University of Guelph, School of Engineering

ENGG*3260 Thermodynamics

Lab 1: Water Saturation Temperature And Saturation Pressure

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1. Introduction

The saturation temperature of the water is defined as the temperature in which liquid water changes from the saturated mixture phase to the saturated vapor phase. During this switch water changes from a mixture of liquid and vapor to vapor completely. When analyzing such phase switch, one can analyze that there is a directly proportional relationship between saturation temperature and pressure. In theory, as pressure increase, the saturated temperature increases proportionally. In this lab, we prove this theory by analyzing the temperature of water in a beaker as the pressure change.

2. Objective

The main objective of this lab is to analyze and understand how a change in pressure in a system affects the saturation temperature. To understand this concept, the relationship between the saturation temperature (Tsat) and the saturation pressure (Psat)of water should be analyzed and represented on a Pressure-Temperature graph. The data is then compared to the ideal liquid saturation vapor graph provide from the text.

3. Methodology

A beaker filled with hot water was placed in a sealed bell jar. The pressure in the sealed bell jar was controlled using a vacuum pump by tightening and releasing the valve. The bell jar was sealed using a rubber vacuum platform. Pressure is measured using a pressure gauge reader, and the temperature was measured using a thermocouple.

4. Results

4.1. Experimental Values

Trial #	Temperature (°C)	Vacuum Pressure (inch of Hg)	Abolute Pressure (kPa)	Interpolated Pressure from Table A4 (kPa)	% deviation
1	78	-15	46.97415	44.0084	6.739054362
2	74.5	-16	43.58776	37.8575	15.13639305
3	72.3	-17.5	38.50818	34.6037	11.28340322
4	68	-19	33.42859	29.0984	14.88119622
5	65	-20.5	28.34901	25.043	13.20131374
6	62.6	-21.5	24.96262	22.8309	9.336973137
7	59.7	-22.9	20.22167	19.272	4.927713782
8	56.2	-24	16.49664	16.7672	1.613626604
9	51.6	-24.5	14.80345	13.4435	10.11600402
10	46.3	-25.7	10.73978	10.312	4.148341738

Table 1: Experimental Results

4.2. Experimental Graph representation

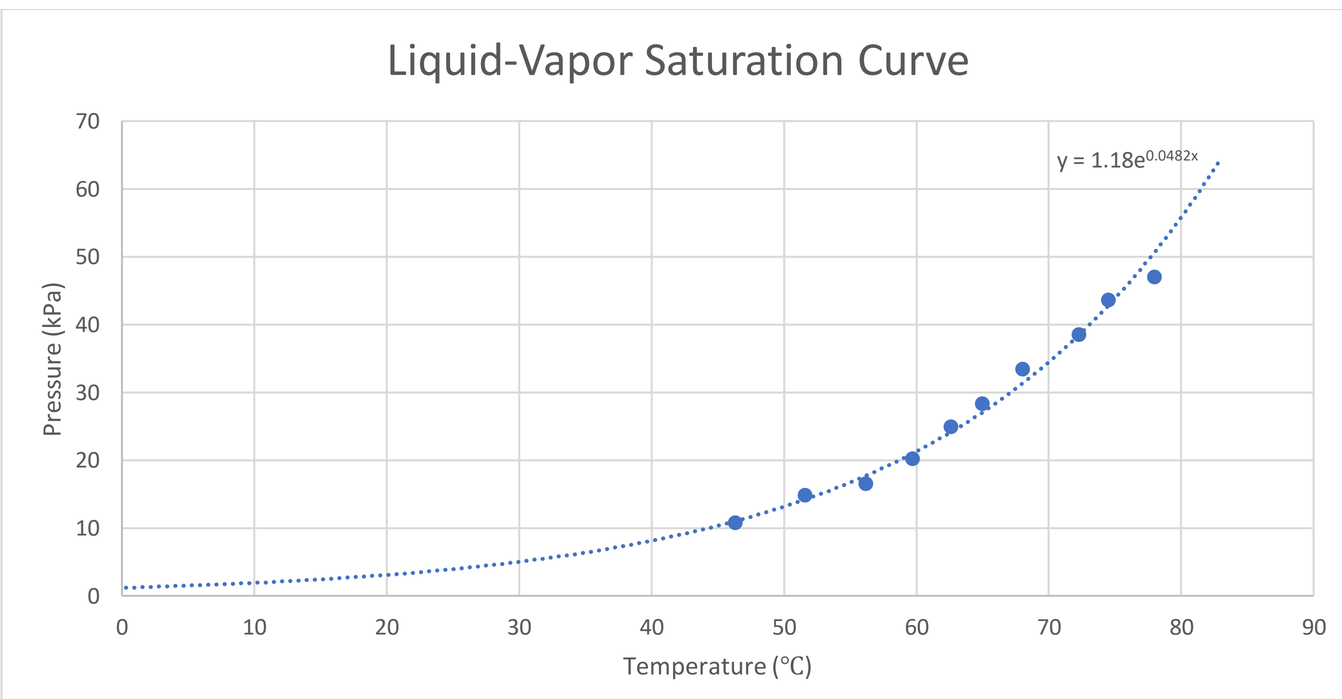

Figure 1: Experimental Results Plot

The plot in Figure 1 shows the saturation temperatures versus pressure using the experimental values collected during the lab. The graph demonstrates an exponential function (y=1.18e^0.0482).

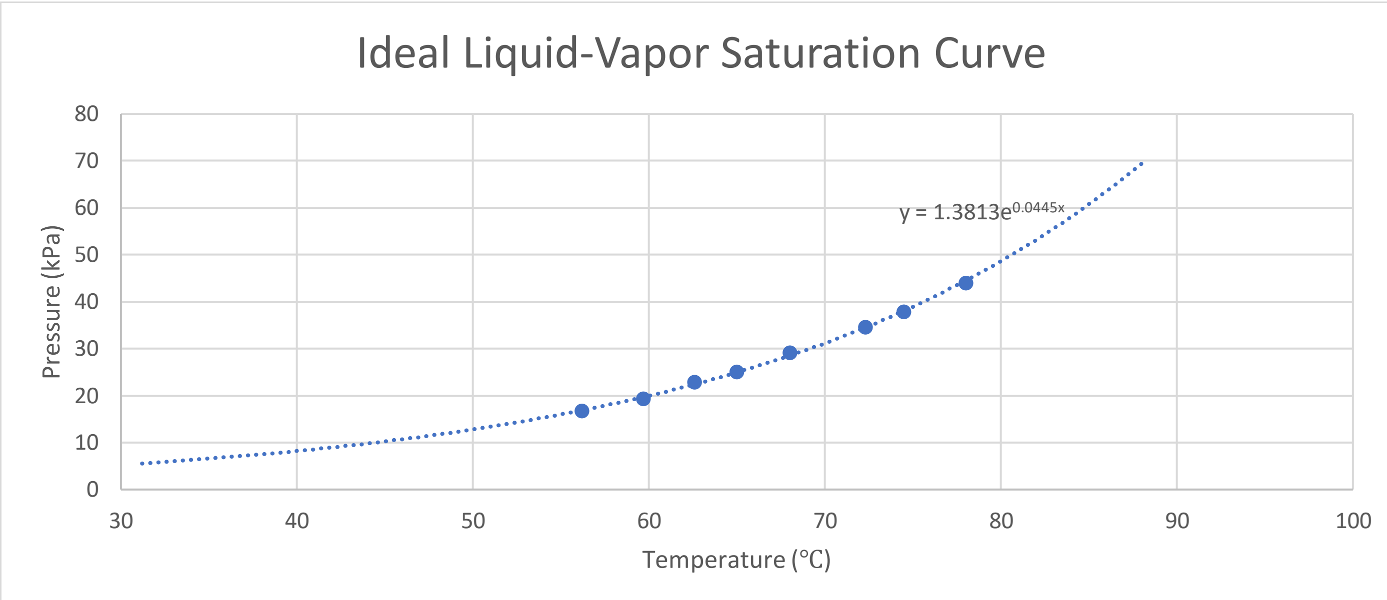

Figure 2: ideal Liquid- Vapor Saturation Curve after interpolation

The plot in figure 2 represents the Ideal Liquid-Vapor Saturation Curve that was graphed using the values from Table A-5 in the text. Values were calculated using the interpolation method as described in the sample calculation section (Section 4.3).

4.3. Sample Calculations

Absolute Pressure

$P = P_{atm} - P1 = 98.65 - (24.0 \times 3.39) = 17.29\ kPa$

(Conversion: 1 in. of Hg = 3.39 kPa)

Interpolation for Pressure from property table

$$P_{sat@57.1°C} = \frac{57.1-55}{60-55} * (19.947 - 15.763) + 15.763 = 17.52\ kPa$$

$$\text{Percentage Error (\%)} = \frac{To-Tp}{To}\ x\ 100 = \frac{17.52-17.29}{17.52}\ x\ 100 = 1.31\ \%$$

5. Observation And Analysis

By reviewing figure 1 and figure 2 in the results section (4.2), one can analyze that the pressure and temperature graphs acquire an exponential correlation. This proves the directly proportional relationship introduced in the introduction section above (Section 1). The exponential equation obtained from figure 1 shows the correlation of the measured temperature and the saturated pressure. The exponential equation from the collected data is calculated to be y = 1.18e0.0482x.

To predict the temperature at a pressure of 200KPA we use the following equation 200 = 1.18e0.0482x to solve for x. The value of x is calculated to be x = 107.5 oC. Using the ideal saturated temperature values obtained from table A-5, the temperature at 200 KPA is calculated to be 120.2 oC. Percentage error was calculated to be 10.4% which is relatively acceptable. This percentage error is caused mostly by human error and parallax error due to the fact that all data was collected manually through observation. More details on error can be reviewed through table 1 in section 4.1.

6. Conclusion

Through the results calculated above, it was concluded that the temperature and the pressure are directly proportional to each other. The graph is an exponential function, as the laws of thermodynamics are obeyed. The maximum percentage error is calculated to be 15.14% which is caused by human error/ parallax error. Through different pressures, the boiling point of water varies. It is faster to reach boiling point as pressure decreases. This property is very useful in many different engineering applications in which reaching boiling point with less energy is required

7. References

Cengel, Yunas A. and Boles, Michael A. Thermodynamics: An Engineering Approach, *8th Edition.* New York: McGraw-Hill Education, 2015.