**10. PROPERTIES OF PURE SUBSTANCES**

**PURE SUBSTANCE:** A substance is said to be pure substance which has same chemical composition throughout its mass. Pure substance can be more than one component and/or phase. E.g. Air (21% O2 & 79% N2), Container filled with water or water and its vapour, Container filled with water (Solid, Liquid, Vapour), Etc…

**SATURATION POINT:** It’s a point where phase change just begins.

**SENSIBLE HEAT TRANSFER:** Heat transfer without phase change. Temperature changes.

**LATENT HEAT TRANSFER:** the heat or energy that is absorbed or released during a phase change of a substance. Temperature remains constant because heat supplied or rejected are used in bond formation or braking.

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| **PHASE TRANSFORMATION OF PURE SUBSTANCE (H2O):** | | |
| Temperature-Entropy Diagram for Water - Wolfram Demonstrations Project | | An Introduction to Phase Change Materials | SpringerLink |
| A rigid tank with a volume of 2.00 m^3 contains 7.34 kg of saturated  liquid-vapor mixture of water at 75 ? C. Now the water is slowly heated.  Determine the temperature at |  | |

In phase change process Pressure and Temperature remains constant.

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| **LATENT HEAT OR ENTHALPY OF EVAPORATION/ VAPORISATION/ CONDENSATION:**  **RELATION BETWEEN PRESSURE AND TEMPERATURE:** If Pressure increase Boiling temperature also increases and vice versa.  **CRITICAL POINT:** It’s point where saturated liquid line, saturated vapour line meet. At critical point,   |  |  | | --- | --- | |  |  | |  |  |   Liquid directly converts to vapours. There is no constant temperature vaporisation. |  |
| **P-V DIAGRAM FOR PURE SUBSTANCE (H2O):**  Slop of liquid line is almost constant because liquids are incompressible. Same way vapours are compressible so slope of line is significant for vapour line. | PV DIAGRAM OF PURE SUBSTANCE IN THERMODYNAMICS - Mechanical engineering  concepts and principles  **H-S (MOLLIER) DIAGRAM FOR PURE SUBSTANCE (H2O):**  Slope of constant pressure line,  During phase change, slope = = Constant. |
| **C:\Users\Shiv\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.MSO\8D7E9855.tmp**  In super-heated region, enthalpy & slope increases with Temp. |

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| In PV diagram, If pressure increase | |
|  |  |

At triple point, According to Gibb’s Phase Rule, Degree of freedom, .

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| **PHASE TRANSFORMATION PROCESSES** | | |
| Vaporisation | Melting or Fusion | Sublimation |
| Condensation | Freezing or Solidification | Deposition |

In PT Diagram of pure substance (H2O),

|  |  |  |  |
| --- | --- | --- | --- |
| **General Substance ()** | | **Water ()** | |
|  |  |  |  |

**CLAPEYRON EQUATION:** Draw PT diagram and get slope experimentally to find latent heat during phase change.

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| --- | --- |
| Using 4th Maxwell Equation, |  |

**CLAUSIUS-CLAPEYRON EQUATION:** Draw PT diagram and get slope experimentally to find latent heat.

|  |  |  |  |
| --- | --- | --- | --- |
| Put below mentioned assumption of Clausius in Clapeyron Eq.,   |  |  | | --- | --- | |  |  | |  |

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| --- | --- |
| **SUB COOLED LIQUID:** | **DEGREE OF SUB COOLING:** |
| **SATURATED MIXTURE OR WET STEAM:** | |
| **SUPERHEATED VAPOURS:** | **DEGREE OF SUPERHEATING:** |

**PROPERTIES OF SATURATED MIXTURE:**

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| --- | --- |
| **Dryness Fraction or Quality of Steam ():**  Represents Mass Fraction of Vapour. |  |
| **Wetness Fraction or Liquid Fraction:**  It Represents Mass Fraction of Liquid. |  |
| **Specific Volume of Saturated Mixture/ Wet Steam:** |  |
| **Specific Enthalpy of Saturated Mixture/ Wet Steam:** | |
| **Specific Entropy of Saturated Mixture/ Wet Steam:** | |
| **Specific Internal Energy of Saturated Mixture/ Wet Steam:** | |

**PROPERTIES OF DRY SATURATED STEAM:**

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| **Specific Enthalpy of Dry Saturated Steam:** |
| **Specific Volume of Dry Saturated Steam:** |
| **Change of Entropy During Phase Change Process:** |
| **Specific Entropy of Dry Saturated Steam:** |
| **Specific Internal Energy of Dry Saturated Steam:** |

**PROPERTIES OF SUPERHEATED STEAM:** Superheated Vapour can be treated as ideal gas.

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| **Specific Enthalpy of Superheated Vapour:** |
| **Specific Volume of Superheated Vapour:** |
| **Specific Entropy of Superheated Vapour:** |
| **Specific Internal Energy of Superheated Vapour:** |

**GIBB’S PHASE RULE:**

|  |  |  |
| --- | --- | --- |
| No. of Phases | Degree of Freedom | No. of Components |

**DEGREE OF FREEDOM ():** The number of properties required to identify the state of system.

**For Simple Compressible System/ Pure Substance:**

**DEGREE OF FREEDOM AT VARIOUS POINTS:**

DOF For Saturated Liquid:

DOF For Saturated Vapour:

DOF For Superheated Vapour:

DOF For Saturated Mixture:

DOF For Saturated Triple Point:

**THROTTLING OF WET STEAM:** It’s Isenthalpic & Adiabatic irreversible process. Due to throttling pressure and temperature after process decrease & Entropy increases due to irreversibility. Hence, due to friction heat generates and dryness fraction of wet steam increases. (TS Diagram Representation)

**THROTTLING OF DRY SATURATED STEAM:** Due to throttling pressure and temperature after process decrease & Entropy increases due to irreversibility. Hence, due to friction heat generates and dry saturated steam molecules absorbs generated head and steam becomes Superheated Steam. (TS Diagram Representation)

**EVALUATION OF CONDITION OF STEAM FROM VARIOUS PROPERTY:**

1. Use Conditions.
2. Use values to compare with .

**STEAM TABLES:**

1. Saturated Water-Temp. Table

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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1. Saturated Water-Pressure Table

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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1. Superheated Water Table

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| --- | --- | --- | --- | --- |
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|  |  |  |  |  |

We can corelate DOF with steam tables. The same thing is highlighted with bolt font (No. of property).

**CHANGE IN ENTHALPY FOR SOLIDS & LIQUIDS:**

|  |  |
| --- | --- |
|  |  |

**REFERENCE POINT FOR CALCULATION:**

**CALCULATION OF ENTHALPY FROM REFERENCE POINT:**

**CALCULATION OF ENTROPY FROM REFERENCE POINT:**