Class :2nd stage
Subject: thermodynamics
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Experiment No. 3: Calculate the efficiency of the boiler steam

Objective :

1. To demonstrate the relationship between the pressure and temperature of saturated steam in equilibrium.

2. To demonstrate the vapor pressure curve. Theory and Principle Marcet Boiler has been developed for investigating the relationship between the pressure and temperature of saturated steam, in equilibrium with water, at all pressure between atmospheric pressure and 10 bar.

Theory:

Marcet Boiler is a bench top unit designed for the demonstration of the basic principal in thermodynamics studies which is the boiling phenomenon. Students will be able to study the relationship between the pressure and temperature of saturated steam in equilibrium with water. The saturation pressure curve can be determined at the pressure within 10 bar.

The measure value of the slope of the graph (dT/dP)SAT obtained from the practical results can be compared with corresponding values calculatedfrom the data in steam tables. Clausius (1822-1888) the German Physicist and one of the founders of Thermodynamics was instrumental in deriving the relevant Clausius-Clapeyron relationship:

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$$\left(\frac{dT}{dP}\right)_{SAT} = \frac{Tv_{fg}}{h_{fg}}$$

$$\left(\frac{dT}{dP}\right)_{SAT} = \frac{T(v_f - v_g)}{(h_f - h_g)}$$

$$h_f + h_{fg} = h_g \qquad \therefore h_{fg} = h_g - h_f$$

Therefore,

$$\left(\frac{dT}{dP}\right)_{SAT} = \frac{T(v_f - v_g)}{(h_f - h_g)} = \frac{T(v_f - v_g)}{h_{fg}}$$

the value of v_g is much larger than v_f , then :

$$\boxed{\left(\frac{dT}{dP}\right)_{SAT} = \frac{Tv_g}{h_{fg}}}$$

where :

V_f = specific volume of water
V_g = specific volume of steam
h_f = enthalpy of water
h_g = enthalpy of steam
h_{fg} = enthalpy of evaporation

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Apparatus:1- Pressure Transducer, 2-Temperature Controller/Indicator,3 . Pressure Indicator, 4. Control Panel, 5. Bench, 6-Bourdon Gauge,7- Temperature Sensor, 8.Pressure Relief Valve, 9.Water Inlet Port & Valve,10. Heater.

Figure (3-1): Boiler equipment.

Procedure

1. Open the hand valve. Then switch on the power supply.

2. Wait and observe the steam released from the hand valve. This is to assure there is no air/gas left in the boiler. Danger: The steam is hot; DO NOT stay near to the hand valve.

3. After steam is released about 1 minute, close and lock the hand valve and continue the heating process until the pressure gauge reaches the maximum reading of 16 bars.

4. During heating process, pressure and temperature will increase. Take both the temperature readings started at 1 bar and continue the reading until 16 bar. Record your readings in table.

5. Once pressure increase until 6 bars, switched 'OFF' the system.

Work Sheet

Table 1

Experimental					Theory		
Data (experiment)				Result	Data (steam table)		Result
Absolute Pressure, P (bar)	Temperature Reading, T (^{0}C)	Pressure difference, dP (bar)	Temperature difference, dT (^{0}C)	Measured slope dT/dP (K/bar)	Steam specific volume, v_g (m^3/kg)	Enthalphy of evaporation h_{fg} (kJ/kg)	Calculated slope T. v_g / h_{fg} (K/bar)
1							
2							
3							
4							
5							

1. Plot a graph of Temperature (0C) vs Absolute Pressure (bar). Label your graph.

2. Show the dT and dP at data between pressure 3 bar to 3.5 bar in the graph

3. Measure the slope and compare to your theory result.

4. Show all your calculation in separate sheets.

5. Why we need to release the air/gas from the equipment before the experiment?

6. Compare the experimental result with theoretical result. Give your comments.

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Discussion

1. Defined the relationship between the pressure and temperature?

2. If we increase the pressure, what will happen to the temperature?

3- What is the definition of the boiler And what are its uses and purpose?

4- What are the type of boiler and what kind of fuel is used?

5- What factors increase boiler efficiency?

6- What are the factors that reduce and influence the efficiency of the boiler?