Enhancing food engineering education with interactive web-based simulations

Alexandros Koulouris, Georgios Aroutidis, Dimitrios Vardalis, Petros Giannoulis and Paraskevi Karakosta

Alexander Technological Education Institute
57400 Thessaloniki, Greece

Objective

Develop an open, learner-centered, ***web-based interactive*** *environment through which* ***self- and guided learning*** *of fundamental phenomena in food processing can be understood with the help of simulation modules*

Basic Features

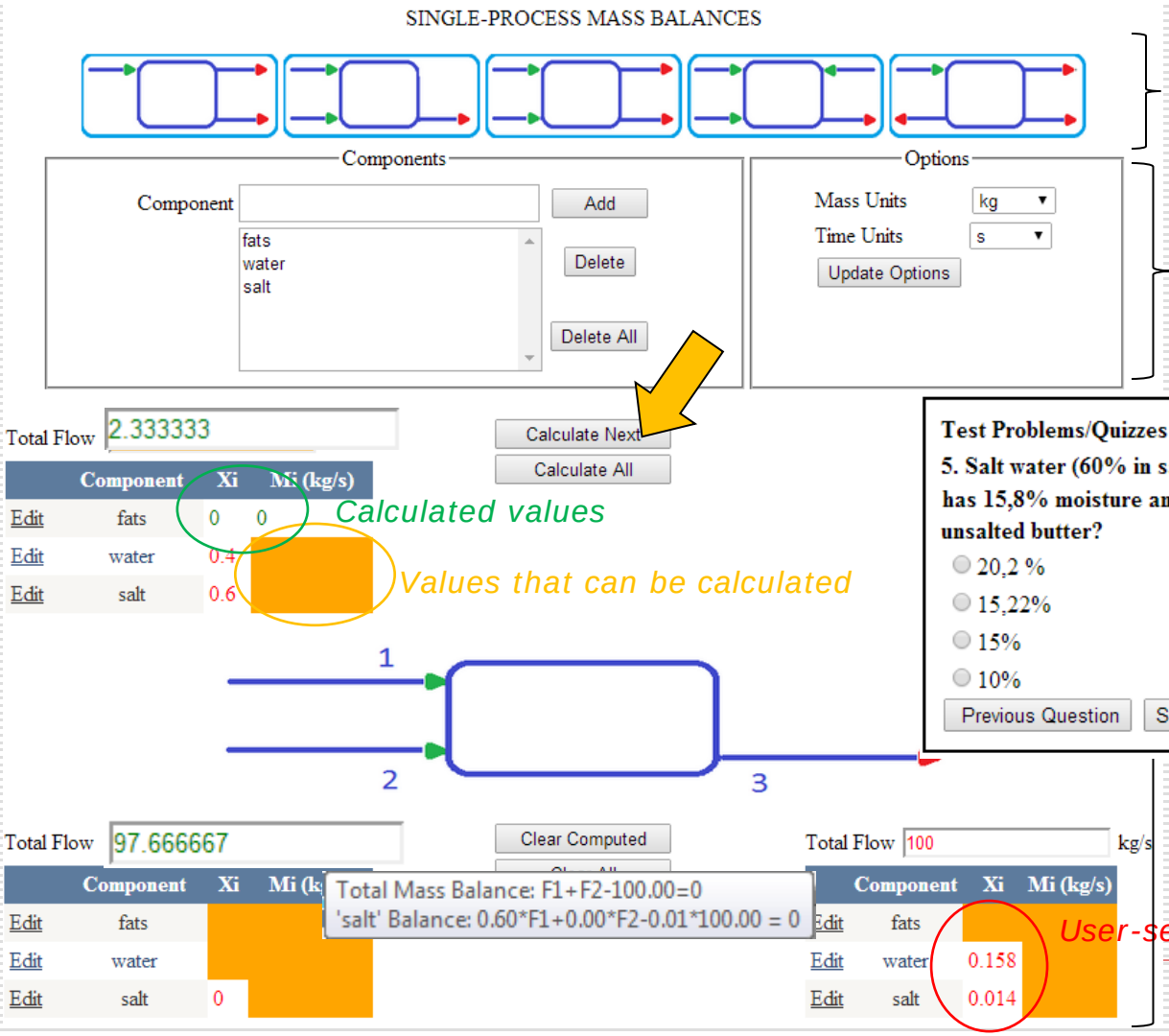
- ***Visualization***: use of video, charts etc. to create a visual representation of the phenomenon
- ***Computation***: use of simulation for the mathematical depiction of the phenomenon
- ***Experimentation***
  - *Free*: allow editing of key parameters and recalculation
  - *Guided*: solve provided quizzes/problems through multiple-choice questions

FEPSIM Project

- ***F****ood* ***E****ngineering* ***P****rocess* ***SI****mulation* ***M****odules*: project co-financed by the European Union and Greek national funds
- Work In Progress
- (Hopefully) soon, it will go up in: www.food.teithe.gr/fepsim

FEPSIM Project HomePage

Material Balance Module



Select block

Define components

Test Problems/Quizzes

5. Salt water (60% in salt) is mixed with butter. If the resulting salted butter has 15,8% moisture and 1,4% salt, what is the moisture of the original unsalted butter?

- 20,2 %
- 15,22%
- 15%
- 10%

Previous Question | Submit Answer | Reset Quiz | Next Question

“How-to-use” Instructions

Experiment Instructions - Google Chrome

localhost/fepsim/MemberPages/Instructions.aspx?contentFile=MassBalance

Material Balances: How to use the page

Select the block with desired input/output structure by clicking on the appropriate icon on the top of the page.

Insert components in the component list by entering a name in the Component box and clicking the **Add** button. A listed component can be removed by selecting it from the list and clicking the **Remove** button. Click **Remove All** to delete all components.

In the Options box, select the mass units and time units of choice and click the button **Update Options**.

Next to each block stream, there is a box for the stream flowrate and a table with all components with their mass fraction and mass flow.

Initially all value boxes are empty. To enter the mass fraction (X_i) or flowrate (M_i) of a component, first click Edit at the corresponding table row, enter/edit the value and click Update to apply or Cancel to dismiss the changes.

As you enter data, the boxes are colored based on their state:

- Text in **red** indicates a value entered by the user
- Text in **red background** indicates that the entered text is invalid (i.e. not a number or invalid number)
- Text in **green** indicates a calculated value
- Text in **green background** indicates a calculated but invalid number (e.g. flow<0)
- **Orange background** in an empty box indicates that this value can be calculated (and cannot be set by the user)

If, as you enter data, there exist boxes whose value can be calculated (orange background), you can click the **Calculate Next** or **Calculate All** buttons to have these values calculated and displayed.

Calculate Next forces the calculation of the next single value only.**Calculate All** forces calculation of all values that can be calculated based on the available data.

Moving the cursor over any edit box, a tooltip pops up that explains the state of the corresponding value and, if calculated, the equations used to obtain the displayed value.

User-set values can be edited only if there are no calculated values; otherwise they are frozen.

Click the **Clear Computed** button to have all calculated values removed. **Clear All** empties all values from the edit boxes.

Steady-State Heat Transfer-Planar Module

FOOD ENGINEERING PROCESS SIMULATION MODULES

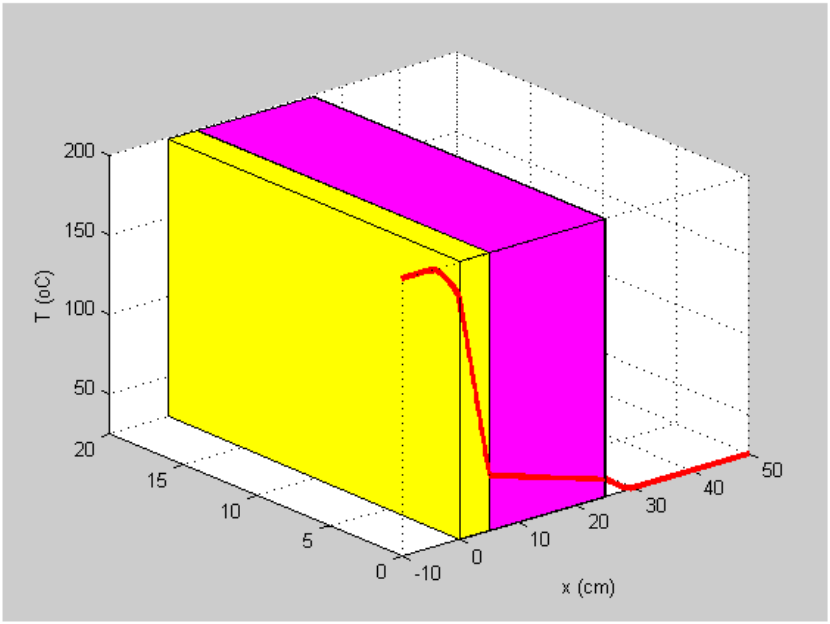
EN ▾ [Log In]

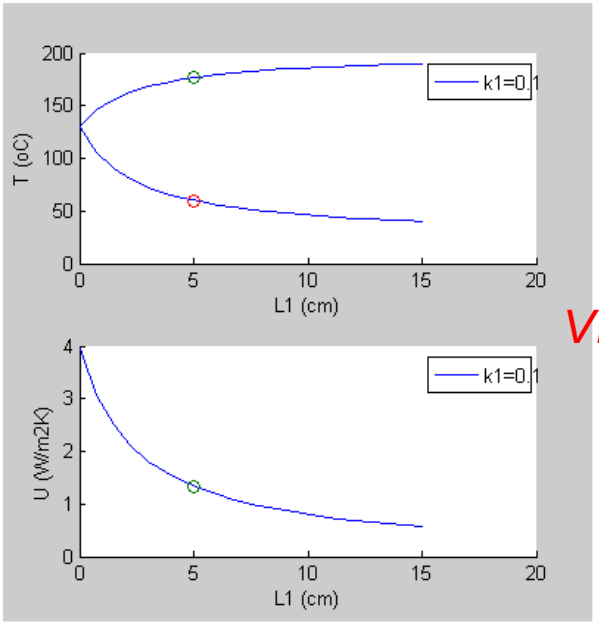
Home | Experiments | About

STEADY-STATE HEAT TRANSFER: PLANAR GEOMETRY

T_i (°C)	200	T_o (°C)	25
h_i (W/m^2°C)	10	h_o (W/m^2°C)	20
Number of Layers: 2 ▾		Refresh	Clear
L_1 (cm)	5	k_1 (W/m°C)	0.1
L_2 (cm)	20	k_2 (W/m°C)	2
U (W/m^2°C)	1.33	q/A (W/m^2)	233.33

Experimentation/Computation





Visualization

Help Instructions

Testing your knowledge

Test Problems/Quizzes

1. If the width of a layer is increased, what would you expect to happen to the overall heat transfer coefficient U and the temperature difference ΔT at the wall surfaces?

- U decreases and ΔT increases
- U increases and ΔT decreases
- Both increase
- Both decrease

Previou

Test Problems/Quizzes

2. If the heat conductivity of a layer is increased, what would you expect to happen to the overall heat transfer coefficient and the temperature difference at the wall surfaces?

- U decreases and ΔT increases
- U increases and ΔT decreases
- Both increase
- Both decrease

Prev

Test Problems/Quizzes

3. If two layers have the same width but different heat conductivity (k) values, w

- In the layer with the larger k
- In the layer with the smaller k
- It depends

Previous Question | Submit Answer | Reset Quiz | Next Question

Quiz Result

You answered: In the layer with the larger k
Incorrect!

The correct answer is in the layer with the smaller k.

Next Question | Reset Quiz

Refreshing Theory

Experiment Help - Google Chrome

localhost/fepsim/MemberPages/Help.aspx?contentFile=HeatTransferSSPlanar

Steady State Heat Transfer: Planar case

One-dimensional (along x-axis) heat transfer through a homogeneous solid planar wall is governed by Fourier's law:

$$\frac{q}{A} = -k\frac{dT}{dx}$$

The negative sign denotes that heat flows in the direction of decreasing temperature ($dT < 0$). Under steady state conditions, the above equation after integration yields the following equation for a plane of width L:

$$\frac{q}{A} = k\frac{\Delta T}{L}$$

where now ΔT is considered positive and, therefore, the negative sign has been removed.

Heat flow between a fluid of temperature T_∞ flowing over a hotter solid surface of temperature T_s is given by Newton's law of cooling:

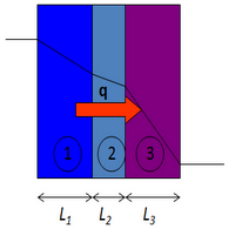
$$\frac{q}{A} = h(T_s - T_\infty)$$

In the most general case of heat transfer between two fluids at different temperatures separated by n planar layers, the combination of the above laws yields the following equation for the heat transfer rate based on the *overall heat transfer coefficient*, U:

$$\frac{q}{A} = U\Delta T$$

$$\frac{1}{U} = \frac{1}{h_i} + \sum_{j=1}^{n}\frac{L_j}{k_j} + \frac{1}{h_o}$$

Under steady-state conditions, q/A is the same through every plane perpedicular to the direction of heat flow.



Nomenclature

q: rate of heat flow in W

A: heat transfer area in m^2

Steady-State Heat Transfer-Cylindrical

FOOD ENGINEERING PROCESS SIMULATION MODULES

EN [Log In]

Home | Experiments | About

T_i (°C) 200 T_o (°C) 25

h_i (W/m^2°C) 1000000 h_o (W/m^2°C) 4

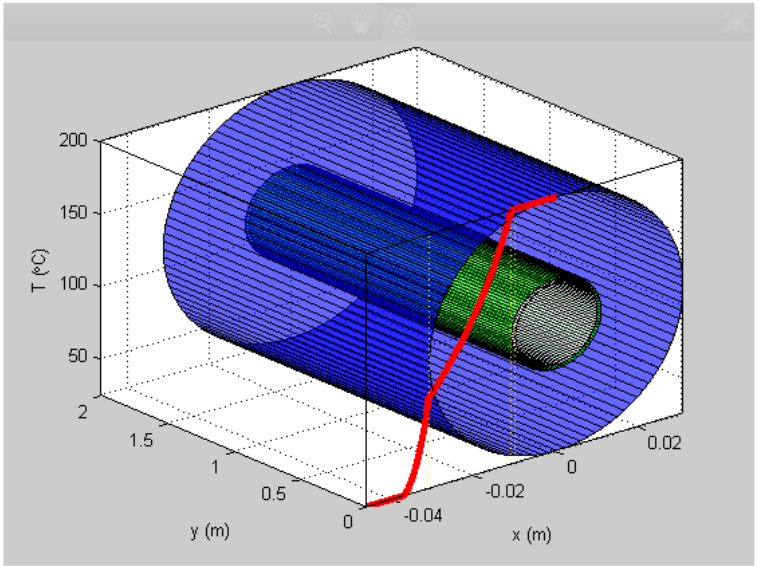
r_i (cm) 1

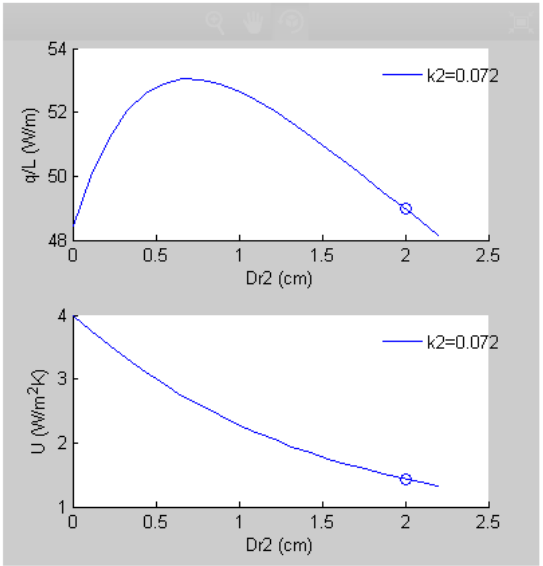
Number of Layers 2

Δr_1 (cm) 0.1 k_1 (W/m°C) 1000 Refresh Clear

Δr_2 (cm) 2 k_2 (W/m°C) 0.072

U (W/m^2°C) 1.44 q/L (W/m) 48.97





Help Instructions

Conclusions/Future Work

- The modules are in the development stage and will include material from
  - Material and energy balances
  - Flow mechanics
  - Heat transfer
- Website will be found at www.food.teithe.gr/fepsim
- We plan on having a users forum where you could leave your comments or suggest corrections/improvements
- We will start introducing the use of these modules in the classroom to assess potential impact in understanding the material

Scope

- Do we see this project as a step towards the “end of classroom”?
  - NOT!
- We perceive these modules as
  - Lecturing aids for the teacher
  - A knowledge “battlefield” for the learner
- *Learning by examples*

Acknowledgments

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: ARCHIMEDES III Investing in knowledge society through the European Social Fund.