

Practical significance of the Second and Third Laws of Thermodynamics and their collective effect on Human Life

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Abstract - Although thermodynamics seems to be a complex science, it has complete pervasion over human life and the relevance of the laws can be felt thereby. The first law of thermodynamics describes the quantified inter-conversion of heat and work, the second law highlights the quality aspect of this process and lays certain constraints on the thermodynamic processes. The third law describes the disorderliness of a system and sums up saying the disorderliness of the universe is increasing continuously. These aspects can be experienced in practical human life wherein every commodity that has a certain use, needs to be regularly maintained for service failing which, there will be increase in disorder and the commodity will become unusable. This paper considers three cases viz. Industrial setup and machines, Automobiles and the Human Body, where the laws of thermodynamics govern the serviceability and efficiency of the system. A conclusion is drawn towards the end indicating the pervasiveness of the laws of thermodynamics.

Key Words: Thermodynamics, energy, entropy, heat, work, efficiency, maintenance

1. INTRODUCTION

Thermodynamics can be defined as the science of energy and entropy. But as these terms represent an advanced stage of study, in the basic stage, one can define thermodynamics as the science of inter-conversion of heat and work. Since thermodynamics is a science, it can be attributed as a systematic study of processes. There are four laws of thermodynamics that govern a thermodynamic process. In these, the Zeroth law defines a state of thermal equilibrium wherein the foundation of another field of study called Heat Transfer is laid. Similar to an electric current, heat flows from a point at higher temperature to a point at lower temperature until equilibrium is established. The voltage in this process is the difference of temperatures which is also known as the thermal gradient. The First law of thermodynamics is the Law of conservation of energy. Since heat and work are alternate forms of energy, this law provides the quantitative constraints of inter-conversion of heat and work. Although the First law says that for a cycle the cyclic integrals of heat transfer and work transfer are equal, there is no clarity regarding the efficiency of conversion. This can be understood by the Second law of thermodynamics which considers the quality of inter-conversion. According to this, a thermodynamic process cannot take place if it exchanges heat with a single thermal reservoir and there cannot be natural heat transfer against a negative thermal gradient. Thus it can be observed that as

the laws progress, there is a refinement in the constraints of the process. The Third law of thermodynamics deals with the disorder of the system during a process. It dictates the effect of a process on the system-surrounding interface. Every process, whether reversible or irreversible has a path followed which is positive. Thus every path contributes to the increase in disorder of a system-surrounding interface. This can be understood by considering the following example. While moving downhill in a car, when the brakes are applied, the kinetic energy is converted to heat by the brake shoes and the car comes to rest. But the same energy cannot be regained by reversing the process wherein the car moves uphill and the brakes are cooled. Thus in a reversible process, every path contributes to increase in disorderliness of the universe. Considering this as the basis, following study can be undertaken wherein for every commodity in use, there is a tendency of increase in disorder. It is not possible to stop this but by certain methods, the disorder can be controlled indeed.

2. THE SECOND LAW OF THERMODYNAMICS

The second law of thermodynamics has two statements depending upon the context of application[1] viz. the Kelvin-Planck statement i.e. "It is impossible to construct an engine, which while working in a cycle produces no other effect except to extract heat from a single reservoir and do equivalent amount of work" and the Clausius statement i.e "It is impossible for a self acting machine working in a cyclic process unaided by any external energy, to convey heat from a body at lower temperature to a body at higher temperature". Both the statements are negative statements and cannot be proven mathematically. However, their truth cannot be denied by the fact that one cannot design a system that negates either or both of these statements. This makes the second law of thermodynamics a factor to decide the feasibility of a process. This itself paves way to the concept of efficiency which represents the ability of a system undergoing a process to convert the given input into a desired output. But according to the second law, it can be clearly stated that one can reach nearer to maximum efficiency but cannot attain it. This itself paves way to the third law of thermodynamics which talks of orderliness of the system at absolute zero. Thus if a system is not completely efficient, there is certain disorder and this disorder keeps on getting magnified with time. The following sections discuss this concept at large.

3. INDUSTRIAL SETUP AND MACHINES

In order to have a continuity of study, let an automobile manufacturing industry be considered. The setup mainly comprises of dies that are used to form the sheet metal to the desired shape, assembly units or workstations where the assembly takes place and a testing unit where the testing takes place. For the study, there should be certain defined input and a desired output on the basis of which, the efficiency of the process can be measured.

Consider the setup comprising of dies and punches where sheet metal forming has to be undertaken. Every set has to work for a determined number of cycles. On operating the dies once, there certain amount of wear that takes place. A cumulative effective of this leads to considerable wear. The principle of disorder lies in the fact that if allowed to work without maintenance, the dies tend to be more inaccurate while forming the sheet metal. For that matter, the effectiveness of maintenance depends upon the ability to restore the lost dimensions which further adds to the inaccuracy. Thus the setup has an inbuilt tendency to wear if kept unattended and even if regularly maintained, there is increase in inaccuracy of the die over a period of time. This requires efficient design and replacement after the end of serviceable life.

Another setup is the Assembly workstation which has fixtures to aid the assembly of the automobile. The factor that further contributes to the disorder of the system is the product variety that the company may offer. This requires proper upkeep of the fixtures when not in use. Additionally, when the same fixture is used for a large number of assemblies, there is increase in wear of the fixture that adds to further errors in alignment of the components and variations in the torque required to join the same.

This clearly shows that the metallic as well as the non-metallic components of the setup have a natural tendency to reach disorder if left unattended or regularly maintained as the lost accuracy cannot be regained by maintenance. As explained in the example mentioned in the introduction, every process thus adds to increase in disorder to validate the third law of thermodynamics.

4. AUTOMOBILES

Continuing the study further, the product of the automobile manufacturing company i.e an automobile shall be taken up as an example to explain the application of the third law of thermodynamics. Right from the day on which a particular automobile is commissioned, it begins its journey towards deformation and disorder. On regular use, there are fatigue stresses induced in the components that tend them to lose their strength over a considerable period of time. The sheet metal used to build the structure of the automobile, tends to corrode even though there is a protective coating applied to it. This can be experienced by the automobile users to a huge extent. Disorder sets up in every system if it is left unattended and if maintenance is carried out, there are

inaccuracies introduced in the system. Because of this, the sheet metal eventually corrodes, the battery gradually loses its functional ability, the rotating and reciprocating parts of the engine undergo wear and deform over a period of time. The efficiency of functioning of these parts depends greatly upon the frequency of application. But in the correct context, continuous use also introduces inaccuracies due to excessive wear. This renders an image of pervasion of the second and third law of thermodynamics, not only in thermal or heat related process but also in the processes where use of materials is concerned.

5. THE HUMAN BODY

To further extend the study, the human body shall be considered as the system and principle of disorder shall be addressed thereby. The human body is indeed a marvel of bio-mechanics, thermodynamics and life sciences. In this section, the organ system, circulatory system and the digestive system shall be considered and effect of ageing and improper care on the disorderliness of the system shall be highlighted. This study shall be undertaken considering only the thermodynamic aspect.

The human body is a combination of systems. There is extreme control and coordination among these systems. However, every living being has four major characteristics viz. locomotion, respiration, reproduction and growth. When it comes to growth, it is an irreversible process wherein there is visible increase in disorder of the body as a law of nature.

The cell is a basic unit of life. Group of cells forms a tissue and group of tissues forms an organ. A group of organs make an organ system. Every organ system is connected to perform a specific task. However, as the person grows, there is reduction in the effectiveness of the organs due to various reasons attributed to food, life style and so on. The organs are continuously subjected to varying operating conditions. Due to the effect of intermittent changes, the organs lose their strength, vigor and get easily fatigued. The increase in disorder occurs when a particular organ is not properly functional and undergoes medical treatment. Post treatment, the organ rarely completely regains its lost functionality. This gradually hinders the functionality of other organs and there is disorder introduced that prevails and magnifies thereafter.

The circulatory system comprises of the heart, the veins and arteries. The concept of disorder introduced in the system can be understood by something that can be experienced by frequent travelers. During overnight journeys, some of the travelers prefer buses or trains that have sitting or semi-sleeping arrangement wherein the traveler is more or less in a sitting posture. Due to gravity, the posture and extended period of lack of movements, blood tends to accumulate in the limbs and the same can be validated by observing slightly swollen feet in the morning. Thus, if left unattended, there can be increase in the local blood pressure of the foot

and this can lead to internal rupture on account of the continuous inflow of blood. This speaks about the increase disorder of the system that is indicated by the deviation from normal physical behavior.

The digestive system is the key to well being of an individual. Overall health of a person depends upon the effectiveness of the digestive system. Firstly, if the person starves for a considerable period, the inner lining of the alimentary canal is affected and this leads to increase in acidity of the same. On completely utilizing the glycogen available, the body starts to break down the proteins and other necessary elements to keep itself alive thereby increasing the disorder due to no intake of food. This can lead to permanent digestive problems and hinder the functioning of the associated organs. Thus disorder in one system leads to disorder in another, thereby increasing the overall disorder. This clearly indicates that the body always tends towards disorder.

Thus observing an overall scenario, the human body is something that seems to be constantly inching towards more and more disorder with age. Thus the suggested key to success would be maintaining least disorder in every activity to the most possible extent.

6. CONCLUSION

Thus it can be concluded that, the basic tendency of the universe is to attain disorder by one or the other means. In event a system is regularly overhauled, one cannot ascertain regaining of earlier accuracy thereby introducing an additional disorder. Thus every system follows this principle and tends towards complete disorder validating the second and third laws of thermodynamics to a greater extent thereby proving their all pervasive nature.

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