**thermoforming lab (1.5 hours)**

**Summary:** Thermoforming is an industrial manufacturing technique used to make many different types of packaging. Any models used should be tested and any necessary post-processing should be accounted for in the instructions and time allotment.  \*We have a Vaquform thermoformer\*

**Specific tasks before activity:**

1. Print any molds, or order from Amazon. Magnetic letters/numbers for fridges are fun and useful as they stay in place on the thermoformer surface through the magnets.
2. Sheet selection for thermoforming – HIPS at 0.2-0.5mm is recommended for ease of use and lower required thermoforming temperature.
3. Any 3D printed molds should follow the design recommendations from the thermoformer manufacturer

**ILOs:**

1. Operate a small-scale thermoformer and understand the operating principles
2. Recall the material properties necessary for thermoforming

**Equipment list:**

* Thermoforming machine
* Plastic sheet choices to mold
* Molds
  + Coins
  + Keys
  + Anything flat that is a personal belonging and heat resistant
  + Olympic medal
  + We can make a mold of a medallion shape that is specific to the summer camp

**Intro:**

Thermoforming is a useful procedure that can make a variety of different products that we use and are familiar with in our everyday lives, such as takeout containers or plastic cups. The process is simple, we start with a thin sheet of plastic, heat it up so it is soft and pliable but not to the extent that it would start melting, pull it over a mold, then we remove it from the mold and cut out the desirable part. Being able to control the temperature is extremely important, because often there is a specific temperature window at which the plastic is ideal for thermoforming (not burning, discolored, melting, etc).

**Procedure:**

1. Load the material that we are going to mold into the thermoforming machine
2. Turn the machine on, to heat the material
3. Put the mold to where it needs to be mounted / where it can come into contact with the material
4. Once the material is pliable enough, pull it over the mold (this will change depending on the machine, for our machine it seems like we just need to pull down the lever to which the material was heating up on)
5. Hold it there, until there is some indication the process is complete (again, depends on the specifics of our thermoforming equipment)

**Analysis:**

Thermoforming is most commonly used in the packing industry, but it can also be used in transportation, medicine, consumer goods, construction, and many other industries. Thermoforming utilizes thermoplastics (which was the material we thermoformed in this lab); these are any materials that can be heated, then softened and cooled to a particular shape. The main steps of thermoforming are mechanical (placing the sheet into the mold), vacuum (heating the sheet and sealing the edges), and pressure (applying pressure around the mold and cooling to form the desired shape. Thermoforming can be used to preserve food in packaging, form a component of automotive parts, form aircraft interior paneling, create office furniture, be seating on public transportation, and much more. While some thermoforming plastics can be recyclable, there is a large overall carbon footprint because of the inability to recycle some variants of the thermoformed plastics and the high risk of making mistakes with the plastics.

**Discussion questions/debrief:**

* Apart from the material created in the lab, what other materials can you see thermoforming being used to create?
* From these products, take a guess at which industries use thermoforming the most.
* Did you think the thermoforming process was efficient?
* What may be some difficulties associated with thermoforming on a large industrial scale?

**Lab handout needed?**

No, but having an available thermoformed example for students to handle is recommended.

Thermoforming video from industry is part of manufacturing techniques slides.