VARIOUS ASPECTS OF HEAT TRANSFER- A STUDY

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ABSTRACT

The applications of heat transfer are diverse, both in nature and industry. Climatic changes, formation of rain and snow, heating and cooling of the earth's surface, spreading of forest and fires are some of the natural phenomena wherein heat transfer plays a dominant role. The existence of living beings is possible due to the supreme heat source, the sun. The aim of present study is to discuss the mechanism of various types of heat transfer and how the various types of heat transfer processes plays a vital role in our daily life .The principles of heat transfer in engineering systems can be applied to cooking and the human body in order to determine how the body transfers heat Heat transfer plays a very important role in the living systems as it affects the temperature and its spatial distribution in tissues. In various fields, heat transfer problems are encountered which cannot be solved by thermodynamic reasoning alone but requires an analysis based on the science of heat transfer.

Keywords: Conduction, convection, heat transfer, radiation, temperature

I. INTRODUCTION

Recent years have been surging interest among researchers to understand heat transfer aspects in various fields. The laws which govern heat transfer are very important to the engineers in the design, construction, testing and operation of heat exchange apparatus. Electrical engineers apply their knowledge of heat transfer for the design of cooling systems for motors, generators and transformers. Chemical engineers are concerned with the evaporation, condensation, heating and cooling of fluids. An understanding of the laws of heat flow is very important to the civil engineers in the construction of dams, structures and to the architect in the design of buildings. The mechanical engineers deals with the problems of heat transfer in the field of internal combustion engines, steam generation, refrigeration and heating and ventilation [1]. Heat transfer is classified mainly into three types, such as heat conduction, convection and thermal radiation. All forms of heat transfer may occur in some systems at the same time. Heat transfer only occurs because of a temperature difference driving force and heat flows from the high to the low temperature region.

II. METHODS OF HEAT TRANSFER

2.1 Heat Transfer by Conduction

The transfer of energy between objects that are in physical contact is known as conduction. On a microscopic scale, heat conduction occurs as hot, rapidly moving or vibrating atoms and molecules interact with neighboring atoms and molecules, transferring some of their energy (heat) to these neighboring particles. In other words,

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heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from one atom to another. Conduction is the most significant means of heat transfer within a solid or between solid objects in thermal contact as shown in Fig. 1.

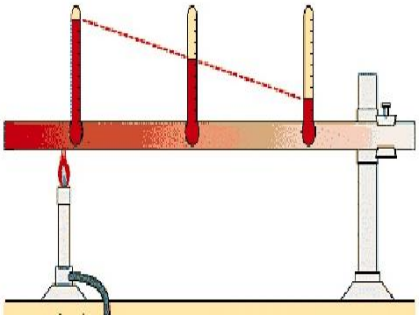

Fig.1 Heat transfer by conduction

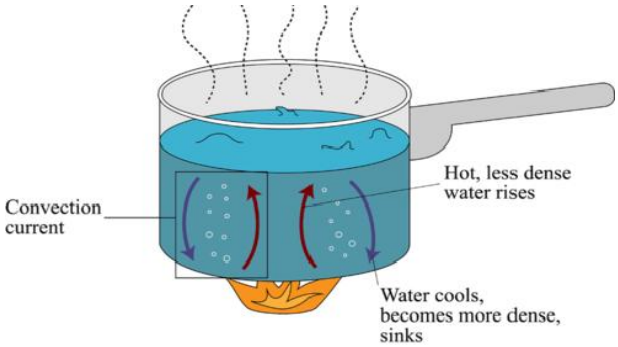

Fig. 2 Heat transfer by convection

2.2 Heat Transfer by Convection

Convective heat transfer is the transfer of heat from one place to another by the movement of fluids. Bulk motion of the fluid enhances the heat transfer between the solid surface and the fluid. Convection (as shown in Fig. 2) is usually the dominant form of heat transfer in liquids and gases. Free or natural convection occurs when the fluid motion is caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. Forced convection is when the fluid is forced to flow over the surface by external means such as fans, stirrers and pumps creating an artificially induced convection current.

2.3 Heat Transfer by Radiation

The transfer of energy to or from a body by means of the emission or absorption of electromagnetic radiation is called heat transfer by radiation. Thermal is energy emitted by matter as electromagnetic waves due to the pool of thermal energy that all matter possesses that has a temperature above absolute zero. Thermal radiation propagates without the presence of matter through the vacuum of space as shown in Fig 3. Thermal radiation is a direct result of the random movements of atoms and molecules in matter. Since these atoms and molecules are composed of charged particles (protons and electrons), their movement results in the emission of electromagnetic radiation, which carries energy away from the surface [2]. Fig. 4 shows that how heat is transferred by conduction, convection and radiation.

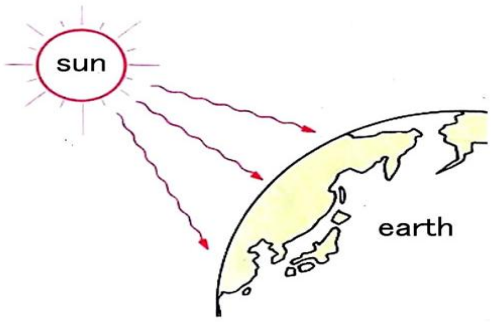

Fig. 3 Heat transfer by Radiation

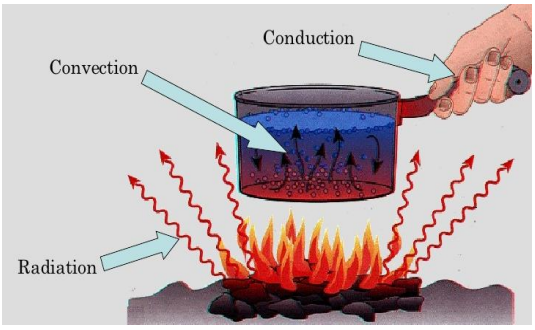

Fig. 4 Different modes of heat transfer

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III. APPLICATIONS OF HEAT TRANSFER IN DAILY LIFE

3.1 Heat Transfer in Cooking

Understanding of what is going on in the kitchen can not only help you avoid disasters but also assist in making the right decision the first time you try out a recipe or wing it. Understanding how heat transfer affects your cooking is a first step in realizing why we choose a particular cooking implement or specific heating method (steaming vs. baking, frying vs. boiling) for one dish but not another. Cooking, ultimately, is about heat, how heat enters the food and what happens to the food when it enters. This article focuses on heat transfer in cooking, or how heat is applied to and enters food. I won't spend much time on the chemical reactions that occur in food during cooking. In cooking, typically there is a heating element (such as a fire), a heat transfer medium (oil, water, air, a pan, etc.) and the food itself. The heat moves from the element through the medium to the food [3]. Most engineers have taken courses in heat transfer and have heard of the big three: conduction, convection and radiation. All three play a vital role in cooking as shown for various methods of cooking in Table 1. Qualitative comparison of maximum temperature and rate of heat transfer for various cooking methods is given in Fig. 5.

Table 1: Common cooking methods & how they cause heat transfer

Method	Conduction	Convection	Radiation
Steaming	High	High	Low
Boiling	High	Moderate	Low
Deep frying	High	Moderate	Low
Sautéing	High	Low	Low
Broiling	Moderate	Low	High
Baking	High	High	Moderate
Grilling	Moderate	Moderate	High
Microwaving	Low	Low	High

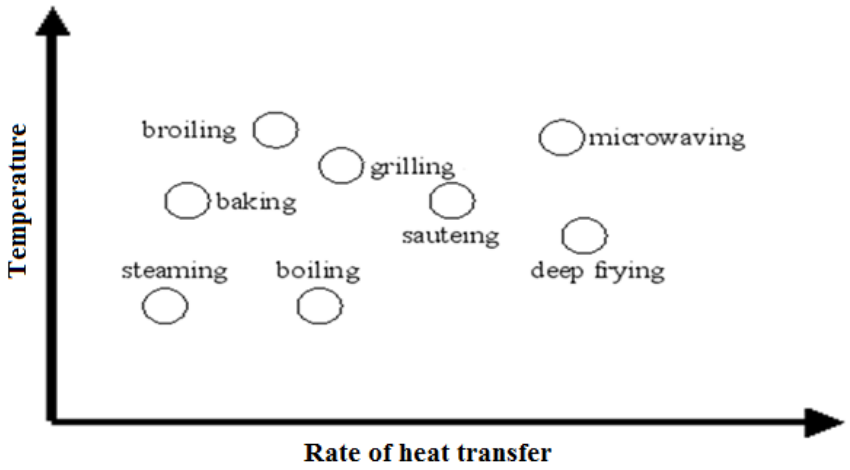

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Fig. 5 Qualitative comparison of maximum temperature and rate of heat transfer using various cooking methods.

3.2 Heat Transfer in Human Body

The principles of heat transfer in engineering systems can be applied to the human body in order to determine how the body transfers heat. Heat is produced in the body by the continuous metabolism of nutrients which provides energy for the systems of the body. The human body must maintain a consistent internal temperature in order to maintain healthy bodily functions. Therefore, excess heat must be dissipated from the body to keep it from overheating. When a person engages in elevated levels of physical activity, the body requires additional fuel which increases the metabolic rate and the rate of heat production [4]. The body must then use additional methods to remove the additional heat produced in order to keep the internal temperature at a healthy level.

In order to ensure that one portion of the body is not significantly hotter than another portion, heat must be distributed evenly through the bodily tissues. Blood flowing through blood vessels acts as a convective fluid and helps to prevent any buildup of excess heat inside the tissues of the body. This flow of blood through the vessels can be modeled as pipe flow in an engineering system [5]. The heat carried by the blood is determined by the temperature of the surrounding tissue, the diameter of the blood vessel, the thickness of the fluid, velocity of the flow, and the heat transfer coefficient of the blood. The velocity, blood vessel diameter, and the fluid thickness can all be related with the Reynolds Number, a dimensionless number used in fluid mechanics to characterize the flow of fluids.

IV. HEAT TRANSFER AND ENERGY EFFICIENCY

In everyday life, there are many things that have to be kept hot or cold. This is achieved through minimizing the three ways of heat transfer. If the rate of heat transfer is low, less energy is required to keep something hot or cold.

4.1 Vacuum Flask

A vacuum flask is designed to prevent heat transfer between the content inside and its surroundings outside. With re-heating or cooling unnecessary, a vacuum flask is a convenient energy saving container. The vacuum prevents any heat transfer through conduction and convection. The silver coating reflects much of the radiation and thus radiation energy transfer is also minimized. So the contents inside a vacuum flask can be kept at a more or less constant temperature for a long time. But the vacuum flask cannot completely stop heat transfer; it can only reduce the rate of the transfer. Moreover, there is still some heat loss through the stopper at the top [6]. Conduction also occurs along the glass shell where the inner and outer walls are connected, bypassing the vacuum. Fig. 6 shows the internal structure of vacuum flask.

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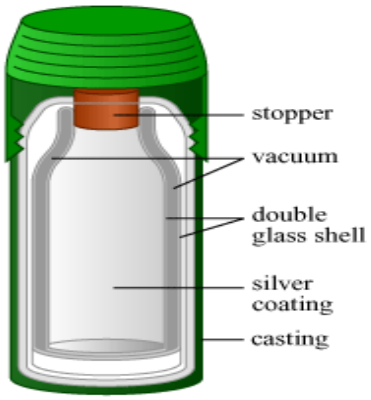

Fig.6 Internal structure of a vacuum flask.

Fig.7 Thermal cooker.

4.2 Thermal Cooker

Chinese people like slow cooking processes (e.g. stewing). People may think that when food is stewed it absorbs heat at a slow rate. In fact this is not the case. When stewing, food is kept at a constant high temperature for a long time. Since much of the heat supplied by the stove is actually lost to its surroundings, a continuous supply of heat is required. Thermal cookers provide a convenient means to stew food in an energy efficient way. As shown in Fig.7, thermal cooker consists of two main parts: a steel inner pot and an outer vacuum flask. The food is first heated as usual in the inner pot. The inner pot is then put inside the outer insulating container which is designed to reduce heat transfer as much as possible.

4.3 Clothes and Blankets

Without suitable clothing and blankets in cold weather, we would need to consume a great deal more energy for indoor heating to keep us warm and comfortable. Clothes and blankets are usually made of materials such as cotton, wool. Since air is a poor conductor of heat, trapped air reduces heat loss through conduction from our body. The materials themselves are also poor heat conductors.

V. CONCLUSION

In everyday life, there are many things that have to be kept hot or cold. This is achieved through minimizing the three ways of heat transfer. If the rate of heat transfer is low, less energy is required to keep something hot or cold. Armed with some fundamental understanding of cooking and heat transfer, anyone can select the perfect cooking method for the dish they want to make. By taking into account the temperature and the rate of heat transfer, you can achieve the exact brownness and doneness you desire. Heat transfer plays a very important role in the living systems as it affects the temperature and its spatial distribution in tissues. The primary role of temperature is the regulation of plethora of rate processes that governs all aspects of the life process. So the principle of heat transfer can be applied to the human body in order to determine how the body transfers heat.

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