**6. ENTROPY**

**ENTROPY IN CLOSED SYSTEM:**

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| Entropy is a property (Extensive Property). |  |  |

**PHYSICAL MEANING OF ENTROPY:** It’s measure of disorderness of the molecules. Greater the disorderness grater is entropy. And lesser is efficiency.

**TEMPERATURE ENTROPY DIAGRAM:**

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| Area under process Curve on T-S diagram represents heat transfer for reversible process. |  |

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| **P-V DIAGRAM** | **T-S DIAGRAM** |
| Area bounded between reversible process curve and Volume axis represents Work transfer for closed system. | Area bounded between reversible process curve and Entropy axis represents Heat transfer for closed system. |
|  |  |

**CHANGE OF ENTROPY IN REVERSIBLE PROCESS:**

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| --- | --- | --- |
| **REVERSIBLE HEAT SUPPLY** | **REVERSIBLE HEAT REJECTION** | **REVERSIBLE ADIABATIC** |
|  |  |  |
| * Entropy of the system increases. | * Entropy of the system decreases. | * It’s Isentropic Process. |

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| **IMP POINTS W. R. T. ENTROPY IN REVERSIBLE PROCESS:**   * In reversible process entropy may increase, decrease or may remain constant depending on heat transfer.   **VARIOUS PROCESS ON T-S DIAGRAM:**  See the figure and observe lines for expansion, compression, head addition and rejection process lines.  1-2: Reversible Adiabatic Compression,  3-4: Reversible Adiabatic Expansion,  2-3: Heat Addition,  4-1: Heat Rejection, | Thermodynamic Process - an overview | ScienceDirect Topics |

**ENTROPY IN IRREVERSIBLE PROCESS:**

**ENTROPY GENERATION:** Entropy generated during process due to irreversibilities in the system.

**IRREVERSIBILITIES:** The factors which makes a process to be irreversible are called irreversibilities.

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| **TYPES OF IRREVERSIBILITIES** | |
| **INTERNAL IRREVERSIBILITIES** | **EXTERNAL IRREVERSIBILITIES** |
| It’s present due to internal factors in the system. E.g. Fluid molecule frictions, Friction between piston and cylinder wall, Etc… | It’s present due to External factors (Surroundings) in the system. E.g. Heat Transfer from External Source (surrounding), Etc… |
| If it’s zero, Process is Internally Reversible Process. | If it’s zero, Process is Externally Reversible Process. |
| If both are zero, the process becomes Totally/ Completely Reversible process. | |
| **CHANGE OF ENTROPY IN IRREVERSIBLE PROCESS** | |
|  |  |
|  | Where, Change of entropy,  Entropy transfer due to heat transfer,  Entropy Generation due to internal irreversibility |

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| **IN REVERSIBLE PROCESS** | **IN IRREVERSIBLE PROCESS** |
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| **REVERSIBLE HEAT TRANSFER** | **IRREVERSIBLE HEAT TRANSFER** |
| Heat transfer through negligible temperature difference. | Heat transfer through finite temperature difference. |

**CHANGE OF ENTROPY IN IRREVERSIBLE PROCESS:**

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|  |  |
| For Irreversible Heat Supply Process, |  |
| For Irreversible Heat Rejection Process, |  |
| For Irreversible Adiabatic Process, |  |
| For Irreversible Adiabatic Expansion Process, |  |
| For Irreversible Adiabatic Compression Process, |  |

**IMP POINTS W. R. T. ENTROPY IN IRREVERSIBLE PROCESS:**

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| --- |
| In irreversible process entropy may increase, decrease or may remain constant depending on amount of heat transfer. |
| Isentropic process need not to be reversible. It can be irreversible process (From above equation,). |
| Isentropic process need not to be adiabatic. It can be irreversible heat rejection process. |

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| **REVERSIBLE ADIABATIC** | **IRREVERSIBLE ADIABATIC** |
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**ENTROPY PRINCIPLE:**

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|  |  | |
|  | For Reversible Process, | For Irreversible Process, |
|  | For Impossible Process, | |

* Entropy of the universe always increases.

|  |  |
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| FIRST LAW FOR CYCLES: | SECOND LAW FOR CYCLES: |
| FIRST LAW FOR PROCESS: | SECOND LAW FOR PROCESS: |

**TdS EQUATIONS:**

Change of property (Entropy, etc…) is independent of path in the process. And properties are point function. To find change in entropy use following equations.

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| --- | --- | --- |
|  |  | |
| For ideal gas, |  | These equations are valid for reversible and irreversible process. |
| Substituting Enthalpy formula in the 1st law, |  |

**SLOP OF VARIOUS PROCESSES ON THE T-S DIAGRAM:**

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| --- | --- | --- | --- |
|  | | | |
| **REVERSIBLE ISOCHORIC PROCESS** | | **REVERSIBLE ISOBARIC PROCESS** | |
|  |  |  |  |
| **REVERSIBLE ISOTHERMAL PROCESS** | | **REVERSIBLE ADIABATIC PROCESS** | |
|  |  |  |  |
| **REVERSIBLE POLYTROPIC PROCESS** | | **OBSERVATION** | |
| Like other processes |  |  | |

**TS DIAGRAM FOR CARNOT CYCLE:** It’s already given in previous chapter.

**CHANGE OF ENTROPY FOR IDEAL GASES:** Change of entropy in terms of,

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| --- | --- | --- |
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**CHANGE OF ENTROPY IN VARIOUS PROCESS:** From above 3 equations,

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| --- | --- | --- |
| For Reversible Isochoric Process, | For Reversible Isobaric Process, | For Reversible Isothermal Process, |
| For Reversible Adiabatic Process, | | |
| For Reversible Polytropic Process, | | |

**CHANGE OF ENTROPY FOR SOLIDS & LIQUIDS:**

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| **CHANGE OF ENTROPY FOR SURROUNDINGS IN ADIABATIC PROCESS:** |  |

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| **CHANGE OF ENTROPY DUE TO MIXING OF LIQUIDS:** It’s mixing of 2 liquids separated by membrane with initial conditions . | |
| From the First law TD, |  |
| Change of Entropy for mixing, |  |
|  |  |
| Given, |  |
| **It’s irreversible process.** | |

|  |  |
| --- | --- |
| **CHANGE OF ENTROPY DUE TO MIXING OF IDEAL GASES:** It’s mixing of 2 ideal Gases separated by membrane with initial conditions . | |
| Change of Entropy for mixing, |  |
|  |  |
| **It’s irreversible process.** | |
| **CHANGE OF ENTROPY DUE TO MIXING OF DIFFERENT IDEAL GASES:** It’s mixing of 2 ideal Gases separated by membrane with initial conditions And final Conditions . | |
| Here, & |  |
|  |  |
| **It’s irreversible process.** | |
| **CHANGE OF ENTROPY DUE TO MIXING OF SAME IDEAL GASES:** It’s mixing of 2 same ideal Gases separated by membrane with initial conditions And final Conditions . | |
| Here, | Hence, |

**CHANGE OF ENTROPY FOR THERMAL RESERVOIRS:**

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| --- | --- |
| **HEAT SOURCE:** | **HEAT SINK:** |
| **COMBINED HEAT SOURCE & SINK:**   |  |  |  | | --- | --- | --- | |  |  |  | | |

**CHANGE OF ENTROPY FOR FINITE BODIES:**

**FINITE BODY:** It has limited volume and size. If infinite body is considered are called reservoirs.

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| For single Steal Block, |  |
| Two Steel Blocks Joined Together, |  |

**CHANGE OF ENTROPY FOR CYCLIC DEVICES:**

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| --- | --- |
| For All cyclic devices, | E.g. Refrigerator, Heat Engine, etc… |

**A REVERSIBLE HEAT ENGINE BETWEEN IDENTICAL FINITE BODIES:**

|  |  |
| --- | --- |
| Work done by engine,  For reversible process, | Where,  0 (Because of cyclic process), |

**A REVERSIBLE REFRIGERATOR BETWEEN IDENTICAL FINITE BODIES:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Work Supply to refrigerator,  For reversible process, | Where,  0 (Because of cyclic process), | |  |  | | --- | --- | | Body 2(Q1) |  | |  |  | | Body 1(Q2) |  |   **Given,** |

**CHANGE OF ENTROPY FOR FINITE BODIES & RESERVOIR:**

**ELECTRIC COIL AND ATMOSPHERE:**

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

**COPPER BLOCK PLACING/ DROPPING IN LAKE:**

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

**LIQUID WATER AND ATMOSPHERE:**

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| --- | --- | --- |
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**ENTROPY IN OPEN SYSTEM:**

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| --- | --- | --- |
| **CHANGE OF ENTROPY IN OPEN SYSTEM FOR REVERSIBLE PROCESS** | |  |
| **CHANGE OF ENTROPY IN OPEN SYSTEM FOR IRREVERSIBLE PROCESS** |  | |
| For Steady Flow, |  | |

|  |  |  |
| --- | --- | --- |
| **Closed and Open System** | **Closed System and Irr. Process** | **Open System and Irr. Process (Steady State)** |
|  |  |  |

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| **Reversible Adiabatic Process (Open Sys.)** | **Irreversible Adiabatic Process (Open Sys.)** |
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| **ISENTROPIC EFFICIENCY** | | Ch8, Lesson C, Page 4 - Isentropic Efficiency and TS & HS Diagrams | Ch8, Lesson C, Page 10 - Adiabatic Compresion: TS and HS Diagrams |
| **TURBINE** | **COMPRESSOR** |
|  |  |

**STATEMENTS OF THIRD LAW OF THERMODYNAMICS:**

**STATEMENT-I:** It’s impossible to produce finite absolute **Zero Kelvin** temperature in finite number of operations.

**STATEMENT-II:** Entropy of pure crystalline substance is zero at absolute **Zero** **Kelvin** temperature.