ASPECTS OF THERMODYNAMICS SEEN UNDER THE LIGHT OF ISLAM BY FUTURE MARINE ENGINEERS A POINT OF VIEW

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Abstract

Thermodynamics is the study of energy transformations in natural processes and deals with relations involving heat, work and energy. Thermodynamics is an important subject in the education of future marine engineers. Difficulties with a Thermodynamics course arise both from teaching as well as learning. In Constanta Maritime University (CMU) we look for a simple and clear manner for delivering this discipline. In order to overcome difficulties in understanding the First and Second Laws, we state that Thermodynamics has a clear application to other sciences but also it is compatible with religion. Such an approach often provokes discussions beyond the scheduled lecture hours.

Shipping companies recruit seafarers of various nationalities and form multicultural teams on board the ships. Islam is the second largest religion in Dobrogea County after Christianity. This is why in this paper is described the way in which we refer to the First and Second Laws of Thermodynamics and Muslims' religious beliefs, during Thermodynamics course.

Understanding of these laws and their implications is facilitated by providing examples to illustrate how abstract thermodynamic principles are applied to explain and to solve engineering problems and also to show that Science and faith might go hand-in hand. Such an approach may help to an easier integration of future marine engineers graduating in CMU, in multi religious crews on board the ships.

Keywords: thermodynamics, marine engineers, entropy, Islam

1. Introduction

Over 70% of Earth's surface is covered by water. International exports are most often transported by sea. If a large shipment does not ask for a certain fast delivery, shipping by sea is the most appropriate mode of transportation [1].

Ships include different kind of complex systems like propulsion systems, refrigeration systems, etc. Structures, vehicles and systems have specific features [2]:

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- challenging design due to the fact that marine structures are the largest human made systems;
- complex structures and mechanical aspects resulting from a large range of scales from micro scales for welding and fatigue to full structure scales;
- sea transportation vehicles and structures operate in and on water resulting particular design constrains relevant to sea keeping, capsizing, station-keeping or random motions and loads in an unfriendly environment.

Lately, requirements for marine officers became more and more strict [3]. This trend is based on the changing nature of marine engineering due to the penetration speed of new technologies.

Students in maritime institutions of higher education expect high tech disciplines, based on the demand of marine industry to receive young marine engineers ready to be productive. Also, providers of academic maritime education and training offer to marine engineers an education able to support a long career, since seafaring was always considered the initial stage of working life, which will open the path to shore-based maritime careers [4]. On the other hand, research opportunities in the field of marine engineering ask for professionals with strong scientific background.

Thermodynamics is essential for all engineering students. It is the science dealing with equilibrium, energy, transformation of energy from one form to another and the laws which govern such a transformation. These laws have a vast applicability and are used in different branches of engineering and science, including marine transportation.

Many students have difficulties in understanding the role of entropy in the Second Law of Thermodynamics [5]. This paper deals with the way in which we introduce to future marine engineers, enrolled in Constanta Maritime University, the First and Second Laws of Thermodynamics.

Thermodynamics has an enormous impact on different sciences, being possible to offer various examples for a better understanding. Among the given examples is the harmony between these two laws and religion. Orthodox Christianity is dominant among students in Constanta Maritime University, Islam being the second most followed religion.

During Thermodynamics course we discuss the First Law of Thermodynamics, which is another way of looking at conservation of energy. The statement of conservation of energy is applied when it is considered the change in the internal energy in a system. We discuss the Second Law of Thermodynamics, which deals with irreversibilities. It is introduced the concept of entropy – which is critical to the understanding of this law. Entropy is related to the order and disorder of a system, being also called the 'arrow of time', since time always goes in one direction. We explain this by giving our own example: we become older, not younger. We briefly discuss how Thermodynamics leads to predictions regarding the beginning and the end of the world, concepts that normally belong to religion. This intention resulted from a lack of interest in the debate regarding the extended implications of the Second Law, when we deliver these topics to our students.

2. About basic laws of energy

Bellow it is given a brief overview on the classical way of teaching First and Second Law of Thermodynamics to future marine engineers, in Constanta Maritime University.

Energy is the driving force for the Universe. It is a quantitative property of a system, one form of energy being able to be transformed into another form. The Laws of Thermodynamics govern how and why energy is transformed.

The First Law of Thermodynamics is a statement of the law of energy conservation. According to this law, the change in internal energy of a system (ΔU) is equal to the heat added to the system (Q) minus the work done by the system (L).

The First Law deals with quantities of energy of different forms transferred between the system and its surroundings and with the changes in the energy stored in the system, and do not offer information on the possibility of a spontaneous process proceeding in a specific direction. This law puts no restriction on the direction of a process; but not violating the First Law do not means that a process can take place. The incapacity of the First Law to certify if a process occurs is overpassed by the Second Law of Thermodynamics [6].

A process takes place only if both Laws of Thermodynamics are respected. Besides the fact that the Second Law of Thermodynamics is able to indicate the direction of processes, it states that energy has quality and quantity. The quality of energy is extremely important for engineers, the Second Law offering tools to assess the quality and the degree of energy degradation during a process. By the help of the Second Law, engineers are able to establish the level of perfection of a process and to indicate ways to diminish imperfections. Processes can be classified in reversible or irreversible. A process is reversible if happens very slow, with no loss of energy due to dissipative forces like friction and no heat conduction due to a temperature difference. Practically, such conditions are impossible, so all real processes are irreversible.

The Second Law can be used to determine if a process is reversible or not. This law presents several statements, among them:

- Kelvin-Plank statement – It is not possible to construct a device operating in a cycle (as a heat engine), which realizes only the extraction of heat from a source and its complete conversion to work. It demonstrates the impossibility of the existence of a heat engine having a thermal efficiency of 100%.
- Clausius statement – It is not possible to construct a device operating in a cycle (as a refrigeration system) which extracts heat from a low temperature side and releases it to a high-temperature side without producing other effect.

Future marine engineers should know that a marine diesel engine is less efficient than the reversible one, operating between the same two thermal energy reservoirs.

The Second Law is controlled by the concept of entropy (noted by 'S'). Entropy is the measure of the level of disorder of a system. Any irreversible process increases the level of disorder. The entropy of an isolated system always increases during a process or is kept constant when a reversible process occurs, but never decreases [7]. When there it is no heat transfer, entropy change is due to irreversibility only, their effect being always an increased entropy.

3. Basic information regarding Islam

Shipping is a largely international industry, on ships board being formed multicultural teams from seafarers of different nationalities and religions [8]. For seafarers, the perimeter of the vessel is their home and working place for many months. But this variety of languages and religions on board can increase communication problems and can lead to isolation or conflicts. On board of the ships it is promoted a spirit of interreligious dialogue and respect. Seafarers must respect each other's religious identity, but for this it is needed first the basic understanding of religious beliefs.

Some aspects related to the tradition of Muslims are not unknown for students enrolled in Constanta Maritime University, since the majority of Muslim population living in Romania in concentrated in Dobrogea. Still, some specifications are useful. A survey that I run revealed that 66% of our students have a favourable perception of Islam, 14% have an unfavourable perception of this religion (some of these students associate Islam with violence) and 20% don't know what to think about Islam.

According to Akbar S. Ahmed, Islam is a religion of peace, universalism, brotherhood and the unity of human beings [9]. A good Muslim must balance the world with the principles of the religion. The ideal Muslim is the Prophet Muhammad. He is not divine though He received revelation in the form of Quran – the message of Allah. The Quran reveals that the creation of the Universe and Earth are signs of the existence of God. Thus, the Quran states [10]: "Not without purpose did We create Heavens and the Earth and all that is in between them in vain…" (38:27), or: "He is Allah, the Creator, the Shaper out of naught, the Fashioner…" (60:24), or: "The Originator of Heavens and the Earth! When He decreed a thing, He saith unto it only, Be! And it is" (2:117).

The Quran states that this world is a centre under examination, a mortal and temporary place and that there will be a last day of this Universe [11].

4. Discussion

Without having intention to discuss about the debate between the evolutionist and creationist scientists concerning Thermodynamics, the following approach illustrates that Laws of Thermodynamics are available not only in technical applications, but also in religious context.

Many scientists believe that the Universe could have a beginning, with a state of zero energy and maximum entropy and also assume that the Universe is an isolated system. It is the case of Victor J. Stenger, which in his work called 'The Universe: the ultimate free lunch' states: "the Universe could have begun from a state of zero energy and maximum entropy, and then naturally evolved into what we see today without violating any known principles of Physics" and "the Universe can reasonably be regarded as an isolated system" [12]. This opinion is similar to the one of theologians, which believe in the creation of the Universe. It was previously mentioned that in the Quran, Allah says in several places that the Universe was created.

When we speak to our students about the First Law of Thermodynamics, we underline that energy cannot be created or destroyed. At this point, we can make the connection between Thermodynamics and Islam: since the Universe had a beginning, we can say that it was created. On the other hand, it is rational to affirm that the Universe was created by a power above the law of Thermodynamics, in the way we know it at this moment, by a Supreme Force, a Creator.

Students must understand that the Second Law forbids heat to flow spontaneously from cold to hot bodies, pointing out the way of unidirectional change. We start with a very simple example, since many of our students graduated high schools with humanistic education: a hot brick placed in a cold ship cabin will warm it because the heat is transferred from the hot brick to the cabin, but never the brick will get hotter. If the brick cools to the level of the ambient temperature of the atmosphere, a state of equilibrium will be reached. After this, we can state that when at last the whole heat amount of the Universe would have thus exhausted itself reaching a state of equilibrium, heat exchange will be possible no more and no chemical reaction would be visualized. This description is the heat death of Universe [13]. If we try to find a similar message in Quran, this is one of the results: "All that is on the Earth will perish and only the countenance of thy Lord, Master of Glory and Honour, will survive" (55:27-28) [14].

On board the ships, refrigeration has several applications as: the carriage of some liquefied gases and bulk chemicals, in air conditioning systems or preserving of perishables during their voyage on sea. Most of the systems are vapour compression, basic components of such system being available in Figure 1.

For future marine engineers, this is a good example for the statement of the Second Law, which is that heat does not flow spontaneously from cold to hot. The refrigerator extracts heat from a cool reservoir and releases it to a hotter one, but for this it requires work. The most important assumption for an ideal vapour compression cycle is that irreversibilities within the evaporator, condenser and compressor are ignored. We have to note that the ideal compression refrigeration cycle is not internally reversible cycle, because it contains throttling, which is an irreversible process.

Because of irreversibilities in the components of the actual cycle, there are several differences between the ideal and actual cycles (pressure drop and heat transfer to the surroundings are not negligible, heat rejection in condenser and heat absorption in evaporator do not occur at constant pressures and temperatures, etc.).

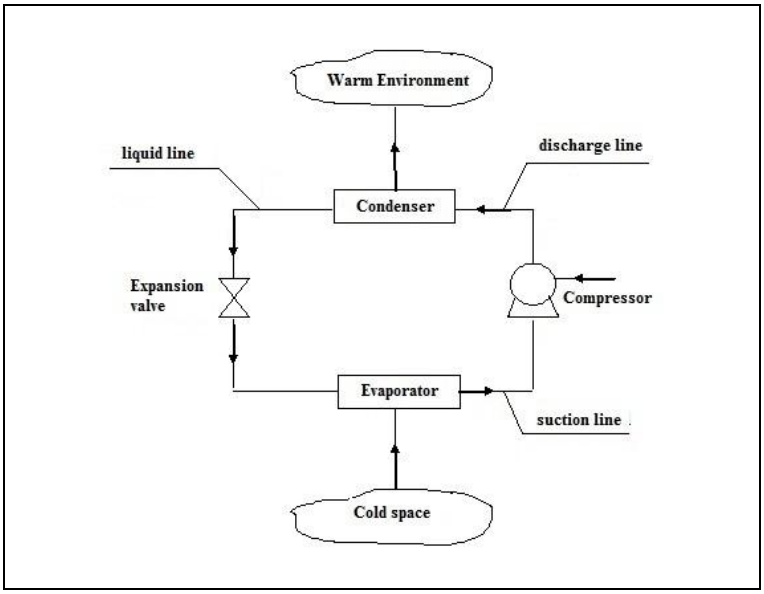

Figure 1. Schematic representation of a simple vapour compression refrigeration system.

The performance of refrigerators is assessed by the Coefficient of Performance (COP), on basis of the First Law of Thermodynamics. It is defined as the ratio between the cooling effect and work input.

When comparing the theoretical performance (ideal) with the real one (actual), we will find always an inequality in concordance with statements of Second Law [15]:

$$COP_t > COP_r \quad (1)$$

When we choose examples for our presentations, they should be strong enough to express the importance of entropy. During Thermodynamics course, delivered to future marine engineers in Constanta Maritime University, we define entropy in the classical way: it is a quantitative measure of the disorder in a system; the change in entropy for a reversible process is directly proportional to the heat amount added to the system and inversely related to the temperature of that system. Another statement of the Second Law is that entropy, or randomness, is constantly increasing. The following example will show this clearly.

Let's consider two identical blocks of different temperatures, T_H and T_C. What is the total entropy change if they are brought into thermal contact? In order to solve this task it is assumed that for each block the heat capacity is constant over this temperature range; also, volume changes are neglected.

Heat flows from the hot body, at T_H to the cold body, at T_C, for the entropy decrease of the warmer block (dS_H) and the entropy increase of the colder block (dS_C) being possible to write:

$$dS_H > -\delta Q/dT_H \tag{2}$$

$$dS_C > \delta Q/dT_C \tag{3}$$

The total entropy change is:

$$dS = dS_H + dS_C > \left(\frac{1}{T_C} - \frac{1}{T_H}\right)\delta Q > 0 \tag{4}$$

The decrease in entropy of the warmer block is more than compensated by the increase in entropy of the colder block. The naturally flow of heat is featured by an overall entropy increase and the bodies continue to exchange heat until their combined entropy is maximized.

Since it is not possible the assessment of entropy change associated with irreversible processes, it will be considered a reversible process which occurs between same endpoints.

The infinitesimal heat transfer is given by:

$$\delta Q_{rev} = CdT \tag{5}$$

resulting the total entropy change:

$$dS = \int_1^2 \frac{\delta Q_{rev}}{T} = C\int_{T_1}^{T_2} \frac{dT}{T} = C\ln\left(\frac{T_2}{T_1}\right) \tag{6}$$

$$\Delta S = \Delta S_C + \Delta S_H = C\ln\left(\frac{T_f}{T_C}\right) + C\ln\left(\frac{T_f}{T_H}\right) = C\ln\left(\frac{T_f^2}{T_H T_C}\right) > 0 \tag{7}$$

$\Delta S > 0$ means that the total disorder has increased. If heat flowed from the cold body to the hot one, then $\Delta S < 0$. This cannot occur naturally.

The continual increase of this concept is a topic of interest to religion and different disciplines, proving that Science and religion are not incompatible. Below are shown other examples to support this statement.

"Entropy is continuously increasing in the Universe in all natural processes, and entropy is not reversible. Billions of years from now, all energy may exist as heat uniformly distributed throughout the Universe. If that happens, the Universe as a closed system will cease to operate because no work will be possible." [16]

At the end of this chapter of Thermodynamics, perceptions of Islam among students are changed: only 9% of interrogated students still have an unfavourable perception of this religion, while 15% still do not know what to think about it. Estimations show that Muslim seafarers represent 18% of the merchant seafarers of the whole world [18], thus we do believe that such kind of approach is contributing also to future integration of our graduates on board of ships.

5. Conclusions

The First Law of Thermodynamics states that energy cannot be created or destroyed, thus the total amount of energy available in the Universe is kept constant. The science cannot explain us why energy is neither created nor destroyed, but religion does give us this information.

The Second Law states that all processes go only in one direction, which is the direction of greater and greater degradation of energy, in other words, to a state of higher and higher entropy. So, the total quantity of energy in the Universe is a constant, but the quantity of available energy is decreasing. When looking at the Universe, Second Law says that at some time in the future no more energy transformations can take place. The Universe will reach some stage of maximum entropy and thermal equilibrium. The Second Law can predict that the Universe must have had a beginning and an end.

The First Law of Thermodynamics is the starting point for the science of Thermodynamics and engineering analysis, while the Second Law can help engineers to have a better viewpoint inside processes- it can lead to design improvements.

In this paper was described the strategy for teaching these two laws to future marine engineers, enrolled in Constanta Maritime University. The traditional way of exposing the theory is combined with various issues associated with the First and Second Laws, which are typically discussed in numerous research works and are not included in classical textbook.

We found possible to associate the concept of conservation of energy with the possibility of intervention of Supernatural to create something from nothing, in the initial creation of the Universe. The statement of the Second Law of Thermodynamics: heat flows spontaneously from a hot to a cold body can be directed also to the heat death of the Universe, not only to an adequately familiarization of students with marine refrigeration - for example.

There are several ways in which the Second Law of Thermodynamics can be stated, all of them equivalent. For an isolated system, the entropy can only increase or, in the limit of a reversible process, remain constant. Efforts to explain as simply and understandably as possible this statement led to a practical example, but also to the theological argument in the prove of the existence of God by rational ways.

Taking advantage of the compatibility between Thermodynamics and religion, we state that laws of Thermodynamics might be seen under the light of Islam, being possible the confirmation of its assertions: existence of God, beginning or end of the Universe.

Multicultural crews live and work together, for the harmony of the ship being needed understanding of other cultures. Presented approach will not allow only a better understand of the First and Second Laws, but will familiarize future seafarers with Islam and the Quran. Results of the personal survey revealed that students' perception of Islam is improved after including teaching of laws of Thermodynamics in the religious context.

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