# **MTRL 466 AGENDA**

| **Project Name:** | Adaptive Architecture |
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| **Group:** | Sinclair #2 |
| **Current Meeting:** | September 19, 2014 |
| **Agenda Prepared By:** | Devy Dyson |

Attendees:

Chad Sinclair - Professor

Devy Dyson - Agenda

Lucas Hawath

Lawrence Lam - Minutes

Michael May

Ben Coull

Igor Vranjes

Agenda:

**Revise Need Statement/Objective/Constraints**

Need Statement: A minimum cost and environmentally friendly thermoforming technique for interior wall panels around 4’ x 4’ in dimension.

Chad: Looks good, much more specific than the last iteration

Objective: Minimize Cost

Constraints:

-Good heat transfer by non-uniform heating

-Deformation of the material by lines

-Have a sufficient thermal expansion coefficient to help deform material under heat (soft)

-Thermal stresses with wire and thermoplastic

-Thermal profile control  
-Resistivity of the wires or metal heating up the thermoplastic

-Material must be thermoplastic with a glass transition temperature between 80-150 \*C

-Sufficient melting temperature above 150 \*C to prevent melting under extreme room conditions (soft)

-Absorb/Reflect sound (soft)

-Heat input of the wires causing the deformation of the material

-Restricted by conduction and convection as heating mechanisms

-Produce on site

-Thermal Conductivity of both the wires and the thermoplastic

Free Variables:

-Thickness of the material

-Voltage used to heat the wires and temperature used to heat the material up

-Size of the wires to cause the deformation

-Material choice

Chad: Suggestion, some are material properties, while others are related to the process. Take a step back, what concepts are common between the ideas that you are looking at

Ben: Heating up a localized area

Chad: What happens if you heat the material in a localized area? That itself is a constraint.

Mike: **Lines as a constraint**

Lucas: Will the two different approaches have different sets of constraints?

Chad: Are all thermoplastics suitable for thermoforming?

Devy: No, some have too low or too high of a Tg

Chad: Define the range for the forming temperature

Chad: Take a step back, do the high level stuff first. When you say heat transfer coefficient, what does that mean?

Devy: Heat transfer coefficient for non-uniform heating

Chad: Start broad then narrow down (like a funnel)

Lawrence: Adding numbers to quantify some of the constraints (rather than “sufficient” or stating the property that we are concerned about)

Chad: How are you going to choose sufficient stiffness and strength etc?

Chad: **Imagine** **the words of Anoush, “Why \_\_\_\_\_?”** *🡨 be able to answer this question to prepare for our final presentation!*

Chad: The constraints are all good, but what are the things that you are actually going to deal with? Focus on the constraints that are going to constrain what you are going to do

Chad: Very little about the forming technique itself in the constraints, currently more about the material. Not about material (if you choose polystyrene for example, all the constraints are gone), about the technique. Pretend you have already selected a material, now what are your constraints?

Devy: Thickness 🡨 free variable

Ben: Heating mechanism

Devy: Conduction, a bit of convection

Chad: Not radiant (lamps)

Chad: As a user, what is variable?

Lucas: Way of arranging the lines

Chad: **Temperature** or **voltage** that you impose

* Be as quantitative as possible
* Start high level and big picture before narrowing it down
* Constraints should be about the process, not the material
* Be prepared to be answer the question of “WHY” numbers and constraints were chosen

**Revise Advantages/Drawbacks of each Method**

**Method 1: heating tape and rod**

Advantages

* Possible to quantify. Biot’s number, Fourier’s law using heat transfer and conductivity coefficients
* Obtain profiles through sag height/width ratio vs. temperature
* Many variables to experiment (thickness of sheet or diameter of wire, ambient temperature)
* Easy to do requires little labour

Disadvantages

* Obtain a uniform temperature gradient at least over the thickness of the sheet
* Is gravity enough or is an external applied force needed
* External electricity source required
* Control the voltage applied and regulating temperature using the tape.

Chad: Only a concept at the moment, no hard line to compare between the two current options

Chad: Use Blair’s method as a comparison point (eg less expensive as Blair’s method)

Chad: Control the temperature profile in the sheet, more complicated 🡨 disadvantage

Lawrence: Less heat, therefore cheaper <- advantage

Devy: No mould <- advantage

Chad: No vacuum <- advantage

* Think of it as in comparison to Blair’s method versus Method 2

**Method 2: Chemical etching and surface modification**

Advantages

* Etching or removal of chosen lines
* Simple weakening the sheet at specific areas and under load would facilitate the process

Disadvantages

* Chemical aspect safety
* Unsure how much the material can be bent
* Thickness obtained + glass transition temperature
* More manual labour to chemically etch
* Difficult to quantify
* Environmental impact

Chad: Well worth someone taking time to summarize Blair’s work and method (describe in your own words) to have as a reference point for these new methods

**Revise Heat Transfer Calculations**

- On Excel

Chad: How are you going to predict the shape/sag of the panel?

Chad: Imagine as a wire (one-dimensional), what are the forces acting on the material?

Chad: How does Blair’s method work? Figure out heat transfer first, and then figure out what is actually happening physically between two wires (what is the material doing)

Creep? Necking?

Devy:

Fourier’s first law – steady state

Chad: Won’t apply if you have a cold sheet and then you apply a heat source

Chad: Top of the sheet is by conduction, losing heat at the bottom of the sheet is by convection

Chad: Need Fourier’s second law

Chad: Need boundary conditions for time initial, time final, and two boundary conditions for position (at the top position, and at the bottom position)

Chad: At t=0, room temperature (Tc) through thickness

Chad: The temperature will never be uniform at Th, since there is heat being removed from the other side

Chad: Be able to create a plot of T vs x/d, different curves for different normalized times

Chad: This works easy (pen and paper) in the 1-D case, where there are clearly defined boundary conditions

Chad: For 2-D, will need to solve **numerically** (refer to Barr’s modelling course), finite difference, small increments

Chad: Determine width and depth of heating

**Revise Literary Research**

-Can we all define thermoplastics (type, properties, etc)?

-Can we all define thermoforming and how it is done?

-Benefits of thermoforming compared to blow forming or vacuum forming?

**ACTION ITEMS**

* Constraints more about process, less about material
* Summarize Blair’s process to use as a reference point for the advantages and disadvantages
* Solve the heat transfer problem using Fourier’s first and second laws
* Graph temperature profile through thickness as a function of time
* Determine what is physically happening when a wire/sheet droops when heated (is the shear stress = viscosity \* shear rate)
* FOR NEXT WEEK: Send Chad background literature review
* FOR NEXT WEEK: Some movement on temperature calculations

Whiteboard images below



