

THE INTERESTING OF LEARNING THERMODYNAMICS THROUGH DAILY LIFE

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Abstract

As an essential basic science in engineering education, Thermodynamics should be received as an interesting and inspiring subject. Unfortunately, the fact is different. Some students find Thermodynamics are difficult, hard to imagine and not understandable. If lecturers could tell the relation of Thermodynamics to daily life, it will surely increase students' motivation to learn. With high motivation, the difficult subject will become easier. This paper presents some examples of phenomena or activities in daily life which are viewing using Thermodynamics. Those examples are (1) understanding the importance of specific volume through the anomaly of water, (2) applying the saturation temperature and pressure in a pressure cooker, (3) understand the importance of specific heat in the wind over the sea shore, (4) experiencing how a fluid's pressure increases by giving work to it, (5) applying the first law of Thermodynamics to determine an Air-Conditioning cooling capacity, and (6) learning how a tire could explode.

Keywords: Thermodynamics, anomaly, work, specific heat

Introduction

Some students think Thermodynamics is a difficult and horrible subject. They do not enjoy learning Thermodynamics. Unlike in solid mechanics, things happen in thermodynamics, for instance increasing internal energy of steam in a tank could not be seen visually. This make some mechanical engineering students get more frustrated in understanding thermodynamics.

Thermodynamics is a basic science that deals with heat and work and those properties of substances that bear a relation to heat & work. Engineers use thermodynamics principles with other engineering sciences, such as fluid mechanics & heat and mass transfer to analyze and design things to meet human needs. Therefore, Thermodynamics is a compulsory subject in Mechanical Engineering Department. Every engineering activity involves an interaction between energy and matter, thus it is hard to imagine an area which does not relate to thermodynamics in some respect. The areas are seen in every where one lives. Many things in ordinary house are using the principles of thermodynamics. Some examples are

heating and air-conditioning systems, the refrigerator, the pressure cooker, the water heater, the iron. Other things displaying thermodynamics' role are automotive engines and power plants (gas and steam). These examples show that thermodynamics has long been an essential part of engineering education.

Learning Thermodynamics might not be easy for the first time. There are some tedious things, such as defining system, getting properties from several tables that are related, interpolating data which are not ready in table, and using the 1st and 2nd law in solving some problems, to be learned. Some properties of the matter in the selected system are pressure, temperature, specific volume (inverse of density), specific heat, internal energy, enthalpy, entropy, availability, work, and heat. Some of these properties are not familiar in daily life. This makes thermodynamics more difficult and unrelated to our life. Therefore, the students think thermodynamics is boring and uninteresting.

This paper presents some examples of thermodynamics related to our daily life. Hopefully, this effort shall help students finding thermodynamics more interesting and enjoy learning thermodynamics.

Before starting with thermodynamics, a brief concept on conceptual teaching-learning will be described in next section.

Contextual Teaching and Learning (CTL)

What is the best way to convey the many concepts that are taught in a particular course so that all students can use and retain that information? How can the individual lessons be understood as interconnected pieces that build upon each other? How can a teacher communicate effectively with students who wonder about the reason for, the meaning of, and the relevance of what they study? How can we open the minds of a diverse student population so they can learn concepts and techniques that will open doors of opportunity for them throughout their lives? These are the challenges teacher face every day, the challenges that a curriculum and an instructional approach based on contextual learning can help them face successfully.

The majority of students in our schools are unable to make connections between what they are learning and how that knowledge will be used. This is because the way they process information and their motivation for learning are not touched by the traditional methods of classroom teaching. The students have a difficult time understanding academic concepts (such as math concepts) as they are commonly taught (that is, using an abstract, lecture method), but they desperately need to understand the concepts as they relate to the workplace and to the larger society in which they will live and work. Traditionally, students have been expected to make these connections by themselves outside the classroom.

According to contextual learning theory, learning occurs only when students (learners) process new information or knowledge in such a way that it makes sense to them in their own frames of reference (their own inner worlds of memory, experience, and response). This approach to learning and teaching assumes that the mind naturally seeks meaning in context—that is, in relation to the

person’s current environment—and that it does so by searching for relationships that make sense and appear useful.

Building upon this understanding, contextual learning theory focuses on the multiple aspects of any learning environment, whether a classroom, a laboratory, a computer lab, a worksite, or a wheat field. It encourages educators to choose and/or design learning environments that incorporate as many different forms of experience as possible—social, cultural, physical, and psychological—in working toward the desired learning outcomes.

In such an environment, students discover meaningful relationships between abstract ideas and practical applications in the context of the real world; concepts are internalized through the process of discovering, reinforcing, and relating. For example, a physics class studying thermal conductivity might measure how the quality and amount of building insulation material affect the amount of energy required to keep the building heated or cooled. Or a biology or chemistry class might learn basic scientific concepts by studying the spread of AIDS or the ways in which farmers suffer from and contribute to environmental degradation.

Contextual Teaching and Learning (CTL) is a concept of teaching and learning that helps teachers relate subject matter content to real world situations and motivate students to make connections between knowledge and its applications to their lives as family members, citizens, and workers and engage in the hard work that learning requires. Contextual teaching and learning strategies:

- **Emphasize problem-based.** CTL can begin with a simulated or real problem. Students use critical thinking skills and a systemic approach to inquiry to address the problem or issue. Students may also draw upon multiple content areas to solve these problems. Worthwhile problems that are relevant to students’ families, school experiences, workplaces, and communities hold greater personal meaning for students.
- **Use multiple contexts.** Theories of situated cognition suggest that knowledge can not be separated from the physical and social context in which it develops. How and where a person acquires and creates knowledge is therefore very important. CTL experiences are enriched when students learn skills in multiple contexts (i.e. school, community, workplace, family).
- **Teach students to monitor and direct their own learning so they become self-regulated learners.** Ultimately, students must become lifelong learners. Lifelong learners are able to seek out, analyze, and use information with little to no supervision. To do so, students must become more aware how they process information, employ problem-solving strategies, and use background knowledge. CTL experiences should allow for trial and error; provide time and structure for reflection; and provide adequate support to assist students to move from dependent to independent learning.
- **Anchor teaching in students diverse life-contexts.** On the whole, our student population is becoming more diverse, and with increased diversity comes differences in values, social mores, and perspectives. These differences can be the impetus for learning and can add complexity to the CTL experience.

Team collaboration and group learning activities respect students' diverse histories, broaden perspectives, and build inter-personal skills.

- **Encourage students to learn from each other and together.** Students will be influenced by and will contribute to the knowledge and beliefs of others. Learning groups, or learning communities, are established in workplaces and schools in an effort to share knowledge, focus on goals, and allow all to teach and learn from each other. When learning communities are established in schools, educators act as coaches, facilitators, and mentors.
- **Employ authentic assessment.** CTL is intended to build knowledge and skills in meaningful ways by engaging students in real life, or "authentic" contexts. Assessment of learning should align with the methods and purposes of instruction. Authentic assessments show (among other things) that learning has occurred; are blended into the teaching/learning process; and provide students with opportunities and direction for improvement. Authentic assessment is used to monitor student progress and inform teaching practices.

Many of these strategies are used in classrooms today. Activities such as team teaching, cooperative learning, integrated learning, work-based learning, service learning, problem-based learning, and others support CTL and are already occurring in many classrooms and schools. Many educators routinely use these activities to encourage inquiry, creative problem solving, and use of higher order thinking skills. These educators see these teaching/learning processes as methods to help all students meet state and local standards.

For CTL to be effective, all strategies must be present in the teaching/learning experience. Implementation of CTL may not require drastic changes in practice for all educators. It may require enhancement of practice in one characteristic and not another. Continual use and reflection on CTL processes broadens and deepens educators' knowledge and ability to facilitate learning.

1. Understanding the importance of specific volume through the anomaly of water

Specific volume is defined as the volume over the mass of substance chosen as the system. Sometimes it is unreasonable why one needs to divide the property with mass. Dividing the properties with mass makes them become intensive properties which are independent of the size of the system. Thus, specific volume is an intensive property. It means the specific volume that is the inverse of density is the same all over the substance in a certain temperature and pressure.

God made water as a special pure substance. Usually, pure substance's volume (thus its specific volume) will increase when it is heated and will decrease when it is cooled. Water is a special substance that its liquid-specific volume is decreasing when it is cooled until 4°C as seen in figure 1. If the cooling is carried on, then the specific volume will increase. Thus, water has its lowest specific

volume (greatest density) at 4°C. This anomaly is designed to save the living creatures under the lake.

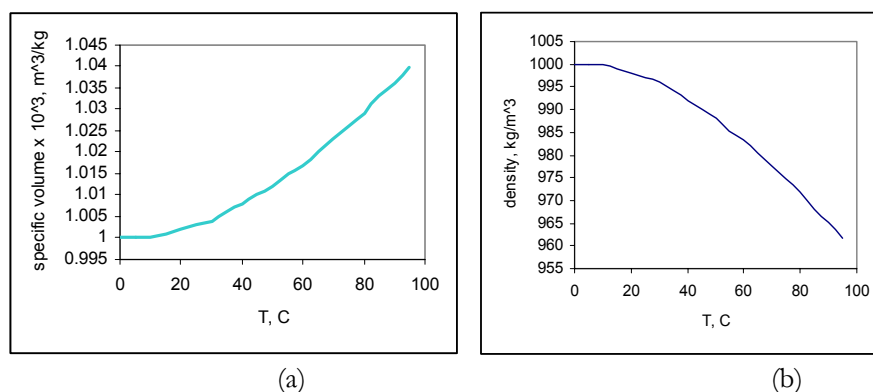


Figure 1 (a) Specific volume of water. (b) Density of water.

How does it happen? When the specific volume is decreasing, its density is increasing. When the water in a pond is above 4°C and begins to cool by contact with cold air, the water at the surface sinks because of its greater density and it is replaced by warmer water from below. This mixing continues until the temperature reaches 4°C. As the surface water cools further, it remains on the surface because it is less dense than the 4°C water below. Water then freezes first at the surface and the ice remains on the surface since ice is less dense than water (specific gravity ice = 0.917). This is how God save the aquatic life during cold winters.

2. Applying the saturation temperature and pressure in a pressure cooker

It is very common to hear people say “water start to boil at 100°C”. Actually, this statement is incorrect. The correct statement is “water start to boil at 100°C at 1-atm pressure”. Water will start to boil at 100°C if the pressure is 1 atm (101.35 kPa). If the pressure inside the tank or pan where the water is heated increases, the water will start at higher temperature than 100°C. That is, the temperature at which water starts boiling depends on the pressure; therefore, if the pressure is fixed, so is the boiling temperature.

At a given pressure, the temperature at which a pure substance starts boiling is called the saturation temperature. Likewise, at a given temperature, the pressure at which a pure substance starts boiling is called the saturation pressure. At a pressure of 101.35 kPa, saturation temperature of water is 100°C. The plot of saturation pressure as a function saturation temperature is given in figure 2.

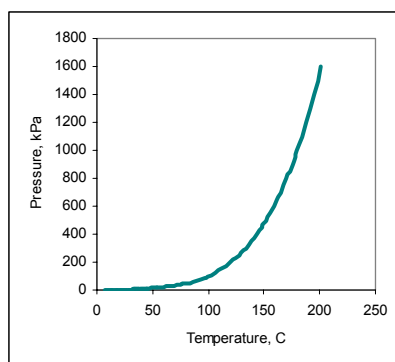


Figure 2. Saturation pressure as a function saturation temperature of water.

From figure 2, it is clear that a substance at higher pressure will boil at higher temperature. In the kitchen, higher boiling temperature means shorter cooking time and fuel savings. So people find way to maintain higher pressure in a pan. The pressure of water inside pan or tank which is heated will increase if the steam could not escape. The pan needs to be sealed closely that no steam could leak out from the pan. This pan is called pressure cooker. A beef stew, for example, may take 1 to 2 hours to cook in a regular pan which operates at 1-atm pressure, but only 20 to 30 minutes in a pressure cooker operating at 2-atm pressure (corresponding boiling temperature 120°C). A safety valve is installed in pressure cooker to avoid excess pressure inside the cooker.

3. Understand the importance of specific heat in the wind over the sea shore

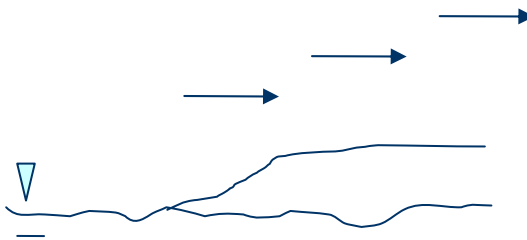


Figure 3. Wind flows to the seashore.

Our daily experience tells that the amount of heat required to increase the temperature of a certain matter is proportional to its mass, to its temperature change and to a quantity which is called specific heat. The specific heat has unit of $\text{J/kg}\cdot^{\circ}\text{C}$. For water at 15°C and pressure of 1 atm, its specific heat is $4180 \text{ J/kg}\cdot^{\circ}\text{C}$. It means that it takes 4180 Joule heat to raise the temperature of 1 kg water by 1°C . A matter which has large specific heat could be good heat storage.

The specific heat of matters are different each other. The sand has specific heat that much lower than water, i.e. $800 \text{ J/kg}\cdot^{\circ}\text{C}$. Since the specific heat of sand is

smaller than water, the sand's temperature increases more than water's in the noon as they receive the same amount of radiation heat transfer from the sun. As the sand's temperature increases, the air over the seashore gets hotter and its density decreases. This light air goes up. Some air over the water (sea) replaces the light air over the seashore. Then, the air is moving from the water to the seashore in the noon. Likewise, the air is moving from the seashore to the sea in the night.

4. Experiencing how a fluid's pressure increases by giving work to it.

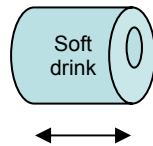


Figure 4. Moving a can of soft drink back and forth.

One form of mechanical work that is called moving boundary work could be explained by doing this simple thing, i.e. moving a can of soft drink as described in figure 4. What will happen if a can of soft drink is moved back and forth? The soda inside will explode out of the can. Why this happens? Because the soda receive boundary work done on it. Work is energy. Thus, the soda will get energy transferred by human in form of work. This work increases the pressure of soda inside the can. The longer we move the can back and forth, the larger the explosion of soda.

Doing this simple experiment will help students remember that not only heat but works done on a system also increase its pressure.

5. Applying the first law of Thermodynamics to determine an Air-Conditioning cooling capacity

Some students will learn the first law of Thermodynamics easier if they know how to apply the law. Here is a simple experiment to apply the 1st law in Air-Conditioning equipment.

Commonly, a unitary AC has two parts: supply outlet and return grille. The procedures for students doing the experiment are:

- Ask the students to measure velocity, dry-bulb and wet-bulb temperature of the air flow at supply outlet and the dimension of the outlet to get the air flow's cross section area.
- Ask students to measure dry-bulb and wet-bulb temperature of the air flow at return grille.
- The students could find specific volume, enthalpy of air flow at supply outlet and return grille from psychrometric chart of software such as EES.
- Then, the students could calculate the air mass flow rate and heat rate or cooling capacity of the AC using the 1st law of Thermodynamics.

This simple experiment gives the students an enjoy activity and it improves their motivation to study.

6. Learning how a tire could explode

This phenomenon sometimes happens to us. How a tire could explode during a trip? This accident is explained best with Thermodynamics. The tire is filled with some pressurized air comes from a compressor. When the air inside is not enough, the car will run slower. People usually use a pressure gage to measure the air pressure in a tire. We put more air when the gage shows less number than we need, such as 30 psig. What will happen if the gage is not working properly? We could put too much air into the tire. Then, the car moves. As the car move, the tire has friction with road along the trip. The friction makes the temperature of the air inside the tire increases. According to ideal gas equation as seen in Equation (1), the air's pressure will increase as the temperature in a fixed volume increases. When the pressure increases beyond the strength of tire's material, the tire will explode.

$$PV = mRT \quad (1)$$

Understanding this ideal gas equation will save us from tire's explosion.

7. Closing

Thermodynamics is a basic science that closes to our daily life. The students enjoy learning this subject when the lecturers show the relation of this subject to their daily lives. Moreover, the students are able to apply the principles of this subject when they work in industries or buildings or even in designing any thermal equipment.

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