Calculation Validation

- Goals
    - Validate mass flow rate calculations
    - Validate outlet temperature calculations
    - Confirm assumed T_{SURR}
- Materials Used
    - Feed tank (trash can w/ hole)
    - Inlet tubing (flex tube for feed tank to square pipe)
    - (6x) Sheet Metal end caps
    - 6 ft, 1” D square pipe
    - (2x) Feed tank height adjusters (crates)
        - 16.5” x 13.75” x 10.5” (WxLxH)
    - (4x) 6ft 2” x 4” wood
    - (2x) 24” 1” x 4” wood
    - (2x) 6ft bamboo rods
    - (4x) Thermocouples
    - (2x) Supermeter (read Thermocouple)
    - (13x) 2⅜” Nails (for pegs)
    - (20x) 2½” Wood screws
    - 500 ml Graduated cylinders
    - Sheet metal shears
    - Welding gloves
    - Duct Tape
    - Modeling Clay
    - Stopwatch (phone)
    - Folding Table

Prototype Build Procedure

1. Rack System
    a. Measure and cut two 2x4’s to 6ft lengths. (Vertical structure)
    b. Measure and cut four 2x4’s to 2ft lengths with 45deg angles (Long braces)
    c. Measure and cut four 2x4’s to 1ft lengths with 45deg angles (Short braces)
    d. Measure and cut two 1x4’s to 2ft lengths (Bamboo cross supports)
    e. Attach 2 long and 2 short braces to the lower end of the vertical structure using 2 ½ in Wood Screws
    f. Attach the Bamboo cross supports to vertical structure at a height of 59in using wood screws
    g. Use a hammer to secure a single nail at 45 deg angle to the thin side of the vertical structure at a height of 40in. Repeat this 4 times at increased height intervals of 4in.

2. Sheet Metal End Caps
    a. Measure and cut 4in squares from sheet metal
    b. Measure and cut 1in squares out of every corner of each 4in square
    c. Drill 1 hole of desired size into center of sheet metal
    d. Bend edges up to form a box
    e. Use duct tape to maintain box shape and close the close the gaps

Heat Transfer Test Plan

1. **Pre-burn Setup**
    a. Set up racks facing each other centered on opposite sides of the kiln
    b. Place HTX on lowest rack peg height
    c. Set up table next to kiln and racks
        i. Stack crates on table
        ii. Place feed tank on top of crates
    d. Place thermocouples in respective locations on HTX and feed tank
        i. T_{IN} in inlet tank
        ii. T_{OUT} at HTX outlet
        iii. T_S located ½ of length of HTX (on bottom)
        iv. T_{SURR} hanging 3” below T_S thermocouple
    e. Take and record initial measurements from each thermocouple
2. **During The Burn**
    a. Fill feed tank to full with garden hose
        i. Keep perpetually full throughout entirety of burn
    b. Take measurements from all thermocouples every 5 minutes until end of burn
3. **Post-burn**
    a. Plug the hole of the HTX outlet to keep water within system over the fire
        i. Release some water to take and record temperature measurement, then re-plug hole
        ii. Repeat this process every minute for 10 minutes

Fluid Dynamics Test Plan

1. **Pre-test Setup**
    a. Set up racks facing each other
    b. Mark heights on feed tank (Full, ¾, ½, ¼, Empty)
    c. Stack crates on elevated surface
        i. Place feed tank on top of crates
        ii. Feed tank outlet must be higher than HTX inlet (when placed on highest rack peg)
    d. Measure and record:
        i. Height of each feed tank level (from ground)

ii. Volume of each feed tank height range
iii. Heights of each peg on rack (from ground)
1. Do this for each rack and take the average

2. Testing Procedure

a. Place cap on outlet of HTX
i. Seal using gasket and duct tape
b. Set HTX pipe on rack peg
c. Fill tank with water to the full, connect feed hose to HTX inlet
d. Time mass flow rate at each height of feed tank
i. For larger diameter holes
1. Record time tank takes to reach each marked height
ii. For smaller diameter holes
1. Fill a graduated cylinder and record the time it takes to reach a certain volume
e. Repeat process 2b until HTX pipe has been tested on every peg height
f. Repeat process 2a until every cap has been tested at every peg height