

# HOW DOES HOTHANDS® HAND WARMER WORK?

## THE EFFECT OF OXYGEN ON HAND WARMER TEMPERATURE

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# Questions

- How does the HotHands<sup>®</sup> hand warmer work?
- How does the level of oxygen affect the temperature of the hand warmer surface?
- How to use the hand warmers more effectively?

# Hypothesis

If the level of oxygen is increased, then the faster the hand warmer will get warmer, and the higher the temperature of the hand warmer will be.

# Materials

- HotHands® hand warmer packs (8)
- Infrared (IR) thermometer
- Oxygen canister with 99.7% Pure Oxygen, and spray (4L x2)
- Label of numbers 1,2,3,4,5,6
- Tape
- Timer
- Lab notebook
- Disposable glove



Photo of the materials was taken by the student on 12/20/2022.

# Design of the Experiment

- **Independent variable:**      **The time each pack is exposed to oxygen.**  
A timer is used to record the time each heat pack is exposed to air/oxygen
- **Dependent variable:**      **The temperature of the hand warmer surface**
- **Replicates: 3**
- **Control Group:**      **The temperature of the surface of the unopened hand warmer package**
- **Constants in the experiment:**
  - Brand and type of hand warmer
  - Ambient temperature (indoor room temperature)
  - Table surface that holds the hand warmers
  - Distance between the thermometer and the hand warmer surface

# Procedure

- Prepare the oxygen canisters. Place heat packs on the table.
- Using the masking tape and permanent marker, label the heat packs 1 to 6:
  - #1: Unopened package. This is a control to track room temperature.
  - #2: 50% surface area open, cover 50% of the perforated surface with tape, air
  - #3: 100% surface area open, air,
  - #4: 100% surface area open, shaken in the air
  - #5: 100% surface area open, pure oxygen level 1
  - #6: 100% surface area open, pure oxygen level 2 (double oxygen level 1)
- Gently spray the oxygen over the surface of heat packs #5 and #6. The frequency of spraying the oxygen over the surface of heat pack #6 is twice of that heat pack #5.
- Record the time and the temperature of each of the heat packs every 5 minutes for 60 minutes.
- Record each temperature three times and calculate the average.
- Record all data in the lab notebook.

# Risk and Safety

- In case the hand warmer becomes overheated, wear gloves to handle it.
- Do not break the inner pack because the contents are harmful to get in the eyes, the mouth and on the skin.
- Control the oxygen release by practicing controlling the spray.
- After use, dispose the hand warmers with regular garbage. Ingredients will not harm environment.

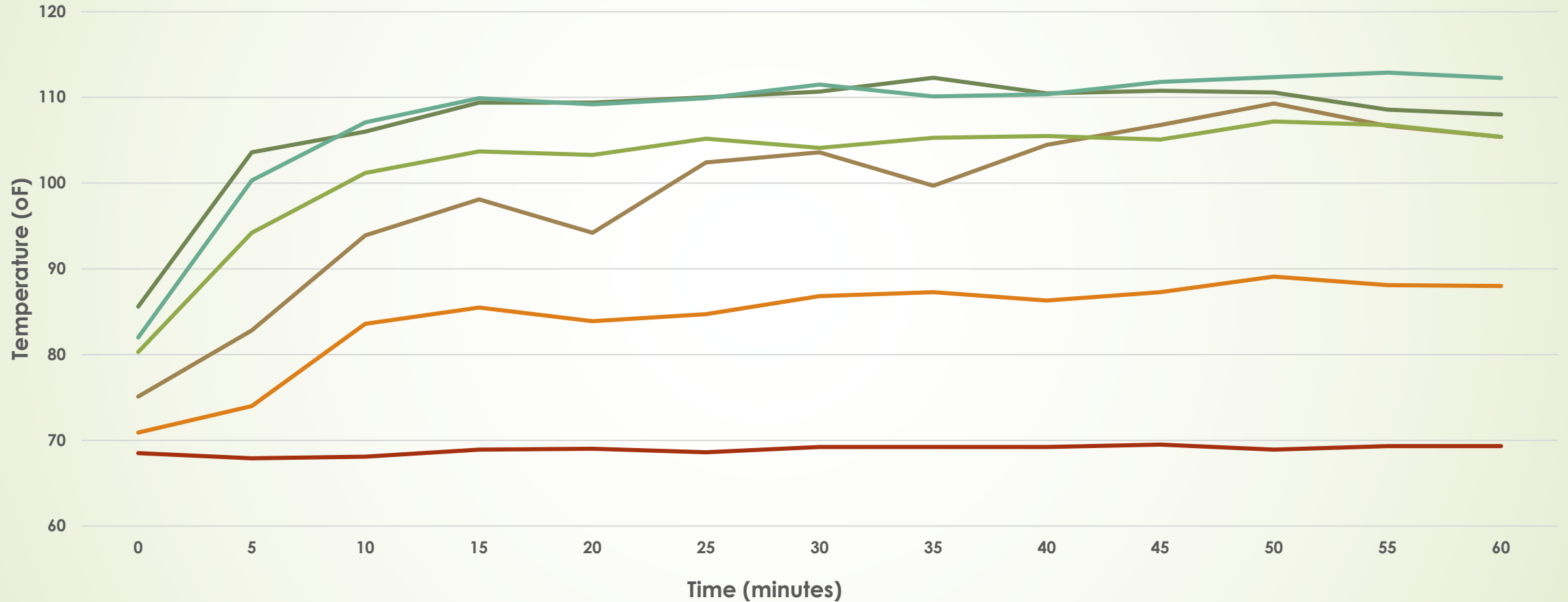
# Data Table

The Effect of Oxygen Level on the Temperature of the Hand Warmers

	Average Temperature of the Hand Warmer (°F)												
Time (min)	0	5	10	15	20	25	30	35	40	45	50	55	60
#1	68.5	67.9	68.1	68.9	69	68.6	69.2	69.2	69.2	69.5	68.9	69.3	69.3
#2	70.9	74	83.6	85.5	83.9	84.7	86.8	87.3	86.3	87.3	89.1	88.1	88
#3	75.1	82.8	93.9	98.1	94.2	102.4	103.6	99.7	104.5	106.8	109.3	106.7	105.4
#4	85.6	103.6	106	109.4	109.4	110	110.7	112.3	110.5	110.8	110.6	108.6	108
#5	80.3	94.2	101.2	103.7	103.3	105.2	104.1	105.3	105.5	105.1	107.2	106.8	105.4
#6	82	100.3	107.1	109.9	109.2	109.9	111.5	110.1	110.4	111.8	112.4	112.9	112.3

# Graph

## The Effect of Oxygen Level on the Temperature of the Hand Warmer



#1: Unopened package

#3: 100% surface area open, air, no pure oxygen

#5: 100% surface area open, pure oxygen level 1

#2: 50% surface area open, air, no pure oxygen

#4: 100% surface area open, shaken in the air, no pure oxygen

#6: 100% surface area open, pure oxygen level 2



# Conclusions

The hypothesis is accepted. The higher the level of oxygen, the faster the hand warmer gets warmer and the higher the temperature of the hand warmers.

1. Hand warmer #4 (100% surface area, shaken in the air without pure oxygen) and #6 (100% surface area, purged with level 2 pure oxygen) were exposed to the highest amount of oxygen, and thus had the highest average temperatures which were about 40°F higher than the control group of unopened hand warmer. Hand warmer #2 (50% surface area open, air, no pure oxygen) reached the lowest temperature which was about 15 °F higher than the control group. So, the higher the level of oxygen, the higher the temperature of the hand warmer.
2. Within the first 5 minutes, hand warmer #4 and #6 increased temperature the fastest. All the hand warmers reached a steady temperature at about 15 minutes. So the higher the level of oxygen, the faster the hand warmer gets warmer.
3. Comparing hand warmer #2 and #3 and reducing the surface area of the perforated region by half decreased the heating rate, the average temperature was about 15 °F lower.
4. Comparing hand warmer #5 and 6 by purging with additional oxygen, #6 was about 6-8 °F warmer than #5. Again, the higher level the oxygen, the higher the temperature of the hand warmer.

## Error Analysis – Random Errors

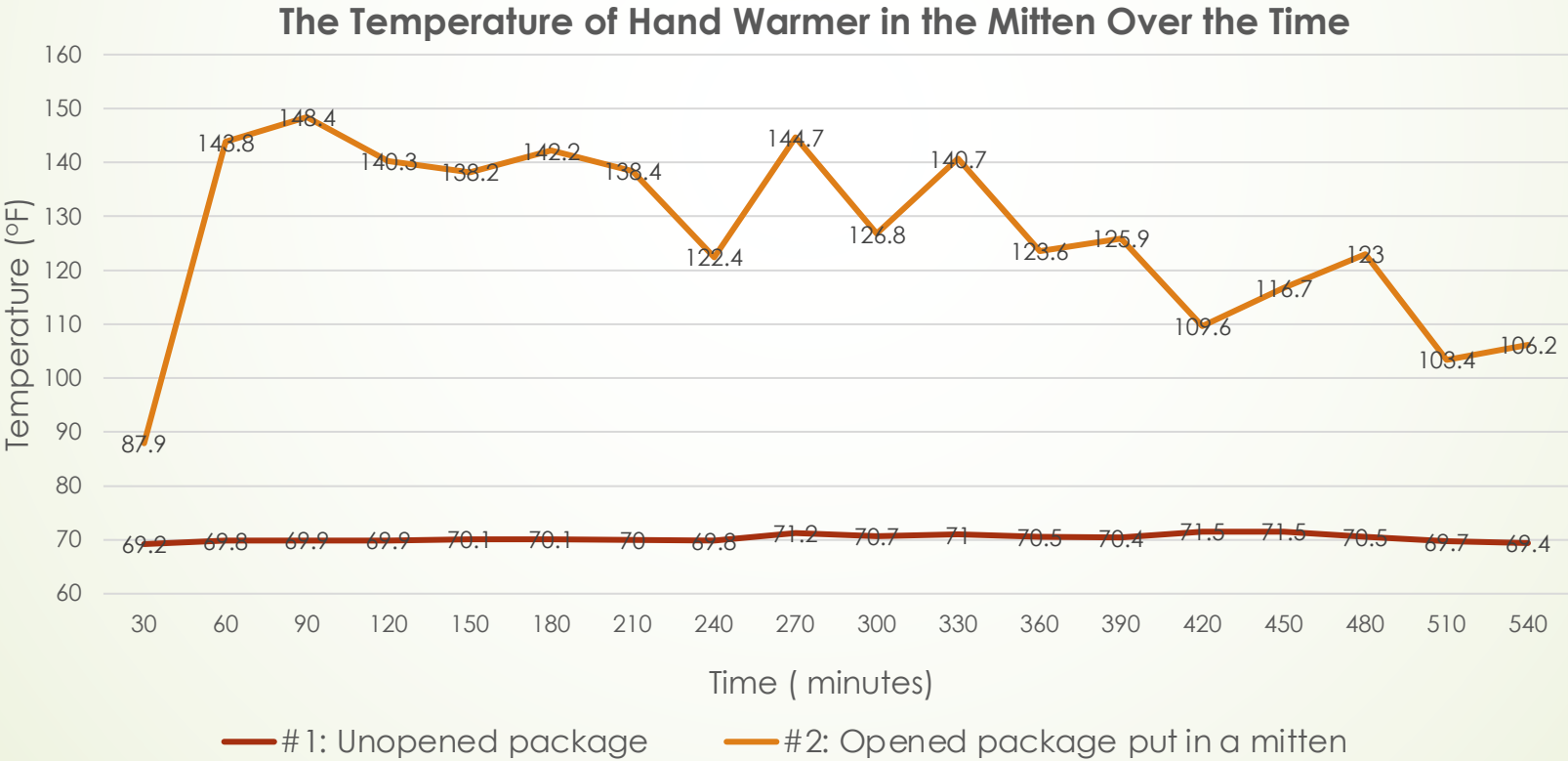
- A random error could be the distance between the thermometer and the hand warmer surface, although the design of the procedure was to keep the same distance of about 2 inches, it is the estimated distance that could fluctuate slightly that causes temperature measurement errors.
- The purge of oxygen into hand warmer #5 and #6 was also done manually, which may cause random errors.

## Error Analysis – Systematic Errors

- A systemic error was in the design of the experiment. The temperature of each hand warmer had to be measured one after the other, and thus was not at exactly the same time point. This can be improved by working with more partners to measure the temperature simultaneously.
- Additionally, the thermometer is not calibrated, therefore, there might be systematic error of all the measured temperature to be deviated at the same degree, but this doesn't change the data pattern or the conclusions.

# Additional Study

To investigate the best way to use the hand warmers in real life, an additional study has been done indoors by shaking the hand warmer to initiate the reaction first, and then putting the hand warmer in a mitten and measuring the temperature every 30 minutes for 9 hours. The hand warmer reached up to 148°F and remained warm for at least 9 hours. So in real life, the best way to use the hand warmer would be shake it to initiate it and then put it in the mitten or pocket as insulation.



# Works Cited

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