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REVIEW ON LAWS OF THERMODYNAMICS

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ABSTRACT

This paper delves into a meticulous examination of the laws of thermodynamics, exploring their historical evolution, fundamental concepts, and contemporary applications. From the foundational principles of energy conservation to the intricacies of entropy and the third law, this review aims to provide a comprehensive understanding of the thermodynamic framework. By synthesizing historical perspectives with recent advancements, the paper contributes to a holistic comprehension of thermodynamics and its indispensable role in diverse scientific disciplines.

Keywords: Zeroth Law, First Law, Second Law, Third Law.

I. INTRODUCTION

The laws of thermodynamics stand as the cornerstone of classical physics, governing the behavior of energy and matter in our universe. As we embark on a journey through the annals of scientific thought, this paper endeavors to present a meticulous review of these foundational principles. From the inception of thermodynamics as a discipline to its contemporary relevance in fields ranging from physics to engineering and beyond, we aim to unravel the intricacies that define our understanding of energy transfer, conservation, and the inevitable march toward equilibrium. By delving into the historical context and merging it with modern perspectives, this review seeks to not only elucidate the laws themselves but also to underscore their profound impact on our comprehension of the physical world. Join us in this exploration of the laws of thermodynamics, where we navigate through the intellectual landscapes that have shaped our understanding of one of the most profound branches of classical physics.

History

The story of thermodynamics goes way back, connecting with the history of physics and chemistry. It all started with ancient ideas about heat. In the 1800s and early 1900s, scientists like Carnot, Clausius, Thomson, and Nernst figured out the laws of thermodynamics. They established principles about heat, energy, and temperature. The laws got numbered, and even though there were some debates, we ended up with the four main laws we have today. They're the basic rules that help us understand how things like heat and energy work.

II. METHODOLOGY

- **Zeroth law**

The zeroth law of thermodynamics says that if two things are at the same temperature as a third thing, they're also at the same temperature as each other. This helps us define temperature without bringing in complicated concepts like entropy. It's a basic rule about how things heat up or cool down, and it's called the "zeroth law" because it came after the first three laws of thermodynamics were already known

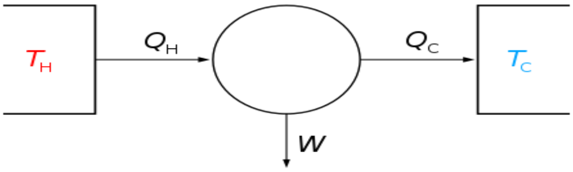
- **First law**

The first law of thermodynamics says that in any process, energy can change forms but is never created or destroyed. For closed systems, the change in internal energy equals the heat added minus the work done. When combining systems, the total internal energy is the sum of the initial systems' energies. This law highlights energy conservation and the importance of internal energy. Work is how energy is transferred, and perpetual motion machines are impossible due to this law.

$$\Delta U_{\text{system}} = Q - W$$

$$U_{\text{system}} = U_1 + U_2$$

$$E_{\text{total}} = KE_{\text{system}} + PE_{\text{system}} + U_{\text{system}}$$



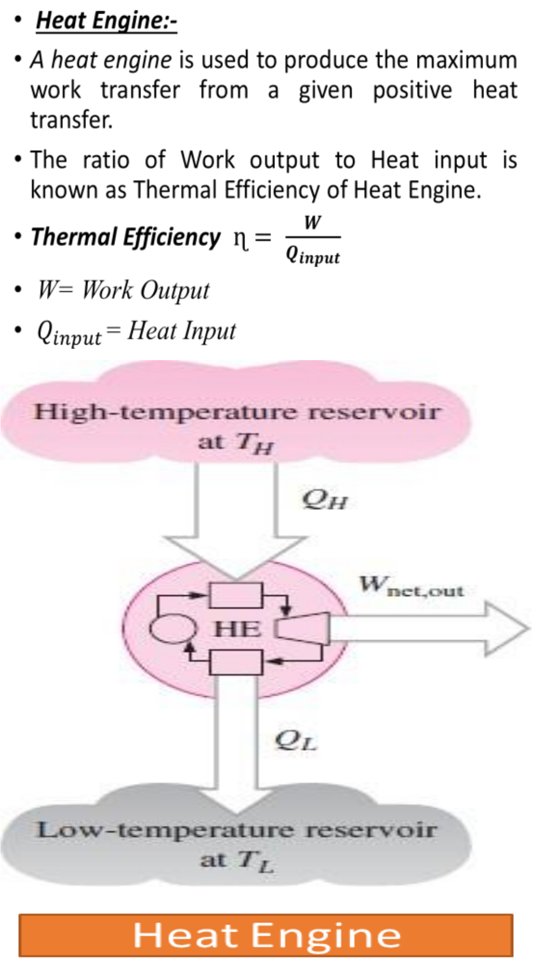
- **Second law**

The second law of thermodynamics basically says that natural processes tend to make things more disordered or spread out. When two systems interact, they eventually reach a balanced state. Entropy is a measure of this disorder. In simpler terms, it means things naturally move from being ordered to more chaotic. Even though we often think about reversible processes, like ideal situations, in reality, all processes are irreversible, and entropy increases as things spread out or become more disordered.

Natural Processes Tend to Increase Disorder: The second law of thermodynamics states that as natural processes occur, things generally become more disordered or spread out.

Irreversibility of Processes: In practical terms, all processes are irreversible. Even though we often consider reversible processes theoretically, in reality, entropy, which measures disorder, tends to increase as things move from an ordered state to a more chaotic one.

The principles you're referring to, known as the second law of thermodynamics, were formulated by several scientists independently. Rudolf Clausius is often credited with developing the concept of entropy and making significant contributions to the second law. Other contributors include Lord Kelvin (William Thomson) and Max Planck. The formulation of the second law evolved over time with contributions from multiple scientists in the 19th and early 20th centuries.



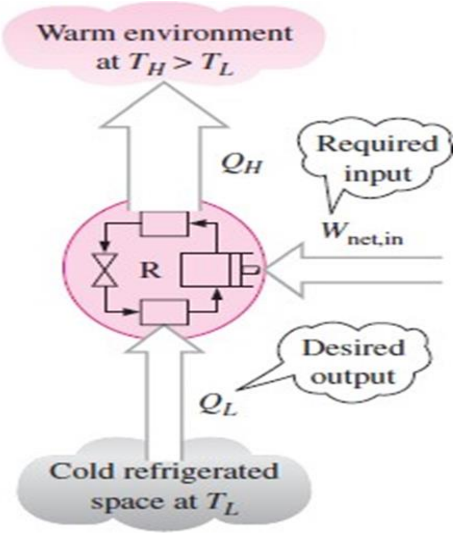
- ***Heat Engine:-***
- *A heat engine* is used to produce the maximum work transfer from a given positive heat transfer.
- The ratio of Work output to Heat input is known as Thermal Efficiency of Heat Engine.
- ***Thermal Efficiency*** $\eta = \frac{W}{Q_{input}}$
- *W= Work Output*
- Q_{input} *= Heat Input*

Heat Pump (Acting as Refrigerator)

Heat engines differ considerably from one another, but all can be characterized by the following :-

1. They receive heat from a high-temperature source (solar energy, oil furnace, nuclear reactor, etc.).
2. They convert part of this heat to work (usually in the form of a rotating shaft).
3. They reject the remaining waste heat to a low-temperature sink (the atmosphere, rivers, etc.)
4. They operate on a cycle.

- Heat engines and other cyclic devices usually involve a fluid to and from which heat is transferred while undergoing a cycle. This fluid is called the working fluid.
- The term heat engine is often used in a broader sense to include work producing devices that do not operate in a thermodynamic cycle.
- Engines that involve internal combustion such as gas turbines and car engines fall into this category.



Third law

The third law of thermodynamics basically says that as things get super cold (like absolute zero cold), the disorder or randomness in a system levels off and becomes constant. At absolute zero, there's only one way the system can be, like a perfectly ordered state. This law helps us understand how things behave when they're extremely cold.

The third law of thermodynamics is often described using the Boltzmann principle:

$$S=kB \ln \Omega$$

Here, S is the entropy of the system, kB is Boltzmann's constant, and Ω is the number of microstates. At absolute zero, there is only one microstate possible (Ω=1), and ln(1)=0, so the entropy (S) is zero at absolute zero temperature.

CASE STUDY OF NUCLEAR POWER ENERGY

An average car consumes about **Part 1** of gasoline a day, and the capacity of the fuel tank of a car is about **Part 2**. Therefore, a car needs to be refueled once every **Part 3**. Also, the density of gasoline ranges from 0.68 to 0.78 kg/L, and its lower heating value is about 44,000 kJ/kg (that is, 44,000 kJ of heat is released when 1 kg of gasoline is completely burned). Suppose all the problems associated with the radioactivity and waste disposal of nuclear fuels are resolved, and a car is to be powered by U-235. If a new car comes equipped with **Part 4** of the nuclear fuel U-235, determine if this car will ever need refueling under average driving conditions (Fig.) Make comments on your solutions .

Condition 1

Given :-

Velocity (V) = 7 L/day

Volume (V_L) = 60 L

Density $_{(p)}$ = 0.75 kg/L

The mass of gasoline used per day is,

$$m_{gasoline} = p \times V$$

$$0.75 \times 7$$

$$= 5.25 \text{ kg/day}$$

Calculate the energy supplied (E)

$$E = m_{gasoline} \times \text{Heating value}$$

$$= 5.25 \times 44000$$

$$= 231000 \text{ KJ/day}$$

Calculate the complete fission of 0.1 kg is

$$6.73 \times 10^{10} \times 0.15$$

$$= 10.095 \times 10^{9} \text{ KJ}$$

Calculate the number of days,

$$\text{Number of days} = \frac{\text{Energy content of fuel}}{\text{Daily energy use (E)}}$$

$$= \frac{10.095 \times 10^{9}}{231000}$$

$$= 43702 \text{ days}$$

Convert Days into Years,

$$\frac{43702}{365} = 119.73 \text{ Years}$$

$$= 120 \text{ Years}$$

In 1st Condition 120 Years is required to refueling

Conditions	Part 1	Part 2	Part 3	Part 4
1	07 Liters	60 Liters	13 Days	0.15 Kg
2	10 Liters	65 Liters	16 Days	0.20 Kg
3	12 Liters	70 Liters	19 days	0.25 Kg

Condition 2.

Given :-

$$\text{Velocity (V)} = 10 \text{ L/day}$$

$$\text{Volume } (V_{L}) = 65 \text{ L}$$

$$\text{Density } (p) = 0.75 \text{ kg/L}$$

The mass of gasoline used per day is,

$$m_{gasoline} = p \times V$$

$$0.75 \times 10$$

$$= 7.5 \text{ kg/day}$$

Calculate the energy supplied (E)

$$E = m_{gasoline} \times \text{Heating value}$$

$$= 7.5 \times 44000$$

$$= 330000 \text{ KJ/day}$$

Calculate the complete fission of 0.1 kg is

$$6.73 \times 10^{10} \times 0.20$$

$$= 13.46 \times 10^{9} \text{ KJ}$$

Calculate the number of days,

$$\text{Number of days} = \frac{\text{Energy content of fuel}}{\text{Daily energy use (E)}}$$

$$= \frac{13.46 \times 10^9}{330000} = 40787.8$$

$$= 40788 \text{ days}$$

Convert Days into Years,

$$\frac{40788}{365} = 111.74 \text{ Years}$$

$$= 112 \text{ Years}$$

In 2st Condition 112 Years is required to refueling

Condition 3.

Given :-

$$\text{Velocity (V)} = 12 \text{ L/day}$$

$$\text{Volume } (V_{L)} = 70 \text{ L}$$

$$\text{Density }_{(p)} = 0.75 \text{ kg/L}$$

The mass of gasoline used per day is,

$$m_{gasoline = p \times} V$$

$$0.75 \times 12$$

$$_= 9 \text{ kg/day}$$

Calculate the energy supplied (E)

$$E = m_{gasoline} \times \text{Heating value}$$

$$= 9 \times 44000$$

$$= 396000 \text{ KJ/day}$$

Calculate the complete fission of 0.1 kg is

$$6.73 \times 10^{10} \times 0.25$$

$$= 16.825 \times 10^9 \text{ KJ}$$

Calculate the number of days,

$$\text{Number of days} = \frac{\text{Energy content of fuel}}{\text{Daily energy use (E)}}$$

$$= \frac{16.825 \times 10^9}{396000}$$

$$= 42487.37 \text{ days}$$

Convert Days into Years,

$$\frac{42500}{365} = 116 \text{ Years}$$

In 3st Condition 116 Years is required to refueling

III. CONCLUSION

To sum it up, this paper explored the basic rules of how energy works in our universe. Understanding these rules is crucial for many areas of science and technology. By continuing to study and apply these principles, we can unlock new discoveries and improve our grasp of the world around us.

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