Transient Temperature Gradient of Apple at Differing Wind Velocities

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Hypothesis

The greater the velocity of wind, the higher the convection coefficient will be. However, the apple will become colder at the slower velocity for the longer period of time.

Objective

- To model the cooling rates of a person walking a distance of 1.4 miles using an apple and wind speeds based off an air conditioning unit
- To exhibit if walking faster for a shorter amount of time or slower for a longer amount of time causes a greater decrease in temperature

Materials

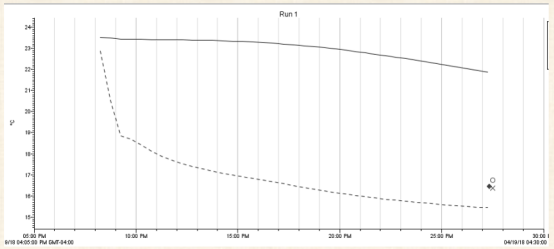
- Granny Smith Apple
- AC unit
- HOBO Datalogger
- 2 Temperature sensors
- Timer
- Anemometer
- IRTC50 ThermoSEEKER

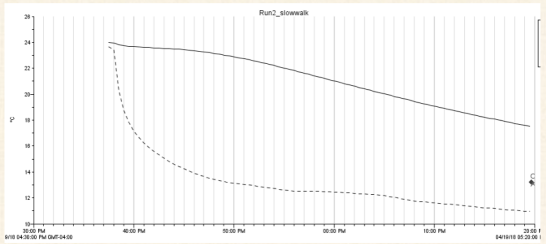
Methods

1. Calculate time needed for slow and fast velocity trials
2. Measure the temperature and velocity of AC unit on high and low
3. Insert HOBO probes in center and surface of the apple
4. Rest probed apple on AC unit and log the temperature data for calculated time
5. Observe plotted temperature changes
6. Calculate convection coefficients
7. Model experiment using COMSOL

Experimental Results

The temperature of the wind from the AC unit was 18.85 ^{0}C. The graphs below show the data from the HOBO Datalogger. On the left is Trial 1 at 2.2 m/s for 17.06 mins and on the right is Trail 2 at 1 m/s for 37.55 mins. The top, solid line is center temperature and the bottom line is surface temperature of the apple. The experiment yielded a final center temp of 21.86 ^{0}C for Trial 1 and 18.31 ^{0}C for Trial 2.

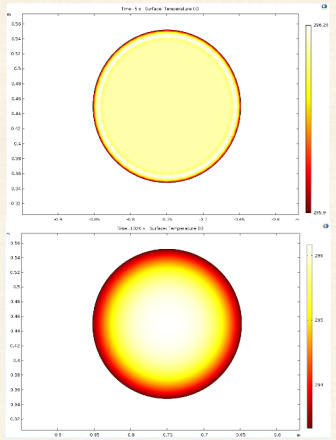




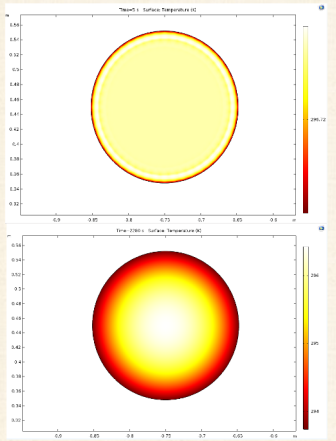
Modeling Results and Discussion

The convection coefficients h were calculated and then used to model the 2 scenarios in COMSOL. The visual models are shown after the first 5 mins and after the full time duration.

Trial 1: 2.2 m/s for 17.06 mins	Temp [^{0}C]
Initial Surface	22.88
Final Surface	15.45
Initial Center	23.52
Final Center	21.86
Calc. h	22.46 W/m^{2}K



Trial 2: 1 m/s for 37.55 mins	Temp [^{0}C]
Initial Surface	23.65
Final Surface	11.29
Initial Center	24.01
Final Center	18.31
Calc. h	12.39 W/m^{2}K



Conclusion

The apple reached a cooler surface and center temp when exposed to a slower air velocity for a longer period of time. At a wind velocity of 2.2 m/s for 17.06 min, the center cooled by 1.7 ^{0}C, while at a velocity of 1 m/s for 37.55 min, the center cooled by 5.7 ^{0}C. The final temperatures obtained by the experiment, COMSOL simulation, and hand calculations were all within 2.4 ^{0}C.

The k value of an apple is similar to the k value of skin, so it can be concluded a person would become colder walking slowly rather than quickly over 1.4 miles. With thermal heat generation considered, the result should still be proportional.

References

1. Drapcho, Caye "BE 4120 Heat and Mass Transfer" Clemson University. Course Materials. 2018.
2. "Apples, raw, granny smith, with skin, Core and stem density". AVCalc LLC. Web. 2018.

Acknowledgements

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