

DETERMINATION OF DRYNESS FRACTION OF STEAM

The dryness fraction of steam can be measured by using the following calorimeters:

1. Tank or bucket calorimeter
2. Throttling calorimeter
3. Separating and throttling calorimeter.

Throttling Calorimeter - The dryness fraction of wet steam can be determined by using a throttling calorimeter which is illustrated diagrammatically in Fig. 1.

The steam to be sampled is taken from the pipe by means of suitable positioned and dimensioned sampling tube. It passes into an insulated container and is throttled through an orifice to atmospheric pressure. Here the temperature is taken and the steam ideally should have about 5.5 K of superheat. The throttling process is shown on h-s diagram in Fig. 2 by the line 1-2. If steam initially wet is throttled through a sufficiently large pressure drop, then the steam at state 2 will become superheated. State 2 can then be defined by the measured pressure and temperature. The enthalpy, h_2 can then be found and hence

$$h_2 = h_1 = (h_{f1} + x_1 h_{fg1}) \text{ at } p_1$$

$$h_2 = h_{f2} + h_{fg2} + c_{ps}(T_{sup2} - T_{s2})$$

$$x_1 = \frac{h_2 - h_{f1}}{h_{fg1}}$$

Separating and Throttling Calorimeter - If the steam whose dryness fraction is to be determined is very wet then throttling to atmospheric pressure may not be sufficient to ensure superheated steam at exit. In this case it is necessary to dry the steam partially, before throttling. This is done by passing the steam sample from the main through a separating calorimeter as shown in Fig. 3. The steam is made to change direction suddenly, and the water, being denser than the dry steam is separated out. The quantity of water which is separated out (m_w) is measured at the separator, the steam remaining, which now has a higher dryness fraction, is passed through the throttling calorimeter. With the combined separating and throttling calorimeter it is necessary to condense the steam after throttling and measure the amount of condensate (m_s). If a throttling calorimeter only is sufficient, there is no need to measure condensate, the pressure and temperature measurements at exit being sufficient.

Dryness fraction at 2 is x_2 , therefore, the mass of dry steam leaving the separating calorimeter is equal to $x_2 m_s$ and this must be the mass of dry vapour in the sample drawn from the main at state 1.

$$\text{Hence fraction in main, } x_1 = \frac{\text{Mass of dry vapour}}{\text{total mass}} = \frac{x_2 m_s}{m_w + m_s}$$

The dryness fraction, x_2 , can be determined as follows

$$* h_3 = h_2 = h_{f2} + x_2 h_{fg2} \text{ at } p_2$$

$$* h_3 = h_{f3} + h_{fg3} + c_{ps}(T_{sup3} - T_{s3}) \text{ at pressure } p_3$$

$$x_2 = \frac{h_3 - h_{f2}}{h_{fg2}}$$

The values of h_2 and h_+ are read from steam tables at pressure p_2 . The pressure in the separator is small so that p_1 is approximately equal to p_2 .

