Purdue University
School of Nuclear Engineering

NUCL 355 - Nuclear Thermal-Hydraulics Laboratory

Experiment 12: Pool Boiling

Objective:
Study critical heat flux (CHF) and pool boiling heat transfer on an electrically heated horizontal wire immersed in a pool of water.

Apparatus:
The experimental setup and the accompanying electrical circuit are shown in Figure 1. A tungsten wire of 0.02" diameter and 3" long is immersed in a pool of water contained in a glass beaker. The beaker is placed on a electrical heat plate which brings the pool water temperature to saturation.

The tungsten wire is connected to a DC power supply unit. The unit is provided with a 0.001 ohm shunt resistance to measure the current flow through the wire. The unit has a switch to provide momentary high power to the wire so that with a pulse of high heat flux a transition from pool boiling region to film boiling is possible. The Variac can be used to increase or decrease the power to the wire.

A thermometer suspended in the water gives water pool temperature. Digital and analog voltmeters are provided with the DC power unit to measure shunt voltage and voltage across the wire respectively.

Precautions:
1. Do not touch the electrodes while the DC power unit is on. Switch power to the electrode off before removing the burnt wire from the electrodes. To confirm that no power is on to the DC unit, pull the power plug from the connecting wall power supply.
2. While replacing the wire, make sure the contact areas on the electrodes are clean.

Procedures:
1. Before starting the experiment or changing the wire, ensure that the power to the DC power unit is off.
2. Clean the surfaces of the power electrodes and the anti-corrosion electrode for any surface deposition.
3. Cut the tungsten wire length to the appropriate length so that it can be secured safely with the electrodes.
4. Fill the beaker with demineralized water to 3/4 of the beaker height and place the wire secured with the electrodes.

5. Turn on the heater and heat the water in the pool to saturation state; check the pool temperature with the thermometer.
6. Turn on the DC power supply. Lower the hot plate power to reduce interference by bubbles in the bulk fluid.
7. Adjust the variable resistor to obtain onset of boiling on the wire surface; Measure pool temperature T_p, shunt voltage V_{sh} and wire voltage V_w.
8. Record all visual observations.
9. Increase the power with the Variac in steps typically 0.25 volts across the wire and record the readings for pool temperature shunt voltage and wire voltage drop.
10. Continue taking readings in step increases in power until the wire burns out. At each step, record T_p, $V_{sh,}$ V_w.
11. Prepare another tungsten wire and install it in the test section;
12. To study film boiling, first develop nucleate boiling on the wire. After steady boiling is observed, typically with 1.5 V across the wire, hit the momentary contact switch to achieve transition to film boiling. Record the readings of current and voltage across wire for different power levels using the Variac.
    While taking film boiling data, the readings must be taken as quickly as possible since the wire will oxidize eventually to burn out.
    Note: in case of steady film boiling, generally film boiling is observed at only certain lengths of wire where the wire becomes red hot and has a vapor film around it.
14. After finishing the experiment, turn off the power and return all apparatus to their original positions.

Calculations and data for the lab writeup:

1. Visually observe pool boiling phenomena; study the flow structure around the wire.
2. Calculate the heat flux, q"
3. Calculate the heated surface temperature, T_w
4. Calculate the boiling heat transfer coefficient, h
5. Calculate CHF
6. Compare the burnout result with Zuber's CHF correlation

References:

1. Incropera and DeWitt, "Fundamentals of Heat Transfer," 4th Edition, Wiley.
2. Collier, J.G., Convective Boiling and Condensation, McGraw- Hill, 1981, p.p. 121-133.
3. Lienhard, J. H., A Heat Transfer Text Book, Pretice-Hall, Inc., Englewood Cliffs, New Jersey, 1981, p.p. 216-238.
4. Pitts, D.R., and Sissom, L. E., Heat Transfer, Schaums Outline Series, p.p. 216-238.

Electrical resistivity (P) and temperature (T) of Tungsten

T(K)	P(μΩ .cm)
300	5.65
400	8.06
500	10.56
600	13.23
700	16.09
800	19.00
900	21.94
1000	24.93
1100	27.94
1200	30.98
1300	34.08
1400	37.19
1500	40.36
1600	43.55

From CRC Table, PPE-380

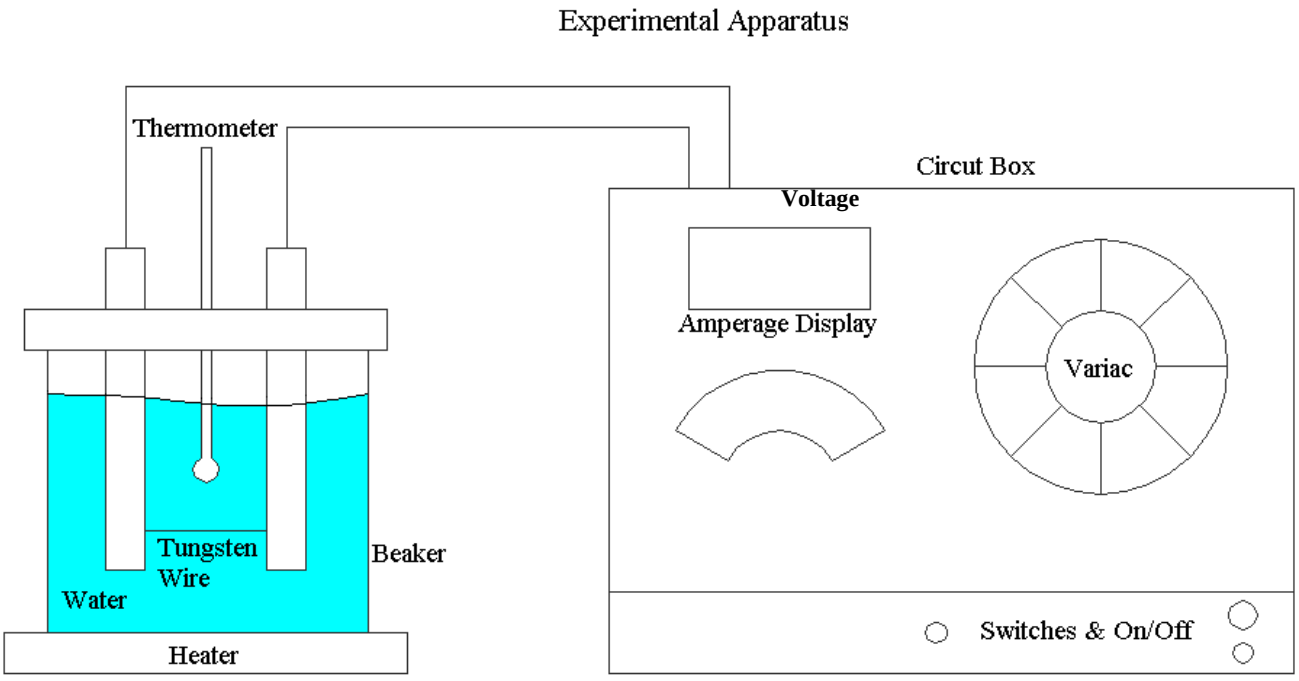

Figure 1 Experimental Apparatus