

#### Bottle in the Sauna

#### Real-world application using Elmer/ElmerGUI

#### T. Zwinger

CSC . Tieteen tietotekniikan keskus Oy CSC . IT Center for Science Ltd.

#### **Problem Outline**



csc

#### **On Bodies and Boundaries**

- A body is a distinct region of the model
- Characterized by different material and/or different physical models



#### **On Bodies and Boundaries**

- A boundary is a lower dimensional entity
   between two bodies or the confinement of a body
- *Boundary conditions:*Dirichlet (value)
  Neumann (gradient)



#### Read the model

- <sup>"</sup> File Open
- Look for foldercontaining yourfiles
- % Choose (Fidap neutral) beerbottle. FDNEUT



### Setup of model

- Chronological order
- Accessed via
   Model
   Setup/Equatio
   n/...



#### Setup of model

- " Model Setup
- " Choose Transient
- *<sup>"</sup>* Timestep intervals 360 (one hour)
- "Rest: default
- <sup>″</sup> Apply

🧭 Check keywords	warn				
MeshDB .					
Include path					
Results directory					
imulation					
Max. output level	4	▼	Steady state max. iter	1	
Coordinate system	Cartesian	₹	Timestepping method	BDF	
Coordinate mapping	123		BDF order	1	
Simulation type	Transient	▼	Timestep intervals	360	1111
Output intervals	1		Timestep sizes	10	
Solver input file	case.sif		2		
Post file	case.ep				
onstants					
Gravity	0 -1 0 9.82				
Stefan Boltzmann	5.67e-08				
Vacuum permittivity	8.8542e-12				
Boltzmann	1.3807e-23				
Unit charge	1.602e-19				

#### Setup of equation(s)

- **Model** Equation
- *Tick Active (!!)*
- " Apply to all bodies
- " Update
- ″ OK

😣 🛇 📀 Equa	tion					
Heat Equation	Helmholtz Equation	K-Epsilon Li				
Activate for this equation set						
Active	$\rightarrow$					
Give Execution	Give Execution priority					
Priority						
Options						
Phase Change	Model	None V				
Convection						
Convection		None V				
Apply to boat	es: Ø Body 2	A V				
Kedit Solver Settings						
Name: Equation	11					
9 <u>N</u> ew	♥ Update     ♥ <u>O</u> k	Remove				

# Setup of material(s)

- **Model** Material
- " Use Material library
  - 1. Water(room temperature) for drink
  - 2. Glass (borosilicate)
  - 3. Air (room temperature)
- " After each, press
  - OK
  - Model Material Add...

11	Seperal	Material	Helmholtz Equation	
	Proper Density Heat Ca Specific Reference Heat exp	Heat Equation ties pacity ( Heat Ratio ( te Temperature ( te Pressure ( pansion Coeff. (	Heimnoitz Equation     K-E <       2235.0       710.0	
	Apply tr Bod Name: G	o bodies: y 1 Bod Mat lass (borosilicate	Austenitic stainless steel (AK Steel 201) Copper (generic) Glass (borosilicate) Gold (generic) Iron (generic) Platinum (generic) Polycarbonate (generic) Polycarbonate (generic) Silver (generic) Silver (generic) Siteel (alloy - generic) Steel (alloy - generic) Steel (ather generic) Steel (stainless - generic) Water (frozen) Water (room temperature) Append Clear OCLOSE OCL	

## Setup of body force(s)

#### **Model Body Force**

- Use to add #ight-hand-side+of PDE
- *For example:* 
  - FlowSolve: gravity
  - HeatSolver: volumetric heat source
  - FreeSurfaceSolver: accumulation/ablation flux

CSC

"Not needed this time (so skip it)

### Setup of initial condition(s)

- Model Initial condition Add
- " Heat Equation
- ″ Temperature 5
- Apply to all bodies

″ OK

	reonarcion		
Heat Equation	Helmholtz Equation	K-Epsilon	Li <
Variables			
Temperature (	5		
Αρριγ το σοαι	-5:		
Apply to boat	es:	2	
Appry to board	es: Ø Body Property 2	2	•
Apply to boat	es: ☑ Body Property 2	2	A (III) >
Appry to board Body 1 Body 3 ame: InitialCo	es: Ø Body Property 2 Indition 1	2	

## Setup of boundary condition(s).

- Model Initial condition Add
- " Heat Equation
- *<sup>‴</sup> Temperature* 90
- Do not apply to any boundary
- Update
- ″ OK

⊗ ⊙ ⊗	BoundaryCond	dition	3
General	Heat Equation	Helmholtz Equation	K-E ⊲ ►
Dirichl	et Conditions		Â
Tempera	ature	90	
Tempera	ature Condition		
Heat F	lux conditions		-
Heat Flu	х		
Heat Tra	ansfer Coeff.		
Externa	l Temperature		
Latent	heat of phase	change	
Phase C	hange		
Heat G	ap		
Heat Ga	p		
Radiati	ion Settings		v
Apply t	o boundaries: Indary 1 🛛 🗌	Boundary 2	
Name: B	oundaryCondition	n 1	
<u>9</u> New	/ Vpdate	<u>≪ 0</u> K <b>−</b> I	Remove

# Assignement of bodies boundary conditions

- Model Set body properties
- Double click on glass
  - . Assign Material Glass
  - . Assign Initial Condition 1
- " Same with air and water
- *with Ctrl+H*



CSC

Update

# Assignement of bodies boundary conditions

- Model Set boundary properties
- Double click on outside of glass
  - . Assign Boundary Condition 1
- ″ Add



### Towards the simulation

#### Model Summary ...

. Checks for consistency of input

#### ″ SIF **Generate** (Ctrl+G)

. SIF = Solver Input File

- " Save (mesh and SIF)
- Save (project)

1	
	z

- Congratulations! You are done.
- Run the simulation by pressing



#### **Controll the simulation**

- A log-window and a graphical convergence history is opening

- "Kill the simulation by:
  - Run 🛛 🔞 Kill Solver

#### Post-processing

- " Press the symbol  $\mathbf{p} \Rightarrow \mathbf{p}$
- " ElmerPost is launched
- In order to load all timesteps:
  - . Read Model File + Select Time Steps: All

CSC

. Use Edit Timestep Controll

#### Post-processing

- Temperature is much to quickly rising
- Wrong physics in boundary condition?



CSC

Temperatures after 5 minutes

# Physically more sane boundary condition

000	BoundaryCond	lition	8
General	Heat Equation	Helmholtz Equation	K-E ◄ ►
Dirichle	et Conditions		-
Tempera	ature		
Tempera	ture Condition	5	
Heat Fl	ux conditions		-
Heat Flu	ix		
Heat Tra	nsfer Coeff.	10.0	
External	Temperature	90	
Latent	heat of phase	change	
Phase C	hange		
Heat G	ap		
Heat Ga	р		
Radiati	on Settings		
Apply to	o boundaries: ndary 1 🛛 🗌	Boundary 2	
Name: B	oundaryCondition	n 1	
9 <u>N</u> ew	V Update	<u> </u>	Remove



CSC

Temperatures after 5 minutes