Using PvT Data For Saturated Water From The Steam Tables, Calculate At 50C:(a) Hg - Hf.(b) Ug - Uf.(c)

Using PvT Data For Saturated Water From The Steam Tables, Calculate At 50°C: (a) Hg - Hf. (b) Ug - Uf. (c)

Understanding the properties of saturated water is fundamental in thermodynamics, especially when analyzing phase change processes such as boiling and condensation. Steam tables serve as an essential resource for engineers and scientists, providing detailed thermodynamic data for water and steam at various pressures and temperatures. In this article, we will explore how to utilize PvT (pressure-volume-temperature) data from the steam tables to calculate specific enthalpy differences and internal energy differences for saturated water at 50°C. These calculations are critical for designing efficient thermal systems, analyzing energy transfers, and performing accurate thermodynamic assessments.

Introduction to Saturated Water and Steam Tables

Saturated water exists at the phase boundary between the liquid and vapor states. At a given temperature, saturated water has specific properties that are well-documented in steam tables, which are organized based on temperature, pressure, and specific volume data.

Key Points About Saturated Water:

- It exists at equilibrium between liquid and vapor phases.
- Its properties are temperature-dependent and can be found in standard steam tables.
- The data include pressure, specific volume, specific enthalpy, and specific internal energy.

Steam tables typically provide data for saturated water and saturated steam at various temperatures, from which critical properties like enthalpy of vaporization are derived.

Understanding the Parameters: Enthalpy and Internal Energy

Before delving into calculations, it is essential to understand the key parameters involved:

- Hf (Enthalpy of saturated liquid water): The specific enthalpy of the liquid phase at saturation.
- Hg (Enthalpy of saturated vapor): The specific enthalpy of the vapor phase at saturation.

- Uf (Internal energy of saturated liquid): The specific internal energy of the liquid phase at saturation.
- Ug (Internal energy of saturated vapor): The specific internal energy of the vapor phase at saturation.

The differences (Hg - Hf) and (Ug - Uf) are significant because they represent the energy required for phase change—namely, the latent heat—and the change in internal energy associated with vaporization.

Step-by-Step Calculation at 50°C

Let's now focus on calculating the specific differences at 50°C, a common reference point in thermodynamics.

Step 1: Find the Saturation Pressure at 50°C

Using standard steam tables, locate the saturation pressure corresponding to 50°C.

From the steam tables:

- Saturation temperature (T): 50°C
- Corresponding saturation pressure (P): approximately 12.352 kPa (or 0.12152 bar)

This pressure is crucial for retrieving the correct property data.

Retrieving Data from Steam Tables

Step 2: Extract Key Properties

Based on the temperature of 50°C, the steam tables provide the following data:

Property	Value
Saturation Pressure (P)	12.352 kPa
Enthalpy of saturated liquid water (Hf)	approximately 209.3 kJ/kg
Enthalpy of saturated vapor (Hg)	approximately 260.9 kJ/kg
Internal energy of saturated liquid (Uf)	approximately 191.8 kJ/kg
Internal energy of saturated vapor (Ug)	approximately 251.3 kJ/kg

Note: Values may vary slightly depending on the source; always refer to the latest or most accurate steam tables.

Calculations of Specific Enthalpy and Internal Energy Differences

(a) Calculate Hg - Hf

This value represents the latent heat of vaporization at 50°C.

Calculation:

$$
Hg - Hf = 260.9\, \text{kJ/kg} - 209.3\, \text{kJ/kg} = 51.6\, \text{kJ/kg}
$$

Interpretation:
- The latent heat of vaporization at 50°C is approximately 51.6 kJ/kg.
- This is the energy required to convert 1 kg of water at saturation temperature from liquid to vapor phase without changing temperature.

(b) Calculate Ug - Uf

This difference signifies the change in internal energy during vaporization.

Calculation:

$$
Ug - Uf = 251.3\, \text{kJ/kg} - 191.8\, \text{kJ/kg} = 59.5\, \text{kJ/kg}
$$

Interpretation:
- The increase in internal energy per kilogram during vaporization at 50°C is approximately 59.5 kJ/kg.
- This energy change accounts for internal energy contributions beyond latent heat, including changes in kinetic and potential energies at the molecular level.

Significance of These Calculations in Thermodynamics

Understanding the differences in enthalpy and internal energy at saturation points is vital for multiple applications:

- Design of Boilers and Condensers: Knowledge of latent heat (Hg - Hf) aids in sizing equipment.
- Energy Balance Calculations: The internal energy difference (Ug - Uf) is used to analyze energy efficiency.

- Thermodynamic Cycle Analysis: Accurate property data allows for precise calculations in Rankine cycles and other heat engine models.

Practical Applications Include:

- Power plant cycle optimization
- HVAC system design
- Refrigeration cycle analysis
- Process engineering involving phase change

Additional Insights and Considerations

When using steam tables for calculations:

- Always verify the temperature and pressure conditions.
- Use the most recent and accurate data tables.
- Recognize the significance of latent heat and internal energy changes in energy transfer processes.
- Be aware of phase equilibrium conditions to ensure valid calculations.

Summary of Key Points:

- At 50°C, the saturation pressure is approximately 12.352 kPa.
- The latent heat of vaporization (Hg - Hf) is approximately 51.6 kJ/kg.
- The change in internal energy (Ug - Uf) is approximately 59.5 kJ/kg.
- These values are critical for thermodynamic system analysis and design.

Conclusion

Utilizing PvT data from the steam tables for saturated water at 50°C enables engineers and scientists to accurately determine important thermodynamic parameters such as latent heat and internal energy differences. Calculating (Hg - Hf) and (Ug - Uf) provides insight into the energy requirements for phase change, essential for designing efficient thermal systems and understanding energy transfer processes. Mastery of these calculations ensures precise analysis and optimal performance in applications ranging from power generation to refrigeration. Always remember to consult reliable steam tables and ensure data accuracy for your specific conditions.

References and Further Reading

- The Properties of Steam by the International Association for the Properties of Water and Steam (IAPWS)
- Thermodynamics: An Engineering Approach by Yunus Çengel and Michael Boles
- Online steam tables and property calculators
- ASHRAE Handbook – Fundamentals

Optimizing your thermodynamic calculations with accurate PvT data from steam tables is a cornerstone of efficient thermal system design.

Frequently Asked Questions

What is the significance of using PvT data for saturated water at 50°C in thermodynamic calculations?

Using PvT data for saturated water at 50°C allows for accurate determination of thermodynamic properties such as enthalpy and internal energy differences, which are essential for analyzing energy transfer processes in steam systems.

How do you find the enthalpy difference (Hg - Hf) for saturated water at 50°C using steam tables?

You locate the saturated water properties at 50°C in the steam tables, identify the values of Hg (vapor enthalpy) and Hf (liquid enthalpy), and subtract Hf from Hg to find the difference: Hg - Hf.

What is the process to determine the internal energy difference (Ug - Uf) for saturated water at 50°C from the steam tables?

First, find the specific internal energy values for saturated vapor (Ug) and saturated liquid (Uf) at 50°C in the steam tables, then subtract Uf from Ug to obtain the internal energy difference.

Why are enthalpy and internal energy differences important in thermodynamic calculations involving saturated water?

They are crucial for calculating work, heat transfer, and energy changes in processes such as boiling, condensation, and other phase change operations in thermal systems.

Can the calculations of Hg - Hf and Ug - Uf at 50°C be directly obtained from standard steam tables?

Yes, standard steam tables provide the necessary data for saturated water at various temperatures, including 50°C, allowing direct extraction of Hf, Hg, Uf, and Ug to compute the differences.

What units are typically used when calculating these thermodynamic properties from the steam tables?

Properties such as enthalpy and internal energy are usually expressed in kilojoules per kilogram (kJ/kg) in the steam tables.

Are the values of Hg - Hf and Ug - Uf temperature-dependent, and how does this affect calculations at 50°C?

Yes, these values vary with temperature; at 50°C, the steam tables provide specific data for saturated water at that temperature, ensuring accurate, temperature-specific property differences for calculations.

Additional Resources

Using PvT Data For Saturated Water From The Steam Tables: Calculate At 50°C (a) Hg - Hf, (b) Ug - Uf

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Introduction

The thermodynamic properties of water and steam are fundamental to countless engineering applications, ranging from power generation to HVAC systems. Accurate data on saturated water and vapor phases underpin the design, analysis, and efficiency calculations of turbines, boilers, condensers, and other thermal systems. Among the most reliable sources of such data are the steam tables, which provide detailed properties at various pressures and temperatures.

This article focuses on the specific case of saturated water at 50°C, exploring the use of pressure-volume-temperature (PvT) data from the steam tables to compute key thermodynamic property differences: (a) the difference between the saturated vapor pressure (Hg) and the saturated liquid enthalpy (Hf), and (b) the difference between the saturated vapor internal energy (Ug) and the saturated liquid internal energy (Uf). Understanding these differences is critical for analyzing phase change processes, calculating work and heat transfer, and evaluating the energy content of water in various states.

Background on Steam Tables and Saturated Water

Steam tables tabulate the thermodynamic properties of water in its various phases—liquid, vapor, and mixed—at equilibrium conditions. The key parameters include:

- Pressure (P): Usually expressed in bar or Pa.
- Temperature (T): In degrees Celsius.
- Specific Enthalpy (H): Energy per unit mass, in kJ/kg.
- Specific Internal Energy (U): Internal energy per unit mass, in kJ/kg.
- Vapor Pressure (Hg): The equilibrium pressure of saturated vapor at a given temperature.

- Specific Volumes (vf for saturated liquid, vg for saturated vapor): Volumes per unit mass.

For a given temperature, the saturation pressure and properties of the liquid and vapor phases are well established. At 50°C, the saturation pressure, as per standard steam tables, is approximately 12.352 kPa (or 0.124 bar).

Step 1: Extracting Data at 50°C from the Steam Tables

To perform the calculations, we first locate the relevant data:

Property	Value at 50°C
Saturation pressure (Hg)	12.352 kPa (0.124 bar)
Enthalpy of saturated liquid (Hf)	approximately 209.3 kJ/kg
Enthalpy of saturated vapor (Hg)	approximately 2792.3 kJ/kg
Internal energy of saturated liquid (Uf)	approximately 105.3 kJ/kg
Internal energy of saturated vapor (Ug)	approximately 2673.0 kJ/kg

Note: The above values are typical from standard steam tables, but actual values may vary slightly depending on the data source.

Step 2: Understanding the Quantities

- Hg (Saturated vapor pressure): This is the pressure exerted by the saturated vapor at 50°C.
- Hf (Enthalpy of saturated liquid): The energy content of water in the saturated liquid phase.
- Hg (Enthalpy of saturated vapor): The total energy (per unit mass) of vapor at saturation.
- Uf (Internal energy of saturated liquid): The internal energy of water in the saturated liquid phase.
- Ug (Internal energy of saturated vapor): The internal energy of water in the vapor phase.

The differences Hg - Hf and Ug - Uf provide insights into the energy content associated with phase change and the energy stored within the phases.

Step 3: Calculating the Differences

(a) Hg - Hf

This represents the latent heat of vaporization at 50°C, i.e., the energy required to convert unit mass of water from saturated liquid to saturated vapor phase.

Calculation:

$$
Hg - Hf = 2792.3\, \text{kJ/kg} - 209.3\, \text{kJ/kg} = 2583.0\, \text{kJ/kg}
$$

Interpretation:
The latent heat of vaporization at 50°C is approximately 2583 kJ/kg. This value is consistent with the general trend that latent heat decreases as the temperature approaches the critical point (373.99°C for water), and at 50°C, it remains substantial.

(b) Ug - Uf

This difference indicates the internal energy change associated with vaporization.

Calculation:

$$
Ug - Uf = 2673.0\, \text{kJ/kg} - 105.3\, \text{kJ/kg} = 2567.7\, \text{kJ/kg}
$$

Interpretation:
The internal energy difference between saturated vapor and saturated liquid at 50°C is approximately 2568 kJ/kg. This closely parallels the latent heat of vaporization, as expected, since internal energy change is a component of the total enthalpy change, with the remainder being PV work.

Step 4: Contextual Analysis and Significance

The Relation Between Enthalpy and Internal Energy

The fundamental thermodynamic relation:

$$
H = U + PV
$$

applies to each phase. For the saturated states, this relation helps understand the energy contributions:

- Hf and Uf represent the energy content of the liquid phase.
- Hg and Ug include the effect of vaporization, pressure-volume work, and phase change energy.

At 50°C, with a relatively low saturation pressure, the PV work component (P·V) is small but non-negligible. Since specific volume values are also available, the PV term can be explicitly calculated and further validated.

Practical Implications

- Power Plants: The large latent heat emphasizes why water is an efficient working fluid for heat transfer in turbines.
- Heating Systems: Knowing the small internal energy difference aids in designing heat exchangers and understanding energy consumption.

- Phase Change Analysis: The close correspondence of Hg - Hf and Ug - Uf illustrates the energy required or released during vaporization.

Step 5: Additional Considerations

Using PvT Data for Precise Calculations

While the above calculations rely on tabulated values, a more detailed approach involves using the PvT data directly, especially when detailed data points are available from the steam tables or software.

- Pressure-Volume Data: PV data at 50°C can be used to refine the PV term calculations.
- Interpolation: For intermediate values, linear or polynomial interpolation between tabulated points ensures accuracy.
- Thermodynamic Consistency: Cross-checks between enthalpy, internal energy, and PV data ensure the internal consistency of the data set.

Conclusion

The utilization of PvT data from the steam tables at 50°C facilitates precise calculations of fundamental thermodynamic property differences for saturated water. The key findings are:

- The latent heat of vaporization (Hg - Hf) at 50°C is approximately 2583 kJ/kg.
- The internal energy difference (Ug - Uf) at the same temperature is approximately 2568 kJ/kg.

These values are critical for thermal system design, efficiency evaluation, and understanding phase change energetics. The close agreement between these two differences underscores the consistency of the thermodynamic data and validates the use of steam tables for detailed energy analyses.

Future work could involve exploring the pressure-volume relationships at 50°C, analyzing the effects of superheating, or extending the methodology to other temperatures and pressures for comprehensive system modeling.

References

- Steam Tables, Thermodynamic Properties of Water and Steam, National Institute of Standards and Technology (NIST) Digital Library.
- Moran, M. J., & Shapiro, H. N. (2008). Fundamentals of Engineering Thermodynamics. John Wiley & Sons.
- Sonntag, R. E., & Borgnakke, C. (2013). Introduction to Thermodynamics: Classical and Statistical. Wiley.

Note: Ensure to verify data with the latest steam tables or thermodynamic software for precise

engineering calculations.

Using Pvt Data For Saturated Water From The Steam Tables Calculate At 50c A Hg Hf B Ug Uf C

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