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ОБУЧЕНИЕ ЧТЕНИЮ И УСТНОЙ РЕЧИ НА АНГЛИЙСКОМ ЯЗЫКЕ ПО СПЕЦИАЛЬНОСТИ «ТЕПЛОФИЗИКА»

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Пособие «Обучение чтению и устной речи на английском языке по специальности «Теплофизика» Захаровой С. С., состоящее из трёх модульных блоков (Units), содержит современные оригинальные тексты на английском языке по изучаемой специальности, лексико-грамматические и коммуникативные задания и упражнения, позволяющие развить навыки чтения, аннотирования научно-технической литературы, а также профессионально-ориентированного общения и устной речи.

Для студентов старших курсов, учащихся магистратуры и аспирантов, обучающихся по специальности «Теплофизика» на факультете «Энергомашиностроение» МГТУ им. Н.Э. Баумана.

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ПРЕДИСЛОВИЕ

Учебное пособие «Обучение чтению и устной речи на английском языке по специальности «Теплофизика» Захаровой С. С., состоящее из трёх модульных блоков (Units), содержит учебные материалы: тексты из оригинальной научно-технической литературы на английском языке; словарные блоки, в которые включены термины и общетехническая лексика; лексико-грамматические упражнения, а также речевые упражнения, разговорные модели и клише, направленные на формирование у студентов навыков и умений вести профессионально-ориентированную беседу на английском языке и выступать с презентацией по соответствующей тематике.

Целью работы является развитие и закрепление навыков чтения, говорения, аннотирования научно-технической литературы на английском языке по изучаемой специальности.

Пособие предназначено для студентов старших курсов, учащихся магистратуры и аспирантов факультета «Энергомашиностроение» МГТУ им. Н.Э. Баумана, обучающихся по специальности «Теплофизика».

Unit 1

Heat Transfer and Thermodynamics

New words and word combinations to be memorized:

equilibrium *n*	равновесие
heat transfer	теплопередача
flow *n*	поток; расход
uninhabitable *adj*	необитаемый
tempt *v*	искушать
erroneous *adj*	ошибочный, неправильный
restrict *v*	ограничивать
primarily *adv*	главным образом
variable *n*	переменная (величина)
uniform *adj*	единообразный; однородный, постоянный
devise *v*	разрабатывать, придумывать
experience *n,v*	опыт; испытывать, знать по опыту
sole *adj*	единственный; исключительный
gross *adj*	общий
generalize *v*	обобщать, делать общие выводы
identify *v*	распознавать, устанавливать
quantify *v*	определять количество

1. Match the words in A with their definitions in B.

A	B
1. equilibrium	(a) the act or process of changing sth from one form to another
2. thermodynamics	(b) the detailed study or examination of sth in order to understand more about it

3. hypothesis	(c) a source of power
4. heat	(d) heat, energy that is sent out in the form of rays
5. transfer	(e) a number or quantity that can vary or be varied
6. energy	(f) a state of balance, especially between opposing forces or influences
7. radiation	(g) the quality of being hot
8. analysis	(h) the process of becoming slowly mixed with the substance
9. variable	(i) the act of moving sb/sth from one place to another
10. diffusion	(j) an idea or explanation of sth that is based on a few known facts but has not yet been proved to be true or correct; guesses and ideas that are not based on certain knowledge.
11.conversion	(k) the science that deals with the relations between heat and other forms of energy

2. Read the following nouns derived from Latin and Greek; mind the pronunciation in the singular and plural forms.

Hypothes**is** – hypothes**es;** bas**is** – bas**es;** dat**um** – dat**a;** symbios**is** – symbios**es;** medi**um** – medi**a;** spectr**um** – spectr**a;** phenomen**on** – phenome**na;** ax**is** – ax**es;** analys**is –** analys**es.**

3. Translate the following words both as nouns and verbs.

Effect, contact, finish, pass, force, place, use, work, size, house, help, stop, cut, result, attempt, drive, range, design, form, experience, process, transport, transfer.

4. Give Russian equivalents to the following words and word combinations.

Net transfer of heat, energy transport, at first glance, conclusion would be erroneous, initial energy, heat flow, a lack of equilibrium, in terms of gross characteristics.

5. You are going to read the introductory Text 1A. Before reading try to answer the following questions. Share your answers with your fellow students. 1. What do you know about the subject of heat transfer? 2. Were you given lectures on the laws of thermodynamics? 3. Do you agree that the sun is the initial source of energy? 4. What do you know about radiation?

5. What would happen if we were to cut off the radiation from the sun? 6. What does classical thermodynamics deal with?

Text 1A.

Heat Transfer and Thermodynamics

The subject of heat transfer, or more generally the *transport of energy,* is of importance to all engineers and scientists, for it is energy, initially derived from the sun, on which the world runs. If we were to cut off the radiation from the sun we would soon find the world to be an uninhabitable sphere, and if we misuse the energy that is currently available to us a similar result may occur for other reasons.

The branch of science that deals with the relation between heat and other forms of energy, including mechanical work in particular, is called *thermodynamics*. Its principles, like all laws of nature, are based on observations and have been generalized into laws that are believed to hold for all processes occurring in nature because no exceptions have ever been found. For example, the first law of thermodynamics states that energy can be neither created nor destroyed but only changed from one form to another. It governs all energy transformations quantitatively, but places no restrictions on the direction of the transformation. It is known, however, from experience that no process is possible whose sole result is the net transfer of heat from a region of lower temperature to a region of higher temperature. This statement of experimental truth is known as the second law of thermodynamics.

Whenever a temperature gradient exists within a system, or whenever two systems at different temperatures are brought into contact energy is transferred. The process by which the energy transport takes place is known as *heat transfer*. The thing in transit, called heat, cannot be observed or measured directly. However, its effects can be identified and quantified through measurements and analysis. The flow of heat, like the performance of work, is a process by which the initial energy of a system is changed.

All heat transfer processes involve the exchange and/or conversion of energy. They must, therefore, obey the first as well as the second law of thermodynamics. At first glance, one might therefore be tempted to assume that the principles of heat transfer can be derived from the basic laws of thermodynamics. This conclusion, however, would be erroneous, because classical thermodynamics is restricted primarily to the study of equilibrium states including mechanical, chemical, and thermal equilibriums, and is therefore, by itself, of little help in determining quantitatively the transformations that occur from a lack of equilibrium in engineering processes. Since heat flow is the result of temperature nonequilibrium, its quantitative treatment must be based on other branches of science. The same reasoning applies to other types of transport processes such as mass transfer and diffusion.

Classical thermodynamics deals with the states of systems from a macroscopic view and makes no hypotheses about the structure of matter. To perform a thermodynamic analysis it is necessary to describe the state of a system in terms of gross characteristics, such as pressure, volume, and temperature, that can be measured directly and involve no special assumptions regarding the structure of matter. These variables (or thermodynamic properties) are of significance for the system as a whole only when they are uniform throughout it, that is, when the system is in equilibrium. Thus, classical thermodynamics is not concerned with the details of a process but rather with equilibrium states and the relations among them. The processes employed in a thermodynamic analysis are idealized processes devised to give information concerning equilibrium states.

6. Answer the questions:

1. What is the subject of heat transfer? 2. What does the world run on? 3. What branch of science is called thermodynamics? 4. How many laws of thermodynamics are described in the text? 5. What does the first law of thermodynamics state? 6. What statement is known as the second law of thermodynamics? 7. What kind of process is known as heat transfer? 8.Can heat be observed or measured directly? 9. How can the effects of heat be identified and quantified? 10. What do all heat transfer processes involve? 11. What must all heat transfer processes obey? 12. What is classical thermodynamics primarily restricted to? 13. What kinds of equilibrium are mentioned in the text?

7. Choose the correct option: a, b or c.

1. Classical thermodynamics deals with

a) condition in which the body temperature is much lower than normal; b) an idea or explanation of something that is based on a few known facts but has not yet been proved to be true or correct; c) the states of systems from a macroscopic view and makes no hypotheses about the structure of matter.

2. Heat flow is a result of

a) measurements and analysis; b) temperature nonequilibrium; c) temperature equilibrium.

3. Heat transfer processes involve

a) fundamental equations; b) reduction of difficulties; c) the exchange and conversion of energy.

4. If we were to cut off the radiation from the sun

a) we would soon find the world to be an inhabitable sphere; b) we would soon find the world to be an uninhabitable sphere; c) we would soon find the world to be full of the new inhabitants.

8. Speak about the laws of thermodynamics, using the information obtained from Text 1A.

9. Put the words in the correct order to make up questions in writing; answer the questions.

1. Heat transfer / is / what / concerned / with? 2. State / what / thermodynamics / the first law of / does? 3. Be identified / can / heat effects / and quantified?

10. Translate the following sentences paying attention to the meanings of 'since'.

1. It's such a long time **since** we've seen you. You must come up to the house soon. 2. In ordinary heat transfer on the Earth, it is difficult to quantify the effects of convection **since** it inherently depends upon small nonuniformities (неоднородности) in an otherwise fairly homogeneous medium (однородная среда). 3. **Since** convection also accomplishes transmission of energy from regions of higher temperature to regions of lower temperature, the term "heat transfer by convection" has become generally accepted. 4. He graduated from the university and we have not seen him **since**. 5. **Since** the introduction of faster processors cooling devices became essential in every computer.

11. Translate the Conditional sentences; mind three types of Conditionals.

1. If we **knew** the temperature gradient and the thermal conductivity at this interface, we **could calculate** the rate of heat transfer. 2. If there **were** more time, I **could finish** my article. 3. If we **don't miss** the bus, we**'ll be** in time for the lecture on thermodynamics. 4. If the decision **had been taken** two years ago, the problem **would have been solved**. 5. If I **were** you, I **would study** computer science. 6. If the device **is tested** successfully, it **will be produced** at our plant. 7. If we **place** a hot body in an evacuated cavity (полость с выкаченным воздухом) having walls at a

lower temperature than the body, the body **will** steadily **lose** energy until its temperature is the same as that of the surrounding cavity. 8. If heat **is transferred** from an object to the surroundings, then the object **can cool down** and the surroundings **can warm up**. 9. I **would be grateful** if you **could send** me some additional information concerning new heat exchangers.

12. Complete the sentences about yourself in the first, second and third conditional and indicate the type of the conditional used. Finish each sentence in the most interesting way you can.

For example: If I spent more time practising, I could become very good at English. (2).

1. If I knew… . 2. If I had attended all seminars,… . 3. If I hadn't spent… . 4. I would have gone… . 5. I could read… . 6. If the weather is fine, I… . 7. Had I made an experiment on heat transfer,… . 8. I would have tried to … . 9. I would do research into thermodynamics, if … . 10. If I hadn't found… . 11. If I had more free time,… . 12. If I wrote the report,… . 13. I would have chatted on the Internet yesterday, if… . 14. If I really make an effort,… .

13. Translate the following sentences paying attention to the Subjunctive Mood.

1. I've got a book on Heat Transfer. **–** Could I have a look at it? 2. I am offered a job in Canada. What would you do in my position? **–** I would go there. 3. We are going to the conference. Mike would like to join us. It is desirable that he should be present there. 4. I am not sure where to go for my holidays, but I might go to Italy. 5. The engineer demanded that the test should be repeated. 6. I wish you wouldn't interrupt me. 7. The students must be attentive lest they should make mistakes. 8. He speaks English as if he were an Englishman. 9. He would have helped with your experiment, but he couldn't come. 10. You could have done this work. Why didn't you try? 11. I wish the teacher could come to my presentation, but he is at the conference in the USA. 12. Repeat these words so that you should remember them. 13. It is essential that we should reduce our expenditure on scientific experiment. 14. The Tubular Exchanger Manufacturers Association recommends that tubes be spaced with a minimum center-to-center distance of 1.25 times the outside diameter of the tube. 15. The fluids may be liquids or gases, and in some heat exchangers more than two fluids might flow. 16. Gases transfer heat by direct collisions between molecules, and as might be expected, their thermal conductivity is low compared to most solids since they are dilute (разбавлять) media.

14. Read the following extracts with the Subjunctive Mood given in bold. Define the main idea of each extract. Could you continue the author's idea? While speaking use as many sentences with the Subjunctive Mood as you can.

1. The average kinetic energy of the hot water particles gradually decreases; the average kinetic energy of the cold-water particles gradually increases; and eventually, thermal equilibrium **could be reached** at the point where the particles of the hot water and the cold water have the same average kinetic energy. At the macroscopic level, one **would observe** a decrease in temperature of the hot water and an increase in temperature of the cold water.

2. What **would happen** if the heat were transferred from hot water through glass to cold water? What **would happen** if the heat were transferred from hot water through Styrofoam to cold water? Answer: the rate of heat transfer **would be different**. Replacing the inner metal can (металлическая банка) with a glass jar **would change** the rate of heat transfer.

15. Read the text paying attention to the sentences with the Subjunctive Mood. Could you suggest your own heading to this text? Think of as many questions to the text as you can and let your fellow students answer them.

Heat Transfer Calculations and the Typical Design Cycle

The engineer must gather sufficient information so that some basic heat transfer calculations **could be made**. This phase **would involve** consideration of the basic heat transfer modes - conduction, convection and radiation and a quantitative assessment of heat transfer modes which need to be considered on the basis of their significance. The calculations **would** most likely **involve** the classical equations for describing heat transfer and **could be** simple linear equations or more complex differential equations using a math program. From this series of calculations the designer **would explore** key aspects of the design and various different parameters, like material selection, or heat transfer coefficients. The design **would** then **proceed** to a fabrication and test phase. Here the prototype **would be built** and a test regime **developed** that **would validate** (подтверждать правильность) the performance of the device. From the test data, the engineer gains the information needed to judge the appropriateness (зд. точность) of his calculations and make design improvements. This process is essentially an iterative (повторяющийся) one and is repeated until a complex combination of time, project budget, and design objectives are reached.

16. Translate into English.

1. Инженеры и учёные должны знать основные законы термодинамики. 2. Теплопередача – это процесс, с помощью которого происходит перемещение энергии. 3. С первого взгляда можно было бы предположить, что принципы теплопередачи можно вывести из основных законов термодинамики. 4. Поскольку поток тепла является результатом отсутствия температурного равновесия, его количественная обработка должна основываться на других отраслях науки. 5. Если мы будем неправильно использовать энергию, которая существует в настоящее время, то мир может стать необитаемым. 6. Теплопередача широко применяется в работе (действии) многочисленных устройств. 7. Первый закон термодинамики гласит, что энергию нельзя ни создать, ни разрушить, но можно только преобразовать из одного вида в другой. 8. Понимание процесса теплопередачи очень важно (crucial) для анализа термодинамических процессов, которые происходят в тепловых двигателях и тепловых насосах. 9. Термодинамика – это область физики, которая связана с соотношением тепла и других свойств, таких как давление, плотность, температура и.т.д. в веществе (substance). 10. Теплопередача управляется (to guide) некоторыми основными принципами, которые стали известны как законы термодинамики.

17. You are going to read Text 1B .

Words and word combinations to help you:

ambient *adj*	окружающий, кругом обтекающий
feasibility *n*	возможность, вероятность (выполнения)
combustion chamber	камера сгорания
bearing *n*	подшипник; опора
capacitance *n*	*эл.* ёмкость, ёмкостное сопротивление
inductance *n*	*эл.* индуктивность; коэффициент (само)индукции

18. Translate the following attributive constructions.

Reactor burnout, ambient air temperature, carbon dioxide concentration, turbine blades, energy transport processes, radiative heat transfer, computer circuits, reaction rate, product degradation, frost formation, detailed heat transfer analysis, electrical circuit calculations.

19. Look through the text and say in what branches of engineering heat transfer processes can be found. Can you give your own examples of heat transfer processes in different branches of engineering? Share your opinion with your fellow students.

Text 1 B

Engineering Heat Transfer.

At one time or another every engineer is likely to be confronted with a heat transfer problem. In the design of computer circuits electrical engineers may be concerned with temperature variations owing to electrical heating; civil and mechanical engineers may need to assess the importance of thermal stresses and strains in the structural design of high-speed aircraft and nuclear reactors; and chemical engineers are often required to design chemical reactors that operate at temperatures high enough so that the reaction rate is reasonably fast, but low enough so that product degradation or reactor burnout is not a problem. Agricultural engineers are interested in the radiative heat transfer that often leads to frost formation when the ambient air temperature is above the freezing point, and the energy transport processes are associated with micro-meteorology. The ecologist is concerned with a variety of heat transfer processes such as the "greenhouse" effect caused by the increasing carbon dioxide concentration in our atmosphere.

To estimate the cost, the feasibility, and the size of equipment necessary to transfer a specified amount of heat in a given time, a detailed heat transfer analysis must be made. The dimensions of boilers, heaters, refrigerators, and heat exchangers depend not only on the amount of heat to be transmitted but also on the rate at which the heat is to be transferred under given conditions. The successful operation of equipment components such as turbine blades, or the walls of combustion chambers, depends on the possibility of cooling certain metal parts by continuously removing heat from a surface at a rapid rate. A heat transfer analysis must also be made in the design of electric machines, transformers, and bearings to avoid conditions that will cause overheating and damage the equipment. The listing in Table 1, which by no means is comprehensive, gives an indication of the extensive significance of heat transfer and its different practical applications. These examples show that almost every branch of engineering encounters heat transfer problems, which shows that they are not capable of solution by thermodynamic reasoning alone but require an analysis based on the science of heat transfer.

In heat transfer, as in other branches of engineering, the successful solution of a problem requires assumptions and idealizations. It is almost impossible to describe physical phenomena exactly, and in order to express a problem in the form of an equation that can be solved, it is necessary to make some approximations. In electrical circuit calculations, for example, it is usually assumed that the values of the resistances, capacitances, and inductances are independent of the current flowing through them. This assumption simplifies the analysis but may in certain cases severely limit the accuracy of the results.

TABLE 1 Significance and diverse practical applications of heat transfer

Chemical, petrochemical, and process industry	*Power generation and distribution*	*Aviation and space exploration*	*Electrical machines and electronic equipment:*	*Transportation*	*Comfort heating, ventilation, and air-conditioning*
Heat exchangers, reactors, reboilers, etc.	Boilers, condensers, cooling towers, feed heaters, transformer cooling, transmission cable cooling, etc.	Gas turbine blade cooling, vehicle heat shields, rocket engine/nozzle cooling, space suits, space power generation, etc.	Cooling of motors, generators, computers and microelectronic devices, etc.	Engine cooling, automobile radiators, climate control, mobile food storage, etc.	Air conditioners, water heaters, furnaces, chillers, refrigerators, etc.

20. Write a summary of Text 1B. The following verbs in Passive and phrases are to help you to make a summary: are described; are summarized; are emphasized; are analysed; attention is given to… ; a study of ... was performed; it is concluded that… .

21. Translate the following questions into English in writing and answer them:

For example: *С какой проблемой, вероятно, столкнётся рано или поздно каждый инженер? What problem is every engineer likely to be confronted with at one time or another? - At one time or another every engineer is likely to be confronted with a heat transfer problem.*

1. От чего зависит успешная работа деталей оборудования? 2. Почему необходимо сделать анализ теплопередачи при конструировании электроприборов, трансформаторов, подшипников? 3. Чем интересуются инженеры, специализирующиеся в области сельского хозяйства? 4. С каким процессом теплопередачи имеет дело инженер-эколог? 5. От чего зависят размеры бойлеров, обогревателей и теплообменников? 6. Что часто требуется сконструировать инженерам-химикам? 7. Какой анализ требуется сделать, чтобы оценить стоимость, возможность выполнения (feasibility) и размер оборудования, необходимого для передачи определённого количества тепла в данное время?

22. Make a presentation in PowerPoint. You may use the information from Texts 1A, 1B, Table 1 and get the information from the Internet or from any other source to prove the diversity of practical applications of heat transfer. Useful phrases to help you:

Let me just start by introducing myself. My name is… . I am going to speak about… . The main issue is concerned with… . I've divided my presentation into…parts. This diagram/chart shows… . Then I'll move on to… . First(ly)…, second(ly)..., third(ly)… . After that… . Finally… . In conclusion, I'd like to stress the importance of ... .

23. Read Text 1C and discuss the main mechanisms of heat transfer.

Text 1C

Mechanisms of Heat Transfer.

Heat is a form of energy that can cross the boundary of a system. Heat can, therefore, be defined as 'the form of energy that is transferred between a system and its surrounding as a result of a temperature difference.’ There can only be a transfer of energy across the boundary in the form of heat if there is a temperature difference between the system and its surroundings. Conversely, if the system and surroundings are at the same temperature there is no heat transfer across the boundary.

The term ‘heat” is a name given to the particular form of energy crossing the boundary. However, heat is more usually referred to in thermodynamics through the term ‘heat transfer’, which is consistent with the ability of heat to raise or lower the energy within a system.

The literature of heat transfer generally recognizes three distinct modes of heat transmission: conduction, radiation, and convection. Strictly speaking, only conduction and radiation should be classified as heat transfer processes, because only these two mechanisms depend for their operation on the mere existence of a temperature difference. The last of the three, convection, does not strictly comply with the definition of heat transfer because its operation also depends on mechanical mass transport. But since convection also accomplishes transmission of energy from regions of higher temperature to regions of lower temperature, the term “heat transfer by convection” has become generally accepted.

All three are different. Convection relies on movement of a fluid. Conduction relies on transfer of energy between molecules within a solid or fluid. Radiation is a form of electromagnetic energy transmission and is independent of any substance between the emitter and receiver of such energy. However, all three modes of heat transfer rely on temperature difference for the transfer of energy to take place.

The greater the temperature difference the more rapidly will the heat be transferred. Conversely, the lower the temperature difference, the slower will be the rate at which heat is transferred .When discussing the modes of heat transfer it is the rate of heat transfer Q that defines the characteristics rather than the quantity of heat. Although three modes of heat transfer may be combined in any particular thermodynamic situation, the three are quite different and are generally introduced separately.

24. Put questions to Text 1C and answer them.

25. Translate the following sentences paying attention to the Emphatic construction.

1. **It is** the temperature difference between the two neighboring objects **that** causes this heat transfer. 2. **It is** the fraction of solar radiation **that** is reflected by the surface and not absorbed by it. 3. **It is** in this scientific journal **that** you will find necessary information on heat transfer. 4. **It**

is the particles of solid **that** vibrate more vigorously about their fixed positions. 5. **It is** the particles of liquid and gas **that** move about their container more rapidly. 6. **It is** for an ideal gas **that** the heat transfer rate is proportional to the average molecular velocity and the mean free path (средняя длина пути свободного пробега (молекулы). 7. **It is** the radiation **that** is in the infrared region of the electromagnetic spectrum.

Unit 2

Convective Heat Transfer

New words and word combinations to be memorized:

effect *v,n*	воздействовать, влиять; воздействие, влияние
bulk *n*	объём; большие размеры; масса; большая часть чего-л.
enhance *v*	повышать; увеличивать, усиливать
buoyancy *n*	плавучесть; способность держаться на поверхности воды
induce *v*	вызывать; стимулировать
stirrer *n*	устройство для перемешивания, мешалка
fluid *n*	жидкость, жидкая или газообразная среда
linear *adj*	линейный
abound *v*	изобиловать; иметься в большом количестве
layer *n*	слой
impose *v*	зд. воздействовать
specify *v*	точно определять, устанавливать
parcel *n*	зд. сгусток
extraneous *adj*	внешний
diminish *v*	уменьшать(ся); убавлять(ся)

1. Match the words in A with their definitions in B.

A	B
1. gradient	(a) a substance that can flow freely, as gases and liquids do
2. conduction	(b) the relationship between two different living creatures that live close together and

	depend on each other in particular ways
3. process	(c) a substance or an object that is solid, not a liquid or a gas
4. motion	(d) *(technical)* the rate at which temperature, pressure, etc. changes, or increases and decreases, between one region and another
5. flow	(e) an area within which the force mentioned has an effect
6. solid	(f) a series of things that happen, especially ones that result in natural changes
7. liquid	(g) the process by which heat or electricity passes through a material
8. convection	(h) the steady and continuous movement of sth in one direction
9. field	(i) the act or process of moving or the way sth moves
10. density	(j) a substance that flows freely and is not a solid or a gas, for example water or oil
11. symbiosis	(k) the process in which heat moves through a gas or a liquid as the hotter part rises and the cooler, heavier part sinks.
12. fluid	(l) the thickness of a solid, liquid or gas measured by its mass (=weight) per unit of volume

2. Translate the following attributive constructions.

heat transfer surface, bulk fluid motions, bulk fluid flow streaming, average convection heat transfer coefficient, changed density, density change, fluid density, buoyancy forces, free-stream value, artificially induced convection current, boundary layer theory, fluid mass transport.

3. You are going to read Text 2A. Before reading try to answer the following questions. Share your answers with your fellow students. 1. Do you know that the word ‘Convection’ is of Latin origin? 2. What does this word mean? 3. Why do you think convective heat transfer has grown to the status of a contemporary science? 4. Have you got any idea about advection? 5. Can you give examples from real life where advection occurs?

Text 2 A

Convective Heat Transfer

Convective heat transfer, or simply, convection, is the study of heat transport processes effected by the flow of fluids. The very word convection has its roots in the Latin verb convecto-are, which means to bring together or to carry into one place. Convective heat transfer has grown to the status of a contemporary science because of our need to understand and predict how a fluid flow acts as a ‘‘carrier’’ or ‘‘conveyor belt’’ for energy and matter.

Convective heat transfer, or convection, is the transfer of heat from one place to another by the movement of fluids, a process that is essentially the transfer of heat via mass transfer. Bulk motion of fluid enhances heat transfer in many physical situations, such as, for example, between a solid surface and the fluid. Convection is usually the dominant form of heat transfer in liquids and gases. Although sometimes discussed as a third method of heat transfer, convection is usually used to describe the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming. The process of transport by fluid streaming is known as advection, but pure advection is a term that is generally associated only with mass transport in fluids, such as advection of pebbles in a river. In the case of heat transfer in fluids, where transport by advection in a fluid is always also accompanied by transport via heat diffusion (also known as heat conduction) the process of heat convection is understood to refer to the sum of heat transport by advection and diffusion/conduction.

Free, or natural, convection occurs when bulk fluid motions (streams and currents) are caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. Forced convection is a term used when the streams and currents in the fluid are induced by external means - such as fans, stirrers, and pumps - creating an artificially induced convection current.

Convective heating or cooling in some circumstances may be described by Newton's law of cooling: "The rate of heat loss of a body is proportional to the difference in temperatures between the body and its surroundings." However, by definition, the validity of Newton's law of cooling requires that the rate of heat loss from convection be a linear function of ("proportional to") the temperature difference that drives heat transfer, and in convective cooling this is sometimes not the case. In general, convection is not linearly dependent on temperature gradients, and in some cases is strongly nonlinear. In these cases, Newton's law does not apply.

Convective heat transfer is clearly a field at the interface between two older fields: heat transfer and fluid mechanics. To study the interdisciplinary is valuable, but it must come after one possesses the disciplines, not the other way around. For this reason, the study of any convective heat transfer problem must rest on a solid understanding of basic heat transfer and fluid mechanics principles.

It is worth reexamining the historic relationship between fluid mechanics and heat transfer. During the past 100 years, heat transfer and fluid mechanics have enjoyed a symbiotic relationship in their development, a relationship where one field was stimulated by the curiosity and advance in the other field. Examples of this symbiosis abound in the history of boundary layer theory and natural convection. The field of convection grew out of this symbiosis, and if we are to learn anything from history, important advances in convection will continue to result from this symbiosis. Thus, the student and the future researcher would be well advised to devote equal attention to fluid mechanics and heat transfer literature.

The convection mode of heat transfer actually consists of two mechanisms operating simultaneously. The first is the energy transfer due to molecular motion, that is, the conductive mode. Superimposed upon this mode is energy transfer by the macroscopic motion of fluid parcels. The fluid motion is a result of parcels of fluid, each consisting of a large number of molecules, moving by virtue of an external force. This extraneous force may be due to a density gradient, as in natural convection, or due to a pressure difference generated by a pump or a fan, or possibly to a combination of the two.

The principal difference is that in forced convection the velocity far from the surface approaches the free-stream value imposed by an external force, whereas in natural convection the velocity at first increases with increasing distance from the heat transfer surface and then decreases. The reason for this behavior is that the action of viscosity diminishes rather rapidly with distance from the surface, while the density difference decreases more slowly. Eventually, however, the buoyant force also decreases as the fluid density approaches the value of the unheated surrounding fluid. This interaction of forces will cause the velocity to reach a maximum and then approach zero far from the heated surface. The temperature fields in natural and forced convection have similar shapes, and in both cases the heat transfer mechanism at the fluid-solid interface is conduction.

Convection heat transfer depends on the density, viscosity, and velocity of the fluid as well as on its thermal properties (thermal conductivity and specific heat). Whereas in forced convection the velocity is usually imposed on the system by a pump or a fan and can be directly specified, in natural convection the velocity depends on the temperature difference between the surface and the fluid, the coefficient of thermal expansion of the fluid (which determines the density change per unit temperature difference), and the body force field, which in systems located on the earth is simply the gravitational force.

The evaluation of the convection heat transfer coefficient is difficult because convection is a very complex phenomenon. It is sufficient to note that the numerical value of a system depends on the geometry of the surface, on the velocity as well as the physical properties of the fluid, and often even on the temperature difference. In view of the fact that these quantities are not necessarily constant over a surface, the convection heat transfer coefficient may also vary from point to point. For this reason, we must distinguish between a local and an average convection heat transfer coefficient. For most engineering applications, we are interested in average values.

4. Answer the questions:

1. What is convective heat transfer? 2. What enhances heat transfer in many physical situations? 3. What kind of process is known as advection? 4. When does free, or natural, convection occur? 5. When is the term ‘forced convection’ used? 6. What does Newton's law of cooling state? 7. What must the study of any convective heat transfer problem rest on? 8. What is the principal difference between forced convection and natural convection? 9. What does convection heat transfer depend on? 10. Why is the evaluation of the convection heat transfer coefficient difficult? 11. What does the numerical value of a system depend on?

5. Choose the correct option: a, b or c.

1. In natural convection the velocity at first increases

a) with decreasing distance from the heat transfer surface and then decreases; b) with increasing distance from the free-stream value and then decreases; c) with increasing distance from the heat transfer surface and then decreases.

2. The action of viscosity diminishes rather rapidly with distance from the surface,

a) while the density difference decreases more slowly; b) while the density difference increases more slowly; c) while the density difference decreases more rapidly.

3. The buoyant force also decreases as

a) the fluid density eliminates the value of the unheated surrounding fluid; b) the fluid density approaches the value of the heated surrounding fluid; c) the fluid density approaches the value of the unheated surrounding fluid.

4. This interaction of forces will cause the velocity

a) to reach a maximum and then approach zero far from the unheated surface; b) to reach a maximum and then approach zero far from the heated surface; c) to reach a maximum and then approach zero near from the heated surface.

5. We must distinguish between

a) a local and an high convection heat transfer coefficient; b) a local and an average convection heat transfer coefficient; c) a linear and an average conduction heat transfer coefficient.

6. Speak about the convective heat transfer, using the information obtained from Text 2A.

7. Choose the appropriate word in brackets to complete the sentences.

1. (**Because** /**Although**) sometimes discussed as a third method of heat transfer, convection is usually used to describe the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming. 2. This extraneous force may be (**because** /**due to)** a density gradient, as in natural convection, or **(due to** /**because)** a pressure difference generated by a pump or a fan, or possibly to a combination of the two. 3. The fluid motion is a result of parcels of fluid, each consisting of a large number of molecules, moving (**by virtue of** / **because**) an external force. 4. Convection heat transfer depends on the density, viscosity, and velocity of the fluid (**in addition/as well as**) on its thermal properties. 5. Evaluation of the convection heat transfer coefficient is difficult (**because/ because of)** convection is a very complex phenomenon. 6. This heat exchanger is often also characterized as a compact heat exchanger (**because/because of)** its large area density. 7. (**As well as** /**As**) the heated air rises from the heater on a floor, it carries more energetic particles with it.

8. Complete the sentences using the words and word combinations from the box.

Solid , buoyant force, liquids, body force field, **bulk fluid flow streaming, free-stream value**

1. Convection is usually the dominant form of heat transfer in________ and gases. 2. In natural convection the velocity depends on the temperature difference between the surface and the fluid, the coefficient of thermal expansion of the fluid and the_________. 3. In forced convection the

velocity far from the surface approaches the______ imposed by an external force, whereas in natural convection the velocity at first increases with increasing distance from the heat transfer surface and then decreases. 4. The_______also decreases as the fluid density approaches the value of the unheated surrounding fluid. 5. Bulk motion of fluid enhances heat transfer in many physical situations, for example between a ________surface and the fluid. 6. Convection is usually used to describe the combined effects of heat conduction within the fluid and heat transference by _________.

9. Translate the following sentences, mind the Participle.

1. **Heated** water expands and becomes more buoyant. 2. The area **selected** becomes particularly important in heat transfer through the walls of tubes in a heat exchanger. 3. When **heated,** fluids expand and become less dense. 4. **Being invisible** to the human eye, we do not see this form of radiation. 5. The approaches **applied** caused the discovery of a new theorem. 6. In contrast to natural convection, forced convection involves fluid **being forced** from one location to another by fans, pumps and other devices. 7. The system **developed** consists of three separate modules. 8. This transfer of heat to the air in the cylinder does work upon the piston, **driving** it downward. 9. Engineering heat transfer problems occur in a wide range of products and industrial processes **ranging** from aerospace to consumer products and mechanical, electrical, and chemical processes. 10. The method **developed** provided good results. 11. **Having googled** his name, I managed to find his e-mail address. 12. At a **given** temperature, the thermal and electrical conductivities of metals are proportional, but raising the temperature increases the thermal conductivity while **decreasing** the electrical conductivity. 13. **Having been tested**, the heat exchanger was put into operation. 14. Once **signed** the contract can not be cancelled.

10. Translate the following sentences, mind the Absolute Participial Construction.

1. The fluid motion is a result of parcels of fluid, each consisting of a large number of molecules, moving by virtue of an external force. 2. With the temperature difference approaching zero, the rate of heat transfer approaches zero too. 3. Professor was delivering a lecture on thermodynamics, with the students listening to him attentively. 4. The device being damaged, they could not continue the experiment. 5. Time permitting, we shall go through all the calculations tomorrow. 6. There are many types of engines, each of them having special

characteristics. 7. The Internet being one of the best resources for up-to-date information, millions of people use it regularly. 8. The technical innovations introduced, the quality of products was improved. 9. The current industrial production has changed greatly, with computers becoming almost standard equipment.

11. Translate into English.

1. Существуют разные способы, которыми энергия может передаваться из одного места в другое. 2. Если теплопроводность очень низкая, может образоваться большой температурный градиент и конвекция могла бы усилиться. 3. Поскольку конвекция очень сложное явление, трудно математически вычислить (evaluate) коэффициент конвективной теплопередачи. 4. Изучение проблемы конвективной теплопередачи должно основываться на понимании основных принципов теплопередачи. 5. Стоит пересмотреть исторически сложившиеся взаимоотношения между механикой жидкостей (fluid mechanics) и теплопередачей. 6. Конвективная теплопередача зависит от плотности, вязкости и скорости жидкой среды, а также от тепловых характеристик. 7. Коэффициент конвективной теплопередачи (heat transfer coefficient) может меняться от точки к точке, учитывая тот факт, что геометрия поверхности, скорость, физические характеристики жидкой среды могут также меняться.

12. You are going to read Text 2B.

Words and word combinations to help you:

propagate *v*	распространять; передавать через среду (звук, свет, тепло)
delve *v*	делать изыскания
complexity *n*	сложность; запутанность
incorporate *v*	соединять(ся), объединять(ся); включать в состав
approximate *v*	приближать(ся); почти соответствовать
random *adj*	случайный
background *n*	предпосылка; происхождение; подготовка
advent *n*	приход; появление

band *n*	полоса
partial *adj*	зд. в частных производных
tabulate *v*	располагать в виде таблиц и диаграмм

13. Translate the following attributive constructions.

cross-sectional area, conduction equation, one-dimensional heat flow, conductor thickness, heat propagation, predominant transport mechanism, density gradients, conduction-band electrons, thermal potential difference.

14. Group the words into pairs of antonyms.

Decrease, solid, external, motion, more, rapid, elastic, high, microscopic, liquid, macroscopic, less, slow, inelastic, low, stagnation, internal, increase.

15. Group the words into pairs of synonyms.

Occur, similar, begin, simple, different, rarely, rapidly, seldom, easy, to take place, start, same, quickly, various.

16. Look through the text and say what you know about Fourier's law of heat conduction. What kind of materials are called insulators? Can you give your own examples of heat conduction processes in different branches of engineering? Share your opinion with your fellow students.

Text 2 B

Heat Conduction

The most efficient method of heat transfer is conduction. This mode of heat transfer occurs when there is a temperature gradient across a body. In this case, the energy is transferred from a high temperature region to low temperature region due to random molecular motion (diffusion). Heat flows through a solid by a process that is called thermal diffusion, or simply diffusion or conduction. In this mode, heat is transferred through a complex submicroscopic mechanism in which atoms interact by elastic and inelastic collisions to propagate the energy from regions of higher to regions of lower temperature. From an engineering point of view there is no need to delve into the complexities of the molecular mechanisms, because the rate of heat propagation can be predicted by Fourier's law, which incorporates the mechanistic features of the process into a physical property known as the thermal conductivity.

Conduction occurs similarly in liquids and gases. Although conduction occurs in liquids and gases, it is rarely the predominant transport mechanism in fluids — once heat begins to flow in a fluid, even if no external force is applied, density gradients are set up and convective currents are set in motion. In convection, thermal energy is thus transported on a macroscopic scale as well as on a microscopic scale, and convection currents are generally more effective in transporting heat than conduction alone, where the motion is limited to submicroscopic transport of energy.

Regions with greater molecular kinetic energy will pass their thermal energy to regions with less molecular energy through direct molecular collisions. In metals, a significant portion of the transported thermal energy is also carried by conduction-band electrons. Different materials have varying abilities to conduct heat. Materials that conduct heat poorly (wood, styrofoam-пенополистирол) are often called insulators. However, materials that conduct heat well (metals, glass, some plastics) have no special name.

The simplest conduction heat transfer can be described as "one-dimensional heat flow". The rate of heat flow from one side of an object to the other, or between objects that touch, depends on the cross-sectional area of flow, the conductivity of the material and the temperature difference between the two surfaces or objects.

Mathematically, it can be expressed as

$$q = -kA\frac{\partial T}{\partial x}$$

where q is the heat transfer rate in watts (W), k is the thermal conductivity of the material (W/m.K), A is the cross-sectional area of heat path, and $\frac{\partial T}{\partial x}$ is the temperature gradient in the direction of the flow (K/m).

The above equation is known as Fourier's law of heat conduction. Therefore, the heat transfer rate by conduction through the object can be expressed as

$$q = kA\frac{\Delta T}{L}$$

where L is the conductor thickness (or length), ΔT is the temperature difference between one side and the other (for example, $\Delta T = T_1 - T_2$ is the temperature difference between side 1 and side 2). The quantity (ΔT/L) in equation is called the temperature gradient: it tells how many 0C or K the temperature changes per unit of distance moved along the path of heat flow. The quantity L/kA is called the thermal resistance.

$$R = \frac{d}{kA}$$

Thermal resistance has SI units of kelvins per watt (K/W). Notice that the thermal resistance depends on the nature of the material (thermal conductivity k and geometry of the body d/A). From the above equations we realize the heat transfer rate as a flow, and the combination of thermal conductivity, thickness of material and area as a resistance to this flow.

Considering the temperature as a potential function of the heat flow, the Fourier law can be written as

$$\text{Heat flow} = \frac{\text{Thermal potential difference}}{\text{Thermal resistance}}$$

If we define the resistance as the ratio of potential to the corresponding transfer rate, the thermal resistance for conduction can be expressed as

$$R_{cond} = \frac{T_1 - T_2}{q} = \frac{L}{kA}$$

It is clear from the above equation that decreasing the thickness or increasing the cross-sectional area or thermal conductivity of an object will decrease its thermal resistance and increase its heat transfer rate.

Conduction heat transfer can readily be modeled and described mathematically. The associated governing physical relations are partial differential equations, which are susceptible to solution by classical methods. Famous mathematicians, including Laplace and Fourier, spent part of their lives seeking and tabulating useful solutions to heat conduction problems. However, the analytic approach to conduction is limited to relatively simple geometric shapes and to boundary conditions that can only approximate the situation in realistic engineering problems. With the advent of the high-speed computer, the situation changed dramatically and a revolution occurred in the field of conduction heat transfer. The computer made it possible to solve, with relative ease, complex problems that closely approximate real conditions.

As a result, the analytic approach has nearly disappeared from the engineering scene. The analytic approach is nevertheless important as background.

17. Translate the following questions into English in writing and answer them:

For example: Какие материалы хорошо проводят тепло? What materials conduct heat well? - Metals, glass, some plastics conduct heat well.

1. Посредством чего переносится значительная часть тепловой энергии? 2. Какие материалы плохо проводят тепло? 3. Как они часто называются? 4. От чего зависит скорость перехода теплового потока с одной стороны предмета на другую? 5.Какой процесс называется тепловой диффузией?

18. Put the words in the correct order to make up questions in writing; answer the questions.

1. Occur/does/where/conduction? 2. Efficient method /is/ what /heat transfer/ the most/ of? 3. Can/ the simplest/how/ described/be/ conduction heat transfer? 4. Resistance/ the thermal/ what/ depend on/does?

19. Try to find out what these outstanding scientists are famous for: Newton, Stefan-Boltzmann, Laplace, Fourier.

20. You are going to read Text 2C. Before reading try to answer these questions. Share your answers with your fellow students. 1. What do you know about electromagnetic spectrum? 2. How is thermal radiation defined? 3. What is called monochromatic radiation? 4. What does the word spectral denote? 5. Have you ever heard of the Stefan-Boltzmann law of thermal radiation and how it is applied?

Text 2 C

Heat Transfer by Radiation

Radiation heat transfer differs from that by convection and conduction because the driving potential is not the temperature, but the absolute temperature raised to the fourth power. Furthermore, heat can be transported by radiation without an intervening medium.

Radiation is the process of transferring heat by emitting electromagnetic energy in the form of waves or particles**.** Radiation can transfer heat through empty space, while the other two methods require some form of matter-on-matter contact for the transfer.

Radiant heat is simply heat energy in transit as electromagnetic radiation. All materials radiate thermal energy in amounts determined by their temperature, where the energy is carried by photons of light in the infrared and visible portions of the electromagnetic spectrum**.** In this case, heat moves through space as an electromagnetic radiation without the assistance of a physical substance. All objects that contain heat emit some level of radiant energy. The amount of radiation is inversely proportional to its wavelength (the shorter the wavelength the greater the energy content) which is, in turn, inversely proportional to its temperature (in °K).

When a body is placed in an enclosure whose walls are at a temperature below that of the body, the temperature of the body will decrease even if the enclosure is evacuated. The process by which heat is transferred from a body by virtue of its temperature, without the aid of any intervening medium, is called thermal radiation.

The physical mechanism of radiation is not completely understood yet. Radiant energy is envisioned sometimes as transported by electromagnetic waves, at other times as transported by photons. Neither viewpoint completely describes the nature of all observed phenomena. It is known, however, that radiation travels with the speed of light *c*, equal to about in a vacuum.

From the viewpoint of electromagnetic theory, the waves travel at the speed of light, while from the quantum point of view, energy is transported by photons that travel at that speed. Although all the photons have the same velocity, there is always a distribution of energy among them.

Radiation phenomena are usually classified by their characteristic wavelength. Electromagnetic phenomenon encompasses many types of radiation, from short-wavelength gamma-rays and x-rays to long-wavelength radio waves. The wavelength of radiation depends on how the radiation is produced. For example, a metal bombarded by high-frequency electrons emits x-rays, while certain crystals can be excited to emit long-wavelength radio waves. Thermal radiation is defined as radiant energy emitted by a medium by virtue of its temperature. In other words, the emission of thermal radiation is governed by the temperature of the emitting body.

The Sun's heat is an example of thermal radiation that reaches the Earth. Radiative heat is transferred directly into the surface of any solid object it hits (unless it is highly reflective), but passes readily through transparent materials such as air and glass. An ideal thermal radiator or a blackbody, will emit energy at a rate proportional to the forth power of its absolute temperature and its surface area. Mathematically, that is

$$q_{\text{emitted}} = \sigma A T^4$$

where σ is a proportionality constant (Stefan-Boltzmann constant = 5.669×10^{-8} $W/m^2.K^4$). The above equation is called the Stefan-Boltzmann law of thermal radiation and it applies only to the blackbodies. The fourth-power temperature dependence implies that the power emitted is very sensitive to temperature changes. If the absolute temperature of a body doubles, the energy emitted increases by a factor of $2^4 = 16$.

For bodies not behaving as a blackbody a factor known as emissivity *e*, which relates the radiation of a surface to that of an ideal black surface is introduced. The equation becomes

$$q_{\text{emitted}} = e\sigma A T^4$$

The emissivity ranges from 0 to 1; $e = 1$ for a perfect radiator and absorber (a blackbody) and $e = 0$ for a perfect radiator. Human skin, for example, no matter what the pigmentation, has an emissivity of about 0.97 in the infrared part of the spectrum. While a polished aluminum has an emissivity of about 0.05.

Thermal radiation from a body is used as a diagnostic tool in medicine. A thermogram shows whether one area is radiating more heat than it should, indicating a higher temperature due to abnormal cellular activity. Thermography or thermovision in medicine is based on the natural thermal radiation of the skin. Most advantage is the radiance free of the measuring principle.

Certain body regions have different temperature levels. If one exposes the body e.g. to a cooling attraction, then the body zones of the skin react, in order to repair the heat balance of the body. Thereby the thermal regulation of diseased body regions and organs is different to healthy one. The so-called "regulation thermography" is based on this principle.

Thermal radiation always encompasses a range of wavelengths. The amount of radiation emitted per unit wavelength is called monochromatic radiation; it varies with wavelength, and the word “spectral» is used to denote this dependence. The spectral distribution depends on the temperature and the surface characteristics of the emitting body. The sun, with an effective surface temperature of about 5800 K (10,400°R), emits most of its energy below 3 μm, whereas the earth, at a temperature of about 290 K (520°R), emits over 99% of its radiation at wavelengths longer than 3 μm. The difference in the spectral ranges warms a greenhouse inside even when the outside air is cool because glass permits radiation at the wavelength of the sun to pass, but it is almost opaque to radiation in the wavelength range emitted by the interior of the greenhouse. Thus, most of the solar energy that enters the greenhouse is trapped inside. In recent years, the combustion of fossil fuels has increased the amount of carbon dioxide in the atmosphere. Since carbon dioxide absorbs radiation in the solar spectrum, less energy escapes. This causes global warming, which is also called the “greenhouse effect.”

Consequently, the integration of radiation heat transfer into an overall thermal analysis presents considerable challenges, including the need for carefully stated boundary conditions and assumptions necessary for the appropriate inclusion in the thermal circuit of a system.

21. Put questions to Text 2C and answer them.

22. Write a brief summary of Text 2C using the following key word combinations:

Process of transferring heat; thermal radiation; driving potential; raised to the fourth power; considerable challenges; electromagnetic spectrum; ideal thermal radiator; Stefan-Boltzmann law of thermal radiation; physical mechanism of radiation; monochromatic radiation; spectral distribution.

Unit 3.

Heat Exchangers

New words and word combinations to be memorized:

shell-and-tube (heat) exchanger	кожухо-трубный теплообменник (*с комбинацией*

	параллельного и перекрёстного токов)
double-pipe exchanger	двухтрубный теплообменник
stacked-plate structure	уложенная рядами пластинчатая структура
plate-fin exchanger	пластинчатый ребристый теплообменник
plate-and-frame exchanger	пластинчатый каркасный теплообменник
conspicuous *adj*	видный, заметный; обращающий на себя внимание
boiler feed-water heater	водонагреватель котла
gas-fired hot water heater	газовый водонагреватель
condenser coil	охлаждающий змеевик
energy payback	окупаемость энергетических затрат
counter flow	противоток, обратное течение
cross flow	перекрёстный ток; поперечный ток
extruded	прессованный
the log (logarithmic) mean temperature difference (LMTD)	логарифмическая средняя разность температур
fin *n*	*тех.* ребро, ребристый выступ
contact heat exchanger	смесительный теплообменник
core *n*	сердцевина; внутренность; ядро; *тех.* стержень
immiscible *adj*	не поддающийся смешению, несмешивающийся
annular *adj*	кольцеобразный, кольцевой
inlet header	впускной коллектор
doughnut baffle	кольцеобразная отражательная перегородка
orifice *n*	отверстие, сопло, насадка
tube bundle	пучок труб

1. Match the words in A with their definitions in B

A	B
1. baffle	a) the act of paying sth back
2. condenser	b) a container in which water is heated to provide hot water and heating in a

	building
3. core	c) any flat or level surface
4. shell	d) a machine used for making air or water warmer
5. heater	e) the central part of an object
6. plane	f) any structure that forms a hard outer frame
7. payback	g) a device that cools gas in order to change it into a liquid
8. boiler	h) *(technical)* a screen used to control or prevent the flow of sound, light or liquid

2. Translate the following attributive constructions.

Tubular structure, water-cooled steam condenser, boiler feed-water heater, combustion air regenerator, gas-fired hot water heater, pumping power requirements, heat transfer enhancement devices, heat storage device.

3. Make up sentences in writing with the following words. Use them both as verbs and nouns.

Transfer, increase, conduct, compress, progress, contract, transport.

4. You are going to read Text 3A. Before reading try to answer the following questions. Share your answers with your fellow students. What do you know about heat exchangers? Do you think it is profitable to optimize designs of heat exchangers in terms of an economic return on the investment but also in terms of the energy payback of a system and why?

Text 3A

Heat Exchangers

Heat exchangers are generally devices or systems in which heat is transferred from one flowing fluid to another. The fluids may be liquids or gases, and in some heat exchangers more than two fluids might flow. These devices may have a tubular structure, of which the double-pipe and shell-and-tube exchangers are perhaps the most prevalent, or a stacked-plate structure, which includes the plate-fin and plate-and-frame exchangers, among some other configurations. Perhaps the most conspicuous and historically the oldest applications can be found in a power plant. The steam generator or boiler, water-cooled steam condenser, boiler feed-water heater, and combustion air regenerator, as well as several other types of equipment are all heat exchangers. In most homes, common heat exchangers are the gas-fired hot water heater, and the evaporator and condenser coils of a central air-conditioning unit. All automobiles have a radiator and oil cooler, along with a few other heat exchangers.

When a heat exchanger is placed into a thermal transfer system, a temperature drop is required to transfer the heat. The magnitude of this temperature drop can be decreased by utilizing a larger heat exchanger, but this will increase the cost of the heat exchanger. Economic considerations are important in engineering design, and in a complete engineering design of heat exchange equipment, not only the thermal performance characteristics but also the pumping power requirements and the economics of the system are important. The role has taken an increasing importance recently as engineers have become energy conscious and want to optimize designs not only in terms of a thermal analysis and economic return on the investment but also in terms of the energy payback of a system. Thus economics, as well as such considerations as the availability and amount of energy and raw materials necessary to accomplish a given task, should be considered.

A heat exchanger is a device in which heat is transferred between a warmer and a colder substance, usually fluids. Common types of heat exchanger flows include parallel flow, counter flow, and cross flow. In parallel flow, both fluids move in the same direction while transferring heat; in counter flow, the fluids move in opposite directions; and in cross flow, the fluids move at right angles to each other. Common constructions for heat exchangers include shell and tube, double pipe, extruded finned pipe, spiral fin pipe, u-tube, and stacked plate.

When engineers calculate the theoretical heat transfer in a heat exchanger, they must contend with the fact that the driving temperature difference between the two fluids varies with position. To account for this in simple systems, the log mean temperature difference (LMTD) is often used as an "average" temperature. In more complex systems, direct knowledge of the LMTD is not available, and the number of transfer units (NTU) method can be used instead.

There are three basic types of heat exchangers: recuperators, regenerators and direct contact heat exchangers.

In a recuperator the hot and cold fluids are separated by a wall and heat is transferred by a combination of convection to and from the wall and conduction through the wall. The wall can include extended surfaces, such as fins, or other heat transfer enhancement devices.

In a regenerator the hot and cold fluids alternately occupy the same space in the exchanger core. The exchanger core or “matrix” serves as a heat storage device that is periodically heated by the warmer of the two fluids and then transfers heat to the colder fluid. In a fixed matrix configuration, the hot and cold fluids pass alternately through a stationary exchanger, and for continuous operation two or more matrices are necessary. Another approach is the rotary regenerator in which a circular matrix rotates and alternately exposes a portion of its surface to the hot and then to the cold fluid.

In a direct contact heat exchanger the hot and cold fluids contact each other directly. An example of such a device is a cooling tower in which a spray of water falling from the top of the tower is directly contacted and cooled by a stream of air flowing upward. Other direct contact systems use immiscible liquids or solid-to-gas exchange. The Direct contact heat exchanger is used to transfer heat between the molten salt and air. The direct contact approach is still in the research and development stage.

The simplest arrangement of this type of heat exchanger consists of a tube within a tube. Such an arrangement can be operated either in counterflow or in parallel flow, with either the hot or the cold fluid passing through the annular space and the other fluid passing through the inside of the inner pipe.

A more common type of heat exchanger that is widely used in the chemical and process industry is the shell-and-tube arrangement. In this type of heat exchanger one fluid flows inside the tubes while the other fluid is forced through the shell and over the outside of the tubes. The fluid is forced to flow over the tubes rather than along the tubes because a higher heat transfer coefficient can be achieved in cross-flow than in flow parallel to the tubes. To achieve cross-flow on the shell side, baffles are placed inside the shell. These baffles ensure that the flow passes across the tubes in each section, flowing downward in the first, upward in the second, and so on. Depending on the header arrangements at the two ends of the heat exchanger, one or more tube passes can be achieved. For a two-tube-pass arrangement, the inlet header is split so that the fluid flowing into the tubes passes through half of the tubes in one direction, then turns around and returns through the other half of the tubes to where it started. Three- and four-tube passes can be achieved by rearrangement of the header space. There are three types of baffles used in shell-and-tube heat exchangers: orifice baffle; disk-and-doughnut baffle and segmental baffle. A variety of baffles have been used in industry, but the most common kind is the disk-and-doughnut baffle.

The shell-and-tube heat exchanger has fixed tube sheets at each end, and the tubes are welded or expanded into the sheets. This type of construction has the lowest initial cost but can be used only for small temperature differences between the hot and the cold fluids because no provision is made to prevent thermal stresses due to the differential expansion between the tubes and the shell. Another disadvantage is that the tube bundle cannot be removed for cleaning.

These drawbacks can be overcome by modification of the basic design. In the improved arrangement one tube sheet is fixed but the other is bolted to a floating-head cover that permits the tube bundle to move relative to the shell. The floating tube sheet is clamped between the floating head and a flange so that it is possible to remove the tube bundle for cleaning. This heat exchanger has one shell pass and two tube passes.

In the design and selection of a shell-and-tube heat exchanger, the power requirement and the initial cost of the unit must be considered.

In gas heating or cooling it is often convenient to use a cross-flow heat exchanger. The cross-flow heat exchanger is widely used in the heating, ventilating, and air-conditioning industry. In such a heat exchanger, one of the fluids passes through the tubes while the gaseous fluid is forced across the tube bundle. The flow of the exterior fluid may be forced by natural convection.

In this type of exchanger the gas flowing across the tube is considered to be mixed, whereas the fluid in the tube is considered to be unmixed. The exterior gas flow is mixed because it can move about freely between the tubes as it exchanges heat, whereas the fluid within the tubes is confined and cannot mix with any other stream during the heat exchange process. The mixed flow implies that all of the fluid in any given plane normal to the flow has the same temperature. The unmixed flow implies that although temperature differences within the fluid may exist in at least one direction normal to the flow, no heat transfer results from this gradient.

In the design of heat exchangers it is important to specify whether the fluids are mixed or unmixed, and which of the fluids is mixed. It is also important to balance the temperature drop by obtaining approximately equal heat transfer coefficients on the exterior and interior of the tubes. If this is not done, one of the thermal resistances may be unduly large and cause an unnecessarily high overall temperature drop for a given rate of heat transfer, which in turn demands larger equipment and results in poor economics.

5. Answer the questions:

1. What kind of device is a heat exchanger? 2. Are economic considerations important in a complete engineering design of heat exchange equipment and why? 3. Where can the oldest applications of heat exchangers be found? 4. What common heat exchangers are used in most homes? 5. Why has the role of heat exchangers increased recently? 6. What basic types of heat exchangers are mentioned in the text? 7. What more common type of heat exchanger is widely used in the chemical and process industry? 8. How many types of baffles are used in shell-and-tube heat exchangers? 9. Where is it convenient to use a cross-flow heat exchanger?

6. Choose the correct option: a, b or c.

1. In Direct Contact Heat Exchangers the hot and cold fluids contact each other

a) directly; b) direct; c) direction.

2. The role of the economics of the system has taken on increasing importance recently as engineers have become energy

a) conspicuous; b) conscious; c) consciously.

3. An example of the Direct Contact Heat Exchanger is a cooling tower in which a spray of water falling from the top of the tower is directly contacted and cooled by a stream of air flowing

a) rearward; b) downward; c) upward.

4. To achieve cross-flow on the shell side, baffles are placed

a) inside the shell; b) outside the shell**;** c) inside the shelf.

5. In a fixed matrix configuration, the hot and cold fluids pass alternately through a

a) moving exchanger; b) stationary exchanger; c) stationery.

6. A variety of baffles have been used in industry, but the most common kind is the

a) segmental baffle; b) disk-and-doughnut baffle; c) orifice baffle.

7. Comment on the statements. Do you agree with them? Give your arguments.

Engineers have become energy conscious nowadays. Economic considerations and economic return on the investment are important in engineering design of heat exchangers.

8. Speak about various types of heat exchangers and describe the improved modification of the shell-and-tube heat exchanger using the information from Text 3A or your own information; words and word combinations from the box are to help you.

Energy payback of a system, economic return on the investment, to optimize designs, increasing importance, the most conspicuous applications, recuperators, regenerators, immiscible liquids, annular space, shell-and-tube arrangement, inlet header, a variety of baffles, gaseous fluid, in turn, the lowest initial cost, tube bundle, floating-head cover, heat transfer enhancement devices, drawbacks, basic design, improved arrangement, flange, shell pass.

9. Put the words in the correct order to make up questions in writing; answer the questions.

1. Direction / in / what / the fluids / do / move / in counter flow?   2. Angles / at / what / the fluids / do / move / in cross flow? 3. What / used / is / an"average" / as / temperature / simple / in /systems? 4. Method / can / used / be / what / more / in / systems / complex?

10. Translate the sentences paying attention to the functions of the Infinitive.

1. There are a series of substances through which heat must consecutively pass in order to be transferred out of the house. 2. Let us consider the heat transfer through the water that is being heated in a pot on a stove to understand convection in fluids. 3. To further illustrate this relationship between heat transfer, temperature change and change of state, one has to consider this experiment. 4. The report on heat transfer problems to be delivered at the conference is of primary importance. 5. There is much to be learned in thermodynamics. 6. There are many situations in engineering design when the objective is to reduce the flow of heat. 7. The question to be raised here is: “What is the temperature of the skin-insulation interface?” 8. This is not an easy decision to make since we know that the temperature we "feel" depends on the material and is related to the true temperature in a complex manner. 9. This equation needs to be solved. 10. Not to have consulted the manual was a mistake. 11. We have some issues to discuss. 12. In spite of efforts to insulate houses to reduce heat losses via their exteriors, considerable heat is lost, which can make their interiors uncomfortably cool or cold.

11. Translate the sentences paying attention to the Infinitive Constructions.

1. Engineers expect new heat exchangers to be designed in the years to come. 2. Radiation is found to be the process of transferring heat by emitting electromagnetic energy in the form of waves or particles. 3. Convection appears to play a major role in transporting energy from the center of the Sun to the surface, and in movements of the hot magma beneath the surface of the earth. 4. The new instrument is expected to help scientists solve many important problems. 5. By studying the problems in thermodynamics we are sure to study the laws of its development. 6. Professor Petrov is known to be doing the experiment to prove his theory. 7. The invention of computers proved to be a turning point in the history of mankind. 8. The scientist is said to have made a very important discovery. 9. At one time or another every engineer is likely to be confronted with a heat transfer problem. 10. When analyzed, the theory proved to be false. 11. Our model of convection considers heat to be energy transfer that is simply the result of the movement of more energetic particles. 12. The students waited for the professor to speak. 13. Refrigerators and heat pumps are examples of heat engines which cause energy to be transferred from a cold area to a hot area. 14. Conduction is considered to be the transfer of heat through matter with no displacement of the matter.

12. Translate the sentences paying attention to the Gerund.

1. Those of us who live in colder winter climates are in constant pursuit of methods of keeping our homes warm without spending too much money. 2. We make efforts to reduce the heat loss by adding better insulation to walls and attics, caulking (зд. заклеивать) windows and doors, and buying high efficiency windows and doors. 3. Household electricity is most frequently manufactured by using fossil fuels or nuclear fuels. 4. In colder winter climates we are told to dress in layers before going outside. 5. The heat engine is a device that uses heat transfer as the source of energy for doing work. 6. Suppose that the thermometer can be connected to a computer with software that is capable of collecting temperature-time data. 7. Melting occurs at a constant temperature. 8. Convection can also lead to circulation in the liquid, as in heating a pot of water over a flame. 9. Once the sample of water reaches this temperature, boiling occurs. 10. Our initial aim is to obtain a broad perspective of this field of science without becoming involved in details. 11. As a general rule, the thermal conductivity of liquids decreases with increasing molecular weight. 12. You can learn what the new words mean by looking them up in the dictionary. 13. Besides studying at the university he worked as a programmer. 14. Making

presentations requires special skills. 15. Attention must be given to increasing heat transfer rates in the reactor and in the turbine and decreasing heat transfer rates in the pipes between the reactor and the turbine.

13. Translate into English:

1.Теплообменник - это устройство, созданное для эффективной теплопередачи от одной жидкой среды к другой. 2. Делая теоретический расчёт теплопередачи в теплообменниках инженеры должны учитывать разницу температур между двумя жидкостями. 3.Теплообменники широко используются в кондиционерах, холодильных установках и для обогрева пространства. 4. Во многих домах обычные теплообменники представляют собой нагреватели для горячей воды, работающие на газе. 5. Когда теплообменник помещают в систему теплопередачи, то для передачи тепла требуется падение температуры. 6. Все автомобили имеют радиатор и охлаждающее устройство наряду с несколькими другими теплообменниками. 7. В конструкции теплообменников важно определить, смешиваются ли жидкие среды или не смешиваются. 8. В смесительных теплообменниках горячие и холодные жидкие среды прямо контактируют друг с другом.

14. Look through Text 3B and say what you know about the classification of heat exchangers.

Text 3B

Baffled Heat Exchangers and Compact Heat Exchangers. Classification of Heat Exchangers.

The flow of the shell-side fluid in baffled heat exchangers is partly perpendicular and partly parallel to the tubes. The heat transfer coefficient on the shell side in this type of unit depends not only on the size and spacing of the tubes and the velocity and physical properties of the fluid but also on the spacing and shape of the baffles. In addition, there is always leakage through the tube holes in the baffle and between the baffle and the inside of the shell, and there is bypassing between the tube bundle and the shell. Because of these complications, the heat transfer coefficient can be estimated only by approximate methods or from experience with similar units.

According to one approximate method, which is widely used for design calculations, the average heat transfer coefficient calculated for the corresponding is multiplied by 0.6 to allow for leakage and other deviations from the simplified model.

In some heat exchanger applications, the heat exchanger size and weight are of prime concern. This can be especially true for heat exchangers in which one or both fluids are gases, since the gas-side heat transfer coefficients are small and large heat transfer surface area requirements can result.

Compact heat exchangers refer to heat exchanger designs in which large heat transfer surface areas are provided in as small a space as possible. Applications in which compact heat exchangers are required include an automobile heater core in which engine coolant is circulated through tubes and the passenger compartment air is blown over the finned exterior surface of the tubes and refrigerator condensers in which the refrigerant is circulated inside tubes and cooled by room air circulated over the finned outside of the tubes. Another application is an automobile radiator. The engine coolant is pumped through the flattened, horizontal tubes while air from the engine fan is blown through the finned channels between the coolant tubes. The fins to the coolant tubes help transfer heat from the exterior surfaces of the tube into the airstream. Experimental data are required to allow one to determine the gas-side heat transfer coefficient and pressure drop for compact heat exchanger cores. Fin design parameters that affect the heat transfer and pressure drop on the gas side include thickness, spacing[1], material, and length.

Given the heat exchanger requirements, the designer can estimate the performance of several candidate heat exchanger cores to determine the best design.

Given the large variety of applications and structural configurations of heat exchangers, as just discussed, it becomes important to provide a classification scheme to help in their selection process.

1. *The type of heat exchanger: (a) recuperator and (b) regenerator.* A recuperator, as discussed earlier, is the conventional heat exchanger in which heat is recovered by the cold fluid stream from the hot fluid stream. The two fluid streams flow simultaneously, possibly in a variety of flow arrangements, through the heat exchanger. In a regenerator, the hot and cold fluids alternately flow through the exchanger, which essentially acts as a transient energy storage and dissipation unit.

2. *The type of heat exchange process between the fluids: (a) indirect contact, or transmural, and (b) direct contact.* In a transmural heat exchanger, the hot and cold fluids are separated by a solid material, which is typically of either tubular or plate geometry. In direct contact heat exchanger, as the name suggests, both the hot and cold fluids flow into the same space without a partitioning wall[2].

3. *Thermodynamic phase or state of the fluids: (a) single phase, (b) evaporation or boiling, and (c) condensation.* This criterion refers to the state of phase of the hot and cold fluids, and the three categories refer to cases where both fluids maintain single-phase flow and one of the two fluids undergoes flow evaporation or condensation.

4. *The type of construction or geometry: (a) tubular, (b) plate, and (c) extended or finned surface.* A typical example for each of the first two categories, respectively, is the shell-and-tube heat exchanger and the extended - or finned-surface exchanger. The extended - or finned-surface exchanger could either have a tubular (tube-fin) or plate (plate-fin) geometry. It is often referred to as a compact heat exchanger, especially when it has a large surface area density, i.e., relatively large ratio of heat transfer surface area to volume.

Thus, based on this simple scheme, an automobile radiator, for example would be classified as a transmural recuperator with single-phase fluid flows and a finned (tube-fin type construction) surface. This heat exchanger is often also characterized as a compact heat exchanger because of its large area density. Likewise, a boiler feed-water heater, which is a shell-and-tube heat exchanger would be classified as a transmural recuperator of a tubular construction with condensation in one fluid (feed-water is heated by the condensation of steam extracted from a power turbine). Students should bear in mind, however, that classification schemes serve only as guidelines and that the actual design and selection of heat exchangers may involve several other factors.

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[1]Spacing – зд. расположение, размещение.

[2]Partitioning wall – зд. разделительная перегородка.

15. Translate the following questions into English in writing and answer them:

For example: Где применяется компактный теплообменник?

Where is a compact heat exchanger applied? - A compact heat exchanger is applied in an automobile radiator.

1.Чему уделяется главное внимание (to be of prime concern) при проектировании теплообменников для особых применений? 2. Какие типы теплообменных процессов между жидкостями вы знаете? 3. Какую геометрическую форму имеет кожухо-трубный теплообменник? 4. Каковы термодинамические фазы или состояния жидкостей? 5. Как можно оценить коэффициент теплопереноса?

16. Write a summary of Text 3B. The following verbs in Passive and phrases are to help you to make a summary: are considered; are discussed; are outlined; are reviewed; it is concluded that… ; an analysis was made of… ; a short description of … is given… .

17. Make a presentation in Power Point. You may use the information from Texts 3A, 3B and get the information from the Internet or from any other source to characterize various types of heat exchangers, their thermal analysis, structural and geometry features. Prove the diversity of practical applications of heat exchangers. You may choose any heat exchanger for a detailed analysis as well.

18. Read Text 3C to find out the description of different types of heat sinks, as well as scientific principles that explain how they work. Say in what branch of engineering the heat transfer phenomenon can be applied.

Text 3C

How Heat Sinks Work

Though the term heat sink[1] probably isn't one most people think of when they hear the word computer, it should be. Without heat sinks, modern computers couldn't run at the speeds they do. Heat sinks cool down your computer's processor after it runs multiple programs at once. And without a quality heat sink, your computer processor is at risk of overheating, which could destroy your entire system, costing you hundreds, even thousands of dollars.

But what exactly is a heat sink and how does it work? Simply put, a heat sink is an object that disperses heat from another object. They are most commonly used in computers, but are also found in cell phones, DVD players and even refrigerators. In computers, a heat sink is an attachment for a chip that prevents the chip from overheating and, in modern computers, it is as important as any other component.

If you are not very tech-savvy[2] think of the heat sink like a car radiator. The same way a radiator draws heat away from your car's engine, a heat sink draws heat away from your computer's central processing unit (CPU). The heat sink has a thermal conductor that carries heat away from the CPU into fins that provide a large surface area for the heat to dissipate throughout the rest of the computer, thus cooling both the heat sink and processor. Both a heat sink and a radiator require airflow and, therefore, both have fans built in.

Before the 1990s, heat sinks were usually only necessary in large computers where the heat from the processor was a problem. But with the introduction of faster processors, heat sinks became essential in almost every computer because they tended to overheat without the aid of a cooling mechanism.

Heat can be transferred in three different ways: convection, radiation and conduction. Conduction is the way heat is transferred in a solid, and therefore is the way it is transferred in a heat sink. Conduction occurs when two objects with different temperatures come into contact with one another. At the point where the two objects meet, the faster moving molecules of the warmer object crash into the slower moving molecules of the cooler object. When this happens, the faster moving molecules from the warmer object give energy to the slower moving molecules, which in turn heats the cooler object. This process is known as thermal conductivity**,** which is how heat sinks transfer heat away from the computer's processor.

Heat sinks are usually made of metal, which serves as the thermal conductor that carries heat away from the CPU. However, there are pros and cons[3] to using every type of metal. First, each metal has a different level of thermal conductivity. The higher the thermal conductivity of the metal, the more efficient it is at transferring heat.

One of the most common metals used in heat sinks is aluminum. Aluminum has a thermal conductivity of 235 watts per Kelvin per meter (W/mK). The thermal conductivity number, in this case 235, refers to the metal's ability to conduct heat. Simply put, the higher the thermal conductivity number of a metal, the more heat that metal can conduct. Aluminum is also cheap to produce and is lightweight. When a heat sink is attached, its weight puts a certain level of stress on the motherboard.

One of the best and most common materials used to make heat sinks is copper. Copper has a very high thermal conductivity of 400 W/mK. It is, however, heavier than aluminum and more expensive. But for operating systems that require an extensive amount of heat dissipation, copper is frequently used.

So where does the heat go once it has been conducted from the processor through the heat sink? A fan inside the computer moves air across the heat sink and out the computer. Most computers also have an additional fan installed directly above the heat sink to help properly cool the processor. Heat sinks with these additional fans are called active heat sinks, while those with the single fan are called passive heat sinks. The most common fan is the case fan, which draws cool air from outside the computer and blows it through the computer, expelling the hot air out of the rear.

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[1] Heat sink[1] – теплоприёмник

[2] Tech-savvy – зд. технически подкованный, грамотный.

[3] Pros and cons – доводы за и против.

19. Round-table discussion. Speak about the main reasons for using different types of heat sinks in computer engineering. Say whether any type of heat sinks described is used in your computer. Is it worth having a heat sink in personal computers and why?

Play the part of a computer specialist or heat transfer specialist to prove the necessity of using heat sinks. Use the following words and phrases:

As some of you know I am a specialist in charge of computer maintenance. I am here in my function as a heat transfer specialist. The general opinion is that heat sinks are… . From what I know of heat sinks… . Heat sink seems to be a kind of… . My process of reasoning is like this. Today's topic is of particular interest to those of you who… . I'd like to focus your attention on… .I think you'll be surprised to see that… . Let me point out that… . My talk is particularly relevant to those of us who… . Let's look more closely at… . Let's move on/turn to… . Before we go on, let me clarify one point. Today I'd like to give you an overview of… . I'd like to share an amazing fact/figure with you. In view of all these details… . Before I go on, let me summarize the key issues. I'd like to stress/highlight/emphasize the following points. Before I stop, let me go over the key issues again. That's all I wanted to say about… . To sum up (then), we… . This brings me to the end of my report.

Supplement.

I. To be done after Unit 1.

1. Translate the sentences paying attention to the Passive Voice.

1. Conceptually, the thermal conductivity **can be thought of** as the container for the medium-dependent properties which relate the rate of heat loss per unit area to the rate of change of temperature. 2. The rate of conductive heat transfer between two locations **is affected by** the temperature difference between the two locations. 3. Materials with relatively high thermal conductivities **are referred to as** thermal conductors**.** Materials with relatively low thermal conductivity values **are referred to as** thermal insulators**.** 4. Heat **is** generally **transferred by** conduction at considerably higher rates through solids in comparison with liquids and gases. 5. The more vigorous motion of particles **is reflected by** a temperature increase. 6. Devices that utilize heat to do work **are often referred to as** heat engines. 7. The state of motion of an object **is maintained** as long as the object **is not acted upon** by an unbalanced force.

2. Translate the sentences paying attention to the Degrees of Comparison.

1. **The more** the particles vibrate and rotate, **the greater** the temperature of the object. 2. **The hotter** the object, **the more** it radiates. 3. Heat transfer occurs **more readily** when the temperature of the surroundings is significantly **less** than the normal body temperature. 4. In winter heat is transferred from the roof of a house to the **colder** ambient environment not only by convection but also by radiation, while the heat transfer through the roof from the interior to the exterior surface is by conduction. 5. Metallic liquids have **much higher** conductivities than nonmetallic liquids.

3. Act out the dialogues with your fellow students.

At the International Conference.

DIALOGUE 1

Mr Clark, a British scientist, is talking to Oleg Smirnov, his Russian counterpart (коллега), at an international conference during a break.

Clark: Your recent experiments have been a great success, Mr. Smirnov. Congratulations!

Smirnov: Thank you very much. You've read my last article, then, haven't you?

C: Of course I have. I'm very interested in your research, and I hardly ever miss your publications. By the way, when are you going to give a talk on your work?

S. Some time next week at the Research Centre, but I can't tell you definitely yet.

C. Could you ring me up and let me know?

S. Certainly.

C. Thanks a lot.

DIALOGUE 2

-Oh, the first session is to start in a few minutes.

- Yes, we must be going now. Or we'll be late.

- I hope we'll continue our talk sometime later.

-And do you know how long the first session is?

- If I am not mistaken, till twelve.

-Then, let's meet in the lobby as soon as the interval starts.

-Agreed.

4. Match the sentences from column A with the sentences from column B to make up brief dialogues.

A	B
1. Mr. Benett's in conference just now.	a. That's OK. Never mind.
2. Fred's just got a new appointment!	b. With pleasure.
3. Are you pleased with your new appointment?	c. It's no trouble at all.
4. I'm afraid I'll have to cancel my appointment for today.	d. Quite right. What can I do for you?
5. I'm sorry to give you so much trouble.	e. When do you think he'll be free?
6. Let's, make an appointment for 11o'clock	f. Shall I put you down for another day?

next Wednesday.	
7. I'm a bit early, I'm afraid.	g. Well, yes and no…
8. A cup of tea?	h. Yes, let's. Wednesday suits me perfectly.
9. We can go there right away.	i. Oh, has he? Give him my congratulations!
10. Hello. Is that the Embassy?	j. That's perfectly all right
11. Sorry to keep you waiting.	k. Suits me perfectly.

5. Make suitable responses to keep the dialogue going. Act out the dialogue.

Making an Appointment

(You want to make an appointment with Mr. Jackson, the production manager of a company you are doing business with.)

Secretary: Mr. Jackson's office. Good morning!

You: This is ____________________. Could I____________________?

S: Mr. Jackson's in conference on heat transfer problems just now, but I think he'll be free soon.

Y: I'd like ___________________________.It's important.

S: Will you call back later or leave your telephone number?

Y:_______________________.

6. Give an appropriate response to the following phrases. The first one has been done for you. Practise it with your fellow students.

1. I think the boss has got a real problem with his contract.- Yes, but I am sure he'll sort it out.

2. Do you like coffee?- … 3. I don't like his new CD.- … 4. How was the lecture?- ... 5. What are you doing this evening?- ... 6. What's the matter? (= What's the problem)-… 7. Could I possibly borrow your dictionary?- ... 8. We were wondering if you'd like to come with us?- ... 9. She finally got her visa to travel.- … 10. He's passed his driving test.- …

II. To be done after Unit 2.

1. Act out the dialogues with your fellow students.

Visiting the laboratory and firm.

DIALOGUE 1.

-Oh, Mr. T., I am very glad to see you. How are you keeping these days?

- Fine, thank you. And how are you getting along?

- Very good, thanks. Would you like some tea?

-Thank you. I've just had some.

- I remember you were willing to see our laboratory.

- Oh yes, it was very kind of you to let me come.

- Now, if you don't mind let's go to the lab floor right away. I'll be glad to show you round.

-Thank you.

DIALOGUE 2.

- And what do you think of the laboratory?

- Oh, it's amazing. So many modern things. I am really deeply impressed. Thank you again for this invitation and opportunity to see it all for myself.

- Very good. But if you don't mind I'd like to speak about the device your university has developed this year. We would like to buy two or three pieces.

- I think we'd discuss it some other day when Mr. A. is present.

DIALOGUE 3.

-Well, you see, Mr. C., can you now give me your price of this device?

-Oh, it depends on many factors; like the number you are going to buy, the time and the terms of delivery, the set of spares (комплект запчастей) and so on. Do you know exactly how many devices you wish to have?

-I'm afraid I don't know for the moment. But I'll tell you next week.

-Fine, contact me next week and we'll settle the matter. The number is on my card.

-Thank you. I hope we'll do good business for our both parties.

2. Match the sentences from column A with the sentences from column B to make up brief dialogues.

A	B
1. Could you hand me that pen?	a. Thanks very much.
2. Sorry, I must have got the wrong number.	b. Of course. Here you are.
3. May I come in?	c. I'd love to. / I'd like to.

4. Do you mind if I open the window?	d. Not at all. / You are welcome.
5. Thanks for the help.	e. You too. / Same to you.
6. I think we should leave now.	f. Yes, of course. / Please do. / Certainly.
7. You must come round for dinner.	g. No, of course not. / No, not at all.
8. Have a good weekend.	h. It doesn't matter. / Don't worry. / Never mind.
9. Best of luck in your new project.	i. So do I. / I think so too.

3. Give an appropriate response to the following phrases. The first one has been done for you. Practise it with your fellow students.

1. Sorry, I interrupted you. - Never mind.

2. Do you mind if I close the door?- ... . 3. Could you pass me the file?- ... . 4. Can I see you for a moment?- … . 5. I think it's going to rain.- … . 6. Have a good holiday.- … . 7. I'm sorry. I've taken the wrong file.-… . 8. Shall I introduce you to Jim?- ... . 9. Do you mind if I turn on the radio?- ... .10. Can you tell me where room 25 is, please? -… . 11. Can I take another biscuit?- ... 12. Have you finished with the paper?-... .

III. To be done after Unit 3.

1. Act out the dialogues with your fellow students.

At the International industrial exhibition on heat exchangers.

DIALOGUE 1.

Alexey Antonov is an engineer from a factory which is taking part in an International industrial exhibition in Sokolniki Park. Mr. Bennett, a businessman from Canada, is talking to Antonov.

Bennett: Have you seen our new model of a heat exchanger, Alexey?

Antonov: Yes, and I must say it's a very up-to-date design.

B. Thanks. I'm happy to hear that.

A. We're interested in buying some of these heat exchangers for our factory.

B. Are you? How many would you like to buy?

A. I can't give you a definite answer now, I think it may be quite a big order. Would you like to visit the factory and talk to the Managing Director.

B. I’d love to if you could arrange it soon, because I’m leaving Moscow next Saturday.

A. No problem, Mr. Bennett.

B. Good. Thanks a lot.

DIALOGUE 2.

Secretary: Mr. Bennett’s office. Good morning.

Antonov: Good morning. Can I speak to Mr. Bennett, please?

S. Just a moment. I’ll put you through.

Bennet: Bennett here.

A. Good morning, Mr. Bennett. This is Antonov from Moscow. We bought some heat exchangers from you.

B. Yes, I remember. What can I do for you, Mr. Antonov?

A. You see, Mr. Bennett, we are having some trouble with one of the heat exchangers, and I’d like to see you about it.

B. When would you like to come?

A. The sooner the better. Will tomorrow morning be too early?

B. That’s quite all right. Will 10 o’clock in the morning suit you?

A. Yes, perfectly. Till tomorrow, then. Good-bye.

B. Good-bye.

DIALOGUE 3.

B. So what exactly is the trouble, Mr. Antonov? We tested all the heat exchangers very carefully, and your inspectors were here during the tests, weren’t they?

A. Yes, that’s true, and the heat exchangers operated normally for a time after we installed them at our factory. But towards the end of the first month we began to find some very funny defects in the heat exchangers . I’ve got a list of them here. Will you have a look, please?

B. Certainly. (He goes through the list.)

Yes, I quite agree with you. It’s more than funny. You see, we’ve never had any trouble with this model. I’m afraid you’ll have to go to the factory and discuss it there.

A. Yes, actually I’ve thought of that, too. But I’m only staying here a week, and I wouldn’t like to put off my visit to the end of my stay. The sooner I go, the better.

B. No problem, Mr. Antonov. It won’t take me long to make arrangements. You’ll be able to visit the factory tomorrow. How about that?

A. Suits me perfectly! And how do I get to the factory?

B. Just leave your telephone number with the secretary. I'll ring you tomorrow morning, and we'll go there together.

A. It's very kind of you, Mr. Bennett. I'm really sorry to give you so much trouble.

B. No trouble at all, Mr. Antonov. I'm interested, too. Any more questions to ask me?

A. No, that's all, thanks.

B. Till tomorrow, then. Bye!

A. Bye!

2. Make up a dialogue of your own using your imagination.

Will Mr. Antonov get reimbursement of expenses? (эк. возмещение) Give your reasons to prove your point of view. Will the problem with defected heat exchanger be solved?

Some phrases to help you:

When can you give us the test results? What is the deadline for finishing work? Who is the development engineer? How much does this installation weigh? What are its dimensions and applications? May I see its basic technical data? We would like to talk with the quality control manager. May we see this heat exchanger in operation? What is the service life of the heat exchanger?

3. Match the sentences from column A with the sentences from column B to make up brief dialogues.

A	B
1. Could you possibly open that window? It's very hot in here.	a. No, hardly anything.
2. What would you like to do this weekend?	b. Yes, of course. / Go ahead. / You can borrow my dictionary if you promise to look after it.
3. I'm a bit short of money. Do you think you could possibly lend me some? / Can you lend me some?	c. I don't know really. Any ideas?
4. I've got some tickets for a concert of classical music and I was wondering if you'd like to go with me?	d. I'm afraid I can't. / I wish I could but, - I haven't any money on me at all.

5. Could I possibly borrow your dictionary?	e. Yeah, sure. / Of course. / I don't mind.
6. I've finished reading the book you lent me.	f. It depends how much it is.
7. Are you going to buy this computer?	g. Have you? What did you think of it? Did you like it?
8. Are you ready yet?	h. Either. I'll be in all day.
9. When shall I phone you, morning or afternoon?	i. Not quite. (=not completely)
10. Do you know much about aircraft engines?	j. No, actually I think I'd rather stay at home and do my English homework.

4. Give an appropriate response to the following phrases. The first one has been done for you. Practise it with your fellow students.

1. Could I borrow your pen, please?-Sorry, I'm using it.

2. Why don't we meet this afternoon and practice our English for an hour?- … 3. Could I use your mobile phone? -... 4. Could you tell me the way to the university?-... 5. Can you read a newspaper in English? -... 6. What time will you arrive?-... 7. Are you tired?-...8. Is there a flight to Paris this evening? -... 9. Where shall we go?-... 10. What would you like to eat?-... 11. Do you want to go out?-... 12. What time shall we go?-... 13. I was wondering if I could (possibly) borrow your book ?-... .

Словари

1. Hornby A.S. Oxford Advanced Learner's Dictionary, 6th ed. Oxford: Oxford University Press, 2000.

2. The American Heritage Dictionary of the English language. New York. American Heritage Publishing Co., Inc.1969.

3. Англо-русский технический словарь / Под. ред. инж. А.Е. Чернухина, М. - Л. Государственное технико-теоретическое издательство, 1934.

4. Большой англо-русский политехнический словарь / С.М. Баринов, А.Б. Борковский, В.А. Владимиров и др. М.: Руссо, 2002.

5. Большой англо-русский словарь / Под ред. И. Р. Гальперина. М. Русский язык, 1987.

6. Русско-английский технический словарь / Под. ред. А.Е. Чернухина, М. Военное издательство Министерства Обороны СССР, 1971.

Учебная литература

1. Bejan A. Convection Heat Transfer. Fourth Edition. John Wiley & Sons, Inc. 2013.

2. Bonamy D. Technical English 2, Longman, 2008.

3. Brieger N., Comfort J. Early Business Contacts: Materials for Developing Listening and Speaking Skills for the Student of Business English, Prentice Hall, 1989.

4. Kreith F., Manglik R. M., Bohn M. S. Principles of heat transfer. Seventh Edition. Stamford. Cengage Learning, 2011.

5. Learn to Read Science. Курс английского языка для аспирантов. Учебное пособие. М.: Флинта; Наука, 2005.

6. Murphy R. English Grammar in Use. Fourth Edition. Cambridge University Press, 2012.

7. Redman S., English Vocabulary in Use (Pre-Intermediate & Intermediate). Second Edition. Cambridge University Press, 2003.

8. Бонк Н. А. Английский шаг за шагом: в 2т. М.: РОСМЭН, 2013.

9. Казакова Т. А. Практические основы перевода. Translation Techniques. English↔Russian. Учебное пособие. Спб.: Лениздат; Союз, 2002.

10. Пумпянский А.Л. Чтение и перевод английской научной и технической литературы: Лексика, грамматика, фонетика, упражнения. Минск: Попурри, 1997.
11. Фрейдина Е.Л., Самохина Т.С., Тихонова И.С., Ковалёва Л.Б., Михайлова А.В. Основы публичной речи: Learning to Speak in Public. М: Гуманит. изд. центр ВЛАДОС, 2000.

Сайты

http://www.physicsclassroom.com/class/thermalP/Lesson-1/Rates-of-Heat-Transfer
http://www.physicsclassroom.com/class/thermalP/Lesson-1/Methods-of-Heat-Transfer
http://www.physicsclassroom.com/class/thermalP/Lesson-2/What-Does-Heat-Do
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html#c1
http://www.engineersedge.com/heat_exchanger/general.htm
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