Class :2nd stage
Subject: thermodynamics
Ass.lec. Zainab Abdul-kareem Farhan
E-mail: zainab.abdul-kareem@mustaqbal-college.edu.iq

Experiment No(6): Measurement of dryness Fraction by separating calorimeter.

Objectives:-

1- Measurement of dryness fraction of steam.

2- Understanding various methods of measurement of dryness fraction.

3- Arrangement of various components for set up of throttling and separating Calorimeter.

Introduction:

Dryness fraction defined as the fraction of mass of vapor to mass of the mixture of water and vapor expressed as (X).

If the fraction is lowered less than (70%), this cause corrosion damage in tubes that transferred vapor and spoilage turbine by cavitation effect that its caused by presence of water drops accompanying with vapor flowing through turbine unit.

Equipment used:-

1- Boiler 2- separating calorimeter 3- Throttling calorimeter 4- Class container 5- Pressure gauge 6- Thermometer 7-condenser

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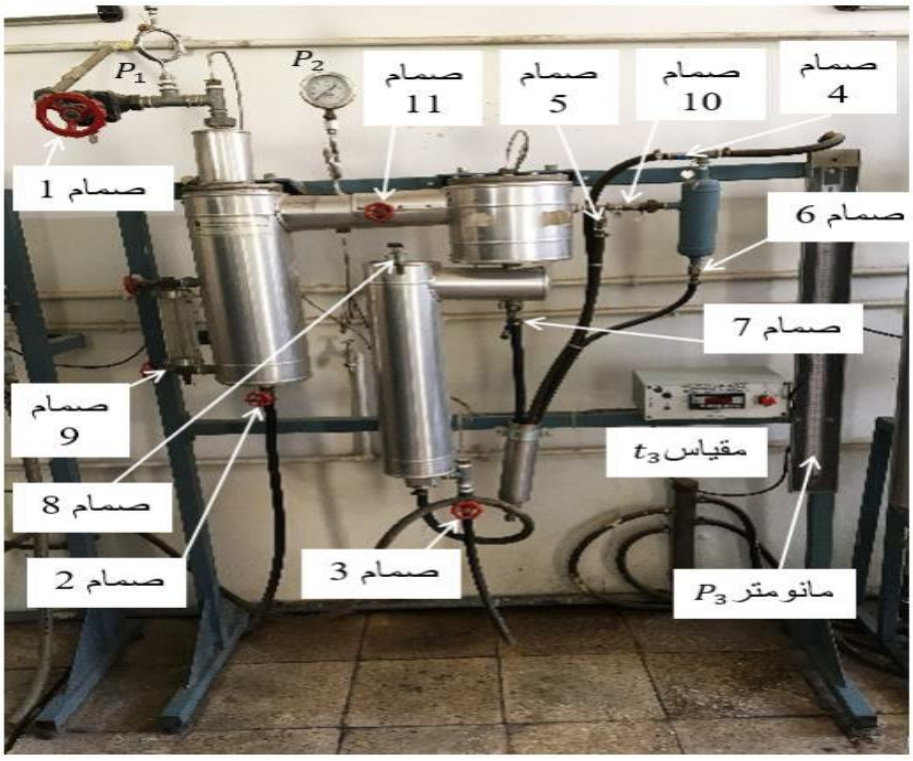


Figure(6-1): Dryness equipment.

Theory:-

The dryness fraction of wet steam is standard to quality of vapor and water drops contained inside the mixture of water vapor, its defined as (x):

$$\text{Dryness fraction } (x) = \frac{mass\ of\ dry\ vapor}{total\ mass\ of\ mixture}$$

The mixture of water vapor enters the equipment with mass (m) to separating calorimeter where is disposed from a few drops of water by a sudden change for the direction of bath of wet steam mixture, where its mass (m_1) of water drops falls down by gravity, then the remaining steam is passed through throttling calorimeter that it contains a narrow orifice, and throttling process occurs to change the state of steam from wet steam to saturated steam.

- Process (1-2): moisture separation.
- Process (2-3): throttling to pressure(P3)

$m=m_1 + m_2$

Apply energy balance to separating calorimeter

$mh_1= m_1h_{f1} + m_2h_2$

$h_1 = hf_1 + X_1h_{fg1}$

$m(hf_1 + X_1h_{fg1}) = m_1h_{f1} + m_2h_2$

$X1 = \frac{m2}{m1+m2} \cdot \frac{h2-h1}{hfg1}$

$h_3 = h_2$

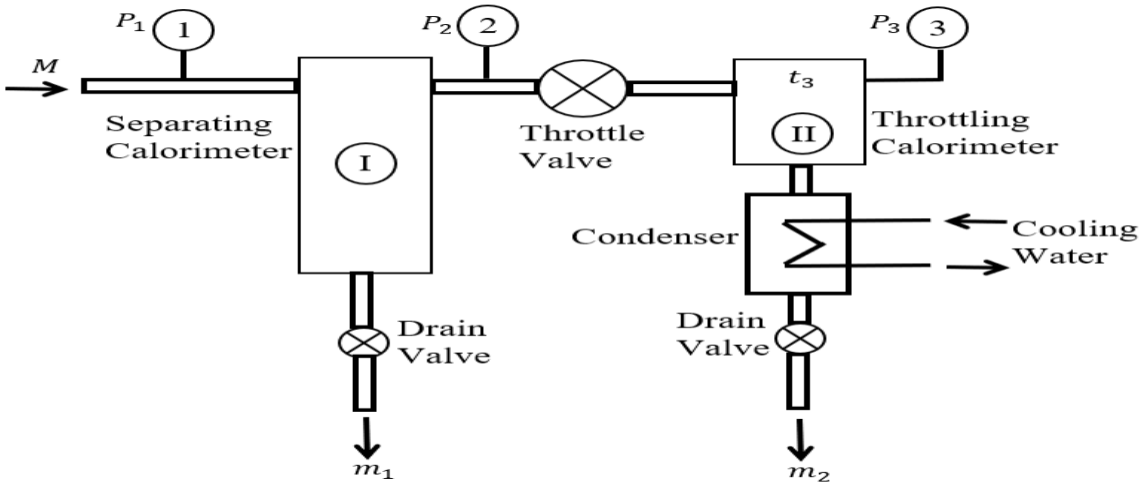
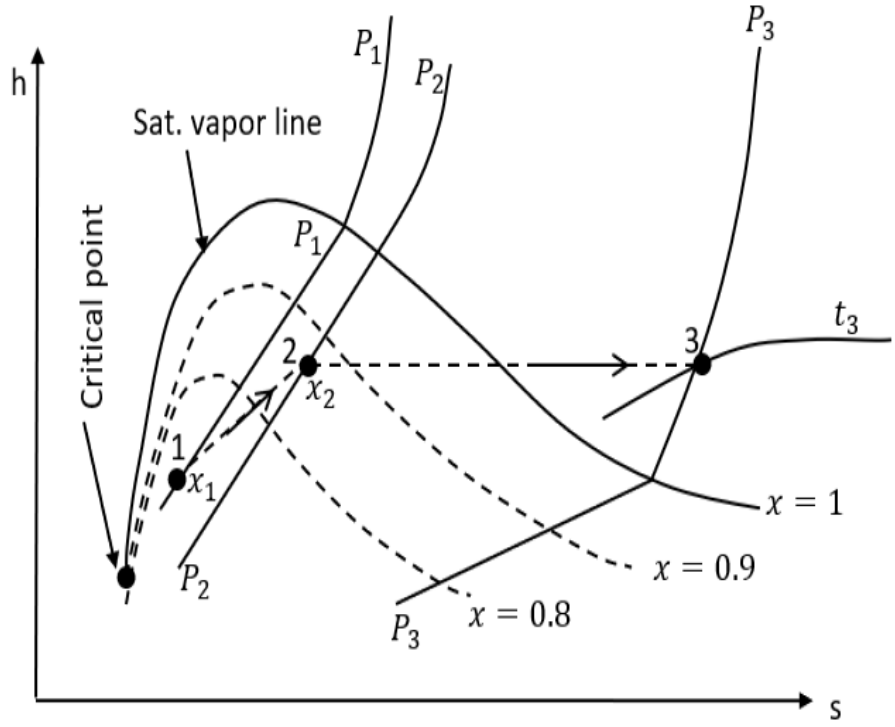


Figure (6-2): Schematic diagram of dryness equipment.



Figure(6-3): diagram explained dryness fraction.

Throttling and Separating Calorimeters are used to measure the dryness fraction of steam. If the steam is sufficiently dry to enable it to reach a supersaturated state by throttling process, then a solitary throttling calorimeter can serve the purpose. If on the other hand, the steam is very wet, then a separating calorimeter is used. When the dryness fraction of the steam is somewhere in between, then a combined setup of Throttling and Separating Calorimeter is used.

1- Separating calorimeter

The equality of wet steam is usually defined by its dryness fraction. When the dryness fraction, pressure and temperature of the steam are known, then the state of wet steam is fully defined. In a steam plant it's at times necessary to know the state of

steam. For wet steam, this entails finding the dryness fraction. When the steam is very wet, we make use of a separating calorimeter.

Construction of separating calorimeter is as shown in figure:

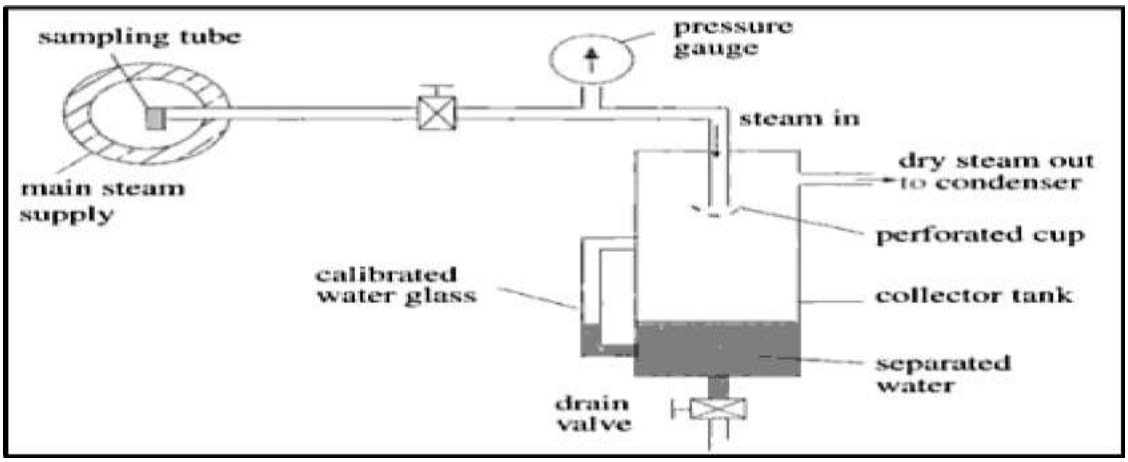


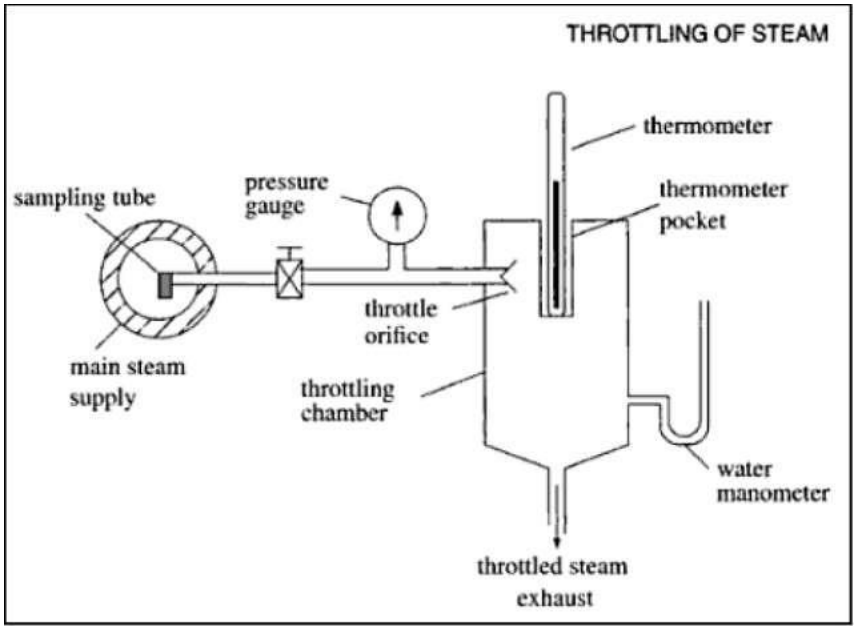
Figure (6-4): separating calorimeter.

The steam is collected out of the main steam supply and inters the separator from the top. The steam is forced to make a sharp turn when it hits the perforated cup (or any mechanism that produce the same effect).this result in vortex motion in the stem and, and water separates out by the centrifugal action. The droplets then remain inside the separator and are collected at bottom, where level can be recorded from the water glass. The dry steam will pass out of the calorimeter into a small condenser for the collection of the condensate. However, not all the water droplets remain in the collector tank. Some water droplets pass through to the condenser, and hence this calorimeter only gives a close approximation of the dryness fraction of the steam.

From the results obtained from the two collectors, the dryness fraction may then be found from

2- Throttling calorimeter

If we have steam that is nearly dry, we make use of a throttling calorimeter as shown in Fig (2). This calorimeter is operated by first opening the stop valve fully so that the steam is not partially throttled as it passes through the apparatus for a while to allow the pressure and temperature to stabilize. If the pressure is very close to atmospheric pressure, the saturation should be around 100 ^{o}C, it may be assumed that the steam is superheated. When the condition has become steady, the gauge pressure before throttling is read from the pressure gauge. After throttling, the temperature and gauge pressure are read from the thermometer and manometer respectively. The barometric pressure is also recorded.



Figure(6-5): Throttling calorimeter.

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Procedure:-

Before starting the experiment, it is necessary to remove the condensate water remaining from the previous experiment from the machine to make the calculations accurate. Use Figure 1 when performing the experiment steps as follows

1- Make sure that there is water inside the manometer scale at zero reading

2- Close the valve 1

3- Operate the steam boiler to the required pressure and make sure the steam reaches the valve1

4- Open the valves 2-9

5- Close the terminals 10 and 11

6- Open valve 1 gradually to allow for steam entry and ensure that all condensation residues are expelled from the previous test of LEDs 2 and 9

7- After a short while, the steam will flow into the first part of the oil. Open the throttle valve 11 slowly and wait for a few minutes until the second throttle reaches the stable temperature.

8- Close the valve 1 and wait for a few moments until the meter reading becomes zero

9- Shut the valves 2, 4, 5, 6, 7, 9, 11

10- Open the valves 3, 8, 10

11- Operate the temperature measuring device

12- Place a graduated baker with a volume greater than 2 liters below the 3 valve to collect the condensate water. Place another vessel that is the same size as the first one. Place it under valve 2 to collect the collected water from the separation valve with the remaining 2, 3 closed

13- Then slowly open the throttle valve 11 and record the reading of the manometer

(P P_3) and try to control the opening of the throttle valve 11 to get stable readings for several minutes and then record the reading of the pressure gauge (P_2) And temperature (t_3).

14- Close the valve 1 and wait a little while to complete the water pool in the opening price and then open the 2, 9 and measure the volume of water out of the V_1 and the volume of the water out of the throttle (V_2)

15- Start calculating the dryness of wet steam

Discussion:-

1- Mention the reasons for error in the results?

2- What is calorimeter?