

THERMODYNAMICS (Hand out No. 1)

Thermodynamics = Study of the exchange of heat, energy and work between a system and its surroundings.

Adiabatic - Describes a process in which no heat is exchanged with the environment.

Adiabatic Process = No heat is exchanged during change, that is, the system is insulated from its surroundings.

Adiabatic Efficiency of a Compressor - The ratio of the work input required to raise the pressure of a gas to a specified value in an isentropic manner to the actual work input.

Adiabatic Efficiency of a Nozzle - The ratio of the actual kinetic energy of the fluid at the nozzle exit to the kinetic energy value at the exit of an isentropic nozzle for the same inlet state and exit pressure.

Adiabatic Efficiency of a Turbine - The ratio of the actual work output of the turbine to the work output that would be achieved if the process between the inlet state and the exit state was isentropic.

Air-Standard Assumptions - Assumptions used to simplify analysis of complex gas cycles. These assumptions are: (1)The working fluid is air, which continuously circulates in a closed loop and always behaves as an ideal gas. (2)All the processes are internally reversible. (3)The combustion process is replaced by a heat addition process. (4)The exhaust process is replaced by a heat rejection process.

Air-Standard Cycle - A cycle for which the air-standard assumptions are applicable.

Availability - The maximum useful work that can be obtained from a system at a given state in a specified environment.

Binary Vapor Cycle - A power cycle that is a combination of two cycles, one in a higher temperature region and the other in a lower temperature region.

Boundary - A real or imaginary surface that separates a system from its surroundings.

Carnot Cycle - The Carnot cycle is composed of four reversible processes. Two of the processes are isothermal and two are adiabatic. The Carnot cycle can be executed in either a closed or a steady-flow system.

Carnot Efficiency - The efficiency of a Carnot cycle operating between two thermal reservoirs. The Carnot efficiency is the highest efficiency that a heat engine operating between two temperatures can have. The Carnot efficiency is equal to $(1 - (\text{lowest temperature}) / (\text{highest temperature}))$.

Carnot Heat Engine - A Carnot heat engine is a hypothetical heat engine that operates on the Carnot cycle.

Carnot Principles - (1) The efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs. (2) The efficiencies of all reversible heat engines operating between the same two reservoirs are the same.

Carnot Refrigerator or Carnot Heat Pump - A refrigerator or heat pump that operates on the reversed Carnot cycle.

Chemical Reactions: A chemical reaction is a process that leads to the transformation of one set of [chemical substances](#) to another.

Clausius Inequality - The Clausius inequality states that the cyclic integral of dQ/T (change in heat over temperature) is always less than or equal to zero. (The equality holds for totally reversible or internally reversible cycles, while the inequality holds for irreversible cycles.)

Clausius Statement - States that it is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower temperature body to a higher temperature body. The Clausius Statement is a form of the second law of thermodynamics

Closed Feedwater Heater - A device that is often used in vapor power plants. In a closed feedwater heater, heat is transferred from steam extracted from a turbine to feedwater entering a boiler. The steam and feedwater do not mix.

Closed System - A system with fixed mass. Heat, work energy, and volume are not necessarily fixed.

Closed systems = No mass can be exchanged, only heat, energy and work. These are usually encountered in the laboratory .

Coefficient of Performance of a Heat Pump - A measure of the efficiency of a heat pump. The coefficient of performance of a heat pump is defined as the fraction of the desired output over the required input of the heat pump.

Coefficient of Performance of a Refrigerator - Coefficient of performance of a refrigerator is the efficiency of a refrigerator and is defined as the fraction of the desired output over the required input of the refrigerator.

Cold-Air-Standard Assumption - Used to simplify the analysis of gas cycles. Includes all of the air-standard assumptions in addition to the assumption that the working fluid (air) has constant specific heats.

Compression Ratio - The ratio of the maximum volume to the minimum volume formed in the cylinder of a reciprocating engine.

Conservation of Energy Principle (for a general steady-flow system with multiple inlets and exits) - The total energy crossing boundary as heat and work per unit time equals the total energy transported out of control volume with mass per unit time minus total energy transported into control volume with mass per unit time.

Conservation of Mass Principle (for a control volume) - The net change in mass within control volume equals the total mass entering control volume minus total mass leaving control volume.

Cutoff Ratio-The ratio of the cylinder volumes before and after the combustion process in a diesel engine.

Cyclic Process - A process in which the initial and final states are identical.

Diffuser- A device that increases the pressure of a fluid by decreasing the velocity of the fluid.

Endothermic change = one in which ΔH is + , heat is absorbed.

Enthalpy-Enthalpy is a measure of the total [energy](#) of a [thermodynamic system](#).

Enthalpies of Formation-The standard enthalpy of formation is a measure of the energy released or consumed when one mole of a substance is created under standard conditions(in the standard state of 1 atm of pressure and temperature of 298.15 K) from its pure elements.

Entropy - A measure of molecular disorder.

Entropy Balance for Closed Systems - The entropy change of a closed system during a process is equal to the sum of the entropy transferred through the system boundary by heat transfer and the entropy generated within the system boundaries as a result of irreversibilities.

Entropy Balance for Control Volumes - The rate of the entropy change within the control volume (dS_{cv}/dt) during a process is equal to the sum of the rate of entropy transfer through the control volume boundary by heat transfer, the net rate of entropy transport into the control volume by mass flow, and the rate of entropy generation within the boundaries of the control volume as a result of irreversibilities.

Entropy Generation-A measure of the irreversibilities or imperfections which occur during a cycle.

Exothermic change = one in which ΔH is $-$, heat is liberated.

Extensive Property - A property dependent on the size or extent of the system. (Most extensive properties are denoted by uppercase letters.)

Externally Reversible - A process is called externally reversible if no irreversibilities occur outside the system boundaries during the process.

Flow Work (or Flow Energy) - The work required to push mass into or out of the control volume. Flow work is necessary for maintaining a continuous flow through a control volume.

Heat Engine - A heat engine is a device used to convert heat to work. All heat engines can be characterized by the following: (1)They receive heat from a high-temperature source (solar energy, oil furnace, nuclear reactor, etc.). (2)They convert part of this heat to work (usually in the form of a rotating shaft). (3)They reject the remaining waste heat to a low-temperature sink (the atmosphere, rivers, etc.). (4)They operate on a cycle.

Heats of Reactions-The Heat of Reaction (also known as Enthalpy of Reaction) is the change in the [enthalpy](#) of a chemical reaction that occurs at a constant pressure.

Heat Pump - A heat pump is a device that transfers heat from a low-temperature medium to a high-temperature medium.

Heat Regeneration - A process during which heat is transferred to a thermal energy storage device (regenerator) during one part of the cycle and is transferred back to the working fluid during another part of the cycle.

Heat Reservoir - A heat reservoir is a thermal energy reservoir that supplies or absorbs energy in the form of heat. Both sources and sinks are heat reservoirs.

Ideal Cycle- A model cycle which resembles an actual cycle but contains no internally irreversible processes.

Internal Energy =Energy intrinsically possessed by a system (due to mass, structure, temperature, etc.)

Ideal Gas Law - An equation of state that is generally accurate only at low pressure and/or high temperature. The ideal gas law states that: $PV = nRT$

where P = pressure, V = volume, n = number of moles, R = universal gas constant, and T = temperature.

Ideal Rankine Cycle - An ideal Rankine cycle does not involve any internal irreversibilities and consists of the following four processes: 1-2, isentropic compression in a pump; 2-3, heat addition in a boiler at constant pressure; 3-4, isentropic expansion in a turbine; 4-1, heat rejection in a condenser at constant pressure.

Increase of Entropy Principle - States that the total entropy change associated with a process must be positive or zero.

Intensive Property - A property which does not depend on mass. (Intensive properties are usually denoted by lowercase letters.)

Internal Energy - A property whose value is the sum of all the microscopic forms of energy.

Internally Reversible - A process where no irreversibilities occur within the system boundaries.

Internally Reversible Adiabatic Process (Isentropic Process) - A process that involves no heat transfer (adiabatic) and no irreversibilities within the system (internally reversible). The entropy of a fixed mass must remain constant during an isentropic process.

Internally Reversible - A process in which no irreversibilities occur within the system boundaries.

Irreversible Process - A process that leaves a trace on the surroundings when reversed.

Irreversibility - Any difference between the reversible work and useful work.

Isobaric - Describes a process for which the pressure is constant.

Isobaric Process = One at constant pressure [$\Delta P = 0$].

Isochoric - Describes a process for which the volume is constant.

Isothermal Process = One at constant temperature (supply or take away just enough heat so that the temperature remains constant).

Isolated System - A special case in which energy does not cross the boundary of the system.

Isolated system = No mass, heat or work can be exchanged. The universe is an example of an isolated system.

Isothermal - Describes a process for which the temperature is constant.

Mass Flow Rate - The amount of mass flowing through a cross sectional area per unit time.

Mixing Chamber - An area where two or more fluids mix together.

Multistage Compression with Intercooling - A technique where a gas is compressed in stages and cooled between each stage by passing the gas through a heat exchanger called an intercooler.

Nozzle - A device that increases the velocity of a fluid at the expense of pressure.

Open feedwater heater - An open feedwater heater is a mixing chamber where steam extracted from a turbine mixes with feedwater entering a boiler.

Open System or Control Volume - A selected region in space, often used to study mass flow. Both mass and energy can cross the boundary of an open system.

Open systems = Mass can be exchanged in addition to heat, energy and work.

Path - The series of states a system passes through during a process.

Pressure ratio - The ratio of high pressure to low pressure in a Brayton cycle.

Process - Any change that a system undergoes from one equilibrium state to another.

Pump - A device that functions like a compressor, but handles liquids instead of gases.

Pure Substance - A substance that has a single composition throughout.

Refrigerator - A device that transfers heat from a low temperature medium to a high temperature medium.

Regeneration - A process in which a feedwater heater uses steam extracted from a turbine to preheat water entering a boiler. Regeneration is often used in power plants.

Reversible change Or Reversible Process = an idealized change carried out very slowly by allowing one restraining variable to be infinitesimally different from its equilibrium value; the system is essentially at equilibrium at all times during the change.

An alternative definition of a *reversible process* is a process that, after it has taken place, can be reversed and causes no change in either the system or its surroundings.

Reversible Process - A process in which the system can be returned to its initial state without leaving any trace on the surroundings. (Both the system and the surroundings can be returned to their initial states at the end of a reversible process.)

Reversible Work - The maximum amount of useful work that can be obtained as a system undergoes a process between specified initial and final states.

Sink - A sink is a reservoir that absorbs energy in the form of heat.

Source - A source is a reservoir that supplies energy in the form of heat.

Standard Conditions- (pressures of 1 atm and temperature of 25°C)

Steady-Flow Process -A process during which a fluid flows steadily through a control volume. A steady-flow process is characterized by the following: (1)No properties (intensive or extensive) within the control volume change with the time. (2)No properties change at the boundaries of the control volume with time. (3)The heat and work interactions between a steady-flow system and its surroundings do not change with time.

Surroundings - The mass or region outside of a system.

Surroundings Work - The work done by or against the surroundings during a process.

System - A quantity of matter or a region in space chosen for study.

THE FIRST LAW OF THERMODYNAMICS(Law of Conservation of Energy)- The total energy of the universe (or any isolated system) is constant. Energy can neither be created nor destroyed but can be converted from one form to another.

Thermal Efficiency - Thermal efficiency is the fraction of the heat input that is converted to net work output. Thermal efficiency is a measure of the performance of a heat engine.

Thermal Energy Reservoir - A thermal energy reservoir is a hypothetical body with a relatively large thermal energy capacity (mass times specific heat) that can supply or absorb finite amounts of heat without undergoing any change in temperature.

Thermodynamic Temperature Scale - A temperature scale that is independent of the properties of the substances that are used to measure temperature.

Thermodynamic Equilibrium - Occurs when the same temperature exists throughout the system.

Third Law of Thermodynamics - States that the entropy of a pure crystalline substance at absolute zero temperature is zero.

Throttling Valve - Any kind of flow-restricting device that causes a significant pressure drop in the working fluid. The pressure drop is often accompanied by a large drop in temperature. Throttling valves are often used in refrigeration and air-conditioning applications.

Totally Reversible - A process is totally reversible if it involves no irreversibilities within the system or its surroundings.

Trap - A trap is a device which allows liquid to be throttled to a lower pressure region but traps any vapor.

Turbine - A device that converts heat energy into work energy.

Uniform-Flow Process - An unsteady-flow process with the following idealizations: (1) At any instant during the process, the state of the control volume is uniform (i.e., it is the same throughout). The state of the control volume may change with time, but it will do so uniformly. (2) The fluid properties may differ from one inlet or exit to another, but the fluid flow at an inlet or exit is uniform and steady. The properties do not change with time or position over the cross section of an inlet or exit.

Unsteady-Flow Process (or Transient-Flow Process) - The process which involves changes within the control volume with time.

Volume Flow Rate - The volume of a fluid flowing through a cross sectional area per unit time.

Working Fluid - A fluid to and from which heat is transferred in a cyclic device.