Laboratory Exercise 2 – Thermodynamics Laboratory

The purpose of this laboratory is to verify the first law of thermodynamics through the use of the microcontroller board, and sensor board. The first law of thermodynamics is a version of the law of conservation of energy. The law of conservation of energy states that energy can change forms but can never be created or destroyed. The first law of thermodynamics focuses on a special internal energy.

The electrical work put through the immersion heater is transferred to heat energy, hence boiling the water.

Part I – Boiling Water

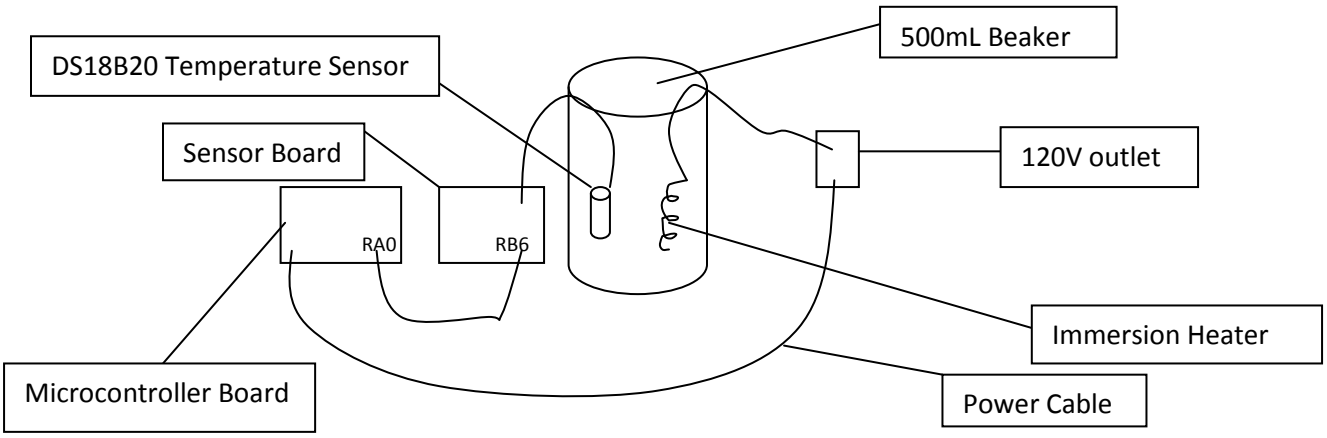
Apparatus

Materials

- 500mL beaker
- DS18B20 Temperature Sensor
- Lewis N Clark Immersion heater
- Wires
- Ribbon Cable
- 120 V outlet
- Water
- Sensor Board
- Microcontroller Board

Note the DS18B20 temperature sensor can be purchased at www.sparkfun.com, and the Lewis N Clark Immersion heater can be purchased from www.Amazon.com.

Setup



Set up the apparatus as shown in the figure above. Leave the immersion heater unplugged until instructed later. Note, that the temperature sensor attaches to the temperature module, then the RB6 pin on the sensor board is attached to the RA0 pin on the microcontroller board for direct monitoring.

Procedure

Below is a snippet from the sample code for pic16f877 that should be put on the microcontroller before continuing the procedure. The complete code can be found in the samples folder.

```
main(void)
{
TRISB = 0b11111111;
TRISD = 0;
TRISC = 0;
lcd_init();
lcd_clear();
lcd_puts("Press * to start");
unsigned char counter1 = 0;
unsigned char counter2 = 0;
unsigned char counter3 = 0;
unsigned char counter4 = 0;
unsigned char Pressed = 0;
while(Pressed == 0)
{
        while(RB1 == 0)//Check if a key is pressed
        {
                ;
        }
        if( (PORTB>>4) == 0b1100)
        {
                Pressed = 1;
        }
}
while(RB1 != 0) //wait for key to be released
{
        ;
}
```

```
Pressed = 0;
unsigned char init_temp = Get_Temp();
lcd_clear();
lcd_puts("Press * to stop");
while(Pressed == 0)
{
        while(RB1 == 0)//Check if a key is pressed
        {
                counter1++;
                if(counter1 == 100)
                {
                        counter2++;
                        if(counter2 == 100)
                        {
                                counter3++;
                                if(counter3 == 15)
                                {
                                counter4++;
                                counter3 = 0;
                                }
                                counter2 = 0;
                        }
                        counter1 = 0;
                }
        }
        if( (PORTB>>4) == 0b1100)
        {
                Pressed = 1;
        }
        while(RB1 != 0) //wait for key to be released
        {
                ;
        }
}
        Pressed = 0;
        lcd_clear();
        unsigned char final_temp = Get_Temp();
        unsigned char lcd_buffer1[16];
        sprintf(lcd_buffer1,"%d",Perform_Calculations(init_temp,final_temp,counter4)
);
        lcd_puts("% converted: ");
        lcd_puts(lcd_buffer1);
while(1)
{
;
}
```

- Fill the 500mL beaker with a 300mL of water
- Insert the temperature sensor into the 500mL beaker
- Plug in, and insert the immersion heater into the 500mL beaker
- Press * on microcontroller board to take temperature reading and start timer
- Press * to take reading and final time
- Measure the current and voltage of the coil or take the wattage

In part one, a simple demonstration of electric power to heat energy is exhibited. Power is measured in watts and is the equivalent of energy per unit time. To find the electric power of the coil, one must simply multiply the current and voltage together or use the wattage given. To find the energy produced, multiply the power by the time taken to boil the water. The first law of thermodynamics states that all the energy from the coil must be transferred to the water. The water takes the energy in a specific form called enthalpy sometimes denoted as Q. The enthalpy will be defined as heat energy, and for constant pressure the enthalpy of the water will be represented by the equation $Q = mc\Delta T$, where m is the mass of the water, c is the specific heat capacity of the water and ΔT is the difference in temperature.

The specific heat capacity of water can then be experimentally calculated by equating the electric energy of the coil and the enthalpy of the water:

electric energy of coil = enthalpy of water
$Pt = mc\Delta T$
where P is the power in watts
t is the time taken to reach boiling
m is the mass of the water, and
ΔT is the change in temperature

The microcontroller will make these calculations for you in the code given below, assuming 300mL of water is put into the beaker and a 300W immersion heater. The % of energy transferred will then appear on the LCD display of the microcontroller board.

```
unsigned char Perform_Calculations(unsigned char init_temp,unsigned char final_temp,unsigned char counter4)
{
        unsigned char enthalpy;
        unsigned char electric_energy;
        unsigned char percent_converted;
        enthalpy = 4 * (final_temp - init_temp);          //find heat energy mass*specific heat
                                                  //capacity*change in temperature
        electric_energy = counter4;                       //find electric energy power*time
        percent_converted = (float)(enthalpy/electric_energy);  //Since both mass and power are 300,
                                                          //they were cancelled
        return percent_converted;
}
```

Discussion questions

Why is the % of energy transfer not 100%? Where does the lost energy go?

Can the first law of thermodynamics be verified from this experiment?

What sources of experimental error are present?