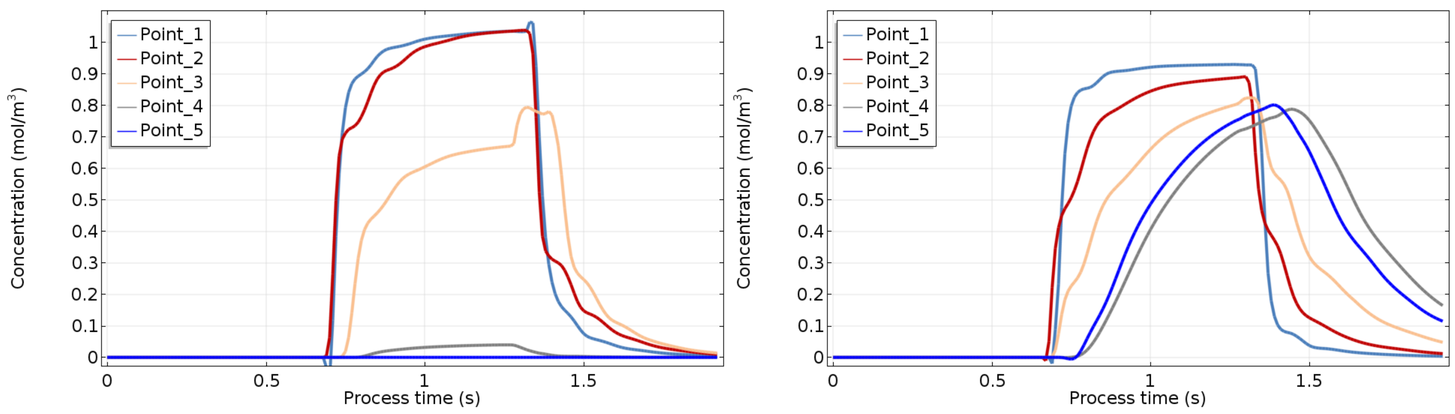


Temperature
Temperature evolution during the sterilization process accompanied with the liquid-vapor-equilibrium diagram depicts plausible medium condensation



Concentration
Surface concentration of sterilization media can be modeled using mass transport of sterilization medium with temperature-dependent diffusivity coefficient





Gas concentration at different points of the package for (left) an open case and (right) closed case

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