**HEAT TRANSFER MEASUREMENT PROTOCOL IN A CONICAL SPOUTED BED**

***Version 1.0***

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# OBJECTIVE

# To measure the heat transfer of biomass in a conical spouted bed.

# SCOPE

To inform the community belonging to the Center for Environmental Engineering Research (CIIA) about the procedure for measuring heat transfer in a conical spouted bed.

# MATERIALS

• Aluminum bar

• Platinum or palladium plate

• Cartridge heater

• Termistor

• Glass

# MANUFACTURING OF PROBE

The heat transfer probe consists of a thin film of palladium mounted on a glass piece of approximately 10 mm in diameter. This configuration was chosen due to the need to measure heat transfer from the probe and its temperature quickly, easily, and with high precision, which requires a small probe area and mass.

Current flows through the probe and reference resistance, causing heating of the palladium film. Voltages before and after the probe, V1 and V2 respectively, are measured and recorded.

The probe is mounted at the end of an electric heater consisting of an aluminum rod 55 mm long and 22.2 mm in diameter. The heating element is a high-density cartridge inserted in the middle of the rod from its other end. The heater temperature is measured by a termistor, and is kept slightly lower than that of the probe to minimize and stabilize the heat loss from the back of the probe. This configuration also stabilizes and limits temperature variations of the glass support. During experiments, the average temperature of the probe and heater is maintained at approximately 83 °C and 80 °C, respectively. This small difference is necessary to maintain controller stability.



Figure 1: Aluminum rod with holes for resistance and termistor.



Figure 2: Front view of the probe with all components and dimensions.

The probe temperature is controlled by modifying the voltage supplied by the programmable power supply. The computer continuously monitors the voltage and calculates the corresponding temperature, so that if it decreases below the set point, it sends a voltage increase command to the power supply, causing an increase in the supplied power and a slight heating of the palladium film, which returns its temperature to the set point. The palladium film acts as a heating element and temperature sensor.

1. STEP-BY-STEP PROBE MANUFACTURING.
2. Melt the glass to attach the palladium or aluminum plate to the probe.
3. Open the holes in the aluminum rod for installation of termistor and resistance/cartridge heater.
4. Seal two wires to measure voltage where one is positive and the other negative.
5. Install circuitry for data reading.
6. CALIBRATION

The probe resistance is measured submerged in a water bath at different temperatures, verifying that there is a linear relationship between both parameters. Therefore, the probe temperature, Tpb, can be obtained from the measurement of its electrical resistance.