Numerical study of thermal evaporation unit for phase change of liquid hydrogen peroxide to vapor

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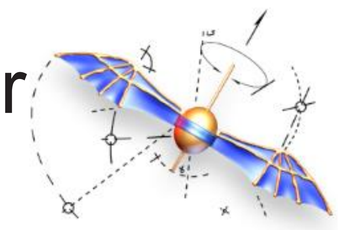


Introduction: Sterilization using vaporized or gaseous hydrogen peroxide (H_2O_2) has become a mainstream in various industrial and medical sectors. In which, small quantities of H_2O_2 solution are mixed with air and evaporated in electrically heated evaporation unit. To better understand the binary phase change behavior of the aerosol mixture and key design elements of these evaporation units, numerical techniques are applied.

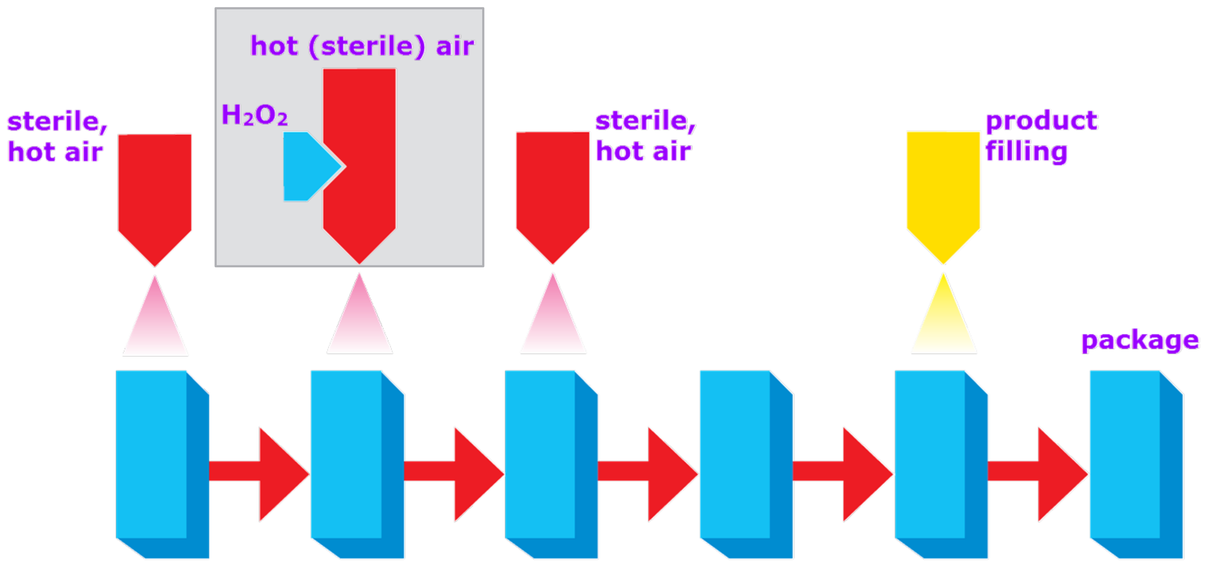
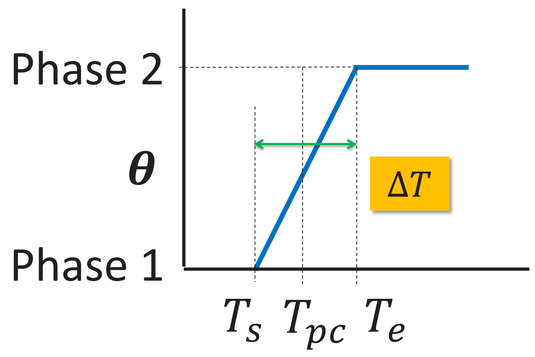


Figure 1. Typical sterilization procedure using vaporized or gaseous H2O2.

Computational Methods: Phase change of the binary system was approximated as a single phase transition using effective material properties of the aerosol (approximated as an ideal gas mixture).



Phase fraction:

$$\theta = \begin{cases} 0: T_{pc} - {}^{\Delta T}/_{2} \rightarrow T_s \\ 1: T_{pc} + {}^{\Delta T}/_{2} \rightarrow T_e \end{cases}$$

Figure 2. Definition of apparent heat capacity formulation for a single phase transition.

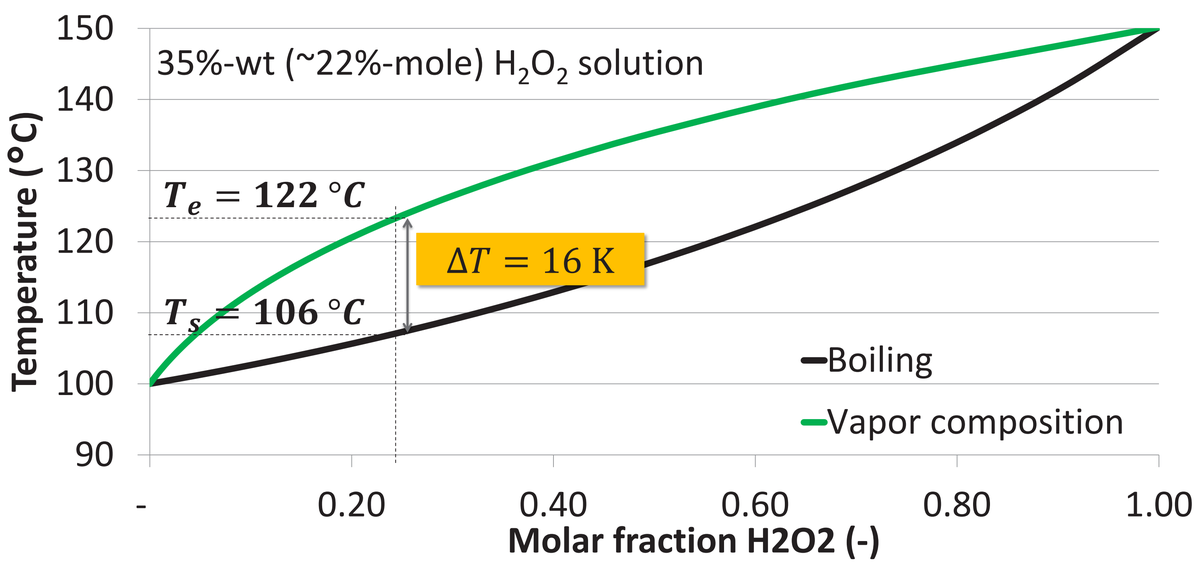


Figure 3. Binary isobaric phase diagram of H_2O_2 solution at 1 atm.

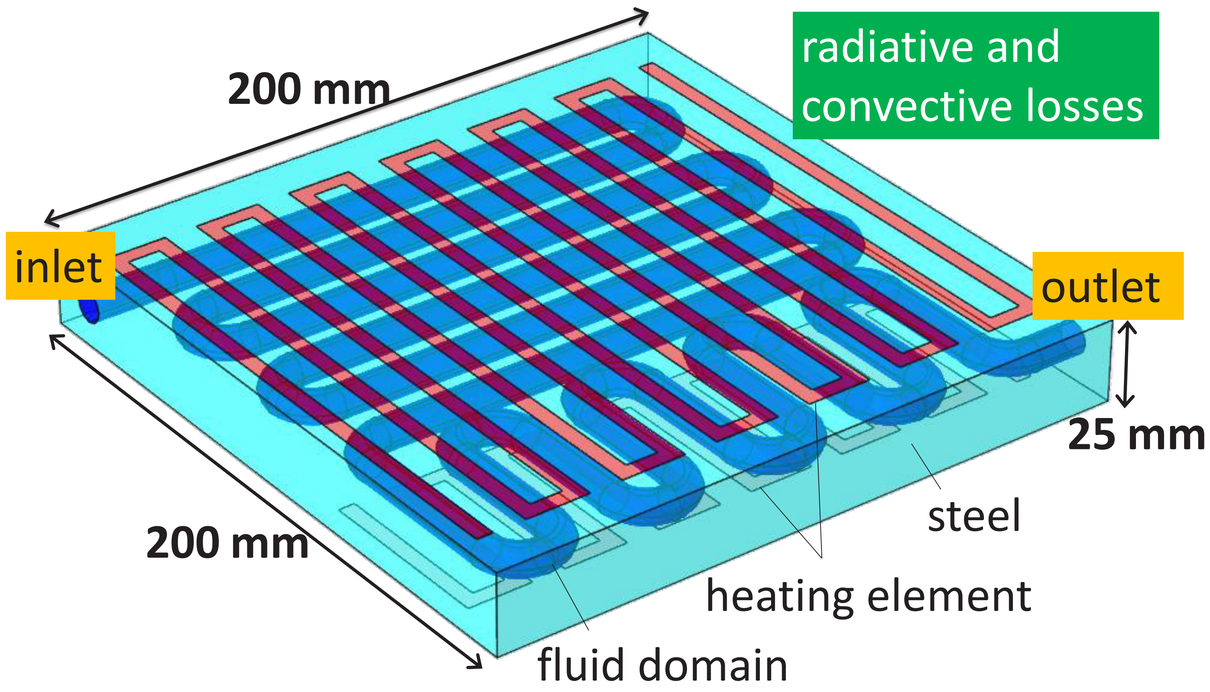


Figure 4. Initial design of an evaporation unit.

Results: Using an auxiliary sweep on heating power, the non-isothermal turbulent phase change flow reached a stable convergence. Full aerosol evaporation and subsequent temperature increase were achieved at the outlet.

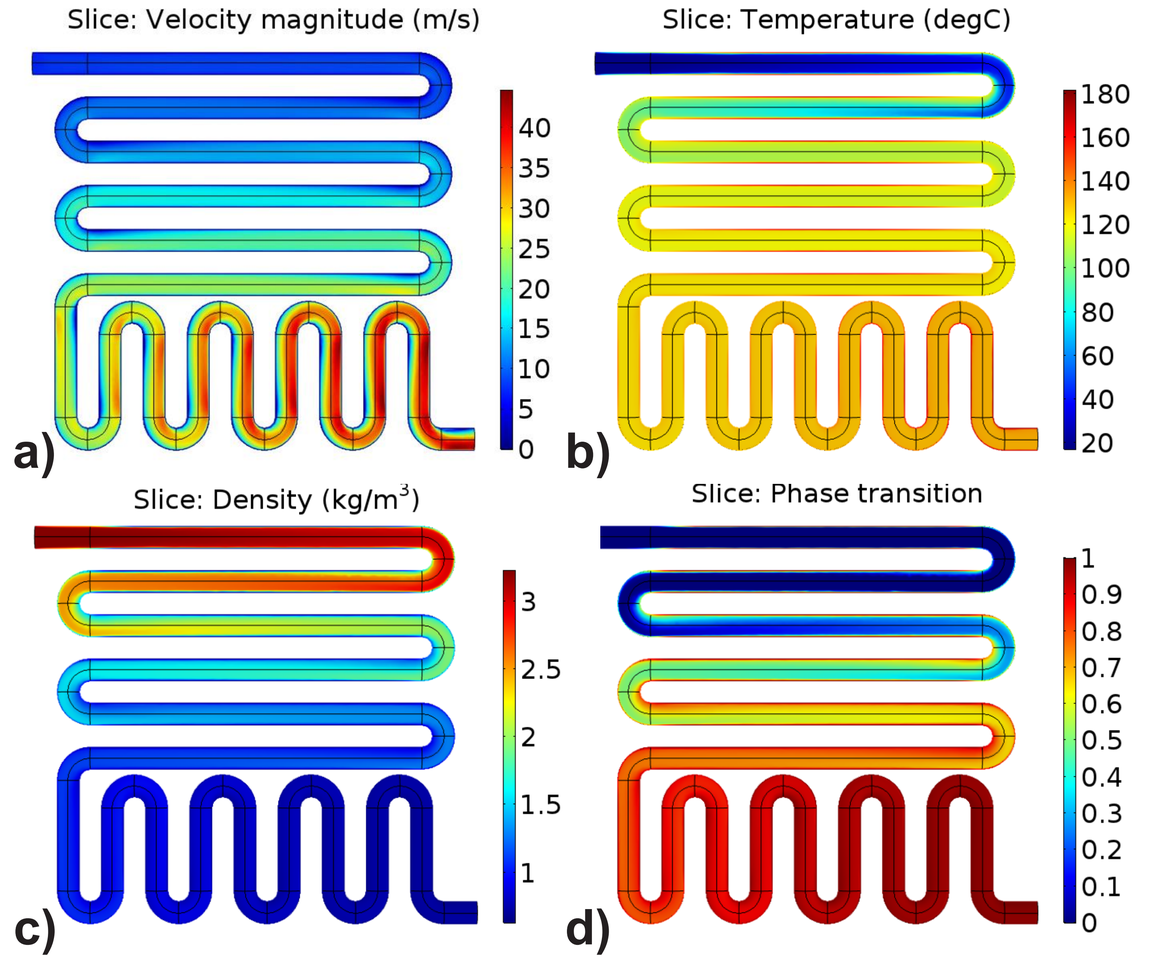


Figure 5. Plots of **a)** velocity, **b)** temperature, **c)** density and **d)** phase change by a heating power of about 2.55 kW.

Conclusions: The binary phase transition of aqueous H_2O_2 aerosol was approximated using apparent heat capacity formulation. Based on the results of the numerical simulations, key design elements of evaporation unit design were identified. Evaluation and validation of the initial numerical model will help in designing optimal evaporation units while saving time and costs.

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