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Evaluating the Effect of Humidity on Insulation

The purpose of this investigation is to determine how different insulations work under different humidity levels. I hypothesized that if the humidity levels (low, medium, and high) and insulations (fiber, denim, foil, and foam) are varied, then the fiber will be the most efficient in low humidity.

To compare the efficiency of different insulations, I defined Heat Transfer Rate (HTR) as the heat transferred through one layer of insulation in unit time at unit temperature difference between the two sides of the insulation (Calories per second per °C). Since heat transferred cannot be measured directly, I designed an Insulation Testing Apparatus (ITA) to measure the temperature changes on objects in ITA and calculate the HTRs for different insulations at different humidity levels. Then the HTRs were analyzed statistically.

The data collected and analysis supported my original hypothesis. Fiber works well for all humidity levels, but foil and foam are not affected by humidity. By comparing the random error ranges, it is evident that HTRs do have statistical differences for the most of combination cases of insulation and humidity; however, HTRs don't have statistical differences for some cases. Thus, I picked up two cases which do not have a statistical difference and performed more experiments and advanced statistical analysis in order to see if the HTRs actually have a statistical difference. By using the T-test, I successfully prove that HTRs have a statistical difference for the two selected cases. These findings have led me to conclude that:

1. Fiber works well for all levels of humidity. However, the efficiency decreases 43% in average when the humidity increases from 50% to 80%
2. Denim is a more environmental friendly insulation. In high humidity level, it is a good substitute for Fiber since their efficiency only has 5% difference in average at 80%RH
3. Two reflective insulation materials (Foam & Foil) can reduce both heat conduction and radiation. Unfortunately, they do not perform as efficiently as Fiber but their efficiency is not affected by humidity.