Thermodynamics for dummies pdf

Thermodynamics is part of natural law - it regulates the use of energy in everything from weather to your diet. I introduce you to the basic concepts of energy, describing how it transforms into both natural and man-made systems. With just four simple laws, a table of material properties, and a calculator, you can find out how much energy it takes to boil eggs or operate a power plant. Soon you will calculate all kinds of interesting facts related to energy. Chapter 1 Thermodynamics in Everyday Life In this chapter is getting another energy to change energy in one form by looking at thermodynamics around you to work and carry heat for you to lay out relationships, reactions, and mix (nothing personal) inspiring you to save the world from an energy-deficient thermodynamics as old as the universe itself , and the universe is simply the largest known thermodynamic system. When the universe ends in a whisper and the total energy of the universe is destroyed to nothing, then thermodynamics will be eliminated. Broadly speaking, thermodynamics is about energy: how it is used and how it changes from one form to another. In many cases, thermodynamics involves using heat to provide work, as in the case of your automobile engine, or working to move the heat, as in your refrigerator. With Thermodynamics, you can find out how efficient things are in using energy for useful purposes, such as carrying airplanes, generating electricity, or even riding bicycles. The term thermodynamics has a Greek heritage. The first part, Thermo, conveys the idea that heat is somehow involved, and the second part, mobility, makes you think of things that move. Keep these two ideas in mind in view of your world in terms of the basic laws of thermodynamics. This book is written to help you understand that thermodynamics is about turning heat into power, a concept that isn't really so complicated after all. Thermodynamics hunks many thermodynamic systems are at work in the natural world. The sun you see in the sky is the ultimate energy source for the earth, which warms the air, land and oceans. Huge masses of air move on the surface of the earth. Giant streams of water rotate in the oceans. This is caused by changes of heat in movement and swirling work. Energy takes many different forms - it can not be created or destroyed, but it can change the form. This statement is one of the fundamental laws of thermodynamics. Consider how energy changes form in storm clouds: Storm clouds have momentum within them. Rubbing against each other creates motion friction between moisture drops in the clouds. Friction causes a buildup of constant charge. When the charge becomes high enough, clouds generate electricity. This power surge of energy can then start a fire on the ground and before you know it, you have a problem of combustion on your hands. Not only As changes do, but the thing (is, a material or substance) also changes the form in many System. Storm clouds evaporate in the air formed by water. As water vapor reaches colder parts of the atmosphere, it condenses to form clouds. Eventually, the amount of moisture in the clouds becomes enough to collect in drops and re-create liquid water, so it rains. One thing people have seen about energy is that it flows in a preferred direction. This observation is another fundamental law of thermodynamics. The heat flows from a hot object into a cool object. The air from the high pressure area is running in the area of low pressure. Some forms of energy are developed by the forces of nature. Air bubbles move upwards in water against gravity as the bounce forces them to grow. Water drops fall into the atmosphere as the force of gravity draws them towards the ground. Another great observation about energy is that if you don't have any energy at all, you don't have any temperatures. The concept of full zero temperature is a fundamental law of thermodynamics. I cover the changing forms of energy and matter and fundamental laws which govern how these changes work in part. Examining the changing forms of energy many clever people have observed the fundamental laws of thermodynamics in natural systems and applied them to create some amazing ways of working by harnessing energy. Heat is used to generate steam or heat the air that runs pistons in the cylinder or spins the turbine. This movement is used to turn on a shaft that can operate a lawn mower; Move a car, a truck, a locomotive, or a ship; Turn on an electric generator; Or driven an airplane. Other clever people have used thermodynamic principles to use work to move heat from one place to another. Refrigerators and heat pumps remove heat from a location to produce a desirable cooling or heating effect. The work required for this cooling appears on your electricity bill every month. In Part II, I show you that the fundamental laws of thermodynamics can tell you how much heat you need to provide to work that can be used to move the car, fly an airplane or turn on an electric generator. You can also use the rules of thermodynamics to find out how efficient something is in using energy. Energy is the basis of every thermodynamic process. When you use energy to do something, it changes along the way. When you start your car, the battery causes the starter to turn on. The battery is a large, heavy box of chemical energy. The battery's job is to convert chemical energy into electrical energy. An electric motor engine (a form of kinetic energy) rotates, and the spark fires plug. These sparks ignite fuel through a combustion process in which chemical energy from gasoline is replaced as thermal energy called internal energy. In a few seconds it takes to start your car, from energy chemical to electric Changes in kinetics to thermal or internal energy. Kinetic Energy provides power to a car battery powering your starter. As the motor turns, in, Energy is converted into a form of mechanical energy called kinetic energy. Kinetic energy involves transferring a mass so that it has velocity. Mass should not be too large for kinetic energy - even electrons have kinetic energy - but the mass has to move. Before you start the car, nothing is growing in the engine so it has no kinetic energy. After the engine starts, it has kinetic energy due to its moving pistons and rotating shafts. If the car is parked while the engine runs, the car does not have kinetic energy as a system until the engine moves the car. Potential energy If you drive your car up a hill and park it there, you change the kinetic energy of the car into another form of energy called potential energy. Potential energy is only available with gravity. You must have a mass located at a height above some ground state. Potential energy converts its name into kinetic energy from its capacity. You look at this conversion process when you park on a hill and forget to brake parking. Potential energy changes back into kinetic energy as your car rolls down the hill. Internal energy When you brake to stop your car, you re-create the energy change form. You know that the car has kinetic energy because it is running. Stopping the car turns all this kinetic energy into heat. The brake pads squeeze on the steel disc or steel drum, creating friction. Friction generates heat - sometimes there is a lot of heat. When the material is hot, another form of energy called internal energy increases. Have you ever smelled a burning smell while driving down long hills? This smell indicates that someone used their brakes to slow down, and the brakes got heated. Do your brakes a favor: Shift to low gear and allow the engine to brake for you. When the engine is used as a brake, the moving car's kinetic energy compresses the air into cylinders, and the energy turns into internal energy as the air heats up from compression. All this internal energy just goes out of the tailpipe. Seeing the energy and work in action until the invention of the steam engine, the man had to slug it out against nature with nature. Horses pulled the coach, pulled the mules plow, sail ships, windmills moved ground grain, and pressed apples into water wheels cider that fermented and the man felt happy for all his labors. The steam engine was able to change these natural work sources and move coaches, plows and ships, among many other things. For the first time, the fire was used to provide something more than just heat — it was used to work. This use of heat to complete the work is what Part III is about. Over time, many different types of work machines were developed, theories were created, and used until a rational system of analyzing heat and work was developed in the field of thermodynamics. Engine: Letting energy work The heat engine is a machine that can carry some source of heat — gasoline, burning coal, Gas, or even the sun — and make it work, usually as a shaft bend. With a rotating shaft, you can move things - think of elevators or race cars. Every heat engine uses four basic processes that interact with the surroundings to complete the engine's work. These processes are heat input, heat rejection, work input and work output. Take your automobile engine as an example of a heat engine. Here are four basic processes that go on under the hood: the work input is compressed into air cylinders. This compression requires work from the engine itself. In the beginning this work comes from the starter. As you can imagine, this process seems to be a lot of work, which is why they don't have those whimsical handles on the front of cars any more. Heat input is burnt in fuel cylinder where heat is added to the engine. Hot air in the cylinder naturally seeks to increase and expand the pressure. Pressure and expansion move down the piston cylinder. The work is output by working engines, pushing gas pistons into cylinders as output. Some of this work air compression in adjacent cylinders. Heat rejection removes heat with exhaust from the final process engine. Refrigeration: Letting work trick heat when Willis made carrier air conditioners a popular home appliance, he made more and more people comfortable and power utilities give a reason for growth and expansion. He brought thermodynamics into the house. Thermo-dynamics has been there all along, and you never realized it. Refrigerators, freezers, air conditioners, and heat pumps are all the same in thermodynamics. Only three basic processes have involved energy interacting with the surroundings in what is known as refrigeration cycles: heat input is absorbed from the heat cool place to keep it cool. Work input work is added to the system to pump out absorbed heat for hot space out of hot space. Heat rejection is rejected for heat hot space. In fact, a fourth process takes place in most refrigeration cycles, but it does not involve changes in energy. Instead of having a working production process in heat engine-like cycles, refrigerators simply use a pressure-reducing device in the system. Energy does not change form in such a device. Getting into the actual gases, gas mix, and combustion reactions is the glamorous side of thermodynamics using energy to generate electricity, cool your home, fly a jet, or race cars around Indianapolis Motor Speedway. But behind the movie stars is a supporting cast and crew of thermodynamic relationships (it's jargon for mathematical equations) to mix real gases, gas, and combustion reactions that make it all happen. In Part 4, you discover the difference between a real gas and an ideal gas. There you see that real gases behave slightly differently than ideal gases. You also explore the thermodynamic properties of a mixture of gases, such as heating, water vapor for air and air And airy purpose. Finally, you calculate how much energy you can get out of fuel in a combustion response to your jet, your race car, or your lawn mower power. If you want to sell jet engines to an aircraft manufacturer, you have to show that your engine burns fuel efficiently. To build a jet engine, you need to know how much energy the combustion response gives an engine and how hot the air is in the engine as a result of combustion. To explore the latter, you use thermodynamic relationships of real gases to calculate properties such as temperature, pressure and energy. To discover old names and new ways of saving energy as you learn about thermodynamics, you'll run across a number of names. Some names may be familiar; Others may be new to you. For example, when you get your electricity bill, it tells you how many watt-hours of electricity you used last month. If you reheat yesterday's leftover pizza, you set your oven to 350 degrees Fahrenheit. (Or, if you live outside the U.S., you set your oven to a few temperatures in degrees Celsius.) That's the big rig that's riding its bumper on the highway burns diesel fuel. How did these words - Watts, Fahrenheit, Celsius and Diesel - become part of our language? In Part V, you discover that these words (and six more) are actually the last names of characters bent on figuring out what energy it is and how to harness it for the benefit of mankind (and maybe line your pockets with some folding money). Pioneers in thermodynamics didn't just work in the good old days; There are pioneers of today as well. In the world of energy, demand constantly increases while energy resources are eroded. Part V shows you ten ways innovative thinkers have improved energy consumption for automobiles, air conditioners, refrigerators and electric power plants. Creating a better future for all has prompted many people to think about using energy in better ways. Even Albert Einstein got a patent for creating a better air conditioning system (see Chapter 18). Maybe you'll be inspired to create your own innovation and make a name for yourself in thermodynamics. Chapter 2 Laying the foundation of thermodynamics is getting comfortable with thermodynamic properties, including how to use thermodynamic processes to understand the rules of thermodynamics, every builder knows the importance of a good foundation. Imagine building a house without making sure the level is safe. Everything going together is just right and having a home will be difficult to stand the test of time. The same can be said for the study of a new subject. Every topic has its own vocabulary, and this chapter is where you explore some of the key concepts used in thermodynamics. Many words are already familiar to you, such as temperature, pressure and density. Others may have heard words you have heard before, but you don't know exactly what they mean — for example, specific heat can be potential and latent heat. I only go beyond words and concepts; I tell you that these ideas in thermodynamics are basic ways of coming together. In thermodynamics, procedures are the means whose purpose - heating your home, for example - is accomplished. A house can use boilers to make hot water that spreads throughout the house to radiators to make warm water. Another house can use a furnace to air and warm a fan to transmit hot air to the house. Both processes serve the same purpose but take different avenues to do it. Just as you can sometimes take a different path to move from point A to point B, the same can happen in thermodynamics. In this chapter, I describe the concept of thermodynamic processes and the paths taken during those processes to move from point A to point B. You may have heard that thermodynamics have two laws. In fact, it has four laws; Two lesser known people deal with temperature and are not actually used in thermodynamic problems. I discuss these laws in this chapter so you will know what all the fuss is about. Defining important thermodynamic properties whether they are solids, liquids or gases, all materials have properties that tell you two things: some properties, such as specific heat capacity, tell you how a material behaves during the thermodynamic process. Other properties such as temperature or pressure tell you what position or position the material is in at any point in the thermodynamic process. For example, let's say you use a hot water bottle to warm up your bed before it gets in. The water is very hot initially. You can use thermodynamic properties of mass and temperature to describe your position or state when you first fill it and its condition after it has warmed your bed. The mass of water in the bottle remains constant, but during the process the temperature of the water bottle is reduced. The thermodynamic property of specific heat capacity explains how quickly the water cools when you put a water bottle in your bed. This way, the typical heat ability tells you how the hot water bottle behaves while it warms your bed. You find more information about the many important content properties in the upcoming sections. Before I delve into the properties myself, you first need a basic understanding of how the properties are measured. If you can measure something, it has a dimension. Some dimensions are described as primary or fundamental dimensions such as length, mass, temperature and time. When you add dimensions to describe properties such as quantity, pressure or energy, you have secondary dimensions or derived dimensions. Dimensions have units attached to them, such as Celsius or Fahrenheit for temperature, inches or meters for length, and kilograms or pounds for mass. Units determine the amount of size of a dimension. Some asset measurements do not contain per dimension and form dimensionless properties is known. Often dimensionally inferior properties are ratios or fractions where Cancel each other. A very common dimensionless property is relative humidity, which is reported as a percentage. The world is divided into two different entity systems: English: the most common in the United States, the English system is formally called the United States customary system, but it's a big mouthful, so the English word you hear most often and I use in this book. Sistem International (SI): Everywhere except the United States, Sistem International is the system of choice. Often the SI system is called a metric system. SI units are now the preferred unit system in thermodynamics textbooks, so they are used in this book. In addition, thermodynamic properties come in two different types; Extensive properties depend extensively and do not have profound properties. Intensive: An intensive property does not depend on mass. Temperature and pressure are examples of intense properties. No matter how much material you have, the temperature and pressure remain the same. They don't change just because you have more or less content on hand. Comprehensive: A wider property depends extensively; It depends on how much content you have. Examples of extensive properties include mass, volume and energy. Not everything is black and white. Some intensive properties are represented by broad properties that are divided by a unit mass. These properties are often known as specific properties, such as specific quantities or specific internal energy. Deep properties are usually represented by a lowercase symbol. Exceptions include temperature (T) and pressure (P). Extensive properties are usually represented by uppercase symbols except mass (M), which uses lowercase. You have to love the exceptions to the rules. Mass mass thermodynamics has a property that describes the amount of material used in a system or process. Many people think that's the same thing as massive weight. But that is not the case. Weight is actually a force applied to an object by gravity. The weight (W) of an object is calculated by multiplying its mass (M) by acceleration of gravity (g): W = M · G. On Earth, the acceleration of gravity is 9.81 m/s^2 squared (m/s^2) or 32.2 feet per second squared ($feet/s^2$). The SI unit for mass is kilogram (kg), and the English unit is pound mass (LBM). The LBM abbreviation is taken from one meter for the Roman word Libra plus mass. The SI unit for weight is Newton (N), and in English units it is pound-force (LBF). The calculation of weight indicates that the amplitude mass of force (F) (M) times acceleration (A): F = M · The product of a are derived from. Newton is therefore defined as 1 n = 1 kg · m/s^2. When mass (m) appears as a variable in an equation, it is italicized in this book. When M appears in units, as it does in the previous equation, it stands for meters and is not italicized in this book. Pressure if you fly balloons There is pressure inside. The result of pressure is Moving inside the balloon and hitting the walls of the balloon. Because the molecules are also bumped from the outside of the balloon, the outside is accentavered as well. These molecular collisions create a normal force that acts on the surfaces of balloons. Figure 2.1 shows that a normal force is perpendicular to the surface. Pressure is defined as a normal force acting on an area and liquids and gases have a thermodynamic property. (When acting on a solid, the same concept is called stress). Figure 2-1: A normal force (F) acts perpendicular to a surface. In honor of Blaise Pascal's experiments in hydraulics, the SI system defines the unit of pressure as Pascal (PA). The unit of pressure is related to the units of force acting on an area by this equation: 1 Pa = 1 N/m^2 Because 1 Pascal is not very pressing, the SI system prefers to use kilopaskal (kPa) for the most practical engineering calculations: 1 kPa = 1,000 Pa to put into this perspective, the pressure of the atmosphere at sea level is about 101 kg. In the English system, units of pressure are defined as pound-force per square inch (PSI). You can convert English to SI units using this formula: 1 psi = 6.895 kpa pressure there are some different scales as thermodynamic property. In a full pressure scale, the zero pressure point is defined by the correct vacuum. Standard atmospheric pressure is defined as 101.325 kilopaskal in SI units or 14.7 pound-force per square inch absolute (pisa) in the English unit system. One at the end of SAI indicates that it is a complete pressure scale. A tire pressure gauge doesn't read the force per 14.7 pounds-square-inch when it's just sitting around in the garage. It reads 0 pound-force per square inch gauge (psig). At the end of the PI, G means that the gauge pressure scale is being used. When you measure your tire pressure and the gauge reads 25 pounds-force per square inch, that means the tire pressure is 25 pounds per square inch above atmospheric pressure. You can convert between gauge pressure and full pressure with the following formula. In this formula, the PCs gauge is pressure, the pabs are full pressure, and pat is atmospheric pressure: PGZ = Pabs - PAT Vacuum Pressure (PVAC) refers to a situation in which the full pressure of gas or liquid is less than atmospheric pressure. You measure vacuum pressure with vacuum gauges. You can change between vacuum pressure and atmospheric pressure with this formula: Pvac = Patm - Pabs pressure is always expressed with positive numbers (unlike temperature when Celsius or Fahrenheit scale is used and negative temperatures are possible). When you use thermodynamic property tables in the appendix for your thermodynamic calculations, entries for pressure are in full pressure values. The temperature temperature explains how hot or cold something is. You are probably familiar with this thermodynamic property. On a And on the windy winter day, you can hear the weather report and hear that the air temperature is 25 degrees Fahrenheit (°F), but with the wind chill it feels like 15 degrees. Or you can feel very comfortable when you are 75 degrees outside, but if you go swimming in 75 degrees of water, you feel very cold. The human body seems temperature, but not really a good thermometer. When you feel something that is hot or cold, what you're actually feeling is the heat moving from or from your skin. When the air is still there, it doesn't remove heat from your skin very effectively, but removes air heat more easily. That is why the air feels cold when the wind runs. Water removes heat more effectively than air, so it makes you feel colder than the air. A metal surface feels colder than a cotton fabric because the metal surface conducts heat from you more quickly temperature is actually a concept that is used to describe the direction in which heat transfer takes place. Heat is a form of energy that naturally flows from warm to cold temperatures. You can feel the heat transferred to or from your body when you are an atmosphere warmer or colder than you. At absolute zero temperature, you can not remove any more heat from any material as it has no energy. I discussed energy in detail later in the energy section. Four different measurement scales are commonly used to determine the amount of temperature: Celsius (°C): Developed by Enders Celsius, this scale defines 100 equally distance points or degrees between boiling and freezing points of water at 1 atmosphere (ATM) pressure. Fahrenheit (°F): Daniel Gabriel Fahrenheit chose the temperature of melting ice baths in salt water solution as a zero point on its scale. He then chose body temperature (96 degrees, in his estimation) as the second point on his scale. After he made up his scale, it turned out that water freezes around 32 degrees and boils around 212 degrees. It has never occurred to him that temperature scales will one day relate to the freezing point and boiling point of pure water. Calvin (K): Largs, known as Scotland's 1st veteran Calvin, suggested William Thomson needed an absolute temperature scale defining zero temperatures as the point where there is zero energy. He calculated based on his scale on the Celsius scale and calculated that the freezing point of water is 273.15 Kelvin (usually rounded to 273 Kelvin in calculations). Rankin (R): A full temperature scale that uses the Fahrenheit scale, William Rankin's system declares the water's deposition point to 459.67 rankin. You usually round this number up to 460 rankin when using it in calculations. Note that Calvin and Rankin scales do not use the degree symbol. The degree symbol was dropped from the Calvin scale in 1967, and some textbooks have followed suit with Rankine. Especially when you use the ideal gas law Use the full temperature scales of Kelvin or Rankin (I introduce you to the ideal-gas law in Chapter 3). Ideal gas law depends on ratio Pressure, temperature, and volume. These ratios are based on absolute zero as a starting point to properly create the pressure and volume scale with temperature. You can use Celsius or Fahrenheit scales when the calculation includes a temperature difference. You cannot use Celsius or Fahrenheit scales when the calculation includes a temperature ratio. If you're ever in doubt about what scale to use, you can't go wrong with calvin or rankin scales. You only need three formulas to convert from one temperature scale to another. You can rearrange these formulas to solve for any other conversion, such as Fahrenheit to Celsius or Rankin to Fahrenheit. Celsius to Fahrenheit: °F = 1.8 · °C + 32. Celsius to Kelvin: °C = K - 273.15. Remember, you can score from 273.15 to 273 if you want. Doing so doesn't really change the answer that much. Fahrenheit for Rankin: °F=R - 459.67. Rounding from 459.67 to 460 requires fewer keystrokes without losing less accuracy on the calculator. When you need to calculate the temperature difference, the change in degrees Celsius is equal to the change in Kelvin. That is: 1 ° C = TK. The same is true in English units; A change of degree in Fahrenheit is equivalent to a degree change in rankin. That's: Don't make the mistake of adding 273 to change in Celsius to find changes in 1°F= 1010 Kelvin or adding 460 to change in Fahrenheit to get changes in rankin. Density density refers to the amount of mass of materials per unit quantity. Density is determined by (1) the mass (M) of a material and divided by volume (V). In the SI system, units are kilograms per cubic meter (kilograms/meters), and in the English system, they are pound-mass per cubic foot (lbm/ft). You calculate the density of a similar material with this equation: 3 = m/v. The density of liquids is often considered uncompressed because they do not change much with temperature and pressure. However, the densities of gases vary considerably with both temperature and pressure. You see this effect with regard to the ideal gas law in Chapter 3. When you use the reciprocal of density, you get a specific amount (v). The specific quantity is ideally used in the gas law equation I describes in Chapter 3. Specific quantity is an intense asset. This is the mass quantity per unit. The units are cubic meters per kilogram (m/kg) in SI units and cubic feet per pound-mass (ft/LBM) in the English system. You can calculate the specific quantity with this equation: v = V/m = 1/ooo. Sometimes the density of material in the thermodynamic property table is given as specific gravity, meaning that the density of material is divided by the density of water.