The Compostable Cooler

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Introduction

Objective: Design, build, and test an insulating cooler container made entirely of compostable materials.

Significance

- Canadians produce 3 million tonnes of plastic waste annually, with only 9% recycled, the majority ends up in landfills.[1]
- Synthetic plastics are harmful and unsustainable, while compostable materials derived from plant and/or animal sources offer a sustainable alternative.[1]
- The cooler market is currently worth $4.6 billion and projected to grow 76% to $8.1 billion by 2025.[2]
- Part of this growth can be attributed to the medical industry where coolers are being used in the context of transport and/or storage of temperature-controlled biopharmaceutical, blood products, and point of care diagnostics.[3,4,5]
- Our design integrates sustainability into a popular everyday product.

Materials

All materials used in this project were selected with sustainability and biodegradability in mind along with their desirable properties.

Facesheet Materials:

- **Sawdust** – An abundant waste material, readily available, biodegradable, and provides manufacturing ease.
- **Rice Bran Wax** – A waste co-product of rice husks, hydrophobic, melts between 80-85°C[6], food-safe, and biodegradable.

Core Materials:

- **Biofoam** – A non-toxic, plant or animal-based material with glycerin as a plasticizer and dish soap as a foaming agent, biodegradable, lightweight, flexible, easy to produce & mould.
- **Cork** – A natural insulator, thermal conductivity: 0.04-0.044 W/mK[7], lightweight, food-safe, biodegradable.

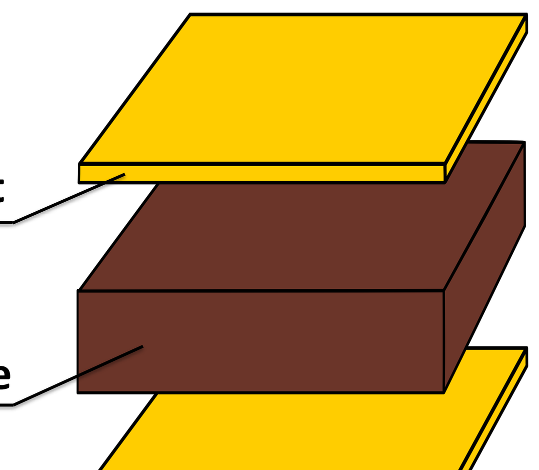
Design Requirements

Capacity	Hold 45 standard sized cans	**Waterproof**	No leakage for a minimum of 48 hours
Strength	Carry 17 kg for 100m	**Durable & Compostable**	Decompose only when left in nature
Insulation	Hold ice for 48 hours in environments up to 40˚C	**Aesthetics**	Visually appealing

Design

Stiff Facesheet
Sawdust & Wax

Insulating Core
Cork & Biofoam



Sandwich Panel Structure offers a high strength-to-weight ratio, providing durability while minimizing weight[8]

Composites combine two or more different materials to create a new improved material with better physical properties[8]

Manufacturing Method

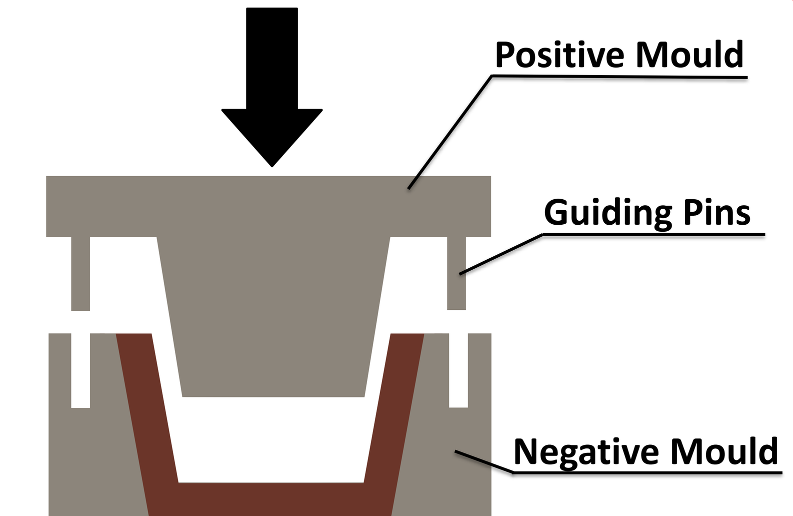
Compression Moulding

A process involving applying pressure to shape materials into the form of a mould

7° draft angle to facilitate easy release of the part and reduce friction between the mould walls and the product[10]

Hand-built with MDF

Sealed with epoxy-resin

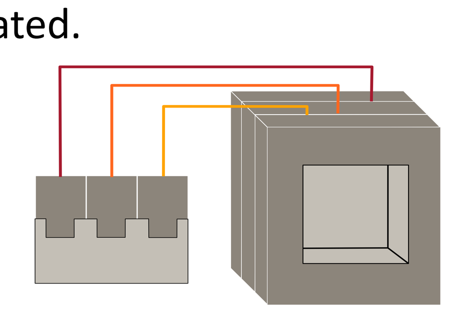


Transfer & Form → Compress & Cool → Demould & Trim

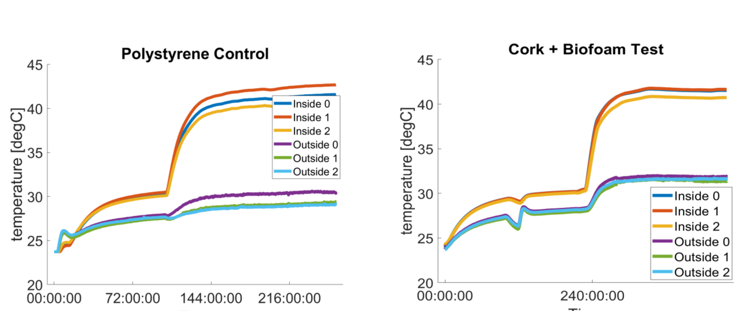
Testing & Results

Heat Flux Test

Based on ASTM C177, the experimental setup consists of a 2'' thick polystyrene box with five walls. An aluminum heating plate is placed at the rear of the box. The sample material is placed in front of the heating element. Heat preferentially flows through the sample towards the open side of the box. The sample has temperature sensors on either side. By analyzing the temperature drop for a given heat input, the thermal conductivity can be calculated.



Heat Flux Test Experimental Setup



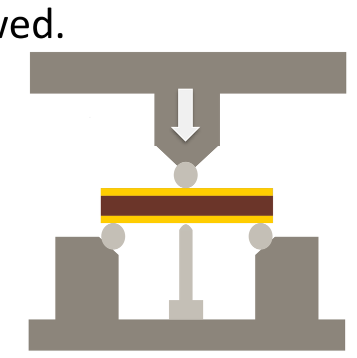
Heat Flux Test Experimental Results

Heat Flux Test Results

The insulating core was found to be 80% more conductive than the extruded polystyrene control sample, necessitating an 80% increase in wall thickness for equivalent performance.

Bending Stiffness Test

The three-point bending test was performed on the composites. First the single samples composed of just the facesheet were tested, followed by the sandwich composite of facesheet and core. The standards *ASTM 790 & ASTM D7264* were followed.

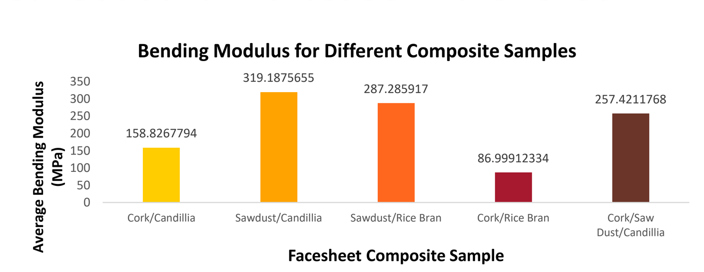


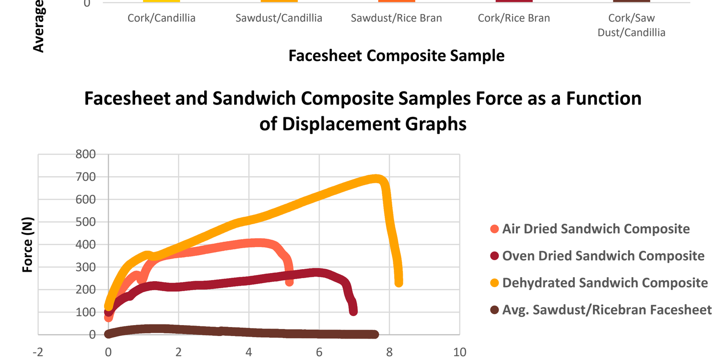
Strength Test Setup

Bending Stiffness Test Results

Final Facesheet Material: Sawdust and RiceBran exhibited high strength (second largest bending modulus) and is affordable.

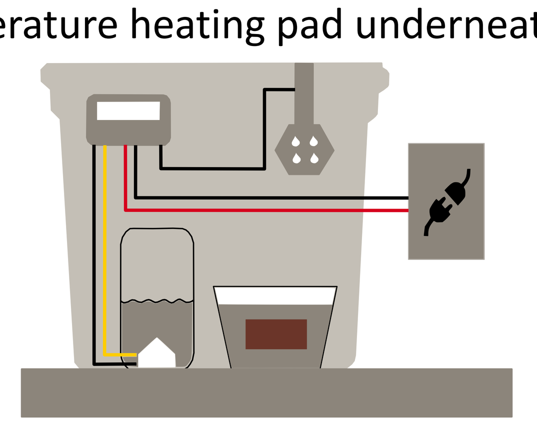
Final Sandwich Composite: Sawdust/RiceBran Facesheet with Biofoam/Cork Core is stronger than the facesheet as it withstood more force.





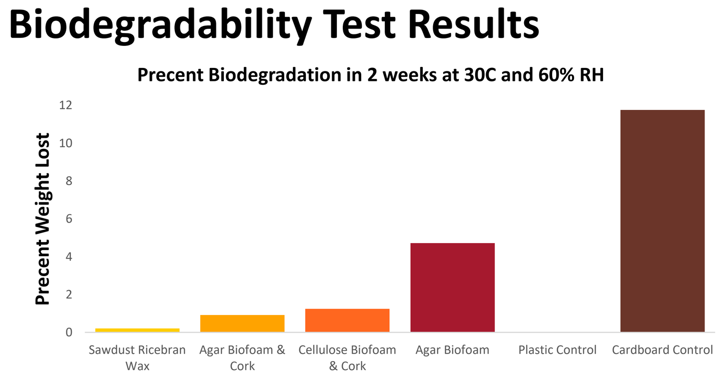
Biodegradability Test

Core and facesheet samples weighed and buried in a mix of equal parts sand, soil and manure and placed in a environmentally controlled chamber for 2 weeks, then removed and weighed again.[9] The environmental controlled chamber was achieved with an ultrasonic mister connected to a relay and a humidity sensor; heat was provided by a constant temperature heating pad underneath.



Biodegradability Experimental Setup

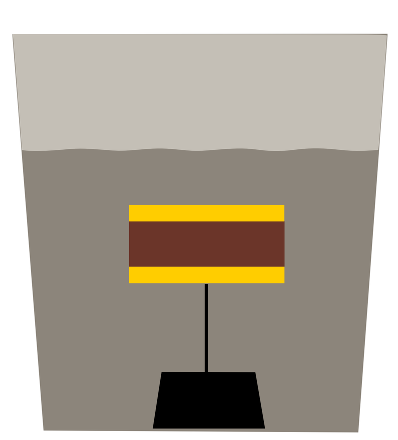
Biodegradability Test Results



In 2 weeks, the biofoam and cork samples lost 0.9-1% of their weight, and the sawdust and rice bran wax lost 0.2%, indicating these samples are biodegradable and durable for the application.

Water Permeability Test

The test took place over two days and was conducted on the facesheet samples. Three samples were tested for each composite, the initial weight of each sample was recorded then the samples were submerged in room temperature tap water for 48 hours. After the 48 hours, the final weight was taken to determine the average weight increase between the three samples to determine the hydrophobicity of the facesheet materials.



Water Permeability Test

Water Permeability Test Results

While sawdust and rice bran sample had the largest % increase (11.6%), it was similar enough to our control of polystyrene (11.5%). It also performed substantially well in the strength test and is the most cost-effective, so for these reasons, it was selected as our final facesheet.

Discussion

Challenges

- **Extended cure time** — *Solution* → CNC machine a thinner metal mold featuring numerous holes to enhance air circulation within the mould.
- **Facesheet Application** — *Solution* → Submerge dried core in vat of melted rice bran wax and sawdust to ensure even and continuous facesheet layer.
- **Consistency** — *Solution* → Inconsistent natural materials result in a variable final product. Need a way to amend the raw material to standardize production
- **Weight** — *Solution* → Saw dust/rice bran wax mixture is heavy, need to optimize thickness of facesheet to maximize strength and decrease weight.

Conclusions

This project has proven that it is possible to manufacture a functional biodegradable cooler from only natural materials. Manufacturing remains the largest obstacle to making the cooler more thermally performant, cheaper, and aesthetically appealing.

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