Unit III

Thermal Properties - Problems

Introduction

Importance of Thermal Properties

Thermal properties are involved in almost every food processing operation. **Knowledge of the thermal properties of foods is essential in the analysis and design of various food processes and food processing equipment** involved in heat transport, with respect to heat transfer or energy use, such as in extrusion cooking, drying, sterilization, cooking etc. The most important thermal properties in food processing such as, specific heat capacity (cp), thermal conductivity (k), and thermal diffusivity of food materials depend mostly on the food's composition, temperature and density. They have a significant effect on the rate of heat transfer into the particulates within the food product.

- When considering heat transfer during food processing, the thermal conductivity of the food plays an important role.
- The thermal conductivity (k) of food determines how fast heat can be evenly transferred to the entire food mass, which in turn affects the quality of the final product.
- Thermal conductivity depends strongly on moisture, temperature and structure of the material. In porous materials the void fraction and the pore structure and distribution affect thermal conductivity significantly. Generally, in multiphase systems (solids, water and air), the effect of geometric distribution of the phases is taken into account by using structural models.

Problem Statements

1. A batch of rice grains is stored in a cylindrical container. The thermal conductivity (kkk) of rice grains is **0.12 W/m·K**. Suppose heat is conducted through a **5 cm thick** layer of rice grains, and the temperature difference between the inner and outer surface of the layer is **10°C**. If the cross-sectional area through which heat is conducted is **0.2 m²**, calculate the heat transfer rate (Q) using Fourier's law of heat conduction.

2. Determine the thermal conductivity of wheat grains at 12.2 % m.c. is packed in to the large sphere at a density of 726 kg/m3. An electric heater inside the small sphere is activated by adjusting the voltage and current to 70 Volt and 0.059 Amperes. After 14 hours, the steady state condition is reached showing constant average temperature of 65.8 ºC outside the small sphere (ri = 4.87 cm) and 35.2 ºC inside the large sphere (ro = 14.9 cm).

3. Determine the specific heat of maize grains from the following observations

Temperature, °C				Weight, kg		
Grain,Ti	Bucket,Ti	Water, Tw	Equilibrium Temp.,Te	Water	Bucket	Grain
73	73	21	30	0.256	0.055	0.09

Specific heat of calorimeter bucket 0.226 kcal /kg °C