

Fluidized Bed Reactor Design for Educational Purposes: A Popcorn Reactor Case Study

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MOTIVATION

Defining the role of a chemical engineer is challenging even for graduates of this field. It often happens that first-year students are not fully aware of “what they are getting into.” The project is aimed at popularizing chemical engineering through demonstrations of its principles and practical applications.

RESULT

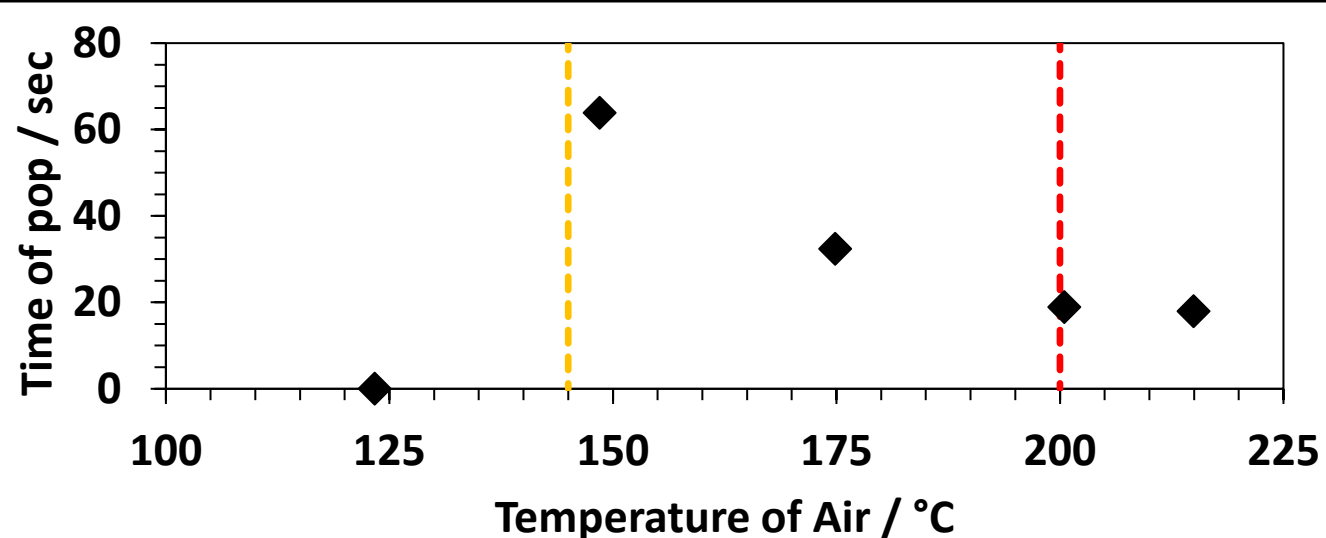


Fig. 1 Dependence of time of popping of kernel on temperature of air.

This graph shows that kernels begin to pop at approximately 145°C and start to burn with little or no popping at 200°C. Therefore, these two temperatures were selected as the lower and upper boundaries.

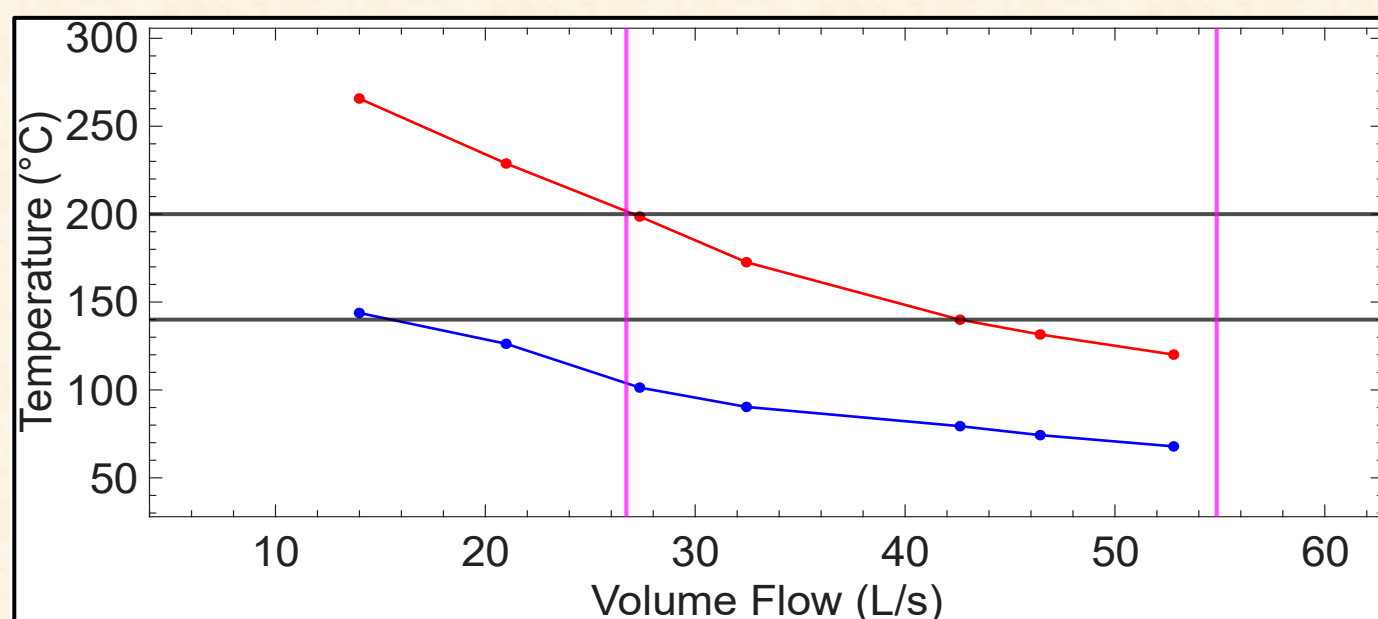


Figure 2. Dependence of air temperature on volumetric flow rate.

The red and blue lines show the measured air temperature at maximum (1,5 kW) and minimum (0,6 kW) heating power, respectively. The magenta lines on the x-axis define the operational boundaries for the flow rate, from the minimum speed required to carry the popcorn out of the reactor to the maximum speed before kernels is blown away. The temperature range on the y-axis is defined in Figure 1. The area under the red line that falls within these temperature and flow boundaries represents the optimal operating conditions.

EXPERIMENTS

To design the reactor, it is essential to define the key process parameters. In this case – temperature of air and its flow. To better understand these parameters, next experiments were designed:

Determination of temperature limits - Individual corn kernels were heated by hot air stream until they popped. Determination of flow characteristics - Individual corn kernels were placed inside the reactor and flow rate at which they flew away was determined. Then same experiment was conducted with popped kernel.

CONCLUSION

This project was to showcase principles of chemical engineering. The primary goal was not to perfect popcorn production, but to provide an application of experimental design, mathematical modelling, and process optimization.

Using mathematical model system variables like temperature and air flow - optimal operating conditions for the reactor were identified:

Heating Power: 2 kW;

Reactor Pipe Diameter: 5 cm

Volumetric Air Flow Range: 30 – 60 L/s

Reactor is designed to be a dynamic and engaging educational tool. Its future purpose is to serve as an interactive exhibit at university open days, science festivals, and outreach campaigns for schools. By demonstrating complex engineering principles through a fun and relatable process, we aim to inspire future students to pursue a career in the field.

PROCESS DESCRIPTION AND SCHEME

Corn is fed into a cylindrical reactor, where hot air is introduced from the bottom, creating a fluidized bed that heats the kernels uniformly. Once the critical temperature is reached, the kernels pop into popcorn. Because of their increased surface area, the popped kernels are carried out of the reactor by the air stream, effectively separating them from the kernels

1 – corn kernels enters in; 2 - Glass tube with metal mesh inserted; 3 - Air heating element(inside); 4 - Air ventilator; 5 - Air enters through the bottom; 6 -Popcorn exit through the outlet;

