Assignment 6: Water Heater System (On/Off, P and PI Control)

Submit by: 21-04-2021 (Wednesday) 1700 Hours

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1. Make a water heater model in which the desired temperature of water is 50°C. No water is withdrawn for first 2500 seconds. Thereafter, the water is withdrawn at the rate of f = 1 litre/min with a duty cycle of 60 %. In the withdrawal period, the amount of water that is withdrawn is instantly replaced from the water which is at 20°C. The overall simulation is from 0 to 7200 seconds. Take the initial temperature of water at 20°C.

   Simulate for the following 3 cases:

   a. On/Off Control
   b. Proportional Control (Kp = 1.25)
   c. Proportional + Integral Control (Kp = 1.25 and Ki = 0.001)

   For all the 3 cases (a, b and c), the following parameters remain the same:

Volume of water in tank	20 L ($M_w \approx 20$ kg)
Resistance of heater coil	17.5 Ω
Power of Heater	$I^2 * 17.5$
Specific heat of water	4200 J/kg °C
Ambient Temperature (T_{amb})	25 °C ± 10 sin(0.00005t)
Temperature of Water	T_w (variable)
Flow Rate	1L/min
Flow Rate Time Period	3 min
Duty Cycle	60 %
1/ R (where R is Thermal Resistance of Insulator)	0.219 W/ °C
Maximum Current Limit	15 A
Time at which water is first withdrawn	2500 sec

2. Plot vs time the following graphs for each case (a, b and c) keeping the simulation time for 7200 seconds.
   i. Graph 1: Temperature v/s Time (take the temperature axis from 15 to 55°C)
   ii. Graph 2:
      - Error e(t)
      - Kp*e(t)
      - Ki*∫e(t)
      - Current

      (In graph 2, plot the appropriate parameters from the above 4 depending on the case a, b or c)

3. For all the three cases, calculate the following parameters from the temperature vs time plot:
    i. Initial rise time
    ii. Peak-to-peak ripple of temperature in steady state
    iii. Steady state temperature
    iv. Offset error in temperature
    v. Ripple period in steady state
4. For all the three cases, calculate the Mean current from the current vs time plot in the steady state.

5. Compare results (3 (i. to v.) and 4) for all the three cases and explain your observations.