# Design model for water distribution system for industrial process autoclaves

**KEA-Phoenix – ESGI Problem 2015**

Kea Phønix ApS produces and provides the full range of autoclaves used in the international food industry for sterilization of products packed in tins, bottles, plastic containers, etc. PHONIX autoclaves, shown in the figure below, are also used in the international pharmaceutical and technical industries. Kea Phønix ApS provides the following types of autoclaves in both black and stainless steel, in standard dimensions and customized models.

- Water Spray autoclaves
- Full Water autoclaves
- Steam autoclaves
- Vertical autoclaves

Fig. 1. PHONIX autoclaves

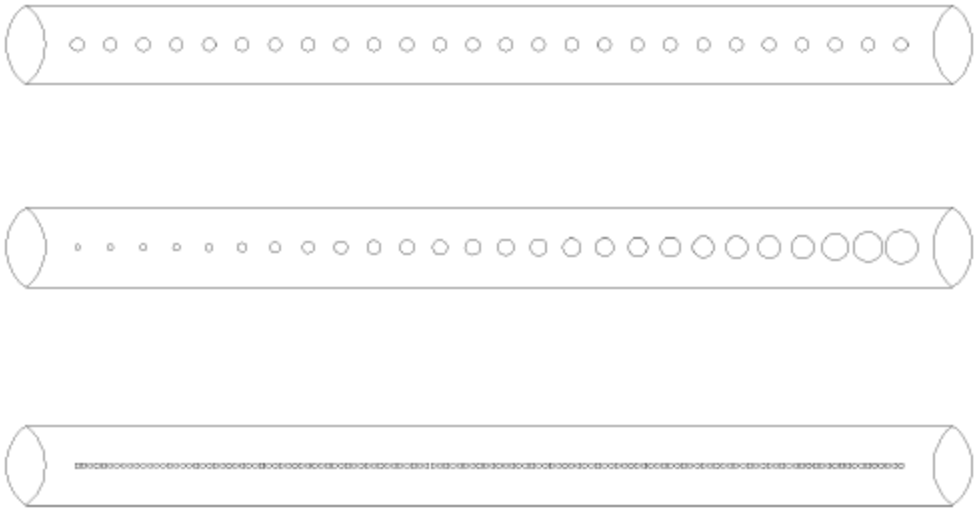

Fig. 2. Examples of possible hole configuration in distribution tube

The methods for sterilization using autoclaves consists of heating the packaged product, under pressure, to a certain temperature, maintaining that temperature for a specific amount of time and then cool down the product again. During both, the heating and cooling process, it is important that the temperature in all parts of the autoclave is kept as uniform as possible. The autoclave considered operates based on the Hot Water Spray process. In such a process, a pre-defined amount of water is used and kept at the bottom of the retort chamber. During the process cycle, including sterilization and cooling, water is recirculated by a high flow rate pump and uniformly distributed across the products baskets in the autoclave through a distribution pipe as indicated in Fig. 2. Water cooling and heating occur through a plate heat exchanger. During the sterilization and cooling phases, the electronic process controller monitors temperature and pressure inside the retort chamber.

Future demands to product sterilization are increasingly moving towards more accurate control of the temperature, pressure and time requirement of the autoclave. The main objective of the work is to secure an optimal, homogeneous heat distribution in autoclaves for sterilization of various items for the food industry etc. based on mathematical modelling. It is a known and important technological challenge to secure an adequate homogeneous heat distribution in the autoclave. The variation in heat in terms of the process is expected to stay within 1K inside the autoclave. Knowing the exact distribution of heat is important to ensure an effective sterilization with a minimum use of resources to ensure there is no uncertainty about the validity of the sterilization process.

The main concentration of the workshop problem will be on the water distribution tube in the autoclave examining various configurations, designs and parameters to optimize the overall water distribution process in the autoclave. This will be a preliminary work in order to attain the objective of having a uniform and homogeneous heat distribution in the autoclave.

It is a basic presumption for the ESGI workshop that a uniform temperature distribution in the product can be achieved by establishing a uniform distribution of water flow through the water distribution manifold. It

is also a basic presumption that there is no temperature loss from inlet to outlet so the problem is a pure fluid distribution problem. Total inlet water flow will be assumed constant for the design point – but analyses concerning maldistribution for other mass flows are also interesting during transient behavior.

### Tasks for the workshop:

- Discussion of a proper measure of maldistribution for optimization purposes. We assume that minimizing this measure as objective function will maximize temperature uniformity.
- Formulation of a mathematical model for the distribution system to calculate the maldistribution for any given geometrical formulation of the distribution manifold.
- Optimization of the distribution manifold geometry. Analysis of objectives and discussion of constraints and limitations of results.

### Problem constraints:

- A 2 or 3D CFD model is not the aim of the project.
- Pressure drop models should be based on reasonably realistic correlations found in literature.
- Model complexity should be limited so total calculation time remains “reasonable”.
- The report is expected to describe the solutions including theoretical background, assumptions, methods and exemplifying calculations demonstrating the validity and practical application of the design model.

### Technical specifications of the water distribution unit for one specific case of the system:

- Distribution Tube Pre-Defined Parameters
- Tube Length: 2870 mm
- Tube Diameter: 168.3 mm
- Downward Holes Diameter: 27 mm
- Side Holes Diameter: 20 mm
- Water Supply Mass Flow Rate: 350 m3/h
- Pressure Difference: 1.3 bar