Module Title:

Freezing of ice cream: how freezing progresses with time and how composition affects freezing time

Module Goal:

Learn the impact of composition on ice cream freezing

Module Learning Outcomes:

- 1. Know the effect of overrun on the freezing time of ice cream
- 2. Know the effect of different ice cream composition on freezing time
- 3. Understanding how extent of freezing varies over the thickness of food being frozen

Problem Details

Slabs of ice cream with different compositions are being frozen from both sides. They are 2 cm thick (half thickness 1 cm) and being frozen with coolant that is -10 °C. Their initial temperature is 2 °C.

Module Step by Step Procedure



Model Set-up

- 1. Double Click on "CU_IceCreamFreezing.xls"
- 2. Click cell A1 and click "open" on the COMSOL Ribbon
- 3. Select the file "CU_IceCreamFreezing.mph" and click open
- 4. In the Excel spreadsheet (see below),
 - a. Enter ice cream composition in cells B12-B18 and B22-B28.
 - b. On the COMSOL ribbon, click the arrow under "Update" and click "update all"
 - c. On the COMSOL ribbon, click Compute
 - d. When updating anything, you must click "update all" again before clicking "compute" again

Student Instructions for Simulation Module (Intended for use by Undergraduate or Graduate <u>Food Science and Engineering</u> students)

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6	wt_Fat			•	0	Wt %	of milk fa	t								
7	wt MSNF				0	Wt %	of MSNF									
8	wt_Sugar		· ·		21	Wt %	of sugar									
9	wt CornSc	lid			1	Wt %	of cornsol	ids								
10	wt Stab				0.5	Wt %	of stabilize	ers								
11	wt Water				77.5	Wt %	of water									
12	overrun				50	% ov	errun									
13																
14	Initial Pr	oduct C	ompo	sition of	f Mixture 2											
15	Name			Expressio	ons	Desci	ription									
16	wt_Fat				0	Wt %	of milk fa	t								
17	wt_MSNF				7	Wt %	of MSNF									
18	wt_Sugar				14	Wt %	of sugar									
19	wt_CornSc	lid			1	Wt %	of cornsol	ids								
20	wt_Stab				0.5	Wt %	of stabilize	ers								
21	wt_Water				77.5	Wt %	of water			_						_
22	overrun				50	% ov	errun									
23																

Results

5. In the COMSOL ribbon

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- a. To see a plot, click 'Plot group' and the plot you would like. It will appear in the COMSOL window then
- b. A list of plots is below. A description and picture of each is in the Appendix. There are 5 total.
- c. If you would like the plot, click 'insert graphics' on the COMSOL ribbon. The plot will be inserted into the Excel sheet



Module Questions and Activities

- 1. Using the weight composition of ice cream listed below:
 - a. how does the freezing time change between ice cream with 50% overrun and 100% overrun?
 - b. does the freezing time change by the same factor as the overrun (i.e. does the freezing time double as the % overrun is doubled?)?
 - c. How does the percent frozen vary over the thickness of slab?

Components	Wt % of Ice Cream
Milk Fat	12
MSNF	11
Sugar	14
Corn Solids	1
Stabilizer	0.5
Water	61.5

2. How does the composition of ice cream (50% overrun) affect the freezing time and percent water frozen? What is the most important component? Use the following 4 ice cream combinations.

Components	Wt % of Ice Cream A (similar to ice/dessert cream)	Wt % of Ice Cream B (similar to milk ice)	Wt % of Ice Cream C	Wt % of Ice Cream D (similar to sorbet)
Milk Fat	12	5	0	0
MSNF	11	11	7	0
Sugar	14	21	14	21
Corn Solids	1	1	1	1
Stabilizer	0.5	0.5	0.5	0.5
Water	61.5	61.5	77.5	77.5

Appendix

The following are example plots for comparing freezing of sorbet at 2 different overrun (30% composition 1 and 50% composition 2)



Temperature along line (pg12) Composition 1 is left and Composition 2 is right. Temperature versus thickness (each line represents 5 minutes)



Temp @ 3 pts; Composition 1 (pg16) Temperature versus time at 3 points for composition 1



Percent Frozen along line (pg19) Composition 1 is left and Composition 2 is right. Percent frozen versus thickness (each line represents 5 minutes)



Average percent frozen Water (pg20) Average percent of frozen water for composition 1 and 2 versus time