THERMODYNAMICS

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Buku ini ditulis dalam Bahasa Inggris yang terdiri dari tujuh bab yaitu konsep dasar termodinamika, persamaan keadaan, differensial dalam termodinamika, hukum pertama termodinamika, konsekwensi dari hokum pertama termodinamika, hukum kedua termodinamika dan entropy dan pontensial termodinamika.

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PREFACE

Praise the presence of Allah subhanahuata'ala, the author can finish this book with the title "Thermodynamics" that can use as references in studying thermodynamics. Thermodynamics is apart of the physics subject that explain about conservation of energy. In this book gives the basic concepts of thermodynamics, the basic laws of thermodynamics and their applications in science and engineering.

This book is written in English which consists of seven chapters namely the basic concepts of thermodynamics, state equations, the differential in thermodynamics, the first law of thermodynamics, the consequences of the first law of thermodynamics, the second law of thermodynamics and entropy and potential thermodynamics. All the subject is included with the application of the thermodynamics science and technology

The author would like thank to the State University of Padang for supporting the publication of the book. Furthermore, thank my beloved wife Fajar Febriany, S.Pd, beloved child Luthfiya Zahrany Fakhrozy, Qatrunnada Azzahra Fakhrozy and Naurah El Mumtaza Fakhrozy and the two beloved parents for their support and prayers.

The author realizes that nothing is perfect, criticism and suggestions for improving the content of this book are highly expected. Wassalam.

Padang, 7 September 2019

Author

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CHAPTER I
BASIC CONCEPTS OF THERMODYNAMICS

1.1 INTRODUCTION

Thermodynamics is a branch of Natural Sciences who studies heat transfer, thermal interconversion and work in a variety of physical and chemical processes. It can also be said to be studying the thermodynamic energy and transpormasinya (Yunus cengel, 2008). An underlying thermodynamics is the principle of conservation of energy. Simply stated during an interaction, energy can change from one form to another but the total amount of energy remains constant. So that energy can not be created or destroyed.

System macroscopic thermodynamics are reviewed based approach that consists of a number of particles called molecules. Macroscopic approach regardless of the behavior of each particle but the average effect of a molecule. This effect is perceived by our senses and can be measured with a gauge. For example, pressure, temperature etc.. This approach is used in classical thermodynamics.

Another approach is the approach in the study of microscopic systems and statistics. Microscopic approach where the system considered consists of a large number of particles, each particle has a particular trait. Statistical approach based on statistics and probability theory (probability theory), in this case sought is the average value for all particles studied. This approach is studied in statistical mechanics and statistical physics. If all these approaches applied to the same system will produce the same results.

Field of Thermodynamics there are Thermodynamics Klassik: Looking at the energy transfer and work in macroscopic systems, regardless of the interaction between the particles and force (microscopic). Statistical Thermodynamics: Seeing the microscopic behavior, describes the energy relationship based on statistical properties of a large number of atoms / molecules. Chemical Thermodynamics: Focus on energy transfer in chemical reactions and work on chemical systems. Engineering Thermodynamics: Use of Thermodynamics in some heat engines and processes involving energy transfer. Examples of heat engine, refrigerator, air conditioning, nuclear power stations, rocket accelerator systems and others

1.2 SYSTEM THERMODYNAMICS (CLOSED SYSTEM, OPEN AND ISOLATED)

Thermodynamic system is a substance (solid, liquid, gas) or materials restricted by a closed surface either real or imaginary closed surface which is the object of investigation. The area outside the system called the Environment. Real or imaginary surface that separates the system with the so-called boundary wall (boundary), the boundary system can be fixed (fixed) or mobile (movable). Physically enveronment is a space that is outside the boundary. So everything that is outside the system is called the surroundings

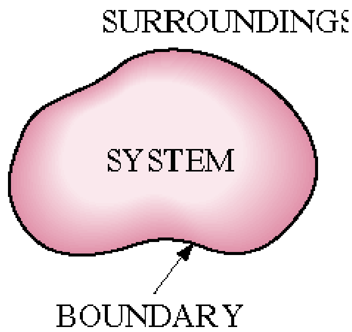


Figure 1-1. System

The system may be considered as a closed or open system depending on whether the mass or volume of the system remains fixed on a selected area of study. **Closed system** consisting of a number of fixed mass and no mass exit barrier system. Limiting closed system can be fixed or mobile. As an example of a closed system is gas in an enclosed tank, the gas piston slinder. But the heat energy can escape. So A closed system is a system that can only exchange energy with the environment, while its mass remains.

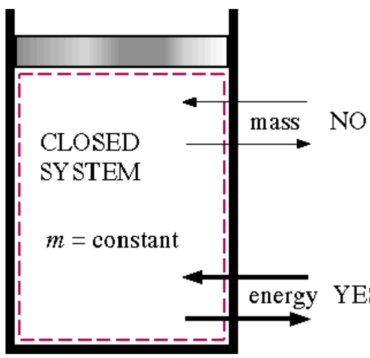


Figure 1-2. Closed system

An **open system** has the mass and energy can cross the barrier wall system. For example, open systems are air pumps, compressors, turbines, valves and heat exchangers. So open system is a system that can perform mass and energy exchange with the environment. Examples of tools that an open system such as compressor, turbine, or nozzle. Nozzle is a tool to convert energy into kinetic energy in the fluid.

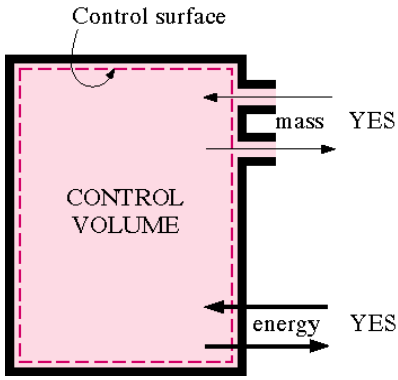


Figure 1-3. An open system

Example applications of open systems

The gas turbine engine is a device that utilizes gas as a fluid to turn a turbine with internal combustion. Gas turbines are widely used by aircraft, jet engines, helicopters and electric energy generation. In the gas turbine kinetic energy is converted into mechanical energy through compressed air that turns the wheels turbine to produce power. System is the simplest gas turbine consists

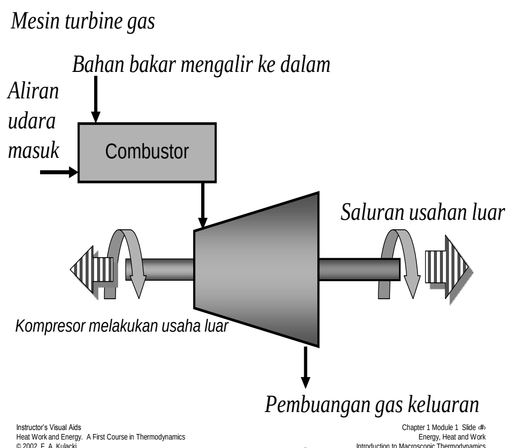


Figure 1-4. Gas turbine system

of three components, namely the compressor, combustion chamber and gas turbine

Working Principle Gas Turbine Systems (Gas-Turbine Engine)

Air into the compressor through the air inlet (inlet). Compressor serves to suck and raise the air pressure, so the air temperature also increases. Then the compressed air enters the combustion chamber. In the combustion chamber combustion process is carried out by mixing compressed air and fuel. The burning process takes place in a state of constant pressure combustion chamber so that it can be said only to raise the temperature. Combustion gases are supplied to the gas turbine through a nozzel that serve to direct the flow to the turbine blades. The power generated by the gas turbine is used to turn the compressor itself and rotate loads such as electric generators, etc.. After passing the gas turbines will be thrown out through the exhaust (exhaust).

Isolated system in general which have masses remain where there is no heat coming out of the wall. So isolated system is a system that can not perform mass and energy exchange with the environment, for example, water in a flask.

1.3 MICROSCOPIC AND MACROSCOPIC POINT OF VIEW

In system thermodynamics, ***macroscopic approach*** reviewed based approach that consists of a number of particles called molecules. ***Macroscopic approach regardless of the behavior of each particle but the average effect of a molecule***. This effect is perceived by our senses and can be measured with a gauge. For example, pressure, temperature etc.. This approach is used in classical thermodynamics. Another approach is the approach in the study of microscopic systems and statistics. ***Microscopic approach where the system considered consists of a large number of particles, each particle has a particular trait***. Statistical approach based on statistics and probability theory. in this case sought is the average value for all particles studied. This approach is studied in statistical mechanics and statistical physics. If all these approaches applied to the same system will produce the same results.

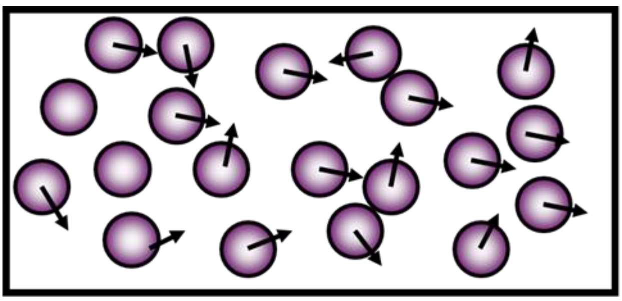


Figure 1-5. Microscopy Approach

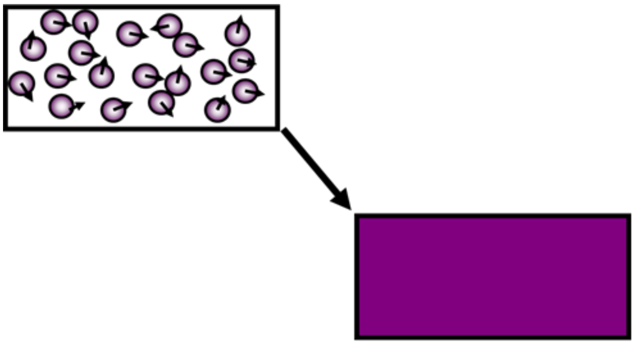


Figure 1-6. Macroscopic Approach

Macroscopic Approach →(Produce Thermodynamics)

- The system is seen as a whole that has certain properties as system properties
- Formulas and physical quantities obtained through experiments
- The number of macroscopic coordinates only slightly
- Thermodynamic coordinates can be measured directly

Microscopy Approach →(Produce Physics Statistics)

- The system considered consists of a large number of particles, each particle has a particular trait
- Formulas and physical quantity derived as theoretically
- Total as Coordinator of microscopic particles same numbering particle of the system
- Thermodynamic coordinates can not be measured directly

1.4 STATE VARIABLE OF THERMODYNAMICS

Some characteristics of the system in a state of equilibrium is called ***property of the system***. The state of the system is determined by the property or system variable that does not depend on the path used to get to a certain condition. Quantities that affect the system is called coordinate thermodynamic or ***coordinate system*** or also called state properties of system. Some thermodynamic properties are ***pressure*** (P), ***temperature*** (T), ***volume*** (V) and ***mass*** (m). The properties system are divided into intensive and extensive properties

Intensive and Extensive properties

Extensive properties is a ***properties of system that directly related to the size of the system***. Some of the extensive properties such as total mass, total volume, and total energy, momentum.

***Intensive* properties** is a ***properties of system* that does not depend on the mass of the system.** Several intensive properties such as temperature, pressure, age, density, color and more. To determine which properties were included into the variable intensive or extensive, can be done by dividing the system into two equal parts. As Figure 1-8

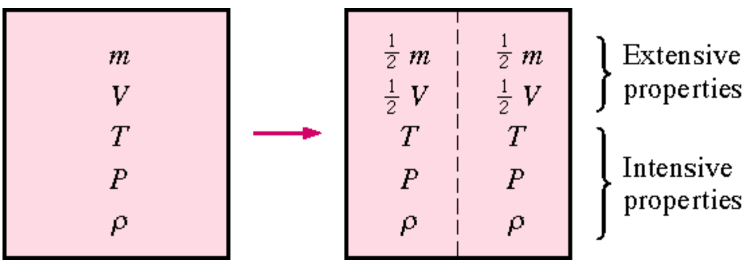


Figure 1-8. Criteria for extensions or intensive nature

If these properties change with the size of the system, then the variable is included into the extensive properties and other is intensive properties. Extensive properties per unit mass is specifics properties. For example, the specific volume, defined as

$$v = \frac{Volume}{mass} = \frac{V}{m}\left(\frac{m^3}{kg}\right)$$

comparisons of properties systems extensively with mole called molal specifics. (n). specific molal volume can be written

$$\text{v} = \frac{\text{V}}{\text{n}}$$

1.5 THERMODYNAMIC EQUILIBRIUM

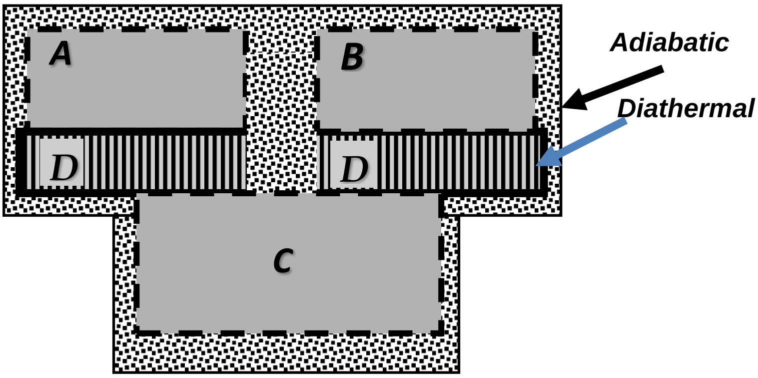
A system is in a state of equilibrium does not change when the system is isolated from its surroundings. Thermodynamic equilibrium will be achieved, if the system is in ***thermal equilibrium*** (uniform temperature), ***mechanical*** (uniform pressure), ***phase*** (the mass of two phases, eg, ice and liquid water, in equilibrium) and ***chemical equilibrium***

- **Thermal equilibrium** : When the temperature of the whole system is really the same although the system is contacted through the diathermal wall the environment
- **Mechanical equilibrium** (pressure): where there is no change in pressure at any point in the system any time, although the pressure can change with altitude
- **Phase Equilibrium**: When the mass of each phase is achieved in a state of equilibrium

- **chemical equilibrium**: If no changes in the chemical composition the system of the changing times.

1.6 ZERO LAW OF THERMODYNAMICS

Two objects are in thermal equilibrium condition is reached when the two objects of the same temperature. If two objects are in a state of thermal equilibrium with a third object, the third object is also said to thermal equilibrium with each other. This fact is recognized by the ***zero laws of thermodynamics***



Two systems are in thermodynamic equilibrium with a third system

1.7 QUASI-STATIC AND NON- QUASI-STATIC PROCESS

- **PROCESS**

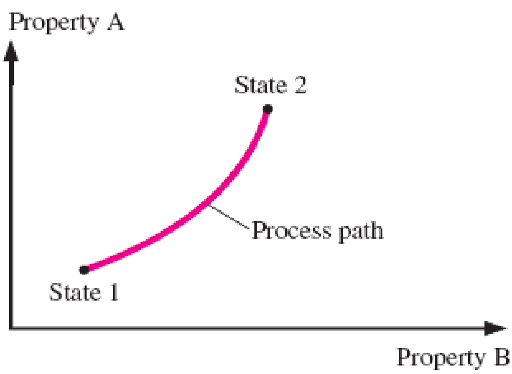


Figure 1-9. Graphs of the state 1 to state 2

Changes state from one state to another is called a **process**. The series of circumstances that passed during the process known as due process. To facilitate the study and analyze (using equation of state) a process we looked at the process from a system running quasistatic. **quasistatic process** is a process that occurs slowly berlahan so that every time the system is always in a state of equilibrium,

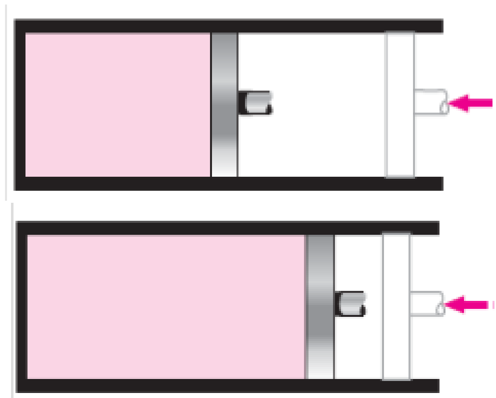


Figure 1-10. Process nonquasistatic and nonquasistatic

and otherwise non kuasistatik. When the gas pressure in the cylinder piston suddenly, molecules that are near the surface of the piston does not have enough time to move the molecules accumulate in the area in front of the piston, thus creating a high pressure area. Because the pressure in the piston is different in the two parts and the process is not done slowly (nonquasistatic) dikatan then the system can not be in equilibrium conditions. So this process occurred in nonkuasistatik.

If the piston moves slowly, the molecules have enough time to move and there is no accumulation of the molecules in front of the piston so that the pressure inside the cylindrical always approach the same in all places, and is said to take place caseatic equilibrium. For both these process are illustrated in Figure 1-10.

In a large partly process which we will study, the thermodynamic properties held constant. Some processes such as table beside. diagram PV of the process isothermal

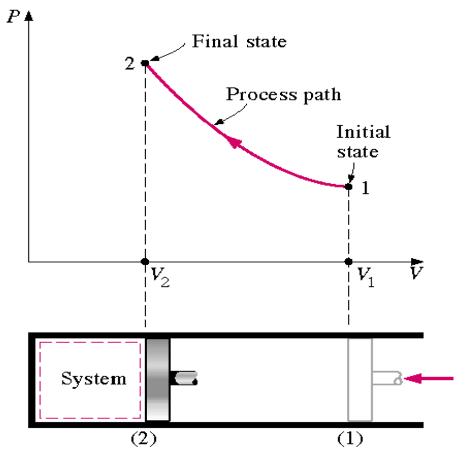


Figure 1-10. Graph P-V in the compression

compression, the state of the system and the state 1 volume 2 volume system where the volume of the process is said to be due to the compression process characterized by reduced volume (fugure 1-10).

- **CYCLE**

Process	Fixed variable
Isobaric	Pressure (P)
Isothermal	Temperature (T)
Isochoric	Volume (V)
Adiabatic	Calor (Q)
Isentropic	Entropy (S)

In the cycle process, initial state same with the final state of system. besides is a cyclic process consists of two processes, A and B. During the (process A), the pressure and the volume change from state 1 to state 2. For one cycle of pressure and volume change from state 2 to state 1 (process B). Acording the process shows that the pressure is a function of volume. So it is conceivable that the thermodynamic properties can be changed

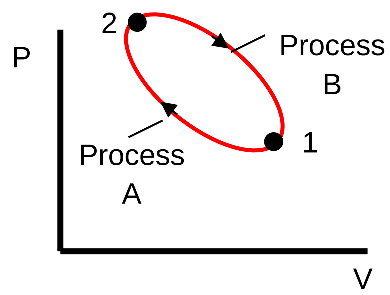


Figure 1-11. Process Cycle

1.8 Temperature and Scale

Although we are familiar with temperature as a measure of "hotness" or "coldness," it is not easy to give an exact definition for it. ***Temperature*** is ***thermodynamic properties*** *that* ***measure the embodied energy of a mass***. When heat energy is transferred to the object, the energy and temperature on the object would rise. In fact the difference in temperature that caused the flow of energy is called the ***heat transfer***, the flow of heat from hot objects to cold.

Temperature scales enable us to use a common basis for temperature measurements, and several have been introduced throughout history. All temperature scales are based on some easily reproducible states such as the freezing and boiling points of water, which are also called the ice point and *steam point*

- ***Ice point*** *:* A mixture of ice and water that is in equilibrium with air saturated with vapor at 1 atm presure
- ***Steam point*** : a mixture of liquid water and water vapor (with no air) in equilibrium at 1 atm pressure

  In making the thermometer scale, X we denote the thermodynamic properties to be used in making a temperature scale. choose linear function

$$T(X) = aX$$

a is a constant to be calculated. To determine the constants of a, we have chosen a fixed point where all of the thermometer should give the same readings for temperature T. Fixed point is used the triple point of water, that is the point at ice, liquid water and water vapor are together in a state of equilibrium. To calibrate we use the triple point cells

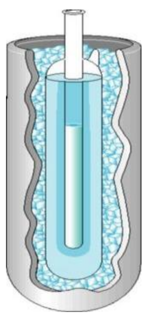


Figure 1-12. triple point cells

To be calibrated thermometer by dipped into the well of the middle triple point cells. Temperature at this condition is equilibrium 273.16 Kelvin (K) (vapor pressure at the triple point of 4.58 mmHg). Can be solved for a

$$a = \frac{273{,}16\ K}{X_{Tp}}$$

X_{Tp} is value of thermodynamic property (Tp) at the triple point, so in general can be written

$$\boldsymbol{T(X) = 273,16K\frac{X}{X_{Tp}}}$$

For liquid thermometer, the Thermodynamic properties is the column length (L), L = L (T) can be written

$$\boldsymbol{T(L) = 273,16K\frac{L}{L_{Tp}}}$$

For gas thermometer at constant pressure, the thermodynamic properties is gas volume V, V=V (T) can be written

$$\boldsymbol{T(V) = 273,16K\frac{V}{V_{Tp}}}$$

For gas thermometer at constant pressure, Thermodynamic property of thermometer is volume of gas V, V = V (T) can be written

$$\boldsymbol{T(P) = 273,16K\frac{P}{P_{Tp}}}$$

For platinum resistance thermometer, Thermodynamic properties are platinum resistance R, R = R (T) can be written

$$\boldsymbol{T(R) = 273,16K\frac{R}{R_{Tp}}}$$

EXAMPLE 1-1

A platinum resistance thermometer 90.35 ohm resistance if entry into the triple point cells. If entriy to other environment is 96.28 ohm resistance. What is the environmental temperature

SOLUTION 1-1

$$T(R) = 273{,}16K\,\frac{R}{R_{Tp}}$$

$$T(R) = 273{,}16K\,\frac{96{,}28\text{ K}}{90{,}35\text{K}} = 280{,}6\ K$$

Kind liquid thermometer scale

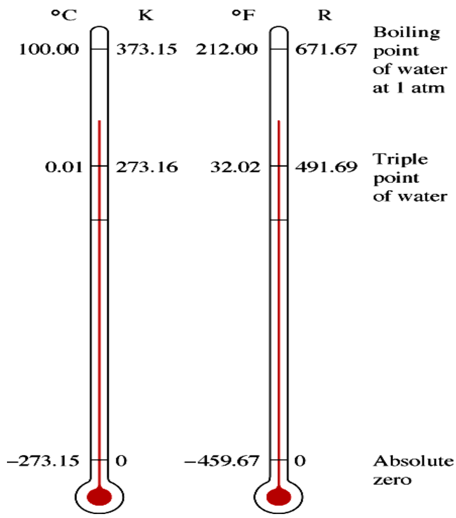


Figure 1-13 Skala termometer

$$\frac{K-273}{100} = \frac{C}{100} = \frac{R}{80} = \frac{F-32}{180} = \frac{R_a-491}{180}$$

$$\frac{K-273}{5} = \frac{C}{5} = \frac{R}{4} = \frac{F-32}{9} = \frac{R_a-491}{9}$$

Thermometer in units of Kelvin K, C in Celsius, R in Reamur, F in Fahrenheit, Ra in the Rankine

Calibration of liquids thermometer

Calibration of thermometer is the process of scaling on a plain thermometer. Calibration of a thermometer through 4 steps / stages:

1. Determine the fixed point below. On the Celsius scale, the fixed point is marked with 0^oC. thermometer inserted perpendicularly into the container funnel containing pure ice. Take a few minute in order to high level of mercury in the capillary tube does not change. This means the temperature of the thermometer is the same as the temperature of ice is being melted.
2. Determining fixed point above. On the Celsius scale, the fixed point is marked with 100^oC. The thermometer placed just above the surface of the water in the vessel. Heat the water to boiling. Allow some time in order to the temperature thermometer equal to the temperature of the water vapor.
3. Divide the distance between fixed point below and fixed point above into equal parts. On the Celsius scale, the distance of the two points divided by 100 parts.
4. The scale can be expanded under the fixed point (negative number) and above a fixed point on (more than 100).

1.9 TYPES OF THERMOMETERS

1. VOLUME-CONSTANT GAS THERMOMETER

Phenomenon that we often find is how to calibrate the two thermometers of different types, such as the mercury thermometer and alcohol thermometer, the scale of the two thermometers that might only be matched at 0 ° C (or 32 F) and 100 ° C (or 212 F). If we use both the thermometer to measure the temperature of the room, the number shown is not necessarily the same. It could be the mercury thermometer showed the number 48 ^{o}C, while the alcohol thermometer shows the number 46 ^{o}C. This is because the speed of expansion of each material is different. Similarly with the other types of thermometers, such as bimetal thermometer. Temperature scale defined in this way depends on properties of the materials used. Since the temperature scale assigned using ordinary thermometer has its limitations, and then we need a standard thermometer. The existence of a standard thermometer helps us to define more accurately the temperature scale, without having to rely on the properties of a material.

Thermometers were nearly perfect/ideal is a constant-volume gas thermometer. The working principle of a constant-volume gas thermometer is keeping the volume of gas in the flask alway constant, by positioning the height of the liquid (mercury) in tube A to the zero position by raising or lowering the tube B. when the temperature increases, the gas pressure also increase.

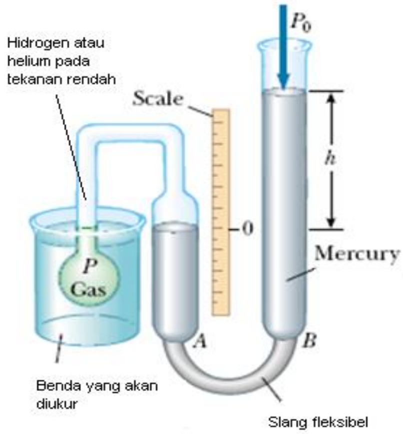


Figure 1-14 a constant-volume gas thermometer

Gas pressure can be known by reading the mercury column height (h) in tube B. Using the equation $P = \rho g h$. The relationship between the temperature of the pressure can be written

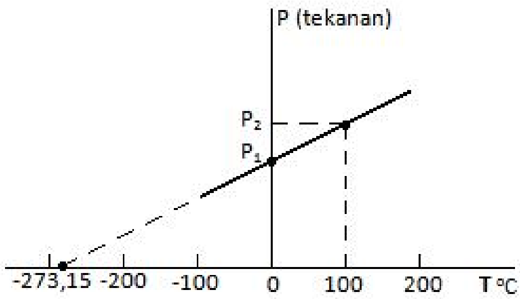
$$T = a + b\,P$$

Where the temperature T, pressure P, a and b are constants determined experimentally gas, usually known. To calibrate the constant volume gas thermometer, we use ice-point temperature and temperature of the steam as a reference point. Temperature of the ice point and steam point depends on air pressure. Usually at a pressure of 1 atm, temperature = 0 C ice point and steam point temperature = 100 ^{o}C. Suppose we calibrate a constant volume gas thermometer in place that has air pressure of 1 atm.

First, the gas tube is inserted into a container with ice cubes and water filled. Set the volume of gas is always fixed by raising or lowering the tube B. If the volume of gas has not changed, record the height of the mercury column (h) on the tube B. Use h to calculate the pressure. Note the pressure of the gas (assuming it's a pressure 1 = P_1)

Second, the gas tube into a container of boiling water. Gas volume be kept fixed. If the volume of gas has not changed, record the height of the mercury column (h) on the tube B. Use h to calculate the gas pressure. (let's just say this pressure 2 = P_2)

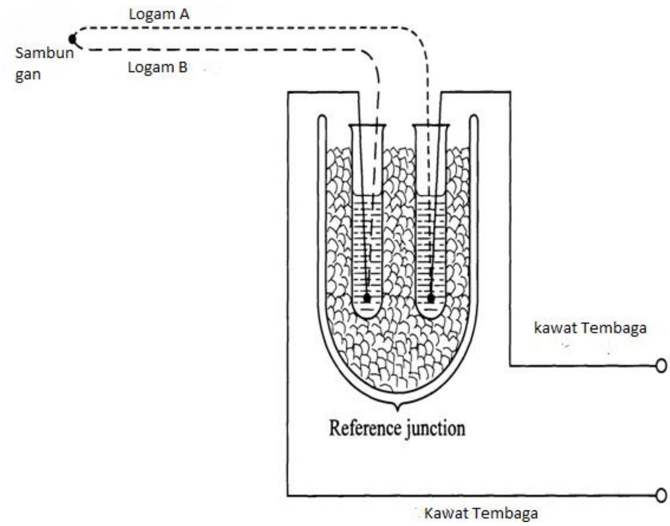
Third, create a chart that maked the relationship between pressure and temperature. As Figure 1-15



P_1 is pressure of ice point (0 ^oC) and P_2 is pressure at steam point (100 ^oC). Drawing straight lines that make connection between P_1 and temperature 0 ^oC, P_2 and tempereature100 ^oC. According the pressure value was obtained, the temperature value can be determine easily.

1.10 TERMOCOUPLE

When two different types of metal tip attached on both ends and the other given temperature difference, then the connection string will arise electromotive force (EMF). GGL can be measured with a galvanometer. The amount of EMF that occurs depends on the magnitude of the temperature difference at both ends of the other



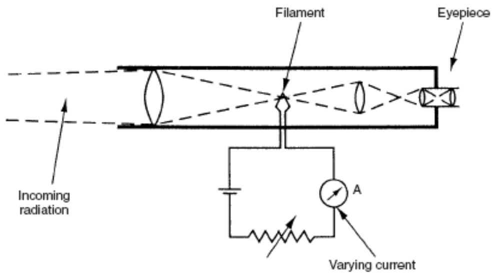
Gambar 1-22. Thermocouple

1.11 PYROMETER

Pyrometer (pyrometer) is a thermometer used to measure very high temperatures (above 1000oC), such as metal smelting temperature and the surface temperature of the sun. Pyrometer was first created by Pieter van Musschenbroek, which uses electrical resistance properties, in general, the electrical resistance of a change if the temperature changes, when the temperature rises the electrical resistance will be greater and vice versa. There are two kinds of pyrometer, the pyrometer optical and total radiation pyrometer.

Optical Pyrometer

Optical pyrometer consists of a telescope. In the telescope tube, there are lens filters of red glass and a filament, as shown in the picture



Gambar 1-23. Optical pyrometer

If the pyrometer is directed into the furnace, by adjusting potentiometer barriers filament bright light equal to the light of the furnace or object to be measured temperature. Based on the current reading ammeter (A), subsequently converted into temperature displayed to monitor.

Radiation pyrometers

Radiation pyrometers are used to measure the temperature of objects that are very hot without touching. the system works is to collect visible and infrared light energy from the object and focus it to a detector by an optical system, such as Fig. The detector converts the energy of photons collected into electrical signals are sent to the control unit is then displayed on the monitor

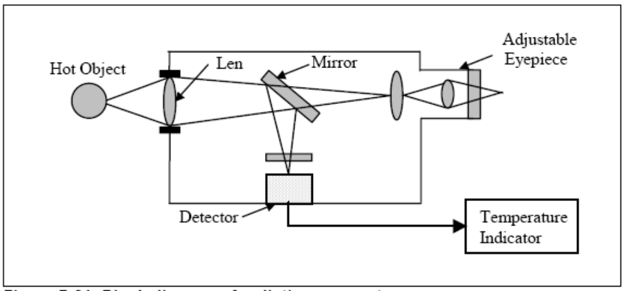


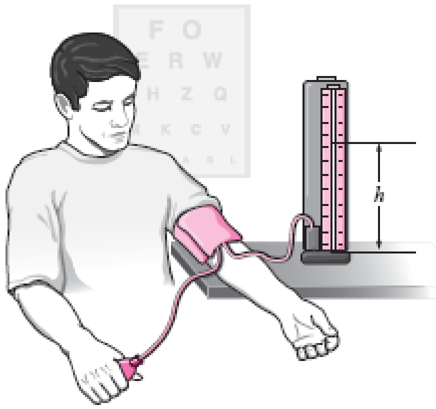
Figure 7-21. Block diagram of radiation pyrometer

Gambar 1-24. Radiation pyrometers

1.12 STRUCTURED TASK

1. What a difference approach to classical thermodynamics with statistical thermodynamics?
2. A large fraction of the thermal energy generated in the engine of a car is rejected to the air by the radiator through the circulating water. Should the radiator be analyzed as a closed system or as an open system? Explain.
3. What is the difference between intensive and extensive properties?
4. When thermodynamic equilibrium is reached?
5. What is the definition of the isothermal, isobaric, isochoric, adiabatic process?
6. What is the zeroth law of thermodynamics?

7. Image Measurement of blood pressure as Figure beside. By using a mercury manometer and stetoskope, systolic pressure (maximum pressure when the heart is pumping) and diastolic pressure (the minimum pressure when the heart is resting) are measured in mmHg. Systolic and diastolic pressure of a healthy person is 120 mmHg and 80 mmHg. That dindikasikan as 120/80. Convert this pressure in kPa, and the length of the water column.



8. The length of the mercury column in the old-fashioned mercury-in-glass thermometer is 15.00 cm when the thermometer is in contact with water at its triple point. Consider the length of the mercury column as the thermometric property X and let (Θ) be the empirical temperature determined by this thermometer. a. Calculate the empirical temperature when the length of the mercury column is 19.00 em. B. If X can be measured with a precision of 0.01 cm, can this thermometer distinguish between the normal freezing point of water and the triple point of water?

REFERENCES

Arthur Shavit, Chaim Gutfinger (1995). Thermodynamics from concepts to Applications. Prentice hall. England

Çengel and Boles(2006), *Thermodynamics: An Engineering Approach, 5*th ed, McGraw-Hill,

Chih Wu (2007). Thermodynamics and heat Powered cycles:A cognitive Engineering approach. Nova Science Publishers, Inc. New York

Claus Borgnakke, Richard E. Sonntag (2013). Fundamentals of Thermodynamics. University of Michigan.Wiley publisher

Fong P(1963). Foundations of thermodynamics. Oxford University Press

Michael J. Moran , Howard N. Shapiro (2006). Fundamentals of Engineering Thermodynamics 5 edition. John Wiley & Sons, Inc. England

R.K. Rajput (2007). Engeenering Thermodynamics, Lexmi publication. NEW DELHI

Richard E. Sontang, Gordon J. Van Wylen (1982). Introduction To Thermodynamics Classical and Statistical 2nd edition. John Wiley & sons,

Sear & Salinger (1974). Thermodynamics, Kinetic Theory, and Statical Thermodynamics. Addison-Wesley

Yung-Kuo lim (1990). Problem and solution on thermodynamics and statical mechanics. World scientific . Singapore

Zemansky (1997). Heat and Thermodynamics, 7th Edition. McGraw-Hill

GLOSSARY

Thermodynamics is a branch of Natural Sciences who studies heat transfer, thermal interconversion and work in a variety of physical and chemical processes.

Thermodynamic system is a substance (solid, liquid, gas) or materials restricted by a closed surface either real or imaginary closed surface which is the object of investigation.

Temperature is thermodynamic properties that measure the embodied energy of a mass.

Pyrometer is a thermometer used to measure very high temperatures (above 1000oC), such as metal smelting temperature and the surface temperature of the sun.

Equation of state is a relation between state variables or thermodynamic coordinate system, (temperature, pressure and specific volume) under conditions of equilibrium.

Expansion coefficient (β) is defined as the ratio between the change in volume dV of the initial volume V per unit change in temperature at constant pressure.

Compressibility coefficient ($\boldsymbol{k}$) is defined as the negative ratio between the change in volume with initial volume per unit change in pressure at constant temperature.

Isichoric process is a process that occurs at constant volume, meaning there is no change of volume.

Isobaric process is a occurs that process at constant pressure.

Isothermal process is a occurs that process at constant temperature, if the system is an ideal gas.

Adiabatic process is a process during which the process takes place, there is no heat in or out system.

Reversible process defined as a process that can return to its original shape without leaving a trace on the environment.

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ABOUT THE AUTHOR

Pakhrur Razi lahir di Kerinci, Jambi, Sumatera, Indonesia pada tanggal 12 August 1979. Gelar Sarjana bidang Fisika diperoleh dari Universitas Negeri Padang (UNP) pada tahun 2002 dan gelar Magister Sains (M.Si) didapatkan dari Institut Teknologi Bandung (ITB) bidang elektronika dan instumentasi pada tahun 2005, selanjutnya gelar Philosophy of Doctor (Ph. D) Center for Environmental Remote Sensing, Department of Information processing and Computer Sciences, Graduate School Advanced Integration Science Chiba University, Japan pada tahun 2019. Bidang keahlian pada program doctor adalah Synthetic Aperture Radar (SAR) Remote Sensing untuk disaster Monitoring. Sejak 2006, penulis tercatat sebagai Dosen di Jurusan Fisika, Universitas Negeri Padang. Delapan tahun kemudian penulis memperoleh jabatan akademik dengan gelar Lektor kepala (Associate Professor). Bidang penelitan penulis adalah aplikasi dan pengembangan satelite SAR untuk mitigasi dan monitoring area berpotensi bencana (gempa bumi dan tsunami, erupsi gunung berapi, tanah longsor/movement, subsidence/uplift, banjir, kebakaran hutan), polusi (udara, sampah) dan oil spill dan ICT untuk pendidikan dan pembelajaran.