Flame Height and Heat Release Rates at Ignition Phase

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Introduction:
- Fire is considered to be unpredictable, which can prove problematic for fire/arson investigations
- Heat can transfer through three major ways, conduction, convection, and radiation
- Oxygen flow can be restricted to a fire when a flame is placed against a wall or in a corner
- Environmental conditions like humidity, wind gusts, and temperature impact fires
- Fire is controlled predominantly by the fire triangle: oxygen, fuel, and heat
- This is an investigation on how fire behaves in its early stages and how different factors impact the height of the flame

Experimental:
- Pools of acetone were placed in small crucibles and were lit in different corner angles: 90°, 135°, and 180°, and different environmental conditions 3°C, 12°C, 19°C
- This was done five times for each angle
- During the first minute of ignition phase, a camera captured the whole crucible and the height of the flames
- For the Heskestad equation: A crucible filled with acetone was placed on a scale attached to a Vernier device, and the acetone was ignited, the loss was mass was measured due to burning

Results:
- The Heskestad equation is used to predict the flame heights at ignition phase based on the size of the pool of acetone
  \[ Z = 0.23Q^{2/5} - 1.02D \]
- \( Z_f \) = visible flame height (m)
- \( Q \) = heat release rate (kW)
- \( D \) = diameter of the pool (m)
- The data collected from all the data points of the flame heights for the different angles on the different with the Heskestad equation are found on Graph 1

Graph 1

- The modified Heskestad equation accounts for the angle of the wall that the pool of acetone was placed next to
- Graph 2 includes the same data collected however it is compared to the modified Heskestad equation

Graph 2

Discussion and Error Consideration:
- Each of the trials contains at least 500 data points of the flame heights measured from Tracker from 5 trials for each angle and ambient temperature
- Based on the two graphs, the modified Heskestad equation seems to fit the data more closely
- There is a trend that the colder the weather, the higher the flame heights during ignition phase are
- There is another trend that smaller the angle of the corner, the higher the flame height appears to be
- All of the values are lower with the modified equation and only one value overlaps with the unmodified equation
- Standard errors are included in the graphs
- Acetone pool size and mineral fiber boards were kept constant
- Wind gusts and other weather factors may have added to error
- Human error in calibration of Tracker software was determined to be ±0.5 cm

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References: