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The Cooler Koozie, optimizing thermal insulation for beverage consumption

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The Cooler Koozie, Optimizing Thermal Insulation for Beverage Consumption

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abstract

- Our Creative Inquiry aims to develop a new koozie design with improved insulating properties than commercially available options
- A temperature hotbox was built to provide a controlled testing environment
- Our koozie design focuses on maximizing air space
  - Air has one of the lowest thermal conductivities of any material and has been used in many insulating applications
- Flexible PVC tubing can be molded and shaped into a koozie design.

research goals

1. Characterize currently available commerical koozie offerings
2. Develop a new koozie with improved insulating properties
3. Compare new koozie design to currently available koozies
4. Compare wet koozie performance compared to dry koozies

introduction

Our koozie design

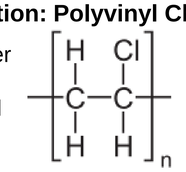
Hypothesis:
Increased air space will decrease total koozie thermal conductivity allowing a beverage to remain cooler for an increase amount of time.

Advantages:
- Decreased thermal insulation
- Cheap materials of construction
- Simple design for ease of scale up for production

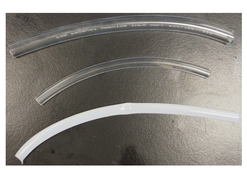
Deficiencies:
- Non flexible design doesn't allow for folding
- Epoxy is prone to breaking

Material of construction: Polyvinyl Chloride (PVC)

- 3rd most widely used polymer
- Flexible and light weight
- Thin walls maximize internal air space



- PVC tubing was wound around a mold and then glued
- 24 h was given for epxoxy curing
  - SciGrip 16 epoxy was used



calculations & results

The thermal conductivity of the koozies was determined by using the rearranged form of the heat transfer equation for conduction. The portion in brackets represents the heat transfer rate in [J/s]

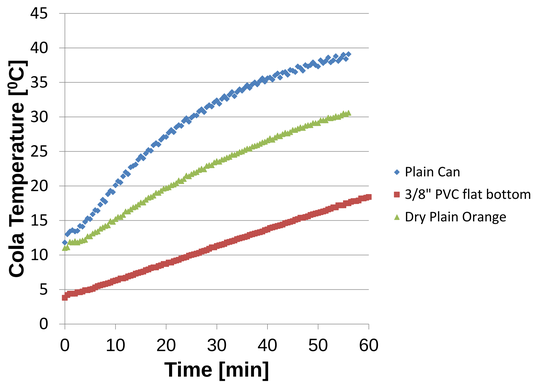
$$k = \frac{[mc_p\,\Delta T_c/dt]\ln(r_o/r_i)}{2\pi h\,(Tc_2 - T_{air})}$$

k= thermal conductivity of koozie [W/(m °C)]
m= mass of cola 0.34 [kg]
c_p= specific heat of cola [4180 [J/(kg °C)]
dT_c= change in temperature of cola from last reading
dt= time elapsed 30 [sec]
r_o= combined cola can and koozie radius 0.035 [m]
r_i= radius of can 0.03 [m]
h= cola can height 0.123 [m]
Tc_2= current cola can temperature [°C]
T_{air}= hot air temperature [°C]

Run #	Plain dry orange koozie	Plain **WET** orange koozie	Neoprene blue koozie	Brand name black koozie	1/4" PVC spirial bottom 2 piece koozie	1/4" PVC spirial bottom 1 piece koozie	3/8" PVC flat bottom koozie
1	0.0971	0.0208	0.0705	0.0462	0.0437	0.0502	0.0415
2	0.0663	0.0455	0.0447	0.0301	0.0558	---	0.0515
3	0.0273	0.0990	0.0628	0.0478	---	---	0.0398
Average	0.0636	0.0551	0.0593	0.0414	0.0498	0.0502	0.0443

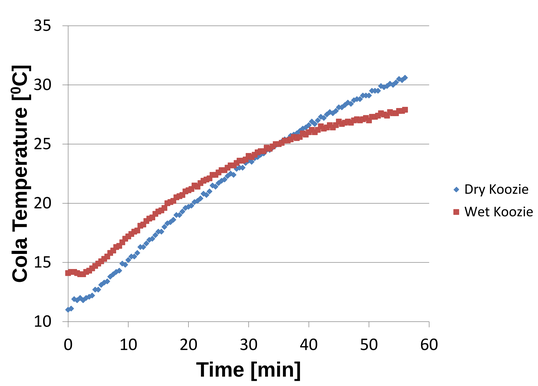
From left to right: Plain orange koozie, neoprene blue koozie, brand name black koozie, ¼" PVC 2 piece koozie, ¼" PVC 1 piece koozie, 3/8" PVC 1 piece koozie, 3/8" PVC flat bottom koozie

*While not all runs have been completed in triplicate, the average for the PVC koozie's thermal conductivities are close (and sometimes better than standard commercial offerings.



The graph above compares the dry plain koozie, the 3/8" PVC flat bottom koozie, and a bare can.

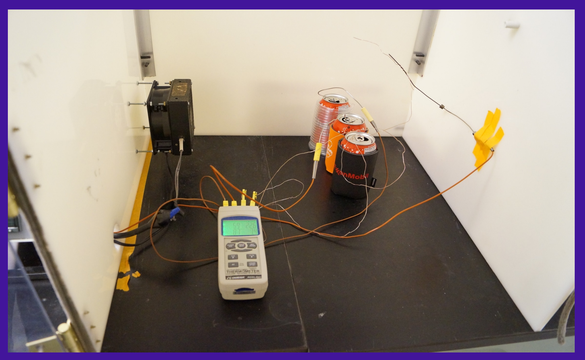
- Insufficient repetition runs have been completed so we are unable to conclude if this difference is significant at this time
- The variation in slope gives a visual representation of the thermal conductivity of the koozie
- Thermal conductivity and the slope of the graph are a direct relationship



This graph compares an experimental run with a dry koozie and wet koozie

- The same koozie was used dry and then wet to eliminate any material differences
- The wet koozie was saturated with cool tap water immediately before the experiment began
- Upon removal it was observed that the koozie was completely dry
- The evaporation of water could have absorbed some of the energy from the hot air leading to a decreased rate of temperature rise
  - More experimentation needs to take place to test this theory

Visual comparison between the wet and a dry koozie prior to testing



conclusions & future work

- PVC designed koozies performed at the same level if not better than commercial offerings
- Determine the slight difference between wet and dry koozie through further testing
- Larger PVC diameter gave slightly better performance, confirming hypothesis
- Investigate the effect of plugging the PVC tube endings to observe trapped air heat transfer

acknowledgments

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