В.В. Кириллова
А.М. Знаменская
Г.И. Найданова
Т.С. Шарапа

АНГЛИЙСКИЙ ЯЗЫК

Учебно-методическое пособие по чтению и переводу научно-технической литературы

для студентов факультета промышленной энергетики

Санкт-Петербург

2014

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ
ВЫСШЕГО ПРОФЕССИОНАЛЬНОГО ОБРАЗОВАНИЯ

**«САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ
ТЕХНОЛОГИЧЕСКИЙ УНИВЕРСИТЕТ
РАСТИТЕЛЬНЫХ ПОЛИМЕРОВ»**

В.В. Кириллова

А.М. Знаменская

Г.И. Найданова

Т.С. Шарапа

АНГЛИЙСКИЙ ЯЗЫК

**Учебно-методическое пособие
по чтению и переводу
научно-технической литературы
для студентов факультета
промышленной энергетики**

Санкт-Петербург

2014

УДК 81.2 Англ. (075)
ББК 802.0Я7
А 648

Кириллова В.В., Знаменская А.М., Найданова Г.И., Шарапа Т.С. Английский язык: учебно-методическое пособие по чтению и переводу научно-технической литературы для студентов факультета промышленной энергетики; СПбГТУРП. – СПб., 2014. – 78 с.

Учебно-методическое пособие содержит тексты по специальности, предназначенные для чтения и перевода, методические рекомендации по подготовке перевода текстов для устного ответа, тексты по разговорным темам для собеседования и словарь. В пособии излагается последовательность работы над текстом научно-технической литературы, а также содержится необходимый лексический материал.

Предназначено для студентов факультета промышленной энергетики.

Рецензенты: канд. филол. наук, доц. кафедры «Иностранные языки» Санкт-Петербургского государственного университета путей сообщения М.М. Четина;
канд. филол. наук, доцент кафедры иностранных языков Санкт-Петербургского государственного технологического университета растительных полимеров З.И. Мартемьянова.

Подготовлено и рекомендовано к печати кафедрой иностранных языков Санкт-Петербургского государственного технологического университета растительных полимеров (протокол № 1 от 29.08.2014 г.)

Утверждено к изданию методической комиссией химико-технологического факультета СПбГТУ РП (протокол № 2 от 09.10.2014 г.)

Рекомендовано к изданию Редакционно-издательским советом университета в качестве учебно-методического пособия.

ВВЕДЕНИЕ

Предлагаемое учебно-методическое пособие предназначено для студентов дневного отделения, обучающихся по направлению 13.03.01 – «Теплоэнергетика и теплотехника», и имеет целью развитие навыков чтения и перевода научно-технических текстов, обучение терминологической лексике, содержащейся в текстах по изучаемой студентами специальности.

Пособие содержит методические рекомендации для чтения и перевода специальной литературы, тексты по специальности, предназначенные для чтения и перевода на занятиях вместе с преподавателем (II и III разделы учебного пособия), тексты для самостоятельного чтения и устного перевода (раздел IV), советы по подготовке перевода текстов для устного ответа, тексты для письменного перевода (в разделе «Приложение»), тексты по разговорным темам для собеседования на экзамене, а также рекомендуемый библиографический список и словарь.

В учебно-методическом пособии также излагается последовательность работы над текстом научно-технической литературы и содержится необходимый лексический материал.

Предлагается перечень разговорных тем для собеседования на экзамене и базовые тексты по разговорным темам.

Терминологический словарь содержит основные слова, встречающиеся в пособии в их контекстуальном значении, и имеет цель облегчить работу над переводом.

I. МЕТОДИЧЕСКИЕ РЕКОМЕНДАЦИИ ДЛЯ ЧТЕНИЯ И ПЕРЕВОДА СПЕЦИАЛЬНОЙ ЛИТЕРАТУРЫ

1. Перевод двучленных и многочленных атрибутивных словосочетаний, выраженных существительными («цепочки» существительных, левые определения)

Двучленные или многочленные атрибутивные словосочетания или «цепочки» существительных – это словосочетания, состоящие из существительного и определений, расположенных слева от него.

В качестве левого определения могут быть существительные (от двух до пяти или шести). Существительным могут предшествовать: прилагательное, причастие, местоимение или числительное, а также сочетания из этих слов, соединённые дефисом.

Необходимо обратить внимание на то, что внутри такого сочетания *слова не отделены друг от друга ни артиклями, ни предлогами, ни запятыми*: ***renewable energy sources, preliminary concentrated light, the simple open gas-turbine power cycle.***

Для перевода «цепочки» существительных важно найти в ней главное, основное слово. Помните, что *основным словом* любой «цепочки» существительных является ***последнее*** *существительное, с которого и следует начинать анализ* такой «цепочки». Все существительные и другие части речи, стоящие слева от основного слова, являются *определениями* к нему (отвечают на вопросы: «какой?», «какие?», «чего?»). Справа от основного слова, указывая на то, что «цепочка» закончилась, может стоять новый артикль, предлог, местоимение, прилагательное, причастие или глагол-сказуемое с предшествующим наречием или без него.

При переводе двучленных словосочетаний («цепочки» состоят из двух существительных) выбираем подходящий вариант.

1. Перевод *начинаем с последнего существительного,* а существительное, стоящее слева, переводится *существительным в родительном падеже:*

water level *– уровень воды,* ***pressure drop*** *– спад (перепад) давления.*

2. «Цепочка», состоящая из двух существительных, первое из которых переводится *прилагательным:*

water vapor *– водяной пар,* ***circulation pump*** *– циркуляционный насос.*

3. Перевод «цепочки» начинаем с последнего существительного, а первое переводим существительным с предлогом ***(в, из, на, для** и др.):*

digester pressure *– температура в котле.*

Перевод многочленных словосочетаний («цепочки» существительных состоят из трёх и более существительных и других частей речи).

1. При переводе многочленных словосочетаний рекомендуется:

1) перевести последнее существительное «цепочки»;

2) разбить остальную часть словосочетания на *смысловые группы* и перевести их (внутри смысловой группы анализ проводится слева направо);

3) перевести всё словосочетание (всю «цепочку»), следуя *справа налево.*

water quality results *– результаты по качеству воды,* ***quality control method*** *– метод контроля качества,* **headbox control system** *–система регулирования напорного ящика*

2. Если прилагательное предшествует «цепочке» существительных, необходимо обратить внимание на то, *к какому слову оно относится*.

high evaporation rate *– высокая скорость испарения,* ***automatic temperature control*** *– автоматическое регулирование температуры*.

3. В состав «цепочки» существительных в качестве определения могут входить числительные, местоимения, причастия, существительные в притяжательном падеже и т.д. Следует обратить внимание, *к какому слову эти оп-*

ределения относятся. Основное слово словосочетания – последнее существительное, которое переводится существительным:

this high pressure steam *– этот пар высокого давления,* **rate determining factor** *– фактор, определяющий скорость.*

4. Иногда одно из слов «цепочки» существительных необходимо перевести *поясняющими словами (группой слов):*

steam pressure measuring device *– прибор для измерения давления пара.*

Упражнение. Переведите предложения, обращая внимание на особенности перевода определений, выраженных существительными, и стоящих перед определяемыми существительными (левое определение).

Используйте образец выполнения упражнения

1. This scientist works at some problem of *low temperature physics.*

Перевод: Этот учёный работает над одной проблемой физики низких температур. Пояснение: *low temperature physics.* “Physics” – последнее – определяемое слово, “temperature”– определение к нему. “Low”– определение к слову “temperature”.

2. My father works at a *pulp and paper mill.*

Перевод: Мой отец работает на целлюлозно-бумажном заводе. Пояснение: *pulp and paper mill*. “Mill” – последнее, определяемое слово, ”pulp and paper” – определение к нему.

1. Natural gas is used for steam generation in gas producing areas.

2. These areas are served by natural gas transmission lines.

3. The furnace height is the function of the regrouped furnace volume.

4. Superheaters requirements may govern exit temperature.

5. Pulverized coal furnaces are usually convertible to firing with oil or gas.

6. The flame shape determines the furnace width and depth dimensions. The design of the amount of heat transfer surface is based on the laws of heat transfer

and economics.

7. Heat is an energy that is transferred across the boundaries of a system because of a temperature difference.

8. When the gases leave the completely water cooled furnace they pass across the superheater furnace. A heat exchanger consists of a metal wall through which heat flows from one fluid to another.

2. Последовательность работы над текстом научно-технической литературы

1. Прочтите весь текст или абзац и постарайтесь понять его общее содержание.

2. Разбейте каждое сложное предложение на отдельные предложения: сложносочинённые – на простые; сложноподчинённые – на главное и придаточное. Напоминаем, что сложносочинённые предложения могут соединяться союзами: **and** – и, **but** – но, **or** – или. Сложноподчинённые предложения соединяются союзными словами и союзами: **who** – кто; который, **what** – что, **which** – который, **that** – который; то, что, **when** – когда, **where** – где, куда, **whose** – чей, **why** – почему, **as for = since** – так как, **because** – потому что, **if** – ли, если, **provided**, **providing** – при условии, что; **whether** – ли, **unless** – если не, **until** – до тех пор, пока не и др.

3. Если вы испытываете трудность при переводе предложения, найдите в каждом предложении *группу сказуемого.* Сказуемое найти легче других членов предложения, так как подавляющее большинство глагольных форм имеет формальные признаки.

4. *Слева от сказуемого* в повествовательном предложении всегда стоит *группа подлежащего*, кроме:

а) предложений с оборотом «there be»;

б) бессоюзных условных предложений с *инверсией*, которые начинаются глаголами: had, were, should, could.

5. Справа от сказуемого находится *дополнение* или *обстоятельство* (если нет дополнения). Обстоятельство может стоять и перед подлежащим.

6. Перевод предложений начинайте с группы подлежащего, затем переводите группу сказуемого и т.д.

7. Перед нахождением слова в словаре уточните, *какой частью речи оно является* в данном предложении, так как часто разные части речи совпадают по форме (work – n,v, increase – n,v, transport – n,v и т.д.).

8. Не спешите брать из словаря первое значение слова, так как *английские слова многозначны.* Прочтите все значения слова и *выберите наиболее подходящее для данного предложения.*

Обратите внимание, не является ли данное слово *частью словосочетания* (pay – платить, pay attention to – обращать внимание на, make – делать, make use of – использовать, account – отчёт, счёт, on account of – из-за, вследствие, take account of – учитывать и т.д.). Помните, что *после глаголов* могут стоять *послелоги*, которые *меняют значение глагола* (make up –составлять, work out – разрабатывать, provide for – предусматривать и т.д.).

9. ***Найти сказуемое помогают следующие формальные признаки***:

1) вспомогательные и модальные глаголы, являющиеся компонентом сказуемого: **am, is, are, was, were, do, does, did, have, has, had, shall, will, should, would, can, could, may, might, must, ought to, need**;

2) три неявных признака сказуемого:

а) окончание -s (-es) – оно совпадает с окончанием существительного во множественном числе и притяжательном падеже.

б) окончание -ed – оно совпадает с окончанием причастия прошедшего времени – Participle II правильных глаголов.

в) отсутствие окончаний (т.е. глагол-сказуемое совпадает по форме с инфинитивом) в Present Simple или использована форма неправильного глагола в Past Simple (рекомендуется повторить три формы неправильных глаголов).

10. ***Найти подлежащее помогают следующие формальные признаки***:

1) подлежащее может быть выражено существительным или несколькими существительными, являющимися однородными членами предложения, стоящими *слева от сказуемого* в повествовательном предложении. Существительные должны быть без предлога.

2) подлежащее, выраженное существительным, может иметь при себе определения, входящие в группу подлежащего: а) левое определение, б) правое определение, в) одновременно левое и правое определения. В качестве правого определения могут использоваться *определительные придаточные предложения, инфинитив или инфинитивный оборот.*

3) подлежащее может быть выражено местоимениями: I, he, she, it, we, they, which, who, nobody, nothing, this, these, one, someone, somebody, anyone, anybody, everyone, everybody, everything, словами-заменителями существительных: that, these и др.

4) подлежащее может быть выражено *инфинитивом с относящимися к нему по смыслу словами* (инфинитивной группой). Этот инфинитив обязательно должен стоять перед сказуемым. Не следует путать инфинитив в роли подлежащего с инфинитивом в роли обстоятельства цели, стоящим в начале предложения. *Если перед сказуемым есть другое подлежащее, то инфинитив – обстоятельство.*

***To provide three pulverizers** is necessary for the efficient operation of the furnace. – Обеспечить три распылителя необходимо для эффективной работы топки.*

5) подлежащее может быть выражено *субъектным инфинитивным оборотом* (сложное подлежащее).

***Heat** is known **to be** a form of energy – Известно, что тепло есть форма энергии.*

6) подлежащее может быть выражено герундием (с относящимися к нему по смыслу словами).

***Making the first measuring instrument** was not an easy thing – Сделать первый измерительный прибор было нелегко*.

7) подлежащее может быть выражено придаточным предложением с подлежащим. Союз that – *«то, что».*

***That bodies expand under heating** was known long ago. – То, что тела при нагревании расширяются, было известно давно.*

II. ТЕКСТЫ ДЛЯ ЧТЕНИЯ

Текст 1. The use of solar energy

One of the uses of solar energy is its transformation into electric energy. Photoelectric converters operate not only aboard space vehicles (космические корабли). They are used to supply hard-to-reach (трудно доступный) sites, for instance, light-houses (маяки), communication facilities (средства связи), etc. with electric power. Such installations can operate continuously for 20 years, and their capacity is up to 500 watts. They are reliable and do not need constantly handling by personal.

At present, mainly semiconductor silicon is used for the manufacture of photocells. Now the researchers have designed photocells on the basis of linking two materials in a single crystal-gallium arsenide and aluminum arsenide. They are most promising for the transformation of preliminary concentrated light since they continue to operate efficiently at temperature of over 200˚ C. Using heat that is released in photocells one can raise the efficiency up to 30%. Their use in solar power station will greatly cut the cost of the photoelectric method of energy transformation.

The problem of wider uses of renewable energy sources – solar, tidal and geothermal ones is of great local importance. So far (пока что) the practical use of solar energy is not very significant but the use of this energy can be profitable in many areas even now. Specialists designed water-heating installations for both seasonable and year-round operation. They have already built solar-powered homes and public buildings with hot water supply, heating and air-conditioning. Within the next few years experimental constructions will go on. After tests the best solutions will be used in standard designs.

The application of solar installations in agriculture has considerable effect. The experience in experimental solar-heating greenhouses (теплица) has shown that, as compared with ordinary greenhouses that receive heat from boiler rooms, the expenses on vegetable-growing are reduced by 60% due to fuel savings alone. Solar-powered installations for drying farm products were also tested successfully.

Текст 2. Renewable energy sources

In the future the energy of the sun, wind, sea and the heat of underground waters will be used on a large scale. These are the so-called "free" energy sources. They will be utilized only when they are more profitable than the traditional ones, because their exploitation is usually much more expensive than energy supply from large electric power stations which run on coal or nuclear fuel.

The utilization of the biomass – agricultural wastes and city runoff – can be found very effective: they can be employed in obtaining gas.

In addition it may happen that new energy sources will be discovered. What if, for example, the vacuum is a boundless ocean of matter in some specific state? Perhaps in the future man will discover some ways of getting energy from this matter? Or, for example, the undiscovered cosmic forces or the annihilation energy which arises from the fusion of matter and anti-matter.

Now this is fantasy which may become a reality. Unknown and undiscovered phenomena can be found more effective, than familiar ones.

Текст 3. Atomic energy

A man that tries to see a single atom is like a man trying to see a single drop of water in the sea. He will see the sea made of great many drops of water but he will not be able to see a single drop. Man has, however, learned the secret of the atom. He has learned to split atoms in order to get great quantity of energy. At present, coal is one of the most important fuels and our basic source of energy. It is quite possible that some day coal and other fuel may be replaced by atomic energy.

The nuclear reactor is one of the most reliable "furnaces" that produce atomic energy. When reactor produces energy it produces energy in the form of heat. In other words, when atoms split in the reactor heat is developed. Gas, water, melted metals and some other liquids circulate through the reactor to carry that heat away. The heat may be carried to pipes of the steam generator that contains water. The steam drives a turbine; the turbine in its turn drives an electric generator. So we see that a nuclear power-station is like any other power-station but the familiar coal-burning furnace is replaced by a nuclear one.

Текст 4. Nuclear power stations

The first industrial nuclear power station in the world was constructed in Obninsk not far from Moscow in 1954. The station was put into operation two years earlier than the British one and three and a half years earlier that the American nuclear power-stations.

A number of nuclear power-stations have been put into operation since 1954. The Beloyarskaya nuclear power station named after academician Kurchatov may serve an example of the peaceful use of atomic energy. The scientists and engineers achieved a nuclear superheating of steam directly in the reactor itself before steam is carried into the turbine. It is certainly an important contribution to nuclear engineering achieved for the first time in the world.

We might mention here another important achievement that is the first nuclear installation where thermal energy generated in the reactor is transformed directly into electrical energy. Speaking of the peaceful use of atomic energy it is also necessary to mention our nuclear ice-breakers. “Lenin” is the world’s first ice-breaker with nuclear installation. Its machine installation is of a steam turbine type and steam is produced by three reactors and six steam generators.

Текст 5. A steam engine

A steam engine is a device that converts the potential energy that exists as pressure in steam, and converts that to mechanical force. Early examples were the steam locomotive trains, and steamships that relied on these steam engines for movement. The Industrial Revolution came about primarily because of the steam engine. The thirty seconds or so required to develop pressure made steam less favored for automobiles, which are generally powered by internal combustion engines.

The first steam device was invented by Hero of Alexandria, a Greek, before 300 BC, but never utilized as anything other than a toy. While designs had been created by varous people in the meanwhile, the first practical steam engine was patented by James Watt, a Scottish inventor, in 1769. Steam engines are of various types but most are reciprocal piston or turbine devices.

The strength of the steam engine for modern purposes is in its ability to convert raw heat into mechanical work. Unlike the internal combustion engine, the steam engine is not particular about the source of heat. Since the oxygen for combustion is unmetered, steam engines burn fuel cleanly and efficiently, with relatively little pollution.

One source of inefficiency is that the condenser causes losses by being somewhat hotter than the outside world. Thus any closed-cycle engine will always be somewhat less efficient than any open-cycle engine, because of condenser losses.

Most notably, without the use of a steam engine nuclear energy could not be harnessed for useful work, as a nuclear reactor does not directly generate either mechanical work or electrical energy – the reactor itself does nothing but sit there and get hot. It is the steam engine which converts that heat into useful work.

Текст 6. First inventors

Thomas Newcomen (1663 – 1729) was an ironmonger by profession, but made a significant contribution to the Industrial Revolution with his invention of the atmospheric steam engine.

Thomas Newcomen was born in Dartmouth, Devon in 1663 and established himself as an ironmonger in his home town. Some of his biggest customers were Cornish tin mine owners, who faced considerable difficulties with flooding as mines became progressively deeper. The standard methods to remove the water – manual pumping or teams of horses hauling buckets on a rope – were slow and expensive, and they sought an alternative.

Contemporary engines worked by using condensed steam to make a vacuum, but whereas Thomas Savery's pump of 1698 had just used the vacuum to pull the water up, Newcomen created his vacuum inside a cylinder and used it to pull down a piston. He then used a lever to transfer the force to the pump shaft that went down the mine: it was the first practical engine to use a piston in a cylinder. Casting the cylinders and getting the pistons to fit was pushing the limit of existing technology, so Newcomen deliberately made the piston marginally smaller than the cylinder and sealed the gap with a ring of wet leather or rope. However, to avoid infringing Savery's patent Newcomen was forced to go into partnership with him.

Thomas Newcomen invented his steam engine in 1705 to pump water from English coal mines. This machine was developed by 1720 and remained in use for 50 years.

His first working engine was installed at a coalmine at Dudley Castle in Staffordshire in 1712. It had a cylinder 21 inches in diameter and nearly eight feet long, and it worked at twelve strokes a minute, raising ten gallons of water from a depth of 156 feet; approximately 5.5 horse power. The engines were rugged and reliable and worked day and night, but were extremely inefficient.

Newcomen engines were extremely expensive but were nevertheless very successful. By the time Newcomen died on 5 August 1729 there were at least one hundred of his engines in Britain and across Europe.

In Russia there was another inventor: **Ivan Polzunov (1728–1766)**

In 1763 a self-taught man (самоучка), the son of a Russian soldier Ivan Polzunov (1728–1766) worked out the project of the first universal steam engine. The construction of the engine involved great difficulties due to lack (из-за недостатка) of necessary instruments, qualified assistants and in general lack of help and support. Polzunov had to do everything with his own hands. Polzunov's engine had been working from August to November 10, 1766, when it was stopped and put out of operation because of a leak in the boilers. But Polzunov did not live to see the results of his work. He died in poverty on May 27, 1766.

Later, in the course of the industrial revolution in England, a number of inventors designed steam engines because the demand for these machines was urgent. A prominent place among these early inventors belongs to James Watt, an instrument maker at the University of Glasgow who perfected Newcomen's engine.

Текст 7. James Watt (1736–1819)

James Watt was born in Greenock on 18 January 1736. His father was a prosperous shipwright. Watt initially worked as a maker of mathematical instruments but soon began to become interested in steam engines. The first working steam engine had been patented in 1698 and by the time of Watt's birth, Newcomen engines were pumping water from mines all over the country.

James Watt worked as an instrument maker at the University of Glasgow. In around 1764 he was given a model Newcomen engine to repair. While repairing the model, Watt noticed the large waste of energy due to alternately heating the steam cylinder with steam and cooling it with injection water. He realized that this loss could be reduced by keeping the cylinder as hot as possible with insulation. He understood that it was possible to use a separate condenser or water-cooled chamber which could be connected to the steam cylinder at the necessary time by a valve.

Later he closed the top of the steam cylinder with a cover or cylinder head, introduced steam alternately on both sides of the piston and thus made the engine double acting. He invented a governer to regulate the speed of the engine, a slide valve to control the admission, expansion and exhaust of the steam, a pump to remove the air and condensate from the condenser, and, in fact, brought the steam engine to a fairly high state of development. His first patent in 1769 covered this device and other improvements on Newcomen's engine.

Watt's partner and backer was the inventor John Roebuck. In 1775, Roebuck's interest was taken over by Matthew Boulton who owned an engineering works in Birmingham. Together he and Watt began to manufacture steam engines. Boulton & Watt became the most important engineering firm in the country, meeting considerable demand. Initially this came from Cornish mine owners, but extended to paper, flour, cotton and iron mills, as well as distilleries, canals and waterworks. In 1785, Watt and Boulton were elected fellows of the Royal Society.

By 1790 Watt was a wealthy man and in 1800 he retired and devoted himself entirely to research work. He patented several other important inventions including the rotary engine, the double-action engine and the steam indicator, which records the steam pressure inside the engine.

Watt died on 19 August 1819. A unit of measurement of electrical and mechanical power – the watt – is named in his honour.

Текст 8. George and Robert Stephensons

George Stephenson and his son Robert Stephenson were pioneering railway engineers and inventors of the 'Rocket', the most famous early railway locomotive.

George Stephenson was born on 9 June 1781 near Newcastle-upon-Tyne. His father was an engineman at a coalmine. Stephenson himself worked at the mine and learned to read and write in his spare time. He gained a reputation for managing the primitive steam engines employed in mines, and worked in a number of different coalmines in the northeast of England and in Scotland.

In 1814, Stephenson constructed his first locomotive, 'Blucher', for hauling coal at Killingworth Colliery near Newcastle. In 1815, he invented a safety lamp for use in coalmines, nicknamed the 'Geordie'.

In 1821, Stephenson was appointed engineer for the construction of the Stockton and Darlington railway. It opened in 1825 and was the first public railway.

"Robert Stephenson and Company" was a locomotive manufacturing company founded in 1823 in Forth Street, Newcastle-upon-Tyne in England by George Stephenson and his son Robert. It was the first company set up specifically to build railway engines.

In 1826 George Stephenson was made engineer for the Liverpool to Manchester Railway. In October 1829, the railway's owners staged a competition at Rainhill to find the best kind of locomotive to pull heavy loads over long distances. Thousands came to watch. Stephenson's locomotive 'Rocket' was the winner, achieving a record speed of 36 miles per hour. It was built at the Forth Street Works of "Robert Stephenson and Company" in Newcastle-upon-Tyne. It is the most famous example of an evolving design of locomotives by Robert Stephenson that became the template for most steam engines in the following 150 years. The locomotive was preserved and is now on display in the Science Museum in London. Though the 'Rocket' was not the first steam locomotive, it was the first to bring together several innovations to produce the most advanced locomotive of its day. This locomotive engine had two notable improvements – a multi-tube boiler and a separate firebox.

The opening of the Stockton to Darlington railway and the success of 'Rocket' stimulated the laying of railway lines and the construction of locomotives all over the country. George Stephenson became engineer on a number of these projects and was also consulted on the development of railways in Belgium and Spain.

George Stephenson died on 12 August 1848 in Chesterfield in Derbyshire. His son Robert worked with his father on many of his projects.

Текст 9. The steam generating unit

The steam generating unit consists of a furnace, a boiler, superheater, economizer and an air heater. The fuel is burned in a furnace. The boiler is composed of a drum. The water level in the drum is mentioned at about mid-point, which permits separation of the steam from the water. There is a bank of inclined tubes which are connected to the drum and permit water to circulate from the drum through the tubes and back to the drum. The hot products of combustion from the furnace flow across the boiler tubes and evaporate part of the water in the tubes. The furnace walls are composed of tubes which are also connected to the boiler drum and form very effective steam generating surface.

The steam which is separated from the water in the boiler drum then flows through a superheater. The superheater is a coil of tubes surrounded by the hot products of combustion. The temperature of the steam is increased in the superheater and the superheated steam flows through a piping to the turbine.

Текст 10. The steam power plant

The function of a steam power plant is to convert the energy in nuclear reactions or in coal, oil or gas into mechanical or electric energy through the expansion of steam from a high pressure to a low pressure in a suitable prime mover such as a turbine or engine. A noncondensing plant discharges the steam from the prime mover at an exhaust pressure equal or greater than atmospheric pressure. A condensing plant exhausts the steam from the prime mover into a condenser at a pressure less than atmospheric pressure. The general central station plants are condensing plants because their sole output is electric energy. Industrial plants are frequently noncondensing plants because large quantities of low-pressure steam are required for manufacturing operations.

The steam-generating unit consists of a furnace in which the fuel is burned, a boiler, superheater and economizer, in which high pressure steam is generated, and an air heater in which the loss of energy due to combustion of the fuel is reduced to a minimum.

The boiler is composed of a drum, in which a water level is maintained at about the mid-point so as to permit separation of the steam from the water, and bank of inclined tubes, connected to the drum in such a manner as to permit water to circulate from the drum through the tubes and back to the drum The hot products of combustion from the furnace flow across the boiler tubes and evaporate part of the water in the tubes. The furnace walls are composed of tubes which are also connected to the boiler drum to form very effective steam-generating surfaces. The steam which is separated from the water in the boiler drum then flows through a superheater which is in effect a coil of tubing surrounded by the hot products of combustion. The temperature of the steam is increased in the superheater to perhaps 800° to 1100° F, at which temperature the high-pressure superheated steam flows through suitable piping to the turbine.

Since the gaseous products of combustion leaving the boiler tube bank are at a relatively high temperature and their discharge to the chimney would result in a large loss in energy, an economizer may be used to recover part of the energy in these gases. The economizer is a bank of tubes through which the boiler feedwater is pumped on its way to the boiler drum.

A reduction in gas temperature may be made by passing the products of combustion through an air heater which is a heat exchanger cooled by the air required for combustion. This air is supplied to the air heater at normal room temperature and may leave the air heater at 400° to 600° F, thus returning to the furnace energy that would otherwise be wasted up the chimney. The products of combustion are usually cooled in an air heater to an exit temperature of 275° to 400° F, after which they may be passed through a dust collector which will remove objectionable dust and thence through an induced-draft fan to the chimney. The function of the induced-draft fan is to pull the gases through the heat transfer surfaces of the boiler, superheater, economizer and air heater and to maintain a pressure in the furnace that is slightly less than atmospheric pressure. A forced-draft fan forces the combustion air to flow through the air heater, duct work, and burner into the furnace.

Coal is delivered to the plant in railroad cars or barges which are unloaded by machinery. The coal may be placed in storage or may be crushed and elevated to the overhead raw-coal bunker in the boiler room.

The coal flows by gravity from the overhead bunker to the pulverizer or mill through a feeder which automatically maintains the correct amount of coal in the mill. In the mill the coal is ground to a fine dust. Some of the hot air from the air heater is forced through the mill to dry the coal and to pick up the finely pulverized particles and carry them in suspension to the burner where they are mixed with the air required for their combustion and discharged into the furnace at high velocity to promote good combustion.

The high-pressure, high-temperature steam is expanded in a steam turbine which is generally connected to an electric generator. From 3 to 5 per cent of the output of the generator is needed to light the plant and to operate the many motors required for fans, pumps, etc., in the plant. The rest of the generator output is available for distribution outside the plant.

The condensed steam, which is normally at a temperature of 70° to 100° F, is pumped out of the condenser by means of a hot-well pump and is discharged through several feed-water heaters to a boiler feed pump that delivers the water to the economizer.

Most steam power plants of large size are now being built for operation at steam pressures of 1500 to 2400 psi, and in some plants pressures up to 5000 psi are being used. Steam temperatures of 1000° to 1100° F are in general use. Turbine-generator capacities of 250,000 kw (1 kilowatt = 1.34 horsepower) are common, and units of 500,000 kw are in operation. Steam-generating units capable of delivering 3,000,000 lb of steam per hr are now in operation. Overall efficiency of the plant from raw coal supplied to electric energy delivered to the transmission line depends upon size, steam pressure, temperature, and other factors, and 40 per cent is now being realized on the basis of a full year of operation.

III. ТЕКСТЫ ДЛЯ ЧТЕНИЯ И ПЕРЕВОДА

Текст 1. Basics of boilers and boiler processes

In a traditional context, a boiler is an enclosed container that provides a means for heat from combustion to be transferred into the working media (usually water) until it becomes heated or a gas (steam). One could simply say that a boiler is as a heat exchanger between fire and water. The boiler is the part of a steam power plant process that produces the steam and thus provides the heat. The steam or hot water under pressure can then be used for transferring the heat to a process that consumes the heat in the steam and turns it into work. A steam boiler fulfils the following statements:

1. It is part of a type of heat engine or process
2. Heat is generated through combustion (burning)
3. It has a working fluid, a.k.a. heat carrier that transfers the generated heat away from the boiler
4. The heating media and working fluid are separated by walls

In an industrial/technical context, the concept “steam boiler” (also referred to as “steam generator”) includes the whole complex system for producing steam for use e.g. in a turbine or in industrial process. It includes all the different phases of heat transfer from flames to water/steam mixture (economizer, boiler, superheater, reheater and air preheater). It also includes different auxiliary systems (e.g. fuel feeding, water treatment, flue gas channels including stack).

The heat is generated in the furnace part of the boiler, where fuel is combusted. The fuel used in a boiler contains either chemically bonded energy (like coal, waste and biofuels) or nuclear energy. Nuclear energy will not be covered in this material. A boiler must be designed to absorb the maximum amount of heat released in the process of combustion. This heat is transferred to the boiler water through radiation, conduction and convection. The relative percentage of each is dependent upon the type of boiler, the designed heat transfer surface and the fuels that power the combustion.

Текст 2. A simple boiler

In order to describe the principles of a steam boiler, consider a very simple case, where the boiler simply is a container, partially filled with water. Combustion of fuel produce heat, which is transferred to the container and makes the water evaporate. The vapor or steam can escape through a pipe that is connected to the container and be transported elsewhere. Another pipe brings water (called “feedwater”) to the container to replace the water that has evaporated and escaped.

Since the pressure level in the boiler should be kept constant (in order to have stable process values), the mass of the steam that escapes has to be equal to the mass of the water that is added. If steam leaves the boiler faster than water is added, the pressure in the boiler falls. If water is added faster than it is evaporated, the pressure rises. If more fuel is combusted, more heat generated and transferred to the water. Thus, more steam is generated and pressure rises inside the boiler. If less fuel is combusted, less steam is generated and the pressure sinks.

Текст 3. A simple power plant cycle

The steam boiler provides steam to a heat consumer, usually to power an engine. In a steam power plant a steam turbine is used for extracting the heat from the steam and turning it into work. The turbine usually drives a generator that turns the work from the turbine into electricity. The steam, used by the turbine, can be recycled by cooling it until it condensates into water and then return it as feedwater to the boiler. The condenser, where the steam is condensed, is a heat exchanger that typically uses water from a nearby sea or a river to cool the steam. In a typical power plant the pressure, at which the steam is produced, is high. But when the steam has been used to drive the turbine, the pressure has dropped drastically. A pump is therefore needed to get the pressure back up. Since the work needed to compress a fluid is about a hundred times less than the work needed to compress a gas, the pump is located after the condenser. The cycle that the described process forms, is called a Rankine cycle and is the basis of most modern steam power processes.

Текст 4. Carnot efficiency

When considering any heat process or power cycle it is necessary to review the Carnot efficiency that comes from the second law of thermodynamics. The Carnot efficiency equation gives the maximum thermal efficiency of a system undergoing a reversible power cycle while operating between two thermal reservoirs at different temperatures.

The maximum efficiency as a function of the steam exhaust temperature can be plotted by keeping the cooling water temperature constant. Assuming the temperature of the cooling water is around 20 ºC (a warm summer day), larger temperature difference leads to a higher thermal efficiency.

Although no practical heat process is fully reversible, many processes can be calculated precisely enough by approximating them as reversible processes.

To give a practical example of the use of this theory on steam boilers, consider the Rankine cycle. The temperature of the hot reservoir would then be the temperature of the steam produced in the boiler and the temperature of the cold reservoir would be the temperature of the cooling water drawn from a nearby river or lake.

Текст 5. Properties of water and steam

Water is a useful and cheap medium to use as a working fluid. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. The force produced by this expansion is the source of power in all steam engines. It also makes the boiler a dangerous device that must be carefully treated.

The theoretical amount of heat that can be transferred from the combustion process to the working fluid in a boiler is equivalent to the change in its total heat content from its state at entering to that at exiting the boiler. In order to be able to select and design steam-and-power-generation equipment, it is necessary to thoroughly understand the properties of the working fluid, steam, the use of steam tables and the use of superheat. These fundamentals of steam generator will be briefly reviewed in this chapter. When phase changes of the water is discussed, only liquid-vapor and vapor-liquid phase changes are mentioned, since these are the phase changes the entire boiler technology is used.

Текст 6. Boiling of water

Water and steam are typically used as heat carriers in heating systems. Steam, the gas phase, water, results from adding sufficient heat to water to cause it to evaporate. This boiler process consists of three main steps: the first step is the adding of heat to the water that raises temperature up to the boiling point of water, also called preheating. The second step is continuing addition of heat to change the phase from water to steam, the actual evaporation, the third step is the heating of steam beyond the boiling temperature of water, known as superheating. The first step and the third steps are the part where heat addition causes a temperature rise but no phase change. When all the water has been evaporated, the steam is called dry saturated steam. If steam is heated beyond its saturation point, the temperature begins to rise again and the steam becomes superheated steam. Superheated steam is defined by its zero moisture content: it contains no water at all, only 100 % steam.

Evaporation

During the evaporation the enthalpy rises drastically. If water is evaporated at atmospheric pressure from saturated liquid to saturated vapor, the enthalpy rise needed is 2260 kJ/kg, from 430 kJ/kg (saturated water) to 2690 kJ/kg (saturated steam). When the water has reached the dry saturated steam condition, the steam contains a large amount of latent heat, corresponding to the heat that was led to the process under constant pressure and temperature. So despite pressure and temperature is the same for the liquid and the vapour, the amount of heat is much higher in vapour compared to the liquid.

Superheating

If the steam is heated beyond the dry saturated steam condition, the temperature begins to rise again and the properties of the steam start to resemble those of a perfect gas. Steam with higher temperature than that of saturated steam is called superheated steam. It contains no moisture and cannot condense until its temperature has been lowered to that of saturated steam at the same pressure. Superheating the steam is particularly useful for eliminating condensation in steam lines, decreasing the moisture in the turbine exhaust and increasing the efficiency (i.e. Carnot efficiency) of the power plant.

Effect of pressure on evaporation temperature

It is well known that water boils and evaporates at 100˚C under atmospheric pressure. By higher pressure, water evaporates at higher temperature – e.g. a pressure of 10 bar equals an evaporation temperature of 184ºC. The pressure and the corresponding temperature when a phase change occurs are called the saturation temperature and saturation pressure. During the evaporation process pressure and temperature are constant, but if the vaporization occurs in a closed vessel, the expansion that occurs due to the phase change of water into steam causes the pressure to rise and thus the boiling temperature rises.

When 22.12 Mpa is exceeded (the corresponding temperature is 374ºC), the line stops. The reason is that the border between gas phase and liquid phase is blurred out at that pressure. The point, where the different phases cease to exist, is called the critical point of water.

Текст 7. Basics of combustion

Combustion can be defined as the complete, rapid exothermic oxidation of a fuel with sufficient amount of oxygen or air with the objective of producing heat, steam and/or electricity. The process of combustion occurs with a high speed and at a high temperature. Essentially, it is a controlled explosion. Combustion occurs when the elements in a fuel combine with oxygen and produce heat. All fuels, whether they are solid, liquid or in gaseous form, consist primarily of compounds of carbon and hydrogen called hydrocarbons (natural gas, coal fuel oil, wood, etc.), which are converted in the combustion process to carbon dioxide (CO_2) and steam. Sulphur, nitrogen, and various other components are also present in these fuels.

Products of combustion

When the hydrogen and oxygen combine, intense heat and water vapor is formed. When carbon and oxygen combine, intense heat and the compounds of carbon monoxide or carbon dioxide are mixed. These chemical reactions take place in a furnace during the burning of fuel, provided there is sufficient air (oxygen) to completely burn the fuel. Very little of the released carbon is actually “consumed” in the combustion reaction because flame temperature seldom reaches the vaporization point of carbon. Most of it combines with oxygen to form CO_2 and passes out the vent. The final gaseous product of combustion is called a flue gas. As mentioned in the introduction to this segment. Combustion can never be 100% efficient. All fuels contain moisture. Other fuel components may form by-products, such as ash, and gaseous pollutants that need emission control equipment.

Types of combustion

There are three types of combustion:

Perfect combustion is achieved when all the fuel is burned using only the theoretical amount of air, but as stated earlier, perfect combustion cannot be achieved in a boiler.

Complete combustion is achieved when all the fuel is burned using the minimal amount of air above the theoretical amount of air needed to burn the fuel. Solid fuels, such as coal, peat or biomass are typically fired at air factors 1.1 – 1.5, i.e. 110 – 150% of the oxygen needed for perfect combustion.

Incomplete Combustion occurs when part of the fuel is not burned, which results in the formation of soot and smoke.

Combustion of solid fuels

Solid fuels can be divided into high grade: coal and low grade: peat and bark. The most typical firing methods are grate firing, cyclone firing, pulverized firing and fluidized bed firing. Pulverized firing has been used in industrial and utility boilers from 60 MWt to 6000 MWt. Grate firing has been used to fire biofuels from 5 MWt to 600 MWt and cyclone firing has been used in small scale 3–6 MWt.

Combustion of coal

Oil and gas are always combusted with a burner, but there are three different ways to combust coal:

1. Fixed bed combustion (grate boilers)
2. Fluidized bed combustion

3. Entrained bed combustion (pulverized coal combustion)

In fixed bed combustion, larger-sized coal is combusted in the bottom part of the combustor with low-velocity air. Stoker boilers also employ this type of combustion. Large-capacity pulverized coal fired boilers for power plants usually employ entrained bed combustion. In fluidized bed combustion, fuel is introduced into the fluidized bed and combusted.

Текст 8. Main types of a modern boiler

In a modern boiler, there are two main types of boilers when considering the heat transfer means from flue gases to feed water: fire tube boilers and water tube boilers.

In a fire tube boiler the flue gases from the furnace are conducted to flue passages, which consist of several parallel-connected tubes. The tubes run through the boiler vessel, which contains the feedwater. The tubes are thus surrounded by water. The heat from the flue gases is transferred from the tubes to the water in the container, thus the water is heated into steam. An easy way to remember the principle is to say that a fire tube boiler has “fire in the tubes”.

In a water tube boiler, the conditions are the opposite of a fire tube boiler. The water circulates in many parallel-connected tubes. The tubes are situated in the flue gas channel, and are heated by the flue gases, which are led from the furnace through the flue gas passage. In a modern boiler, the tubes, where water circulates, are welded together and form the furnace walls. Therefore the water tubes are directly exposed to radiation and gases from the combustion. Similarly to the fire tube boiler, the water tube boiler received its name from having “water in the tubes”.

A modern utility boiler is usually a water tube boiler, because a fire tube boiler is limited in capacity and only feasible in small systems. The various designs of water tube boilers are discussed further in “Steam/water circulation design”.

Текст 9. Steam boilers: Grate furnace boilers

Steam boilers can be classified by their *combustion method*, by their *application* or by their *type of steam/water circulation.* In this chapter the following boiler types will be presented and briefly described, to give the reader a perspective of the various types and uses of various steam boilers:

1. Grate furnace boilers
2. Cyclone boilers
3. Pulverized coal fired (PCF) boilers
4. Oil and gas fired boilers
5. Heat recovery steam generators (HRSG)
6. Refuse boilers
7. Recovery boilers
8. Packaged boilers

Grate furnace boilers

Grate firing has been the most commonly used firing method for combusting solid fuels in small and medium sized furnaces (15 kW–30 MW) since the beginning of the industrialization. New furnace technology (especially fluidized bed technology) has practically superseded the use of grate furnaces in unit sizes over 5 MW. Waste is usually burned in grate furnaces. There is also still a lot of grate furnace boilers burning boifuels in operation. Since solid fuels are very different there are also many types of grate furnaces. The principle of great firing is still very similar for all grate furnaces (except for household furnaces). Combustion of solid fuels in a grate furnace follows the same phases as any combustion method:

1. Removal of moisture
2. Pyrolysis (thermal decomposition) and combustion of volatile matter
3. Combustion of char

When considering a single fuel particle, these phases occur in sequence. When considering a furnace we have naturally particles in different phases at the same time in different parts of the furnace.

The grate furnace is made up a grate that can be horizontal, sloping or conical. The grate can consist of a conveyor chain that transports the fuel forward. Alternatively some parts of the grate can be mechanically movable or the whole grate can be fixed. In the later case the fuel is transported by its own weight (sloping grate). The fuel is supplied in the furnace from the hopper and moved forward (horizontal grate) or downward (sloping grate) sequentially within the furnace.

The primary combustion air is supplied from underneath the fire bed, by which the air makes efficient contact with the fuel, when blowing through the bed, to dry, ignite and burn it. The secondary (and sometimes tertiary) combustion air is supplied above the bed, in order to burn combustible gases that have been released from the bed. The fuel is subjected to self-sustained burning in the furnace and is discharged as ash. The ash has a relatively high content of combustible matter.

Текст 10. Cyclone firing

The cyclone furnace chambers are mounted outside the main boiler shell, which will have a narrow base, together with an arrangement for slag removal. Primary combustion air carries the particles into the furnace in which the relatively large coal/char particles are retained in the cyclone while the air passes through them, promoting reaction. Secondary air is injected tangentially into the cyclone. This creates a strong swirl, throwing the larger particles towards the furnace walls. Tertiary air enters the centre of the burner, along the cyclone axis, and directly into the central vortex. It is used to control the vortex vacuum, and hence the position of the main combustion zone which is the primary source of radiant heat. An increase in tertiary air moves that zone towards the furnace exit and the main boiler.

Cyclone-fired boilers are used for coals with a low ash fusion temperature, which are difficult to use with a PCF boiler. 80–90% of the ash leaves the bottom of the boiler as a molten slag, thus reducing the load of fly ash passing through the heat transfer sections to the precipitator or fabric filter to just 10–20% of that present. As with PCF boilers, the combustion chamber is close to atmospheric pressure, simplifying the passage of coal and air through the plant.

Cyclone firing can be divided into horizontal and vertical arrangements based on the axis of the cylinder. Cyclone firing can also be dry or molten based on ash behavior in the cyclone. Based on cooling media the cyclones are either water-cooled or air-cooled (a.k.a. air cooled). Cyclone firing has successfully been used to fire brown coal in Germany. Peat has been fired in cyclones at Russia and Finland.

Compared with the flame of a conventional burner, the high intensity, high-velocity cyclonic flames transfer heat more effectively to the boiler's water-filled tubes, resulting in the unusual combination of a compact boiler size and high efficiency. The worst drawbacks of cyclone firing are a narrow operating range and problems with the removal of ash. The combustion temperature in a cyclone is relatively high compared to other firing methods, which results in a high rate of thermal NO_x formation.

Текст 11. Pulverized coal fired (PCF) boilers

Coal-fired water tube boiler systems generate approximately 38% of the electric power generation worldwide and will continue to be major contributors in the future. Pulverized coal fired boilers, which are the most popular utility boilers today, have a high efficiency but a costly SO_x and NO_x control. Almost any kind of coal can be reduced to powder and burned like a gas in a PCF-boiler, using burners. The PCF technology has enabled the increase of boiler unit size from 100 MW in the 1950's to far over 1000 MW. New pulverized coal-fired systems routinely installed today generate power at net thermal cycle efficiencies ranging from 40 to 47% lower heating value, LHV, (corresponding to 34 to 37% higher heating value, HHV) while removing up to 97% of the combined, uncontrolled air pollution emissions (SO_x and NO_x).

Fuel characteristics of coal

Coal is a heterogeneous substance in terms of its organic and inorganic content. Since only organic particles can be combusted, the inorganic particles remain as ash and slag and increase the need for particle filters of the flue gas and the tear and wear of furnace tubes. Pulverizing coal before feeding it to the furnace has the benefit that the inorganic particles can be separated from the organic before the furnace. In order to be able to remove ash the furnace easier, the bottom of the furnace is shaped like a “V”.

Burners and layout

Another benefit from pulverizing coal before combustion is that the coal air mixture can be fed to the boiler through jet burners, as in oil and gas boilers. A finer particle is faster combusted and thus the combustion is more complete the finer the coal is pulverized and formation of soot and carbon monoxides in the flue gas is also reduced. The size of a coal grain after the coal grinder is less than 150 mm.

Two broadly different boiler layouts are used. One is the traditional two-pass layout where there is a furnace chamber, topped by some heat transfer tubing to reduce the FEGT. The flue gases then turn through 180º, and pass downwards through the main heat transfer and economizer sections. The other design is to use a tower boiler, where virtually all the heat transfer sections are mounted vertically above each other, over the combustion chamber.

Текст 12. Oil and gas fired boilers

Oil and natural gas have some common properties: both contain practically no moisture or ash and both produce the same amount of flue gas when combusted. They also burn in a gaseous condition with almost a homogeneous flame and can therefore be burnt in similar burners with very little air surplus. Thus, oil and gas can be combusted in the same types of boilers. The radiation differences in the flue gases of oil and gas are too high in order to use both fuels in the same boiler. Combusting oil and gas with the same burner can cause flue gas temperature differences up to 100^{o} C.

The construction of an oil and gas boiler is similar to a PCF-boiler, with the exception of the bottom of the furnace, which can be horizontal thanks to the low ash content of oil and gas. Horizontal wall firing (all burners attached to the front wall) is the most affordable alternative for oil and gas burners.

Текст 13. Fluidized bed boilers

Fluidized bed combustion (сжигание в кипящем слое) was not used for energy production until the 1970's, although it had been used before in many other industrial applications. Fluidized bed combustion has become very common during the last decades. One of the reasons is that a boiler using this type of combustion allows many different types of fuels, also lower quality fuels, to be used in the same boiler with high combustion efficiency. Furthermore, the combustion temperature in a fluidized bed boiler is low, which directly induce lower NO_x emissions. Fluidized bed combustion also allows a cheap SO_x reduction method by allowing injection of lime directly into the furnace.

Principles. The principle of a fluidized bed boiler is based on a layer of sand or a sand-like media, where the fuel is introduced into and combusted. The combustion air blows through the sand layer from an opening in the bottom of the boiler. Depending on the velocity of the combustion air, the layer gets different types fluid-like behaviour. This type of combustion has the following merits:

a) fuel flexibility; even low-grade coal such as sludge or refuse can be burned; b) high combustion efficiency; c) low NO_x emission; d) control of SO_x emission by desulfurization during combustion; this is achieved by employing limestone as a bed material or injecting limestone into the bed; e) wide range of acceptable fuel particle sizes; pulverizing the fuel is unnecessary; f) relatively small installation, because flue gas desulfurization and pulverizing facilities are not required.

Main types: there are two main types of fluidized bed combustion boilers: Bubbling fluidized bed (BFB) and Circulating fluidized bed (CFB) boilers.

In the bubbling type, because the velocity of the air is low, the medium particles are not carried above the bed. The combustion of this type of boiler is generated in the bed.

The CFB mode of fluidization is characterized by a high slip velocity between the gas and solids and by intensive solid mixing. High slip velocity between the gas and solids, encourages high mass transfer rates that enhance the rates of the oxidation (combustion) and desulfurization reactions, critical to the application of CFBs to power generation. The intensive mixing of solids insures adequate mixing of fuel and combustion products with combustion air and flue gas emissions reduction reagents.

In the circulating type, the velocity of air is high, so the medium sized particles are carried out of the combustor. The carried particles are captured by a cyclone installed in the outlet of combustor.

Combustion is generated in the whole combustor with intensive movement of particles. Particles are continuously captured by the cyclone and sent back to the bottom part of the combustor to combust unburned particles. This contributes to full combustion.

The CFB boiler has the following advantages over the BFB Boiler:

- High combustion efficiency;
- Lower consumption of limestone as a bed material;
- Lower NO_x emission;
- Quicker response to load changes

The main advantage of BFB boilers is a much larger flexibility in fuel quality than CFB boilers. BFB boilers have typically a power output lower than 100 MW and CFB boilers range from 100 MW to 500 MW. In recent years, many CFB boilers have been installed because of the need for highly efficient, environmental-friendly facilities.

Текст 14. Heat recovery steam generators (HRSG)

As the name implies, heat recovery steam generators (HRSGs) are boilers where heat, generated in different processes, is recovered and used to generate steam or boil water. The main purpose of these boilers are to cool down flue gases produced by metallurgical or chemical processes, so that the flue gases can be either further processed or released without causing harm. The steam generated is only a useful by-product. Therefore extra burners are seldom used in ordinary HRSGs. HRSGs are usually a link in a long process chain, which puts extremely high demands on the reliability and adaptability of these boilers. Already a small leakage can cause the loss of the production for a week. Problems occurring in these boilers are more diverse and more difficult to control than problems in an ordinary direct heated boiler.

HRSGs in power plants

Gas turbines and diesel engines are nowadays commonly used in generating electricity in power plants. The temperature of the flue gases from gas turbines is usually over 400ºC, which means that a lot of heat is released into the environment and the gas turbine plant works on a low efficiency. The efficiency of the power plant can be improved significantly by connecting a heat recovery boiler (HRSG) to it, which uses the heat in the flue gases to generate steam. This type of combination power generation processes is called a combined cycle.

Since the flue gases of a gas turbine are very clean, tubes can be tightly seated or rib tubes can be used to improve the heat transfer coefficient. These boilers are usually natural circulation boilers. If the life span of the power plant is long enough, the boiler is usually fitted with an economizer. If more electrical power output is wanted, but the temperature of the flue gas is insufficient, the boiler can be equipped with an extra burner (that burns the same fuel as the gas turbine) in order to increase the flue gas temperature and thus generate steam with a higher temperature.

Текст 15. Refuse boilers

The standard refuse (or waste) recovery boiler incinerates solid or liquid waste products. This boiler type is not to be mixed with the recovery boilers used in pulp and paper industry. Therefore, we will always refer to refuse boilers when talking about waste and recovery boilers when we mean the specific chemical recovery process used in the pulp and paper industry.

The combustion of waste differs radically compared to other fuels mostly due to the varying properties of waste. Also, the goal when combusting waste is not to produce energy, but to reduce the volume and weight of the waste and to make it more inert before dumping it on a refuse tip.

Waste is burned in many ways, but the main method is to combust it in a grate boiler with a mechanical grate. Other ways to burn waste is to use a fixed grate furnace, a fluidized bed for sludge or rotary kilns for chemical and problematic waste. Waste is usually “mass burned”, i.e. it is burned in the shape it was delivered with minimal preparation and separation. The main preparation processes are grinding and crushing of the waste and removal of large objects (like refrigerators). Waste has to be thoroughly combusted, so that harmful and toxic components are degraded and dissolved.

Waste can be refined into fuel, by separating as much of the inert and inorganic material as possible. This is called refuse derived fuel (RDF) and can be used as the primary fuel in fluidized bed boilers or burned as a secondary fuel with other fuels. RDF is becoming more common nowadays.

Текст 16. Recovery boilers

All paper is produced from one raw material: pulp. One of the most common methods used to produce pulp is the Kraft process, which consists of two related processes. The first is a pulping process, in which wood is chemically converted to pulp. The second is a chemical recovery process, in which chemicals used in pulping are returned to the pulping process to be used again. The waste liquid, from where chemicals are to be recovered, is called back liquor.

The largest piece of equipment in power and recovery operations is the recovery boiler. It serves two main purposes. The first is to “recover” chemicals in the black liquor through the combustion process (reduction) to be recycled to the pulping process. Secondly, the boiler burns the organic materials in the black liquor and produces process steam and supplies high pressure steam for other process components.

Black liquor is injected into the recovery boiler from a height of six meters. The combustion air is injected at three different zones in the boiler. The burning black liquor forms a pile of smelt at the bottom of the boiler, where complicated reactions take place. The smelt is drained from the boiler and is dissolved to form green liquor. The green liquor is then causticized with lime to form white liquor for cooking the wood chips. The residual lime mud is burnt in a rotary kiln to recover the lime. Energy released by the volatilization of the liquor particles in the recovery boiler yields a heat output that is absorbed by water in the boiler tubes and steam drum. Steam produced by the boiler is utilized primarily to satisfy heating requirements, and to co-generate the electricity needed to operate the various pieces of machinery in the plant.

Текст 17. Bio-energy boilers

Renewable energy production is becoming a worldwide priority as countries strive for sustainable growth and better living conditions. Many countries (e.g. EU) have already set demanding targets to increase electricity production using bio-energy resources and have introduced attractive incentives to accelerate this process. Bio-energy solutions are based on a local fuel supply and thus provide price stability, a secure supply of heat and power, and also local employment. Biofuels are increasingly becoming locally traded commodities, which will further secure fuel price stability and availability. At the same time, green certificates and emission trading offer new opportunities for financing bio-energy projects.

Boilers combusting biofuels can be used to produce only electricity, but they are mostly used in combined heat and power (CHP) plants and district heating plants. These boilers are designed to operate on a wide variety of biofuels, including extremely wet fuels such as wood residues, wood chips, bark and sawdust. Smaller boilers use grate firing technology for biofuel combustion, while larger plants use fluidized bed combustion technology. Smaller grate fired plants for thermal heat production, (<10 MWth), have fire tube boilers, while larger ones are fitted with integrated water/fire tube boilers.

One of the world's largest solid biofuel-fired circulating fluidized bed (CFB) boiler (550 MWth) has been built at Alholmens Kraft power plant at Pietarsaari, Finland. The CFB boiler with auxiliary equipment and the building was delivered by Kvaerner Pulping Oy and commissioned in autumn 2001.

Текст 18. Packaged boilers

Packaged boilers are small self-contained boiler units. Packaged boilers are used as hot water boilers, aiding utility boilers and process steam producers. Packaged boilers can be both water tube and fire tube boilers. Packaged boilers can only be used with oil and gas as fuel without separate preparation devices. A packaged boiler can also be rented if there is a need for a temporary boiler solution.

The benefits of packaged boilers over common utility boilers are:

- Short installation time and low installation costs
- Small space usage
- Lower acquisition cost
- Better quality surveillance in work
- Standardized units

The drawbacks of packaged boilers are:

- Higher power consumption
- Cleaning periods more frequent

IV. ТЕКСТЫ ДЛЯ ЧТЕНИЯ И УСТНОГО ПЕРЕВОДА

Подготовка текстов для устного ответа

Для устного ответа на занятиях переводятся тексты из данного пособия. Переводя тексты, студент должен выписывать в отдельную тетрадь незнакомые слова с транскрипцией и переводом, пользуясь общим англо-русским словарем и терминологическим словарем, прилагаемым в конце данного пособия.

При ответе студент читает и устно переводит отдельные отрывки из всех подготовленных текстов по указанию преподавателя. При чтении и переводе текстов студенты могут изредка пользоваться своей тетрадью, где выписаны слова с транскрипцией и переводом. Использование письменных переводов текстов не допускается.

Текст 1. Pump types

The conditions under which liquids are to be transported vary widely and require a careful analysis before the proper selection of a pump can be made.

The conditions that will influence the selection of the type of pump are: 1) the type of liquid to be handled, that is, its viscosity, cleanliness, temperature and so on, 2) the amount of liquid to be handled, 3) the total pressure against which the liquid is to be moved, 4) the type of power to be used to drive pumps.

Pumps may be divided into four major classifications:

1) Piston pumps or reciprocating pumps driven by engine or electric motors.
2) Centrifugal pumps driven by steam turbines or electric motors.
3) Rotary pumps driven by steam turbines or electric motors.
4) Fluid-impellent (жидкостный) pumps which are not mechanically operated but are fluid-pressure operated.

Centrifugal pumps

The centrifugal pump consists of an impeller or rotating section to produce the flow and a casing to enclose the liquid and to direct it properly as it leaves the impeller at its center and parallel to the shaft. The velocity of the liquid with respect to the impeller is in a direction opposite to the impeller motion. The impeller blades are curved backward to permit the liquid to flow to the rim (край) of the impeller with minimum friction. As the liquid leaves the impeller, it is thrown in a spiral motion forward with a certain velocity.

The water is graded away from the impeller by two basic types of casing: the volute and the turbine or diffuser. Liquid enters the impeller in the center, is thrown to the outside, and leaves the pump through the expanding spiral or volute casing. The casing has the volute shape to permit flow with a minimum of friction and to convert a part of the velocity head into static head. The static head is the head that overcomes resistance to flow.

The turbine or diffuser pump has the same type of impeller as the volute pump. The casing has a circular shape, and within the casing is a diffuser ring on which are placed vanes (лопасть). The vanes direct the flow of liquid and a decrease in the velocity of the liquid occurs because of an increase in the area through which the liquid flows. Thus, part of the velocity head is converted into static head as in the volute pump. For multistage pump the diffuser pump has a more compact casing than the volute pump. Generally, the volute pump will be used for low-head high capacity flow requirement and diffuser pump for high-head requirement.

Both volute and diffuser pumps are classified by the type of impeller, the number of stages and the type of suction used.

When two or more impellers are mounted on the same shaft and act in series, the pump is called a multistage pump, the number of stages corresponding to the number of impellers. Usually each stage produces the same head, and the total head developed is the number of heads produced per stage.

The types of impellers installed in centrifugal pumps are as numerous as the uses to which the pumps are put. Each of the impeller types has a specific purpose.

The axial-flow type is used to pump large quantities of fluid against a relatively small static head. It is not a true centrifugal pump but is designed on the principles of airfoil shapes. The radial pump is used for handling smaller quantities of fluid against a high head, because the centrifugal force is high but the flow path is small and restrictive. The open impeller is designed to handle dirty liquids such as sewage, where the flow path must be less restrictive. The partially radial impeller covers (отвечает) intermediate pumping conditions.

Текст 2. **Fans**

Fans are used extensively in the heating and ventilating industry and in most power plants. Their basic design principles fall into two cases: axial-flow fans and centrifugal or radial fans. Axial flow fans are basically rotating air-foil fan similar to the propeller of an airplane.

The simplest axial flow fan is the small electric fan used for circulating air in rooms against very little resistance. Axial-flow fans for industrial purposes are the two blades or multiblade propeller type, and the multiblade airfoil type. Air enters the fan section from the left and flows over the rotor with a minimum of turbulence owing to the streamline form of the rotor and drive mechanism. The air stream is straightened by guide vane located on the discharge side, thus decreasing the rotational energy of the air by converting it to energy of translation.

The axial-flow fan operates best under conditions where the resistance of the system is low, as in the ventilating field. The axial-flow fan occupies a small space, is light in weight, is easy to install, and handles large volumes of air.

Centrifugal fan may be divided into two major classes: 1) the long-blade or plate type fan and 2) the short-blade multiblade fan. The blades of either type may be pitched towards the direction of motion of the fan, radially, or away from the direction of motion of the fan.

A plate-type radial blade rotor with double inlet is best suited for handling dirty gases since there are no pockets in the blades to catch and collect the dirt. The fan is designed for induced-draft service.

Текст 3. **Blowers**

Blowers may be divided into 2 types: 1) rotary and 2) centrifugal.

A common type of rotary blower is the Roots (рутсевский) two-lobe blower (вентилятор с двумя зубчатыми колесами). Two double lobe impellers mounted on parallel shaft connected by gears rotate in opposite directions and at the same speed. The impellers are machined to afford only a small clearance between them and between the casing and impellers. As the lobes revolve, air is drawn into the space between the impellers and the casing, where it is trapped (задерживается) and discharged in volumes equal to the space between the impellers and casing, and the operation is repeated four times for each rotation of the shaft.

In order to change the volume rate (обменный расход) of flow, the blower speed is changed. The pressure developed by the blower can force the air through the piping system. The volume of air delivered by the blower will not change. Thus the blower is called a positive-displacement blower (вентилятор с положительной подачей).

Care should be taken in operating any positive-displacement blower. A safety valve should be placed on the discharge line to prevent the discharge pressure becoming excessive. This valve will prevent overloading the discharge line and the driving motor. The advantages of the rotary blower are: 1) simple construction, 2) positive air movement, 3) economy of operation and low maintenance.

Centrifugal blowers and compressors operate on the same principle as centrifugal pumps and resemble the closed-impeller centrifugal pumps. The casing or housing is constructed of heavy steel plate, and the impeller is an aluminum-alloy casting. If care is taken in providing the proper drive motor, the overload characteristics of the centrifugal blowers will cause no trouble.

Текст 4. Centrifugal compressors

Multistage centrifugal blowers are generally named compressors. They resemble multistage centrifugal pumps and many of the problems of their designs are similar to those in pumps designs.

The impellers of a complete centrifugal compressor unit are of the single-suction type and passages lead the air or gas from the discharge of one impeller to the suction side of the next impeller.

Because of an increase in temperature of the gas or air as the pressure is increased, cooling is generally necessary. If the pressures are not high, cooling water circulated in labyrinths between impellers may be sufficient. When high pressures are encountered, the gas may be cooled in interstage coolers.

Axial-flow compressors are designed on the principles of the airfoil section (вентиляторы лопастного типа), and the blade shapes will be similar to the axial-flow fan. These compressors are an essential part of the gas-turbine cycle. The advantages of centrifugal and axial-flow blowers and compressors are:1) non pulsating discharge of the gas, 2) no possibility of building up excessive discharge pressures, 3) a minimum of parts subject to mechanical wear, 4) no valve necessary, 5) minimum of vibration and noise, 6) high speed, low cost and small size or high capacity.

Текст № 5. Power plant cycles

A cycle is a series of operations, which regularly repeat themselves for the purpose of converting a portion of the stored energy of a fuel into a work. There are two general types of power cycles: the closed cycle and the open cycle.

In the closed cycle the working fluid begins at some initial condition, undergoes certain changes and returns to the initial condition.

The Rankin cycle

The simplest ideal of theoretical power plant steam cycle is called the Rankin cycle. The system contains: 1) a steam generating unit by which energy is added to the fluid in the form of heat transfer from a burning fuel; 2) a prime mover or steam turbine; 3) a condenser by which energy is rejected to the surroundings by the heat transfer, and 4) a boiler feed water pump.

The following assumptions are made for the Rankin cycle:

1) The wording fluid, usually water, is pumped into the bailer evaporated info steam in the boiler, expanded in the prime mover, condensed in the condenser and returned to the boiler feed pump to be recirculated through the equipment again and again in a closed circuit under steady flow conditions, that is at any given point in the system, the conditions of pressure, temperature, flow rate etc are constant.

2) All the heat is added in the steam-generated unit, all the heat that is rejected is transferred in the condenser. And there is no heat transfer between the working fluid and the surroundings at any place except in the steam-generating unit and the condenser.

3) There is no pressure drop in the piping system, there is a constant high pressure, p1, from the discharge side of the boiler feed pump to the prime mover, and a constant low pressure, p2, from the exhaust flange of the prime mover to the inlet of the boiler feed pump.

4) Expansion in the prime mover and compression in the pump occur without friction or heat transfer.

5) The working fluid leaves the condenser as liquid at the highest possible temperature which is the saturation temperature corresponding to the exhaust pressure, p2.

If the steam-generating unit is a boiler only, the steam that it delivers will be wet, and its quality and enthalpy can be determined by throttling calorimeter. If a super heater is included in the steam-generating unit, the steam that is delivered will be superheated and its enthalpy can be determined from its pressure and temperature by use of the superheated steam table.

The condensate leaving the condenser and entering the boiler feed pump is always saturated water at the condenser pressure, and its enthalpy can be found from the steam tables at the given condenser pressure.

The Rankin-cycle efficiency is the best that is theoretically possible with the equipment. Better theoretical efficiencies are possible by using more equipment in the more complex cycles.

If should be noted that only a small part of the energy supplied in the boiler as heat is converted into work and the rest is lost in the condenser.

The loss resulting from the heat-transferred to the condenser cooling water is, to a large extent, inescapable. The temperature of the cooling water varies only with the atmospheric conditions, thus, it remains almost constant. To lower it by artificial means would require additional energy.

ПРИЛОЖЕНИЯ

1. Тексты для письменного перевода

Текст 1. COMBUSTION

Burning or combustion is a special form of oxidation: oxygen combines rapidly with certain types of fuel, such as coal, oil, gas or wood, and substantial amounts of heat are liberated.

Under some conditions, combustion may be self-starting. For example, coal piled outdoors combines slowly with oxygen in the air giving off heat. If the heat does not dissipate fast enough, temperature rises, and the reaction speeds up until it eventually becomes rapid enough to be called burning.

Such spontaneous combustion is relatively uncommon, except in outdoor coal piles. (It also occurs occasionally in storage bins and bunkers.) Combustion usually begins when heat from an outside source is applied to a fuel. The burning process is initiated by striking the match to generate enough friction heat to set it aflame. The flame's heat is used to light kindling, and the kindling's heat to start the logs. This method of using an easily lighted object to provide heat for ignition of a harder-to-light fuel is common in engineering.

You are well aware that some things burn more readily than others. In general, the degree of flammability depends on how easy it is to burn the particular substance into a gas, because nothing truly burns until it is a gas. This, in turn, depends on the nature and quantity of the substance, compared with the amount of heat available to start combustion. It is easier to start wood-burning than coal, and easier to ignite a twig than a log.

Note that, while combustion is essentially a chemical reaction, most of the practical problems of fuel-burning are mechanical.

Текст 2. BURNING EQUIPMENT

There are two general methods of firing fuel commonly employed: 1) on stationary grates, or 2) on stokers. Also coal may be pulverized to the consistancy of

70 per cent through a 200-mesh screen and burned in suspension. The types of solid fuel encountered in various parts of the world and the general conditions under which they must be burned are so variable that it is impossible to-design one type of grate or stoker that is exactly suited to all fuels. The problem becomes one rather of suiting the equipment to the type of fuel to be handled.

To a certain extent, the design of the furnace must be considered coincidentally with the selection of fuel-burning equipment, so that satisfactory ignition and heat release may be ensured. The choice of equipment for a given set of conditions is limited, and, although any stoker will burn any fuel only one design as a rule will give satisfactory results. Coals may be broadly classified as follows:

Group 1. This group includes the anthracites and semi-anthracites which should be burned without agitation of the fuel bed.

A fuel of this class is satisfactorily burned on travelling grate or chain-grate stokers, on which the coal is fed in a comparatively thin, uniform layer. As combustion progresses, the ash covers the surface of the stoker and acts as a protective blanket, the fuel being supplied with combustion air as it travels toward the ashpit.

Croup 2. This group includes the bituminous coals of the caking type which require agitation of the fuel bed to break up the mass of coke as it forms as well as to resist the tendency of this fuel to fuse into a mat, or cake, that resists the passage of air and retards the process of combustion. Underfeed stokers of the multiple-retort type are designed to burn coals of this class, for the plungers have a characteristic forward and upward motion. By breaking up the surface of the fuel bed, more air passages are created, with a tendency to increase combustion rate. A few coals of this class have a low ash-fusion temperature with a resulting tendency to fuse and jam the operating parts of the stoker. These coals, particularly if high in sulphur, should be avoided as stoker fuels.

Group 3. This group includes midwestern coals and most of the western bituminous coals. These do not tend to soften but form masses of coke, they require no agitation of the fuel bed and are burned to best advantage on chain-grate stokers.

Group 4. This group consists of most of subbituminous coals and lignites which do not fuse when heated and do not require agitation. They have a tendency to disintegrate or slack on the grate as well as drift and sift through if disturbed. They have a tendency to avalanche on inclined grates and are most satisfactorily burned on chain- or traveling-grate stokers.

Текст 3. STOKERS

A stoker should not only be designed from the combustion point of view, but it must be mechanically strong to withstand all working stresses due to high temperature, etc. A simple design will ensure low first cost minimum maintenance and operation for long periods without failure. Some of the factors to be aimed at in stoker design are: maximum rates of burning, highest continuous efficiency and the unlimited choice of fuels.

Any study of the use of stokers must begin with an analysis of the four principal constituents of coal, namely, moisture, volatiles, mixed carbon and ash, or, more generally, water, tar, coke and dirt. These determine the features which should be embodied in the stoker and furnace equipments so that the proper treatment of the coal at the correct time is effected on its passage through the furnace. Whichever of the two types be used the coal has to be taken from the bunkers to the feeding hoppers on the boilers. The coal falls by gravity from the bunkers through a valve into feeding chutes. In some installations automatic weighers are included in the downspouts between the cut-off valves and the boiler feed hoppers. The cut-off valves may be operated from the firing floor by means of chains. The chutes are one ore two types namely, traversing and fixed.

There are usually two or three chutes for large boilers. The travelling chutes travel the full width of the feeding hopper, the motion being affected by means of a continuously rotating screwed shaft which engages with a special nut attached to the chute. The operating shaft has right- and left-hand helical grooves and the nut is designed so that at the end of its travel it reverses automatically.

The chutes are operated from the stoker drive, there being two or four chutes for large boiler units. Coal chutes are of welded mild steel plates, wearing plates also being included.

Текст 4. ECONOMIZERS AND AIR HEATERS

The largest loss that occurs when fuel is burned for steam generation is the so-called "sensible heat" carried away in the hot flue gas. The efficiency of a steam-generating unit provided with good fuel-burning equipment is a function of the flue-gas temperature.

Theoretically, the minimum temperature to which the products of combustion may be cooled is the temperature of the heat-transfer surface with which they are last in contact. In the conventional boiler the theoretical minimum flue-gas temperature would be the saturation temperature of the water in the boiler tubes. The relative amount of boiler heat-transfer surface required to cool the products of combustion from 1500^{o} F to lower temperatures is based on saturated water in the boiler tubes at 1000 psia. It will be noted that, as the temperature difference decreases, each increment of added surface becomes less effective and that the amount of surface required to cool the gases from 700° to 600° F is about 60 per cent of that required to cool the gases from 1500° to 700° F.

In general, it is not economical to install sufficient boiler surface to cool the gases to within less than 150° F of the saturation temperature of the water in the tubes, because sufficient heat cannot be transmitted to the tubes at such low temperature difference to pay for the cost of the boiler surface.

The gases must be cooled from the boiler exit-gas temperature to the flue-gas temperature required for high efficiency by means of heat-exchangers supplied with fluids at temperatures less than the saturation temperature at the boiler pressure. This can be done in an air heater supplied with the air required for combustion at room temperature or in an economizer supplied with boiler feedwater at a temperature considerably below the saturation temperature, or both. In many installations, it is economical to install a small boiler and a large economizer and air heater and to deliver the gases to the economizer at temperatures as high as 900° F rather than to cool the gases to lower temperatures by a larger boiler.

In a typical economizer feedwater is supplied to the inlet header from which it flows through a number of parallel circuits of 2-in. o.d. tubes of considerable length to the discharge header. If the inlet header is at the bottom so that the water rises as it flows from tube to tube, the hot gas normally enters at the top and flows downward. Thus the coldest gas will be in contact with the coldest tubes, and it is possible to cool the gas to within 125° to 150° F of the temperature of the inlet water if sufficient surface is installed.

Since the economizer has water in the tube and a dry gas around the tube, the major resistance to beat transfer is on the gas side. In order to increase the surface exposed to the gas per linear foot of tube and thus increase the effectiveness of the tubular surface, the economizer has fins welded to the top and bottom of each tube. This increases the surface available for heat transfer from the gas without substantially increasing the pressure drop of the gas as it flows across the surface. The gas flows at right angles to the tubes, and the 2-in. finned tubes are staggered to promote effective scrubbing of the outside surface by the gas so as to improve the overall heat-transfer coefficient.

Where scale-free feedwater is available or acid cleaning of heat transfer surfaces is used to remove scale, the flanged return bends may be eliminated. The flow circuits then consist of continuous welded tubing between inlet and outlet headers.

Текст 5. FURNACES

A furnace is a fairly gas-tight and well-insulated space in which gas, oil, pulverized coal, or the combustible gases from solid-fuel beds may be burned with a minimum amount of excess air and with reasonably complete combustion. Near the exit from the furnace at which place most of the fuel has been burned, the furnace gases will consist of inert gases such as CO_2, N_2 and H_2O vapor, together with some O_2, and some combustible gases such as CO, H_2, hydrocarbons, and particles of free carbon (soot). If combustion is to be complete, the combustible gases must be brought into intimate contact with the residual oxygen in a furnace atmosphere composed principally of inert gases. Also, the oxygen must be kept to a minimum if the loss due to heating the excess air from room temperature to chimney-gas temperature is to be low. Consequently, the major function of the furnace is to provide space in which the fuel may be burned with a minimum amount of excess air and with a minimum loss due to the escape of unburned fuel.

The design of a satisfactory furnace is based upon the “three T’s of combustion”: temperature, turbulence, and time.

For each particular fossil fuel, there is a minimum temperature, known as the ignition temperature, below which the combustion of that fuel in the correct amount of air will not take place.

The ignition temperature of a fuel in air as reported by various investigators depends somewhat upon the methods used to determine it and, for some common gases, is as follows:

Hydrogen (H_2)	1075–1095^o F
Carbon monoxide (CO)	1190–1215^o F
Methane (CH_4)	1200–1380^o F
Ethane (C_2H_6)	970–1165^o F

If the combustible gases are cooled below the ignition temperature, they will not burn, regardless of the amount of oxygen present. A furnace must therefore be large enough and be maintained at a high enough temperature to permit the combustible gases to burn before they are cooled below the ignition temperature. In other words, the relatively cool heat-transfer surfaces must be so located that they do not cool the furnace gases below the ignition temperature until after combustion is reasonably complete.

Turbulence is essential if combustion is to be complete in a furnace of economical size. Violent mixing of oxygen with the combustible gases in a furnace increases the rate of combustion, shortens the flame, reduces the required furnace volume, and decreases the chance that combustible gases will escape from the furnace without coming into contact with the oxygen necessary for their combustion. The amount of excess oxygen or air required for combustion is decreased by effective mixing. Turbulence is obtained, in the case of oil, gas, and powdered coal, by using burners which introduce the fuel-air mixture into the furnace with a violent whirling action. High-velocity steam or air jets and mixing arches may be used to increase the turbulence in furnaces fired with coal on stokers.

Since combustion is not instantaneous, time must be provided for the oxygen to find and react with the combustible gases in the furnace. In burning fuels such as gas, oil, or pulverized coal, the incoming fuel-air mixture must be heated above the ignition temperature by radiation from the flame or hot walls of the furnace. Since gaseous fuels are composed of molecules, they burn very rapidly when thoroughly mixed with oxygen at a temperature above the ignition temperature. However, the individual particles of pulverized coal or atomized oil are very large in comparison with the size of molecules, and many molecules of oxygen are necessary to burn one particle of coal or droplet of oil. Time is required for the oxygen molecules to diffuse through the blanket of inert products of combustion which surround a partially burned particle of fuel and to react with the unburned fuel. Consequently, oil and pulverized coal burn with a longer flame than gaseous fuels.

The required furnace volume is dependent, therefore upon the kind of fuel burned, the method of burning the fuel, the quantity of excess air in the furnace, and the effectiveness of furnace turbulence. The shape of the furnace depends upon the kind of fuel burned, the equipment employed to burn the fuel, and the type of boiler used to absorb the energy if the fuel is burned for steam generation.

Industrial furnaces in which the objective is to create and maintain a region at a high temperature and the furnaces of small steam boilers are constructed of fire brick, a brick that has been developed to withstand high temperatures without softening, to resist the erosive effects of furnace atmospheres and particles of ash, and to resist spalling when subjected to fluctuating temperatures. Low vertical walls may be constructed of fire brick in the conventional manner. High walls which are subject to considerable expansion may be tied to and sectionally supported by an external steel frame.

When a boiler furnace is operated at high capacity, the temperature may be high enough to melt or fuse the ash which is carried in suspension by the furnace gases. Molten ash will chemically attack and erode the fire brick with which it comes into contact. Also, if the ash particles are not cooled below the temperature at which they are plastic or sticky before they are carried into the convection tube banks of the boiler, they will adhere to these surfaces, obstruct the gas passages, and force a shutdown of the unit. Moreover, the function of a boiler is to generate steam, and the most effective heat-transfer surface is that which can "see" the high-temperature flame and absorb radiant energy. The rate of heat absorption expressed in Btu per hour per square foot of projected wall area may be from 1000 to 10,000 times as great as the heat-transfer rate in the boiler surface with which the products of combustion are in contact last before being discharged up the chimney. Consequently, the walls of furnaces for large steam boilers are constructed of boiler tubes.

Текст 6. THE INTERNAL-COMBUSTION-ENGINE POWER PLANT

The internal-combustion-engine power plant may include essential auxiliaries. The fuel is burned directly in the cylinder of the engine or prime mover, and the high pressure thus generated drives the piston downward and rotates a crankshaft.

Air is supplied to the engine silencer and cleaner, the function of which is to reduce noise and remove dust which would accelerate cylinder and piston wear if allowed to enter the cylinder.

A supercharger is installed in the air-intake system. The function of the supercharger is to increase the amount of air supplied to the cylinder by acting as an air pump. This in turn permits burning more fuel and obtaining more power from a given size of cylinder. An intake manifold is used to distribute the air equally from the supercharger to the various cylinders of multicylinder engine.

The exhaust system consists of an exhaust manifold for collecting the discharge gases from each of the cylinders into a common exhaust line, an exhaust silencer or muffler for reducing noise, and the exhaust stack for disposing of the exhaust gases to the atmosphere without creating a public nuisance.

The cooling system includes a pump for circulating water through the cylinder jackets and heads of each cylinder and a heat exchanger to remove the energy absorbed in the engine by the cooling water. The heat exchanger may be air-cooled as in the automobile radiator, or it may be water-cooled. Seldom is raw water fit to circulate directly through the jackets of an internal-combustion engine.

The lubricating oil may be passed through a cooler, filter, and reservoir and is supplied to the engine under pressure by means of an oil pump, usually to a hollow crankshaft. The oil serves as a lubricant, for the rubbing surfaces of the engine and also as a coolant.

The fuel system consists of a storage tank from which the fuel may be supplied to a small day tank or reservoir. The oil is filtered and pumped as needed to the fuel-injection system which is an integral part of the engine.

Since the fuel is burned directly in the cylinder of the prime mover, the internal-combustion-engine power plant is simpler and more compact than the steam power plant. It is seldom built in engine sizes of more than 4000 hp, whereas a 300,000-hp steam turbine is common. It is more efficient than a steam power plant of comparable size but not so efficient as large steam central-station plants, which moreover can burn a cheaper grade of fuel. Consequently, the internal-combustion engine is used primarily in the transportation field for driving automobiles, buses, trucks, tractors, locomotives, ships, and airplanes where a compact, light-weight, efficient power plant of relatively small size is necessary.

Текст 7. SUPERHEATERS

Superheated steam is produced by causing saturated steam from a boiler to flow through a heated tube or superheater, thereby increasing the temperature, enthalpy, the specific volume of the steam.

It should be noted that in an actual superheater there will be a decrease in steam pressure due to fluid friction in the superheater tubing.

Maximum work is obtained when a fluid expands at constant entropy, that is, without friction and without heat transfer to the surroundings. By calculations it will be found that the constant-entropy expansion of 1 lb of dry saturated steam at 1000 psia to a final pressure of 1.0 psia will result in the conversion into work of 417 Btu, whereas the expansion of superheated steam at the same initial pressure, 1000 psia but at 1000° F, to the same final pressure of 1.0 psia will result in the conversion into work of 581 Btu, an increase of 39.3 per cent.

In addition to the theoretical gain in output due to the increased temperature of superheated steam as compared to saturated steam, there are additional advantages to the use of superheated steam in turbines. The first law of thermodynamics states that all the work done by the turbine comes from the energy in the steam flowing through the turbine.

Thus, if steam enters the turbine with an enthalpy of 1300 Btu per lb and the work done in the turbine is equivalent to 300 Btu per lb of steam, the enthalpy of the exhaust steam will be 1300 – 300 = 1000 Btu per lb, neglecting heat transfer to the surroundings. If sufficient energy is converted into work to reduce the quality of the steam below about 88 per cent, serious blade erosion results because of the sandblasting effect of the droplets of water on the turbine blades.

Also, each 1 per cent of moisture in the steam reduces the efficiency of that part of the turbine in which the wet steam is expanding by 1 to ½ percent. It is necessary, therefore, that high-efficiency steam turbines be supplied with superheated steam. The minimum recommended steam temperature at the turbine throttle of condensing turbines for various initial steam pressures is as follows:

Throttle Steam	*Minimum Steam*
Pressure, psig	Temperature, ^{o}F
400	725^{o}
600	825^{o}
850	900^{o}
1250	950^{o}
1450	1000^{o}
1800	1050^{o}

Large power plants currently being built in regions of high fuel cost are designed for operation at pressures of more than 1500 psig. At these high pressures a reduction in the annual fuel cost of 4 to 5 per cent can be made by expanding the steam in the turbine from the initial pressure and 1000 to 1100^{o} F to an intermediate pressure of about 30 per cent of the initial pressure, returning the steam to the steam-generating unit, and passing it through a second superheater, known as a reheater, where it is superheated to 1000 to1100^{o} F, and then completing the expansion of the steam in the turbine. For initial steam pressures above the critical pressure (3206 psia), a second stage of reheating is employed.

The decreased strength of steel at high temperature makes it necessary to use alloy steels for superheater tubing where steam temperatures exceed 800° F. Alloy steels containing 0.5 per cent of molybdenum and 1 to 5 per cent of chromium are used for the hot end of high-temperature superheaters at steam temperatures up to

1050^{o} F, and austenitic steels such as those containing 18 per cent chromium and 8 per cent nickel are used for higher temperatures.

Superheaters may be classified as convection or radiant superheaters. Convection superheaters are those that receive heat by direct contact with the hot products of combustion which flow around the tubes. Radiant superheaters are located in furnace walls where they "see" the flame and absorb heat by radiation with a minimum of contact with the hot gases.

In a typical superheater of the convection type saturated steam from the boiler is supplied to the upper or inlet header of the superheater by a single pipe or by a group of circulator tubes. Steam flows at high velocity from the inlet to the outlet header through a large number of parallel tubes or elements of small diameter. Nipples are welded to the headers at the factory, and the tube elements are welded to the nipples in the field, thus protecting the headers from temperature stresses due to uneven heating during final welding.

The amount of surface required in the superheater depends upon the final temperature to which the steam is to be superheated, the amount of steam to be superheated, the quantity of hot gas flowing around the superheater, and the temperature of the gas. In order to keep the surface to a minimum and thus reduce the cost of the superheater, it should be located where high-temperature gases will flow around the tubes. On the other hand, the products of combustion must be cooled sufficiently before they enter the superheater tubes so that any ash that may be present has been cooled to a temperature at which it is no longer sticky or plastic and will not adhere to the superheater tubes. In a modern two-drum steam generating unit fired by a continuous-ash-discharge spreader stoker, the superheater is located ahead of the boiler convection surface and at the gas exit from the furnace. In installations burning coal having a high content of low-fusing-temperature ash, it may be necessary to place a few boiler tubes ahead of the superheater.

2. Тексты по разговорным темам

1. I'm a first year student

My name's… I'm a first-year student of Saint Petersburg State Technological University of Plant Polymers. I study at the department of industrial heat-power engineering. Others departments are: the chemical technological department, the department of mechanics of automated systems of production, the department of economics and production management, the department of automated control systems of technological processes.

I got interested in Physics when I was at school and now it's my favourite subject. I think I'm good at it. It's also the key subject at our department. Besides Physics the first-year students study mathematics, chemistry, history of Russia, technical drawing, informatics, a foreign language and some other subjects. My weak point is English. I have to work hard at it in order not to lag behind the group.

We have lectures, classes and work in the laboratories. As a rule we have three or four lectures a day. Our lectures begin at 9.30. So I have to get up very early in order not to be late for them. I go to the University by underground (by bus). It takes me about an hour to get to the University. We try not to miss classes and lectures. We usually take notes at the lectures as it will be easier to read up for our exams. We'll have our exams in January and then we'll have vacation.

It's very interesting to study new subjects, but it's not always easy to work regularly.

There are 26 students in our group. Many of them live in the dormitory (student hostel). It's not far from the University and they walk there. Our dean is associate professor... Our sub dean is... The dean's office is on (the third) floor.

We have to study hard so we don't have free time on week days. At weekends we go to the cinema, theatre, museums, exhibitions, or to a disco.

1. What university do you study at?
2. What department (faculty) do you study at?
3. What year student are you?
4. What subjects do you study?
5. Which is your favourite subject?
6. Are you good at English?
7. What subjects are you especially good at?
8. What subject is your weak point?
9. How many lectures (classes) do you have a day?
10. What time do they begin?
11. Do you always come in time to the University?
12. Do you attend the lectures regularly?
13. Why do you sometimes miss lectures (classes)?
14. Do you take notes at the lectures?
15. What do students have to do to make progress in a foreign language?
16. How many exams (final tests) will you have in winter (summer)? In what subjects?
17. What time do you have to get up in order not to be late for lectures?
18. How long does it take you to get to the University?
19. Do you go to the University by underground or by bus?
20. Do you walk to the University?
21. How many students are there in your group?
22. Do you live in one of the dormitories or with you parents?
23. Is St.Petersburg your native (home) town?
24. Do you like St.Petersburg? Why?
25. What do you usually do in your free time?

2. The history of our University

The history of our University dates back to 1931, when the Leningrad Promcooperation Institute was formed. In 1936 it was renamed the Leningrad Technological Institute and in 1959 the Leningrad Technological Institute for the Pulp and Paper Industry. For its merits in training specialists and its research work the Institute was awarded the Order of the Red Banner of Labour in 1981 and since 1987 it has been one of the leading institutions of higher education in Russia.

In 1993 the Institute got the status of University and was renamed Saint Petersburg State Technological University of Plant Polymers.

Various kinds of research are carried out in the University. The main trends of investigations are as follows: creation of new technologies of complex processing of wood and other plants as natural polymers, development of new products, lowering material and energy consumption. The research is closely connected with the teaching process.

The faculty of the University numbers 300 teachers including 17 Academicians and corresponding members of Academies of Sciences, 42 Doctors of Sciences and full professors, more than 200 Candidates of Sciences and associate professors, 4 honored members of the Academy of Technical Sciences, 5 National prize-winners.

The University has the graduate course, doctorate and the councils which grant doctor's and candidate's degrees of technical Sciences. Some world-known scientific schools were created and are directed by the leading scientists of the University. There are 30 chairs in the University.

The University has about 3500 students including 2000 full-time students. The course of study for full-time students lasts 5 years. Every theoretical course is followed by practical training. The third-fourth year's students have practical training at different integrated pulp and paper mills. One of two engineers working in the pulp and paper industry has graduated from the University. Many of its graduates work as chief engineers and general directors of pulp and paper mills.

The University has 5 dormitories for 2000 students. The University has nine departments:

- the chemical-technological department,
- the department of mechanics of automated systems of production,
- the department of industrial heat-power engineering,
- the department of automated control systems of technological processes,
- the department of economics and production management,
- the evening and correspondence departments and some others.

3. My Future Occupation: Industrial Heat-Power Engineering

I study at the department of industrial heat-power engineering of Saint-Petersburg Technological University of Plant Polymers. I am a second year student. Our department trains heat-power engineers. Many of them work at research and design institutes.

Our industry and economy are greatly connected with power engineering. It is impossible to imagine modern life without heat and electricity. Thermal power stations and municipal and industrial boiler houses play an important role in energy system of our country. At present great attention is paid to combined generating of heat and electricity at heat-and-power plants and to centralized heat supply. A qualified specialist should assure that the technological processes and operation of modern equipment along with the cost of heat energy and electricity to be produced suit market requirements. From this point of view the profession of a heat-power engineer is extremely necessary and important and a specialist in this field should be a real professional.

Our department trains qualified engineers capable of operating the most complicated up-to-date technological processes and highly competent in applying modern kinds of equipment and using it in the most efficient manner. After graduating from the university I am going to work as a heat-power engineer. I think that my future work is not easy, but absolutely necessary for our national economy.

Questions

1. What department do you study at?
2. What is your future specialization?
3. Where do the graduates of your department work?
4. Are you going to work as heat-power engineer?
5. Do you like your future occupation?

СЛОВАРЬ

Сокращения, встречающиеся в текстах

сокращение	**читается/означает**	**перевод**
%	percent (per cent) [pə'sent]	процент
° C	degrees Centigrade	градус (Цельсия)
° F	degrees Fahrenheit	градус (Фаренгейта)
A. D.	of our era ['ɪərə]	нашей эры
a. k. a.	also known as	также известный как
B. C.	before Christ [kraɪst]	до нашей эры
Btu	British thermal unit	британская тепловая единица
Btu	British thermal unit	британская тепловая единица
e. g.	for example	например
etc.	[et'set(ə)rə]	и так далее
EU	European Union	Евросоюз
ft	foot (мн. число feet)	фут
hp	horse power	лошадиная сила
hr	hour	час
i. e.	that is	то есть
in	inch	дюйм
kJ/kg	kilojoule per kilogram	килоджоуль на килограмм
kw	kilowatt	киловатт
lb	pound	фунт
mm	millimeter	миллиметр
Mpa	megapascal	мегапаскаль
Mw	megawatt	мегаватт
MWt	megawatt	мегаватт
MWth	megawatt thermal	мегаватт
o. d.	outer diameter	внешний диаметр
psi	pounds per square inch	фунтов на квадратный дюйм
psia	pounds per square inch absolute	фунтов на квадратный дюйм (абсолютное давление)
psig	pounds per square inch gauge	фунтов на квадратный дюйм (избыточное давление)

Температура читается:

25° C – twenty-five degrees Centigrade ['sentıgreıd] (по шкале Цельсия);
34° F – thirty-four degrees Fahrenheit ['færənhaıt] (по шкале Фаренгейта).

Сокращения: обозначения частей речи

сокращение	означает	перевод
a.	adjective	имя прилагательное
adv.	adverb	наречие
cj. (conj.)	conjunction	союз
n.	noun	имя существительное
part.	participle	причастие
pl.	plural	множественное число
prep.	preposition	предлог
pron.	pronoun	местоимение
v.	verb	глагол

A		
ability	[ə'bılıtı]	n способность
absorb	[əb'zɔ:b]	v поглощать
accessibility	[ək,sesə'bılıtı]	n доступность
achieve	[ə'tʃi:v]	v достигать
act	[ækt]	v действовать
addition in addition to	[ə'dıʃn]	n вдобавок
additional	[əd'ıʃnəl]	a дополнительный
admission	[əd'mıʃn]	n доступ
advantageous	[,ædvən'teıdʒəs]	a выгодный
adversaly	['ædvɜ:slı]	adv обратно
affect	[ə'fekt]	v влиять (на)
airfoil	['eəfoıl]	n крыло
alternately	[ɔ:l'tɜ:nıtlı]	adv попеременно
amber	['æmbə]	n янтарь
amount	[ə'maunt]	n количество
application	[,æplı'keıʃn]	n применение
area	['eərıə]	n область, площадь
artificial	[,a:tı'fıʃəl]	a искусственный
asphyxiating	[,æs'fıksıeıtıŋ]	a удушающий
assistant	[ə'sıstənt]	n помощник
assumption	[ə'sʌmpʃən]	n допущение
attach	[ə'tætʃ]	v присоединять

attract	[ə’trækt]	v притягивать
available	[ə’veɪləbl]	a доступный
	B	
bank	[bæŋk]	n батарея, пучок
barge	[ba:dʒ]	n баржа
bed	[bed]	n слой
blade	[bleɪd]	n лопасть
blow	[bləʊ]	v дуть
boil	[boɪl]	v кипеть
boiler fire tube boiler	[‘boɪlə]	n котел жаротрубный котел
bottom	[‘botəm]	n дно
boundary	[‘baʊndərɪ]	n граница
break (broke, broken)	[breɪk]	v разбивать
bunker	[‘bʌŋkə]	n бункер
burn	[bɜ:n]	v сжигать, гореть
burner	[‘bɜ:nə]	n горелка
	C	
capacity	[kə’pæsɪtɪ]	n производительность
carry carry out	[‘kærɪ]	v нести проводить, выполнять
casing	[‘keɪsɪŋ]	n оболочка
cast iron	[,ka:st’aɪən]	n чугун
centrifugal	[,sentrɪfju:gəl]	a центробежный
chamber	[‘tʃæmbə]	n камера
charge	[tʃa:dʒ]	v заряжать
chimney	[‘tʃimnɪ]	n дымоходная труба
circuit short circuit	[‘sɜ:kɪt]	 n короткое замыкание
circular	[‘sɜ:kjʊlə]	a круговой
cleanliness	[‘klɪ:nlɪnəs]	n чистота
clearance	[‘klɪərəns]	n зазор, пространство
coal	[kəʊl]	n уголь
coil	[koɪl]	n катушка, змеевик
collector dust collector	[kə’lektə]	n сборник; пылесборник, пылеуловитель
combustible	[kəm’bʌstəbl]	a 1) горючий n 2) горючее
combustion	[kəm’bʌstʃən]	n сгорание
compound	[‘kəmpaʊnd]	n соединение
condensate	[kən’densaɪt]	n конденсат
conductor	[kən’dʌktə]	v проводник

consumption	[kən'sʌmpʃn]	n потребление
contain	[kən'teɪn]	a содержать
contribution	[,kontrɪ'bju:ʃn]	n вклад
convective	[kən'vektɪv]	a конвективный
conventional	[kən'venʃənəl]	a обычный
converter	[kən'vɜ:tə]	n преобразователь
convertible	[kən'vɜ:tɪbl]	a обратимый
cool	[ku:l]	v охлаждать
cooler interstage cooler	['ku:lə]	n охладитель; межступенчатый охладитель
correspond	[,korɪ'spond]	v соответствовать
cover cover conditions	['kʌvə]	1) v покрывать 2) n крышка отвечать условиям
crush	[krʌʃ]	v размельчить
current alternating current	['kʌrənt]	n ток переменный ток
curved	[kɜ:vd]	a искривленный
	D	
dump	[dæmp]	a сырой
decompose	[,dɪ:kəm'pəʊz]	v разлагать
decrease	['dɪ:krɪ:s] [dɪ:'kr ɪ:s]	1) n уменьшение 2) v уменьшать
deliver	[dɪ'lɪvə]	v подавать, поставлять
demand	[dɪ'ma:nd]	n спрос
density	['densɪtɪ]	n плотность
depend	[dɪ'pend]	v зависеть
depth	[depθ]	n глубина
determine	[dɪ'tɜ:mɪn]	v определять
device	[dɪ'vaɪs]	n прибор
diffuser	[dɪ'fju:zə]	n диффузор
dimension	[dɪ'menʃn]	n размер
direct	[daɪ'rekt]	v направлять
direction	[daɪ'rekʃn]	n направление
discharge	[dɪs'tʃa:dʒ]	1) n разряд 2) v разряжать, разгружать
distribution	[,dɪstrɪ'bju:ʃn]	n распределение

draft
  forced draft
  induced draft
	[dra:ft]	n тяга;
		принудительная тяга
		косвенная (искусственная) тяга

draw (drew, drawn)	[drɔ:]	v тянуть

drive (drove, driven)	[draɪv]	v приводить в движение, запускать
drop	[drop]	n перепад, падение
drum	[drʌm]	n барабан
drying	[‘draɪɪŋ]	n сушка
dust	[dʌst]	n пыль
	E	
economizer non steaming economizer steaming economizer	[ɪ’konə,maɪzə]	n экономайзер; некипящий экономайзер; кипящий экономайзер
effect	[ɪ’fekt]	v осуществлять
efficiency	[ɪ’fɪʃənsɪ]	n производительность
efficiently	[ɪ’fiʃəntlɪ]	a эффективно
effort	[‘efət]	n усилие
eliminate	[ɪ’lɪmɪneɪt]	v удалять
end exhaust end	[end]	n конец выходной конец
engine steam engine	[‘endʒin]	n двигатель паровой двигатель
engineering	[,endʒɪ’nɪərɪŋ]	n техника
entrance	[‘entrəns]	n вход
equipment	[ɪ’kwɪpmənt]	n оборудование
essential	[ɪ’senʃl]	a важный
evolve	[ɪ’volv]	v выделять
evaporate	[ɪ’vəæpəreɪt]	v испарить(ся)
exchanger heat exchanger	[ɪks’tʃeɪndʒə]	n обменник теплообменник
exhaust	[ɪg’zɔ:st]	1) n выпуск, выхлопная труба 2) v выпускать
exit	[‘eksɪt]	n выход
expansion	[ɪks’pænʃn]	v расширение
expensive	[ɪks’pensɪv]	a дорогой
extract	[ɪks’trŋkt]	v удалять
	F	
fan foil air fan axial flow fan long blade plate type fan	[fæn]	n вентилятор вентилятор лопастного типа осевой вентилятор вентилятор с лопастями плоского типа
fault	[fɔ:lt]	n повреждение, сбой
feeder	[‘fɪ:də]	n питатель

feedwater	[‘fɪ:d,wɔ:tə]	n питательная вода
fine	[faɪn]	a мелкий
fire	[‘faɪə]	v зажигать, сжигать
fission	[‘fɪʃn]	n расщепление
flame	[fleɪm]	n пламя
flange	[flændʒ]	n край
flood	[flʌd]	n поток
flow axial flow	[fləʊ]	1) n поток; осевой поток 2) v течь
fluid	[‘flu: ɪd]	n жидкость, жидкая среда
force	[fɔ:s]	1) v направлять, 2) n сила
foundation lay foundation	[faʊn’deɪʃn]	n основы заложить основы
frequency	[‘frɪ:kwənsɪ]	n частота
friction	[‘frɪkʃn]	n трение
fuel fossil fuel	[fjʊəl]	n топливо органическое топливо
furnace cyclone furnace	[‘fɜ:nɪs]	n печь циклонная печь
fusion	[‘fju:ʒn]	n сплавление, спекание
	G	
gas flue gas	[gæs]	n газ топочный газ
gears	[gɪəs]	n pl зубчатый механизм
generate	[‘dʒenəreɪt]	v порождать, образовывать
generation	[,dʒenə’reɪʃn]	n образование
generator steam generator	[,dʒenə’reɪtə]	n генератор n парогенератор
give (gave, given) give up	[gɪv]	v давать v отдавать
governor	[‘gʌvənə]	регулятор
grate	[greɪt]	n решетка
gravity	[‘grævɪtɪ]	n сила тяжести
grill	[grɪl]	n решетка
grind (ground, ground)	[graɪnd]	v размалывать
	H	
handling	[‘hændlɪŋ]	n обслуживание
hardware	[‘ha:dweə]	n оборудование
hazard	[‘hæzəd]	n опасность
head velocity head	[hed]	n напор скоростной напор

heat	[hɪ:t]	n тепло
heater air heater	[‘hɪ:tə]	n подогреватель воздухоподогреватель
housing	[‘hauzɪŋ]	n кожух
hydrogen	[‘haɪdrəʤən]	n водород
	I	
ignition	[ɪg’nɪʃn]	n зажигание, воспламенение
impeller	[ɪm’pelə]	n рабочее колесо
impinge	[ɪm’pɪnʤ]	v действовать на, давить
improve	[ɪm’pru:v]	v улучшать
impurities	[ɪm’pjʊərɪtɪz]	n pl примеси
inclination	[,ɪnklɪ’neɪʃn]	n наклон
inclined	[ɪn’klaɪnd]	a наклонный
include	[ɪn’klu:d]	v включать
induce	[ɪn’dju:s]	v собираться, возникать
inescapable	[,ɪnəs’keɪpəbl]	a неизбежный
influence	[‘ɪnflʊəns]	v влиять
injection	[ɪn’ʤekʃn]	n впуск
inspection	[ɪn’spekʃn]	n осмотр
install	[ɪn’stɔ:l]	v установить
installation	[,ɪnstə’leɪʃn]	n установка
insulation	[,ɪnsjʊ’leɪʃn]	n изоляция
intake	[‘ɪnteɪk]	n всасывание
intermediate	[,ɪntə’mi:dɪət]	a промежуточный
introduce	[,ɪntrə’dju:s]	v вводить
investigate	[ɪn’vestɪgeɪt]	v исследовать
involve	[ɪn’volv]	v включать
	L	
lamp	[læmp]	n лампа
lead (led, led)	[li:d]	v вести
leak	[li:k]	n утечка
leave (left, left)	[li:v]	v покидать, уходить
length	[lenθ]	n длина
level	[‘level]	n уровень
light	[laɪt]	n свет v освещать
lightning	[‘laɪtnɪŋ]	n молния
link	[lɪŋk]	v соединять
liquid	[‘lɪkwɪd]	n жидкость a жидкий
load	[ləʊd]	n нагрузка
lobe	[ləʊb]	n выступ, лопасть
locate	[ləʊ’keɪt]	v располагать(ся)

loose (lost, lost)	[lu:z]	v терять
loss	[loss]	n потеря
	M	
machine	[mə’ʃi:n]	n машина v обрабатывать
machinery	[mə’ʃi:nərɪ]	n механизмы
maintain	[meɪn’teɪn]	v поддержать
maintenance	[‘mentənəns]	n обслуживание
manufacture	[,mænju:’fæktʃə]	v производство
mean	[mi:n]	v означать
means by means of	[mi:nz]	n средства prep посредством
measure	[‘meʒə]	v измерять
melt	[melt]	v расплавлять(ся)
mill pulp and paper mill	[mɪl]	n завод целлюлозно-бумажный завод
minute	[‘mɪnɪt]	a мельчайший
missile guided missile	[‘mɪsaɪl]	n ракета управляемая ракета
mix	[mɪks]	v смешивать
motion	[‘məʊʃn]	n движение
mount	[maʊnt]	v монтировать
move	[mu:v]	v двигаться
	N	
nozzle fixed nozzle	[‘nozl]	n сопло неподвижное сопло
nuclear	[‘nju:klɪə]	a ядерный
number a number of	[‘nʌmbə]	n число несколько
	O	
obtain	[əb’teɪn]	v добывать, получать
occupy	[‘okjʊpaɪ]	v занимать
occur	[ə’kɜ:]	v случаться, возникать
oil	[ɔɪl]	n нефть
operation	[,opə’reɪʃn]	n работа
output	[‘aʊtpʊt]	n выход
outside	[aʊt’saɪd]	adv за пределы, вне
overcome (overcame, overcome)	[,əʊvə’kʌm]	v преодолевать
overhead	[,əʊvə’hed]	a верхний
overloading	[,əʊvə’ləʊdɪŋ]	n перегруз
oxygen	[‘oksɪdʒən]	n кислород

P		
partial	[‘pa:ʃl]	a частичный
passage	[‘pæsɪdʒ]	n проход
perfect	[pəf’ekt]	v совершенствовать
photocell	[‘fəʊtəsel]	n фотоэлемент
pick pick up	[pɪk]	v брать подхватывать
pipe	[paɪp]	n труба
piping	[‘paɪpɪŋ]	n трубопровод
piston	[‘pɪstn]	n поршень
plate	[pleɪt]	n пластина
plant	[pla:nt]	n завод, электростанция
plunger	[‘plʌnʤə]	n плунжер
power	[‘paʊə]	n мощность v снабжать энергией
preliminary	[prɪ’lɪmɪnərɪ]	a предварительный
pressure exhaust p.	[‘preʃə]	n давление выпускное давление
prevent	[prɪ’vent]	v предупредить
prime mover	[‘praɪm’mu:və]	n двигатель
process	[prə’ses] [‘prəʊses]	v обрабатывать n процесс
produce	[prə’dju:s]	v производить
profitable	[‘profɪtəbl]	a выгодный
promote	[prə’məʊt]	v вызвать, способствовать
property	[‘propətɪ]	n свойство
protect	[prə’tekt]	v защищать
provide	[prə’vaɪd]	v обеспечить
pulverized	[‘pʌlvəraizd]	a распыленный

pump
  centrifugal pump
  fluid-impellent pump
  hot-well pump
  multistage pump
  piston pump
  reciprocating pump
  rotary pump
	[pʌmp]	n насос
		центробежный насос
		жидкостный насос
		конденсатный насос
		многоступенчатый насос
		поршневой насос
		поршневой насос
		ротационный насос

put put into operation	[pʊt]	v ставить, класть пустить в эксплуатацию
Q		
quantity	[‘kwontɪtɪ]	n количество
R		
radial	[‘reɪdɪəl]	a радиальный

rarefied	[,reərı’faıd]	a разряженный
rate	[reıt]	n скорость
ratio	[‘reıʃıəʊ]	n отношение
ration	[‘ræʃən]	n порция
raw	[rɔ:]	a сырой
reach	[ri:tʃ]	v достигать
rear	[rıə]	n задняя сторона
reciprocating	[rı’siprəkeıtıŋ]	a поршневой
recover	[rı’kʌvə]	v восстановить
reduce	[rı’dju:s]	v уменьшать
reheater	[ri:’hi:tə]	n подогреватель
release	[rı’li:s]	v освобождать, выделять
relieve	[rı’li:v]	v освобождать(ся)
remain	[rı’meın]	v оставаться
removal	[rı’mu:vəl]	n удаление
remove	[rı’mu:v]	v удалять
renewable	[rı’nju:əbl]	a восстановимый
require	[rı’kwaıə]	v требовать
resemble	[rı’zembl]	v походить (на что-либо)
residual	[rı’zıdjʊəl]	a остаточный
rest	[rest]	n остальное
result result from result in	[rı’zʌlt]	1) n результат 2) v образовываться в результате 3) v приводить к
return	[rı’tɜ:n]	v возвращаться
revolve	[rı’volv]	v вращаться
rim	[rım]	n край
ring	[rıŋ]	n кольцо
rise	[raiz]	1) v расти 2) n рост
room boiler room	[ru:m]	n отделение котельная, котельное отделение
rotary	[‘rəʊtarı]	a вращающийся
rotate	[rəʊ’teıt]	v вращать(ся)
row	[rəʊ]	n ряд
rub	[rʌb]	v натирать
runoff	[‘rʌnof]	n отходы
	S	
saturated	[‘sætʃəreıtıd]	a насыщенный
savings	[‘seıviŋgz]	n pl экономия

scale	[skeɪl]	n масштаб
semiconductor	[ˌsemɪkən’dʌktə]	n полупроводник
separation	[ˌsepə’reɪʃn]	n отделение
set	[set]	n установка
sewer	[‘sju:ə]	n коллектор
shaft	[ʃa:ft]	n вал
sheet tube sheet	[ʃi:t]	n лист трубный лист
shell	[ʃel]	n корпус
shield containment shield	[ʃi:ld]	n щит ограждающий щит
side	[saɪd]	n сторона
similar	[‘sɪmɪlə]	a подобный
sinuous	[‘sɪnjʊəs]	a извилистый
slagging	[‘slægiŋ]	n ошлакование
solution	[sə’lu:ʃn]	n решение
source	[sɔ:s]	n источник
spaced	[speɪst]	a расположенный на расстоянии друг от друга
split	[splɪt]	v расщеплять(ся)
stack	[stæk]	n выводная труба
stage	[steɪdʒ]	n ступень
start	[sta:t]	v начинать
state	[steɪt]	n состояние
station electric power station nuclear power station	[‘steɪʃn]	n станция электростанция атомная электростанция
steam	[sti:m]	n пар
stocker chain-grate stocker	[‘stokə]	n механический погрузчик механическая топка с цепной решеткой
store	[stɔ:]	v хранить
streamline	[‘stri:mlaɪn]	n направление потока
subject	[‘sʌbʤɪkt] [‘sʌbʤɪkt] [səb’ʤekt]	n тема, предмет a подчиненный v подчинять
substance	[‘sʌbstəns]	n вещество
suction	[‘sʌkʃən]	n отсос
suit	[sju:t]	v подходить
superheater	[ˌsju:pə’hi:tə]	n перегреватель
superheating	[ˌsju:pə’hi:tɪŋ]	n перегрев
supplement	[‘sʌplɪmənt]	v дополнять

supply	[sə’plaɪ]	v обеспечить, снабжать
support	[sə’pɔ:t]	v поддерживать
surface	[‘sɜ:fɪs]	n поверхность
surround	[sə’raʊnd]	v окружать
surrounding	[sə’raʊndɪŋ]	n окружающее пространство
T		
table	[‘teɪbl]	n таблица
throttel	[‘θrotl]	n дроссель, клапан
thrust axial thrust	[θrʌst]	n толчок, давление осевое давление
throw (threw, threw)	[θrəʊ]	v сбрасывать
tidal	[‘taɪdl]	a связанный с приливами и отливами
tight	[taɪt]	a непроницаемый
top	[top]	n верх
tower cooling tower	[‘taʊə]	n башня охладительная башня
transfer	[‘trænsfɜ:] [træns’fɜ:]	n передача v передавать
transmission	[trænz’mɪʃn]	n передача
treatment	[‘trɪ:tment]	n обработка
trend	[trend]	n тенденция
trouble	[‘trʌbl]	n нарушение
turbine automatic extration-turbine impulse turbine reaction turbine	[‘tɜ:bɪn]	n турбина турбина с регулируемым отбором активная турбина реактивная турбина
turbojet	[‘tɜ:bəʊdʒet]	a турбореактивный
turbulence	[‘tɜ:bjʊləns]	n турбулентность, завихрение
tube	[‘tju:b]	n труба
tubular	[‘tju:bjʊlə]	a трубчатый
U		
undergo	[ˌʌndə’gəʊ]	v подвергаться
underground	[ˌʌndə’graʊnd]	a подземный
unit	[‘ju:nɪt]	n установка
unload	[ʌn’ləʊd]	v разгружать
urgent	[‘ɜ:dʒənt]	a срочный
user	[‘ju:zə]	n потребитель
V		
valve safety valve	[vælv]	n клапан предохранительный клапан

slide valve		золотник
vane	[vein]	n лопата
vary	[‘veərı]	v меняться, различаться
velocity	[vı’losıtı]	n скорость
vented	[‘ventıd]	a вентилированный
viscosity	[vıis’kosıtı]	n вязкость
volume specific volume	[‘volju:m]	n объем удельный объем
volute	[və’lu:t]	n спиральный корпус
W		
warfare	[‘wɔ:feə]	n война, приемы ведения войны
waste	[weıst]	n отходы
water feed water	[‘wɔ:tə]	n вода питательная вода
wave	[weıv]	n волна
wear	[weə]	n износ
weight specific weight	[weıt]	n вес удельный вес
welding	[‘weldıŋ]	n сварка
wheel	[wi:l]	n колесо
width	[wıdθ]	n ширина
wire	[waıə]	n провод

Библиографический список

1. В.В. Кириллова, Т.М. Вихман. Английский язык: учебно-методическое пособие по переводу научно-технической литературы для студентов и аспирантов технических специальностей. СПб.: СПбГТУРП, 2010. – 154 с.
2. В.В. Кириллова, Лиоренцевич Т.В., Сергеева К.Я., Симпирович С.В., Шарапа Т.С. Английский язык: учебно-методическое пособие для студентов-заочников теплоэнергетического факультета. СПб.: СПбГТУРП, 2007.–110с.
3. Raymond Murphy. English Grammar in use. Cambridge university press. 2010. – 350 p.

СОДЕРЖАНИЕ

Учебное издание

Виктория Витальевна Кириллова
Алла Михайловна Знаменская
Галина Ивановна Найданова
Татьяна Станиславовна Шарапа

Английский язык

Учебно-методическое пособие по чтению и переводу
научно-технической литературы
для студентов факультета промышленной энергетики

Редактор и корректор В. А. Басова
Техн. редактор Л.Я.Титова
Компьютерная вёрстка: А.М. Знаменская Темплан 2014 г., поз. 135

Подп. к печати 15.12.2014. Формат 60х84/16. Бумага тип. №1.
Печать офсетная. Уч.-изд. л. 4,75; усл. печ. л. 4,75. Тираж 200 экз.
Изд. № 135. Цена "С". Заказ

Ризограф Санкт-Петербургского государственного технологического
университета растительных полимеров, 198095, Санкт-Петербург, ул. Ивана Черных, 4.