DETERMINATION OF THE DRYNESS FRACTION USING THE THROTTLING CALORIMETER

In determining the quality of steam, x, an equal enthalpy throttling process is used. When a gas or steam is passed from a high pressure zone to a low pressure zone through a fine orifice, throttling is said to have occurred. This brings the wet steam into the superheat region, where it becomes a pure substance and is defined completely from the knowledge of two properties only, i.e. the temperature and pressure.

For the throttling process, assume that the process is at a relatively low velocity and constant height, i.e.

Specific enthalpy before throttling, h_1 = Specific enthalpy after throttling, h_2

The value of h_2 is obtained from superheat tables at throttled pressure and temperature.

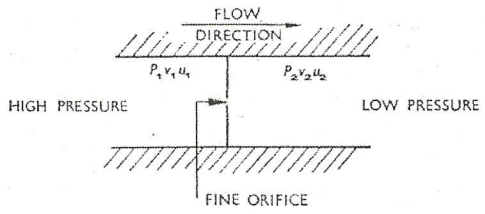
The process is essentially irreversible since friction is used to reduce pressure. The values of both h_f and h_{fg} are obtained from the saturated steam tables at supply temperature and pressure. Hence the supply temperature and pressure *(T and P)* are obtained from

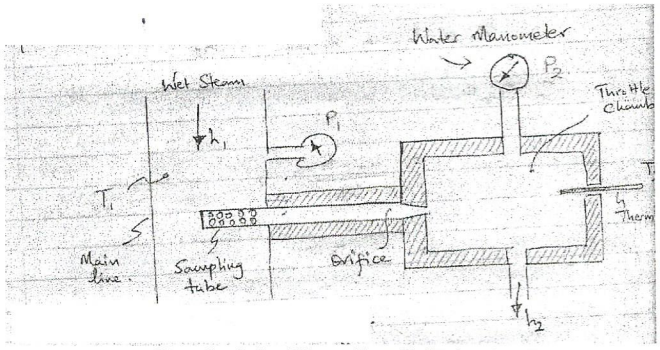
$$h_1 = h_f + xh_{fg} = h_2$$

so that

$$x = \frac{h_2 - h_f}{h_{fg}} \quad \text{or} \quad \frac{h_1 - h_f}{h_{fg}}$$

When a gas or steam is passed through a fine orifice as shown below, it is said to be ***throttled.*** *The gas or steam will pass from the higher pressure to the low pressure side.*





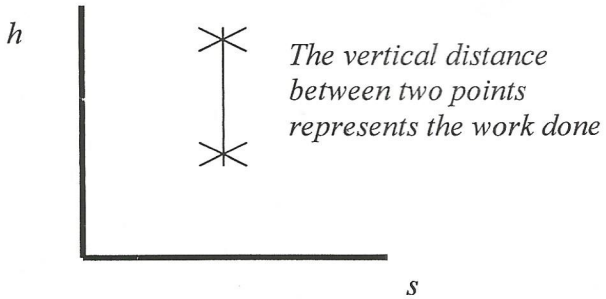
Sketch of the Throttling Calorimeter

Supplementary Reading:

Chapter 4: Basic Engineering Thermodynamics, by Rayner Joel.
Chapter8: Engineering thermodynamics, by Rogers and Meyhew pp 136 – 141.

THE h-s DIAGRAM (MOLLIER DIAGRAM)

This is a diagram using enthalpy and entropy as its coordinates. It is useful when analysing the performance of adiabatic steady flow processes such as nozzles, diffusers, turbines and compressors. For example, the work done by a fluid flowing through a turbine is equal to a drop in enthalpy between the inlet and outlet (assuming no change in kinetic energy). Hence if the thermodynamic state of the fluid at the inlet and outlet can be located as points on the *h-s* diagram, the vertical distance between the two points is proportional to the work done as shown below.



Note:

1. Adiabatric processes which are reversible or isentropic are represented by vertical lines on the diagram.
2. An isentropic process with a wet vapour cannot be expressed in terms of $PV^{\gamma} = C$, *where* $\gamma = cp/cv$. However, $PV^{n} = C$ gives an approximation for isentropic expansion or compression. For this region, $1.135 \leq n \leq 1.300$.