NOT FROM YOUR BELLY BUTTON…

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ABSTRACT

After hearing a presentation given by University of Oregon students on their study *This is Not a Toy,*[1] which examined the insulation properties of plastic bags, we became interested in experimenting with a different type of salvageable material, while improving upon their methods. In our study, we tested the insulation properties of dryer lint. Dryer lint is a byproduct of a common household chore, and is currently thrown away. We sought to determine whether lint could be reused as wall insulation in residential structures, rather than disposed of in landfills. To test the insulation properties of the dryer lint, we used a Semi-Guarded Hotbox. With this method, adapted from *This is Not a Toy*, we found that the dryer lint exceeded the R-13 value of Standard Fiberglass Batt Insulation with a value of approximately R-15. The implications of this case study could lead to the development of a new building material that could contribute to a green revolution.

1. INTRODUCTION

In the winter term of 2007, University of Oregon students Elliot Meier, Tyler Polich and Nate Vaughan designed a process by which they were able to compare the insulation values of typical plastic grocery bags to standard R-13 fiberglass batt insulation. They constructed a cost-efficient, scaled-down version of a Guarded Hotbox[2]. They then ran three kinds of trials testing different materials for their relative heat flows: one with an empty chamber, one with a chamber containing standard R-13 fiberglass batt insulation and one testing a chamber with plastic bags at a density of 151 bags/ft.[3] They then used a ratio of heat flow to R-values to derive the suspected R-value of the plastic bags at the given density.

With specific interest in adapting the ideas and methodologies of the case study, *This is Not a Toy.*[1], for our own investigation, we contacted Tyler Polich to discuss the construction of their Semi-Guarded Hotbox. After speaking with Tyler, we made significant changes to the way we constructed our Semi-Guarded Hotbox for our study of the insulation properties of dryer lint.

Figure 1: 5.4 lbs. of Dryer Lint Insulation

Dryer lint is the aftermath of a large load of laundry. Small fibers extracted from your clothing during the drying process accumulate in your dryer. What do you do with all that lint? You throw it away every week, and it sadly sits in your garbage; its entire thermal value going to waste, literally. When you think about it, all that lint is like a warm fleece blanket wrapped around you on a cold winter night. So, why not make it a nice warm fleece blanket for your house?

Testing the thermal properties of dryer lint against R-13 fiberglass batt insulation is worthwhile now because it will give us values to compare with industry standards to see if it is a suitable, low-impact alternative.

2. <u>INQUIRY</u> QUESTIONS:

Some questions helped us shape our study:
What common materials could be reused as insulation?
What is the best density of lint for insulation?
Could lint be a useful insulation material?

3. HYPOTHESIS

The R-value of insulation made from dryer lint at a density of 3.39 lbs./ft.^{3} will be greater than R-13.

4. METHODOLOGY

Using the Semi-Guarded Hotbox of *This is Not a Toy.*[1] as a basis for design, we constructed our own version that included several modifications. Using this revised form of the Semi-Guarded Hotbox along with data loggers, we tested the insulation value of lint, a common resource used in an uncommon way. To assemble the box, we used:

- 2- 29in x 24in 1/2in pieces of plywood
- 2- 28in x 24in 1/2in pieces of plywood
- 2- 29in x 29in 1/2in pieces of plywood
- 2- 3.5in x 29in 1/2in pieces of plywood
- 2- 3.5in x 28in 1/2in pieces of plywood
- 1- 29in x 29in 1/4in pieces of plywood
- 4- 2in x 2in x 22in corner braces
- 2- tubes of clear silicon caulking
- 1- 28in x28in piece of cardboard
- 18in x 20ft roll of Reflectix Insulation
- 4- 31in x 24in 2in Styrofoam Insulation Panels
- 1- 20ft long 1/2in roll of self-adhesive foam
- Duct Tape
- Wood glue
- Staple gun with 3/8in staples
- 1.25in nails
- 6 data loggers

The alterations made include decreasing the dimensions of the Semi-Guarded Hotbox from XXXXX to 29” x 29” x 29”. We felt that this was a necessary move in order to distribute the heat within the box more evenly over the testing surface. Another modification made was to add an insulated bottom to the box. The Semi-Guarded Hotbox from *This is Not a Toy.*[1] lacked this element, sitting on nothing more than a cement slab. The change allowed for the heat from the space heater to be focused upwards through the testing chamber more effectively. Also, the addition of an interior insulation with a higher R-value (Reflectix) added to a greater focusing of the heat.

We constructed the box as shown in the following diagrams.

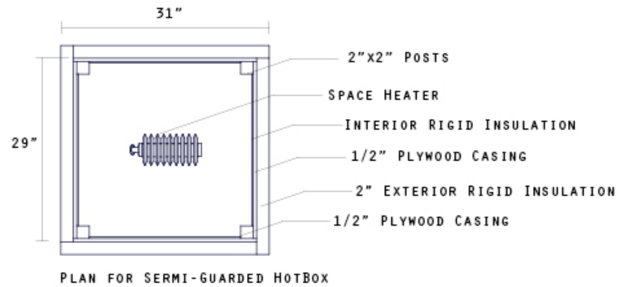

Figure 2: Plan

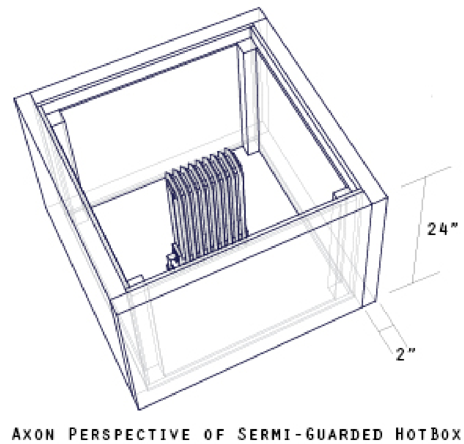

Figure 3: Axon

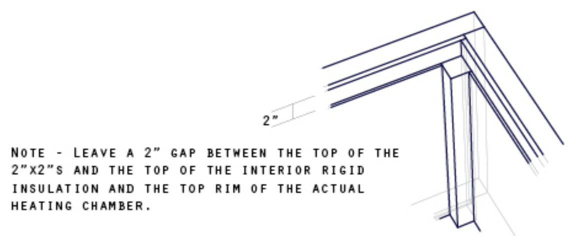

Figure 4: Detail of Corner Construction

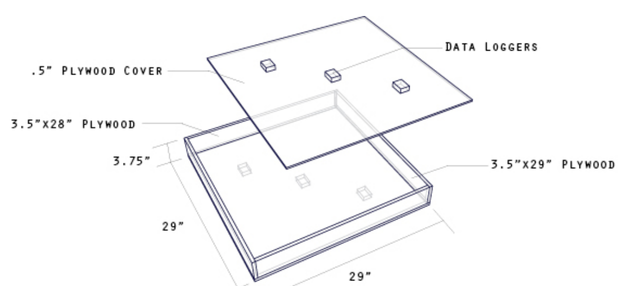

Figure 5: Insulation-Testing Chamber

Once the box was constructed, three data loggers were evenly spaced in a diagonal line across the cardboard baffle. This placement was chosen to achieve the best representation of the data attainable. Three more data loggers were placed on the top of the chamber in corresponding places so the data they collected would be comparable.

The box was first tested without any insulation. The space heater was turned on for a minimum of ten minutes before the data loggers were turned on, shortening the period of time it took to get a consistent heat flow through the testing chamber. The data loggers ran for one hour and fifteen minutes. This length of time was chosen to assure that a consistent flow of heat was occurring through the testing chamber. Three tests were completed following this procedure.

The box was then tested in the same fashion with standard R-13 fiberglass batt insulation. This process was also completed three times.

Finally, with the dryer lint placed into the insulation-testing chamber at the given density of 3.39 lbs/ft,^{3} the testing process was repeated three more times. The equation[3] for calculating the given density for our dryer lint insulation is shown below:

(Mass) / (Volume) = Density

Where:
Mass = 5.4 lbs.
Volume = 1.58932 ft^3 (2.333 ft. x 2.333 ft. x .292 ft.)

Thus:
(5.4 lbs.) / (1.58932 ft^3) = 3.39768 lbs./ft.^{3}

Note: The density of the utilized R-13 Owen Corning[4] Fiberglass Batt Insulation is 0.777 lbs./ft.^{3}.

5. DATA AND ANALYSIS

5.1 Trial 1 Series - Empty Chamber Analysis

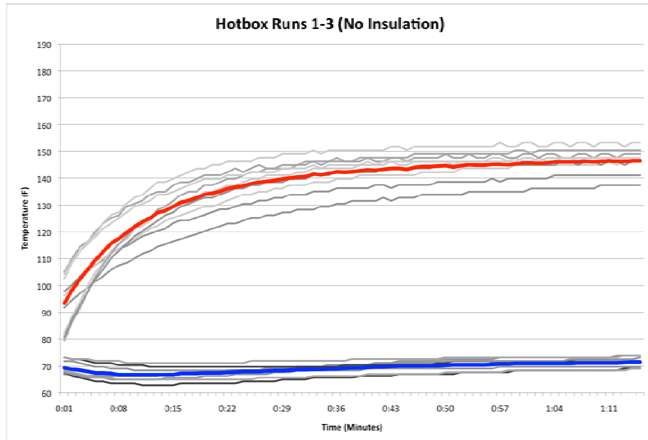

Figure 6: Empty Chamber Temperatures & Averages
Gray: Interior and Exterior Temperatures from Trials 1-3
Red: Average Interior Temperature
Blue: Average Exterior Temperature

Taking the data above, we calculated the heat flow from the inside to the outside of the hotbox with no insulation. To do this, we used the following equation[5]:

(Average final outside temperature) / (Average final inside temperature) = Heat Flow Index

Average Temperature for Trial 1.1 Outside:
(71.77 + 73.84 + 73.15) / 3 = 72.92 °F

Average Temperature for Trial 1.1 Inside =
(141.06 + 146.27 + 137.38) / 3 = 141.57 °F

Heat Flow Index for Trial 1.1 =
(72.972) / (141.57) = 0.51545

Trial 1.2

T_{avg} Outside: (69.02 + 71.77 + 69.02) / 3 = 69.94 °F

T_{avg} Inside: (147.63 + 150.43 + 146.27) / 3 = 148.11 °F

Heat Flow Index: (69.94) / (148.11) = 0.47222

Average Temperature for Trial 1.3 Outside =
(71.08 + 73.84 + 69.71) / 3 = 71.54 °F

Average Temperature for Trial 1.3 Inside =
(149.01 + 153.35 + 147.63) / 3 = 150.00 °F

Heat Flow Index for Trial 1.3 =
(71.54) / (150.00) = 0.47693

Average Heat Flow Index for Trial 1 Series =
(0.51545 + 0.47222 + 0.47693) / 3 = 0.48820

We think the variance in the results is due to the fact that the first test was done indoors, while the other two were conducted outdoors. Contrary to expectations, the heat flow index for the test conducted inside was greater than that of those conducted outside. We thought that the temperature difference from the inside of the box to the outside of the box in the first test was not great enough to create a sufficient heat flow. One theory for this occurrence is that the density of the cold air outside the box directly inhibited the flow of heat from the inside of the box.

5.2 Trial 2 Series - Fiberglass Insulation Analysis

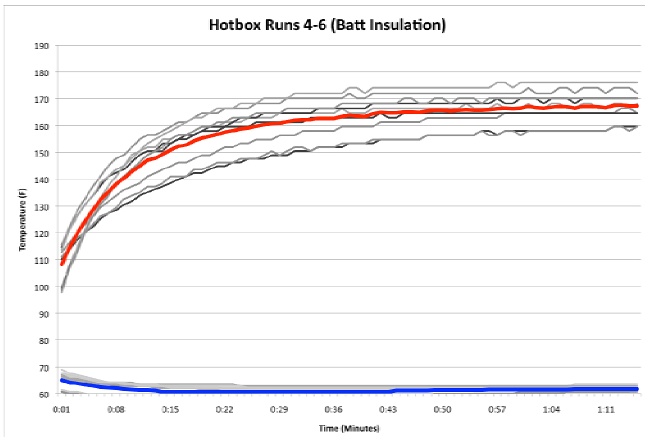

Figure 7: R-13 Fiberglass Batt Insulation Temperatures & Averages
Gray: Interior and Exterior Temperatures from Trials 1-3
Red: Average Interior Temperature
Blue: Average Exterior Temperature

Average Temperature for Trial 2.1 Outside =
(60.8 + 63.54 + 61.48) / 3 = 61.94 °F

Average Temperature for Trial 2.1 Inside =
(159.59 + 164.67 + 159.59) / 3 = 161.28 °F

Heat Flow Index for Trial 2.1 =
(61.94) / (161.28) = 0.38405

Average Temperature for Trial 2.2 Outside =
(61.48 + 62.85 + 61.48) / 3 = 61.94 °F

Average Temperature for Trial 2.2 Inside =
(164.67 + 172.10 + 168.28) / 3 = 168.35 °F

Heat Flow Index for Trial 2.2 =
(61.94) / (168.35) = 0.36790

Average Temperature for Trial 2.3 Outside =
(61.48 + 62.17 + 61.48) / 3 = 61.71 °F

Average Temperature for Trial 2.3 Inside =
(170.16 + 176.16 + 170.16) / 3 = 172.16 °F

Heat Flow Index for Trial 2.3 =
(61.71) / (172.16) = 0.35845

Average Heat Flow Index for Trial 2 Series =
(0.38405 + 0.36790 + 0.35845) / 3 = 0.37013

The data for trial two, with the fiberglass insulation, show significantly lower heat flow indexes in comparison to those in trial one. This is to be expected because the R-13 fiberglass batt insulation slows the heat flow through the box to the exterior.

In this trial, we found nothing unexpected. The interior temperature of the box was significantly higher with insulation than without. The insulation performed as expected.

5.3 Trial 3 Series – Dryer Lint Insulation Analysis

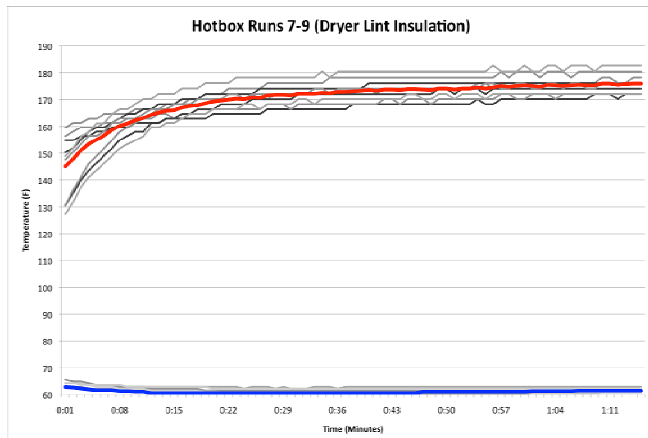

Figure 8: Dryer Lint Temperatures & Averages
Gray: Interior and Exterior Temperatures from Trials 1-3
Red: Average Interior Temperature
Blue: Average Exterior Temperature

Average Temperature for Trial 3.1 Outside =
(60.80 + 60.80 + 60.80) / 3 = 60.80 °F

Average Temperature for Trial 3.1 Inside =
(172.10 + 178.28 + 172.10) / 3 = 174.16 °F

Heat Flow Index for Trial 3.1 =
(60.80) / (174.16) = 0.34910

Average Temperature for Trial 3.2 Outside =
(61.48 + 62.85 + 61.48) / 3 = 61.94 °F

Average Temperature for Trial 3.2 Inside =

(174.10 + 180.48 + 172.10) / 3 = 175.56 °F

Heat Flow Index for Trial 3.2 =
(61.94) / (175.56) = 0.35279

Average Temperature for Trial 3.3 Outside =
(61.48 + 62.17 + 60.80) / 3 = 61.48 °F

Average Temperature for Trial 3.3 Inside =
(176.16 + 182.75 + 176.16) / 3 = 178.36 °F

Heat Flow Index for Trial 3.3 =
(61.48) / (178.36) = 0.34472

Average Heat Flow Index for Trial 3 Series =
(0.34910 + 0.35279 + 0.34472) / 3 = 0.34887

After several trials testing the heat flow for the chamber containing the given density of dryer lint, we found that the heat flow index was, on an average, lower than that of the trials performed with the R-13 fiberglass batt insulation. Originally, we tested the dryer lint at a lower density than the represented trials shown. After the initial test, we measured the surface temperature of the exterior portion of the box's heat chamber with a RayTek gun. The findings showed that the heat flow was not consistent throughout the chamber, indicating an uneven concentration of lint. The dryer lint was supplemented with more lint and then redistributed evenly to ensure dependable results.

5.4 <u>Heat Flow Index Comparison</u>

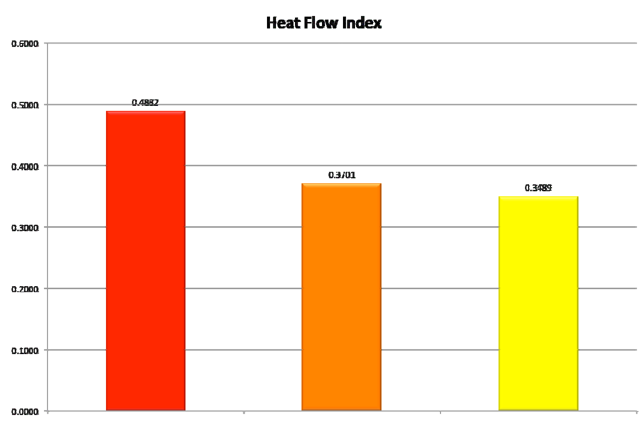

Figure 9: Comparison of Heat Flow Indexes

5.5 <u>R-Value Calculations from Heat Flow Index</u>

Respective Heat Flow Indexes (HFI):
Empty Specimen Box: 0.4882
R-13 Fiberglass Batt Insulation: 0.3701
Dryer Lint Insulation: .3489

Calibrated Heat Flow Resistance is a measure that does XXXXX. It is calculated by subtracting the heat flow index of the wall with insulation from the heat flow index of the empty wall:

HFI (empty wall) - HFI (insulation) = Calibrated Heat Flow Resistance (insulation)

We calculated Calibrated Heat Flow Resistance for the standard insulation:
0.4482 - 0.3701 = 0.1181

and for the dryer lint:
0.4482 - 0.3489 = 0.1393

Dividing the Calibrated Heat Flow Resistance for the dryer lint by that of the standard insulation, we calculated a performance ratio, which showed that the dryer lint resisted 118.01% as much heat as the standard R-13 fiberglass batt insulation:
0.1393 / 0.1181 = 1.1801

Using this ratio, we calculated an R-value for the dryer lint:
(R-13) x 1.1801 = (R-15.3412)

5.6 <u>Temperature Change Calculations</u>

Using the theory behind the heat flow index, that it is only a coefficient to quantify the difference between materials, we attempted another technique to see if we could achieve the same outcome. We chose to use the difference in temperature between the interior and exterior of the box as a comparison.

$\Delta T = (T_{avg}$ Interior$) - (T_{avg}$ Exterior$)$

Empty Chamber Temperature Changes:

T_{avg} Interior: (141.56 + 148.11 + 150.00) / 3 = 146.56 °F

T_{avg} Exterior: (72.92 + 69.94 + 71.54) / 3 = 71.47 °F

ΔT = 146.56 – 71.47 = 75.09 °F

R-13 Fiberglass Batt Insulation Temperature Changes:

T_{avg} Interior: (161.28 + 168.35 + 172.16) / 3 = 167.26 °F

T_{avg} Exterior: (61.94+ 61.94 + 61.71) / 3 = 61.86 °F

ΔT = 167.26 – 61.86 = 105.40 °F

Dryer Lint Temperature Changes:

T_{avg} Interior: (174.16 + 175.56 + 178.36) / 3 = 176.03 °F

T_{avg} Exterior: (60.80 + 61.94 + 61.48) / 3 = 61.41 °F

ΔT = 176.03 – 61.03 = 114.62 °F

R-Value Ratio in Terms of Change in Temperature:

Difference between R-13 and Empty Chamber:
105.40 – 75.09 = 30.31 °F

Difference between Dryer Lint and Empty Chamber:
114.62 – 75.09 = 39.53 °F

(R-13 / 30.31) = (R_{DL} / 39.53)

Where:
R_{DL} = R-value of Dryer Lint

R_{DL} = (39.53 x 13) / 30.31
R_{DL} = R-16.95

We found the results to be significantly different than those found using the heat flow index equations. We feel that the heat flow index ratios were a more accurate approximation of the R-value than that of the change in temperature ratios.

6. CONCLUSIONS & DESIGN LESSONS LEARNED

As we hypothesized, the insulation value of dryer lint is greater than that of R-13 fiberglass batt insulation. Using a ratio comparison of the heat flow index[5] to the R-value, we found that the lint reached an R-value of approximately 15.3412.

This study indicates that the use of dryer lint as an insulation alternative in construction is plausible. It reuses an otherwise discarded byproduct. Further tests would need to be done to address fireproofing, decomposition, and sanitary conditions. Concerning fireproofing especially, treating the dryer lint with a sodium borate powder, like that in Ultra-Touch Insulation,[6,7] might be a possible solution.

The largest lesson learned during the process of this study was that the difference in temperature of the surrounding environment and the interior of the box was not as influential as originally predicted. We also feel that the smaller and fully enclosed box design was potentially more accurate in testing the heat flow through the testing chamber than earlier attempts by *This is Not a Toy*.[1] Further testing using this methodology will help us understand the accuracy of the method and innovate new forms of insulation.

7. REFERENCES

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