Introduction- by Wang Shijun

In this file, the use of property data tables A-4 through A-7 of the textbook by Cengel and Boles is presented.

For the use of these data tables, we assume all properties shown in these tables vary linearly with pressure or temperature over small temperature or pressure ranges. Therefore, we can do a linear interpolation for either temperature or pressure or both to obtain property data at any temperature or pressure.

Before the start of linear interpolation, make a visual observation of how the property of interest varies with temperature or pressure. To avoid potential of error ,it helps to know whether a property we are calculating increases or decreases with temperature or pressure. The details for calculations of this kind are schematically shown in the demos.

The use of water and steam table Table A-4

Temp T °C	Press Psat kPa	Specific volume m^3/kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/kg K		
		Sat liquid v_f	Sat vapor v_g	Sat liquid u_f	Evap. u_{fg}	Sat vapor u_g	Sat liquid hu_f	Evap. h_{fg}.	Sat vapor h_g	Sat liquid s_f	Evap. s_{fg}	Sat vapor s_g
0.01	0.6113	0.001	206.14	0	2375.3	2375.3	0.01	2501.3	2501.4	0.0	9.1562	9.1562
5	**0.8721**	**0.001**	**147.12**	**20.97**	**2361.3**	**2382.3**	**20.98**	**2489.6**	**2510.6**	**0.0761**	**8.9496**	**9.0257**
10	1.2276	0.001	106.38	42	2347.2	2389.2	42.01	2477.7	2519.8	0.151	8.7498	8.9008
15	1.7051	0.001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
….	….	….	….	…	…	….	…	….	…..	….	….	…..

Examples

1. T =5 °C

2. T =13.2 °C

The use of water and steam table Table A-4

Examples

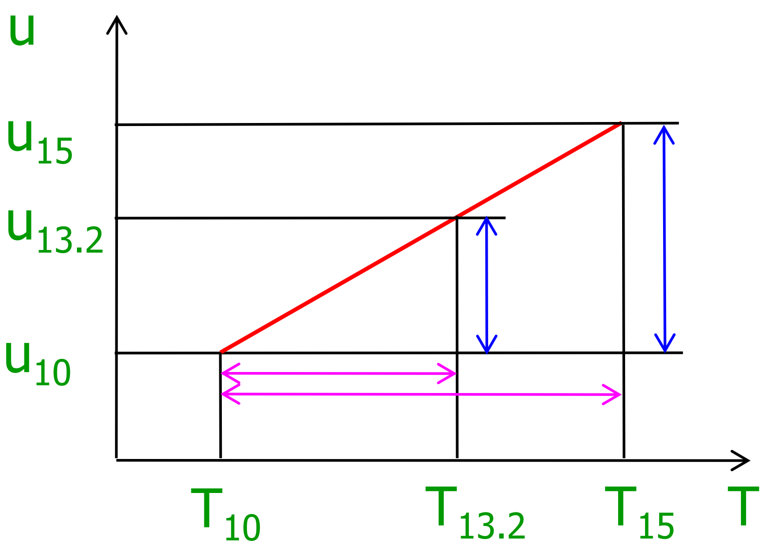
2. T =13.2 °C Value not available in the table, so we need to do a linear interpolation as follows:

$$\frac{u_{T=13.2^{o}C} - u_{T10}}{u_{T15} - u_{T10}} = \frac{T_{13.2} - T_{10}}{T_{15} - T_{10}} \Rightarrow$$

$$u_{T=13.2^{o}C} = u_{T10} + (u_{T15} - u_{T10}) \times \frac{T_{13.2} - T_{10}}{T_{15} - T_{10}}$$

$$= 42 + (62.99 - 42) \times \frac{13.2 - 10}{15 - 10}$$

$$= 55.43 kJ / kg$$



Note: internal energy increases with temperature .

The use of water and steam table Table A-5

Press Psat kPa	Temp T °C	Specific volume m^3/kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/kg K		
		Sat liquid v_f	Sat vapor v_g	Sat liquid u_f	Evap. u_{fg}	Sat vapor u_g	Sat liquid hu_f	Evap. h_{fg}.	Sat vapor h_g	Sat liquid s_f	Evap. s_{fg}	Sat vapor s_g
0.6113	0.01	0.001	206.14	0.0	2375.3	2375.3	0.01	2501.3	2501.4	0	9.1562	9.1562
1	6.98	0.001	129.21	29.3	2355.7	2385	29.3	2484.9	2514.2	0.1059	8.8697	8.9756
1.5	13.03	0.001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	0.1957	8.6322	8.8279
2	17.5	0.001	67	73.48	2326.0	2399.5	73.48	2460	2533.5	0.2607	8.4629	8.7237
….	….	….	….	…	…	….	…	….	…..	….	….	…..

Examples

1. P = 1 kPa

2. P = 1.2 kPa. Not available in the table, so we need to do a linear interpolation as follows

$$\mathrm{u}_{p=1.2kPa} = \mathrm{u}_{p1.5} + (\mathrm{u}_{p1.5} - \mathrm{u}_{p1.0}) \times \frac{P_{1.2} - P_{1.0}}{P_{1.5} - P_{1.0}}$$

$$= ?$$

The use of superheated water table Table A-6

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg K
	P = 0.20 MPa (120.23 °C)				P = 0.30 MPa (133.55 °C)			
Sat	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761	7.0778
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115
250	1.1988	2731.2	2971	7.7086	0.7964	2728.7	2967.6	7.5166
…	…	…	…	…	…	…	…	…

Examples

1. P = 0.2 MPa and T=150 °C
2. P = 0.2 MPa and T=180 °C. Not available in the table, so we need to do a linear interpolation as follows

$$u_{T=180^\circ C} = u_{T150} + (u_{T200} - u_{T150}) \times \frac{T_{180} - T_{150}}{T_{200} - T_{150}}$$

$$= 2576.9 + (2654.4 - 2576.9) \times \frac{180 - 150}{200 - 150}$$

$$= 2623.4 kJ / kg$$

The use of superheated water table Table A-6

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg K
	P = 0.20 MPa (120.23 °C)				P = 0.30 MPa (133.55 °C)			
Sat	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761	7.0778
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115
…	…	…	…	…	…	…	…	…

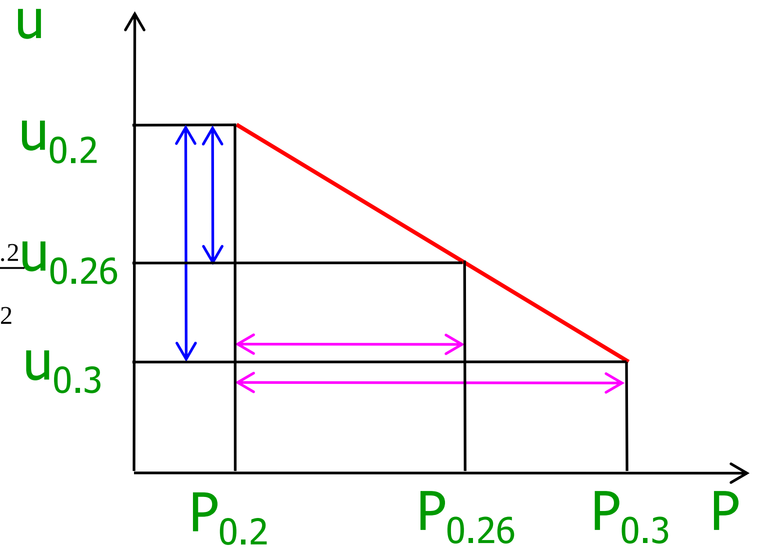
3. P = 0.26 MPa and T=150 °C. Not available in the table, so we need to do a linear interpolation as follows

$$\frac{u_{P\,0.2,T150} - u_{P=0.26MPa,T=150^\circ C}}{u_{P\,0.2,T150} - u_{P\,0.3,T150}} = \frac{P_{0.26} - P_{0.2}}{P_{0.3} - P_{0.2}}$$

$$u_{P=0.26MPa,T=150^\circ C} = u_{P\,0.2,T150} - (u_{P\,0.2,T150} - u_{P\,0.3,T150}) \times \frac{P_{0.26} - P_{0.2}}{P_{0.3} - P_{0.2}}$$

$$= 2576.9 - (2576.9 - 2570.8) \times \frac{0.26 - 0.2}{0.3 - 0.2}$$

$$= 2573.24 kJ/kg$$



Note: internal energy is inversely proportional to pressure over a small pressure range!

The use of superheated water table Table A-6

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg K	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg K
	P = 0.20 MPa (120.23 °C)				P = 0.30 MPa (133.55 °C)			
Sat	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761	7.0778
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115
…	…	…	…	…	…	…	…	…

4. P = 0.26 MPa and T=180 °C. Not available directly in the table, so we need to do a linear interpolation as follows

First, do a linear interpolation to get the value of u at P = 0.26 MPa and T=200 °C
Note: we have known the value of u at P = 0.26 MPa and T = 150 °C from example 3

$$\frac{u_{P0.2,T200} - u_{P=0.26MPa,T=200^oC}}{u_{P0.2,T200} - u_{P0.3,T200}} = \frac{P_{0.26} - P_{0.2}}{P_{0.3} - P_{0.2}}$$

$$u_{P=0.26MPa,T=200^oC} = u_{P0.2,T200} - (u_{P0.2,T200} - u_{P0.3,T200}) \times \frac{P_{0.26} - P_{0.2}}{P_{0.3} - P_{0.2}}$$

$$= 2654.4 - (2654.4 - 2650.7) \times \frac{0.26 - 0.2}{0.3 - 0.2}$$

$$= 2652.18 kJ/kg$$

The use of superheated water table Table A-6

Then, as example 2, do a linear interpolation at P = 0.26 MPa to obtain the value of u at T = 180 ^oC

$$u_{P=0.26MPa,T=180^o C} = u_{P\,0.26MPa,T150} + (u_{P\,0.26MPa,T200} - u_{P0.26MPa,T150}) \times \frac{T_{180} - T_{150}}{T_{200} - T_{150}}$$

$$= 2573.24 + (2652.18 - 2573.24) \times \frac{180 - 150}{200 - 150}$$

$$= 2620.6 kJ / kg$$

The use of compressed liquid water table Table A-7

This table shares similar form as the superheated water table. Therefore, please refer to the demo calculation using Table A-6 for the use of Table A-7

Note: in all the examples above, we take the calculation of internal energy as illustration. Following the same line of calculation, we can obtain all other thermodynamic properties shown on Tables A-4 through A-7, i.e. entropy, specific volume, etc..

End

- Refer to example problems in the textbook for further explanation. Sometimes we must interpolate for temperature as well as pressure.