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Deposition Velocity Dependence on Urban Morphology
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Introduction
- Total population living in urban cities has increased drastically over the last century.
  - Most people spend a majority of their time indoors, especially in urban cities.
- Increased number of densely populated urban cities with many urban structures of varying shapes and sizes.
- Raises concerns for sustainability and human health:
  - Pollution accumulation in urban cities.
  - Increased energy consumption from growing number of buildings.
- Objective: To study the effects of boundary layer interactions on deposition velocity of varying urban morphology.
- In order to provide new insights into
  - Cooling and heating loads of building.
  - Natural ventilation techniques.
  - Pollution deposition and dispersion on/from urban structures.

Methods
- The naphthalene sublimation method is implemented.
  - Tried and tested method for many experiments involving heat and mass transfer.
  - Provides repeatable results.
- Method involves dipping cube surfaces into molten naphthalene.
  - Provides even coating on surface.
- Naphthalene is a hydrocarbon that sublimes very at room temperature.
  - Passive mass transfer of naphthalene to air is very slow.
  - Convective mass transfer of naphthalene, caused by bulk fluid motion, increases mass transfer rate by many folds.
- Experimental Procedure:
  - Measure mass of cubes after coating with naphthalene.
  - Place cube into wind tunnel set up and run wind tunnel at a set speed for a set duration of time.
  - Measure mass of cube after experiment to obtain change in mass of naphthalene for the surface being investigated.
- Deposition velocity is calculated from the change in mass of naphthalene.
  - Mass transfer of naphthalene is related to flow field through the fundamental momentum diffusion equation, Equation 2, and fundamental mass transfer equation, Fick’s Law, Equation 3.
- Fluid shear stress: \( \tau = -\mu \ddot{u} \) (2)
- Fick’s Law: \( J_i = -D_i \mu \ddot{u} y_i \) (3)

Results
- Deposition velocity is shown to be greatest for the fourth cube in a series of four cubes, and most noticeably at higher wind velocities. The fourth cube in the series experiences flow disturbances from boundary layer interactions of all four cubes compared to flow disturbances from boundary layer interactions of only two cubes, at the second cube. These interactions cause the flow to become more turbulent, which increases mass transfer of naphthalene to air.

Future Work and Conclusions
- Deposition velocity has been shown to increase with increased boundary layer interactions.
  - Also has been shown to strongly depend on wind velocity, where increase wind velocity increases deposition velocity.
  - Current work involves investigating a parametric variation in urban layout and morphology where a full scale model city is being investigated.

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References

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