Chapter 1.5

- Steam wetness – or how a system can have both liquid and vapour

Steam wetness

- Can the same entropy as the previous example be achieved when pressure is 1 bar?
- Look at the 1 bar line on p.6 – look on the left column for the saturated state:

Superheated Steam†

p/[bar] (T_s/[°C])	Sat state	T [°C]	50	100	150	200	250	300	400	500
		v								
0	$u = h - RT$	u	2446	2517	2589	2662	2737	2812	2969	3132
	at $p = 0$	h	2595	2689	2784	2880	2978	3077	3280	3489
		s								
	v_g 206.1	v	243.9	281.7	319.5	357.3	395.0	432.8	508.3	583.8
0.006112	u_g 2375	u	2446	2517	2589	2662	2737	2812	2969	3132
(0.01)	h_g 2501	h	2595	2689	2784	2880	2978	3077	3280	3489
	s_g 9.155	s	9.468	9.739	9.978	10.193	10.390	10.571	10.897	11.187
	v_g 129.2	v	149.1	172.2	195.3	218.4	241.4	264.5	310.7	356.8
0.01	u_g 2385	u	2446	2517	2589	2662	2737	2812	2969	3132
(7.0)	h_g 2514	h	2595	2689	2784	2880	2978	3077	3280	3489
	s_g 8.974	s	9.241	9.512	9.751	9.966	10.163	10.344	10.670	10.960

Steam wetness continued

- No, not possible to be superheated at 7.159 $kJ \cdot kg^{-1}K^{-1}$ at 1 bar;
- But that does not mean it is not possible to be at 7.159 $kJ \cdot kg^{-1}K^{-1}$ at 1 bar!
- The condition that makes it possible for the entropy to be less, is condensation of some of it;
- A proportion, x (i.e. m_{vap}/m_{total}), remains as sat steam, and a proportion (1-x) i.e. (i.e. m_{vap}/m_{total}) becomes wet as it condenses into droplets.

For the condition stated

- The actual entropy must be a combination of the wet and dry entropy;
- That is, s = 7.159 kJ/kgK, must be x parts the dry s_g and (1-x) parts the wet s_f;
- $s = xs_g + (1-x)s_f$;
- $7.159 = x(7.359)+(1-x)s_f$;
- s_f is obtained from the saturated data on p.4;
- s_f = 1.303 kJ/kgK – a much smaller value than the dry stem;
- It is smaller because it is more organised in structure and has less chaos.

Entropy of wet steam is:

- To finish: 7.159 = x(7.359)+(1-x)1.303;
- Therefore x = 0.967;
- This is quite dry.

See the video of the high pressure steam safety release valve ‘blowing off’. Immediately at the exit of the tube, the steam is entirely transparent – it is superheated and dry in that region, but then as the steam temperature falls, the wetness increases and the droplets make the cloudy jet.

Video showing superheated steam

https://youtu.be/Bvt6n5fKuKw