Introduction:

• Over 15% of weather-related aviation accidents is attributed to aircraft icing [1]. Aircraft icing is caused by supercooled water droplets that exist in clouds.
• The accumulated ice hinders mechanical functions of wings, reduce lift, and increase drag, all of which pose a major safety problem.
• We will explore the temperature transition and the time it takes for a suspended supercooled droplet to freeze using finite difference.

Conclusions:

• With the optimal parameters, the model yields a freezing time of approximately 55 seconds.
• Using this information, Anti-freezing liquids can be produced to absorb the crystallization and prevent the freezing stage.
• For other solutes such as pollutants dissolved in droplets, similar experiments can be conducted.

Results [2]:

Experimental data using 40 droplets were obtained. From the data, the freezing time of the droplet was estimated using the accepted definition of freezing time.

Mathematical Models [2]:

Cooling Stages (1) and (4):

- Uniform Temperature Solution
- Internal Heat Conduction Model

Recalcescence Stage (2)

Freezing Stage (3):

Heat Balance Model

Moving Boundary Model

Recalescence Stage (2)

Finite Difference Method [3]:

Heat Equation

Forward Difference

Central Second Difference

Difference Equation

CFL Condition

Problem [2]:

Experiment

- Cold airstream monitored by Thermocouple 2 & 3
- Temperatures monitored & recorded by computer
- Liquid nitrogen & air mixed to produce cold air stream
- Moisture scrubbers remove moisture from airstream
- Proper temperature were pushed to second chamber
- Droplet was suspend on thermocouple 1.

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Temperature of Droplet in Solid Cooling Stage

Total Time and Temperature Over All Four Stages

Figure 1: Using data from varying air velocity and the respective predicted model, the solid droplet takes approximately 55 cool.

Figure 3: The droplet takes approximately 55 seconds to freeze.

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References: