ГБПОУ КК НКРП

Основы технологических процессов:

Forging

Основные процессы литейного производства, изготовление отливок; важность процесса ковки. Основные операции, выполняемые на металлорежущих станках

Casting

Основы технологии резания металлов

Metal-Cutting Machines

The Lathe

УЧЕБНОЕ ПОСОБИЕ

по дисциплине «Иностранный язык»
(английский язык)
для студентов 4 курса
специальности 220703
Автоматизация технологических процессов и производств

НОВОРОССИЙСК, 2015

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ КРАСНОДАРСКОГО КРАЯ
ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ПРОФЕССИОНАЛЬНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ
КРАСНОДАРСКОГО КРАЯ

«НОВОРОССИЙСКИЙ КОЛЛЕДЖ РАДИОЭЛЕКТРОННОГО ПРИБОРОСТРОЕНИЯ»

Учебное пособие

по дисциплине «**Иностранный язык**»

(английский)

по теме «Основы технологических процессов:
основные процессы литейного производства, изготовление отливок;
важность процесса ковки. Основные операции, выполняемые на металлорежущих станках.
Основы технологии резания металлов»

для студентов 4 курса специальности 220703 Автоматизация технологических процессов и производств

Новороссийск
2015

ОДОБРЕНО
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Председатель ПК
_______________ С.П. Тихонова

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Рецензия

на учебное пособие по иностранному языку (английский)

«Основы технологических процессов: основные процессы литейного производства, изготовление отливок; важность процесса ковки. Основные операции, выполняемые на металлорежущих станках. Основы технологии резания металлов»

преподавателя Марарь Марины Александровны

ГБПОУ КК НКРП

Учебное пособие «Основы технологических процессов: основные процессы литейного производства, изготовление отливок; важность процесса ковки. Основные операции, выполняемые на металлорежущих станках. Основы технологии резания металлов» преподавателя М.А. Марарь рассчитано для студентов 4 курса специальности 15.02.07 Автоматизация технологических процессов и производств (по отраслям). Количество страниц – 43.

Автор акцентирует внимание на том, что учебное пособие направлено на развитие индивидуальной траектории образования каждого обучающегося. Пособие аккумулирует важные процессы технологических производств и материалы по основным операциям, выполняемых на металлорежущих станках по учебной дисциплине «иностранный язык (английский)».

Актуальность и педагогическая целесообразность данного учебного пособия заключается в развитии умений и навыков у обучающихся по дисциплине «иностранный язык». В системе образования данное учебное пособие связано с другими дисциплинами, изучаемыми в СПО: инженерная графика, электротехника, техническая механика, материаловедение, электронная техника, вычислительная техника, электротехнические измерения, электрические машины, компьютерное моделирование.

Основная идея разработанного учебного пособия заключается в привитии обучающимся навыков профессии посредством иностранного языка, что позволит студентам в будущем ориентироваться в документах, схемах, таблицах не только на родном языке, но и на изучаемом языке, на который ориентируется большинство производителей. Грамматические и лексические упражнения, которые предоставляются автором в пособии, делают этот материал интересным и оптимальным для восприятия студентов старших курсов.

Учебное пособие обладает практической значимостью: ряд заданий после рассматриваемой темы стимулирует интеллектуальную, поисковую и коммуникативную активность и, как следствие, формирует новые навыки студентов, которых, возможно, ранее у них не было (накопление запаса слов, логически правильное построение перевода, т.д.)

Рецензируемое учебное пособие актуально для системы образования, интересно по содержанию, будет доступно и понятно как преподавателю, так и студентам-старшекурсникам, которые осваивают специальность в теории и на практике.

Таким образом, данное пособие учебной дисциплины «Иностранный язык (английский)» может быть рекомендовано для использования в образовательном учреждении ГБПОУ КК «Новороссийский колледж радиоэлектронного приборостроения».

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8 января 2015г.

РЕЦЕНЗИЯ

на учебное пособие, разработанное преподавателем ГБПОУ КК НКРП
Марарь М.А. по разделу «Основы технологических процессов».

Учебное пособие «Основы технологических процессов» предназначено для работы со студентами IV курса специальности 220703 Автоматизация технологических процессов и производств по разделу «Основы технологических процессов».

Пособие содержит тексты по изучаемому разделу, а также задания, по большей части разработанные автором пособия. Материал взят автором из различных источников. Использованы Интернет-ресурсы.

Структура пособия предусматривает подготовку студентов к восприятию текста, работу над текстом непосредственно и разнообразные послетекстовые упражнения, которые дают возможность проконтролировать степень усвоения прочитанного текста, повторить некоторые грамматические явления, активизируя при этом лексический запас по изучаемому разделу и специальности в целом. Пособие хорошо иллюстрировано, что также позволяет обучающимся лучше усвоить учебный материал.

Данное учебное пособие способствует развитию у студентов навыков чтения с непосредственным пониманием, поискового чтения, логического мышления, а также пополнению активного словаря студентов по изучаемой специальности, расширению их кругозора, практическому применению при переводе знаний, полученных в процессе изучения выбранной специальности.

Пособие опробовано автором в учебном процессе и рекомендовано для использования преподавателями колледжа, работающими со студентами IV курса специальности 220703 Автоматизация технологических процессов и производств.

Методист ГБПОУ КК НКРП, преподаватель высшей квалификационной категории

Н.С. Колосова

УЧЕБНАЯ ЧАСТЬ

ОГЛАВЛЕНИЕ

ВВЕДЕНИЕ

Данное учебное пособие «Основы технологических процессов: основные процессы литейного производства, изготовление отливок; важность процесса ковки. Основные операции, выполняемые на металлорежущих станках. Основы технологии резания металлов» предназначено для базового этапа подготовки по иностранному языку и обеспечивает коммуникативную и профессиональную направленность в обучении языку в неязыковой образовательной организации.

Все компоненты учебного пособия построены на единых методических принципах, развивают все виды иноязычной речевой деятельности, позволяют организовать аудиторную и самостоятельную работу по овладению английским языком и формирование межкультурной компетенции будущих специалистов.

Цель учебного пособия - взаимосвязанное развитие у студентов коммуникативной компетенции, достаточной для осуществления устной и письменной деятельности в соответствии с программой.

Учебное пособие включает в себя три раздела (Units), содержащих теоретический материал (Wikipedia) и практические задания. Тематика текстов соответствует реально существующим направлениям подготовки специалистов профиля автоматизации технологических процессов и производств на основе принципов действия механизмов и машин, материалов и процессов обработки и т. д.

Построение заданий к текстам определяется методическим назначением этих текстов: предтекстовые и послетекстовые задания. Раздел может заканчиваться логической схемой, объединяющей в систему наиболее важные понятия и положения его темы. Эти схемы предназначены для обобщения материала по теме, а также служат дополнительной опорой для закрепления активного словаря.

При разработке системы заданий использованы элементы функционально-коммуникативного обучения иностранному языку, при котором явления языка (лексика и грамматика) рассматриваются не только как система языковых правил, но и как система коммуникативных функций. Такие функции типичны для текстов профиля технологических процессов и производств, материалов и процессов обработки и находят свое отражение в типичных грамматических моделях и типичном наборе лексических единиц и словосочетаний. Объем и содержание лексического и грамматического материала определены программой по английскому языку для неязыковых образовательных организаций.

UNIT 1 CASTING

THEORY

Molten metal prior to casting

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a *casting*, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various *cold setting* materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Casting is a 6000 year old process. The oldest surviving casting is a copper frog from 3200 BC.

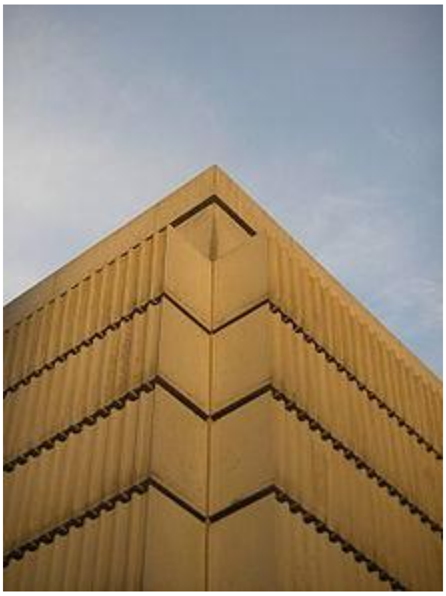
Types

Casting iron in a sand mold

Metal

Metal casting is one of the most common casting processes. Metal patterns are more expensive but are more dimensionally stable and durable. Metallic patterns are used where repetitive production of castings is required in large quantities.

Plaster, concrete, or plastic resin



Juden platz Holocaust Memorial(Nameless Library), by Rachel Whiteread. Concrete cast of books on library shelves turned inside out.

Plaster and other chemical curing materials such as concrete and plastic resin may be cast using single-use *waste* molds as noted above, multiple-use 'piece' molds, or molds made of small rigid pieces or of flexible material such as latex rubber (which is in turn supported by an exterior mold). When casting plaster or concrete, the material surface is flat and lacks transparency. Often topical treatments are applied to the surface. For example, painting and etching can be used in a way that give the appearance of metal or stone. Alternatively, the material is altered in its initial casting process and may contain colored sand so as to give an appearance of stone. By casting concrete, rather than plaster, it is possible to create sculptures, fountains, or seating for outdoor use. A simulation of high-quality marble may be made using certain chemically-set plastic resins (for example epoxy or polyester) with powdered stone added for coloration, often with multiple colors worked in. The latter is a common means of making washstands, washstand tops and shower stalls, with the skilled working of multiple colors resulting in simulated staining patterns as is often found in natural marble ortravertine.

Casting process simulation

Casting process simulation uses numerical methods to calculate cast component quality considering mold filling, solidification and cooling, and provides a quantitative prediction of casting mechanical properties, thermal stresses and distortion. Simulation accurately describes a cast component's quality up-front before production starts. The casting rigging can be designed with respect to the required component properties. This has benefits beyond a reduction in pre-production sampling, as the precise layout of the complete casting system also leads to energy, material, and tooling savings.

The software supports the user in component design, the determination of melting practice and casting methoding through to pattern and mold making, heat treatment, and finishing. This saves costs along the entire casting manufacturing route.

Casting process simulation was initially developed at universities starting from the early '70s, mainly in Europe and in the U.S., and is regarded as the most important innovation in casting technology over the last 50 years. Since the late '80s, commercial programs (such as AutoCAST and MAGMA) are available which make it possible for foundries to gain new insight into what is happening inside the mold or die during the casting process.

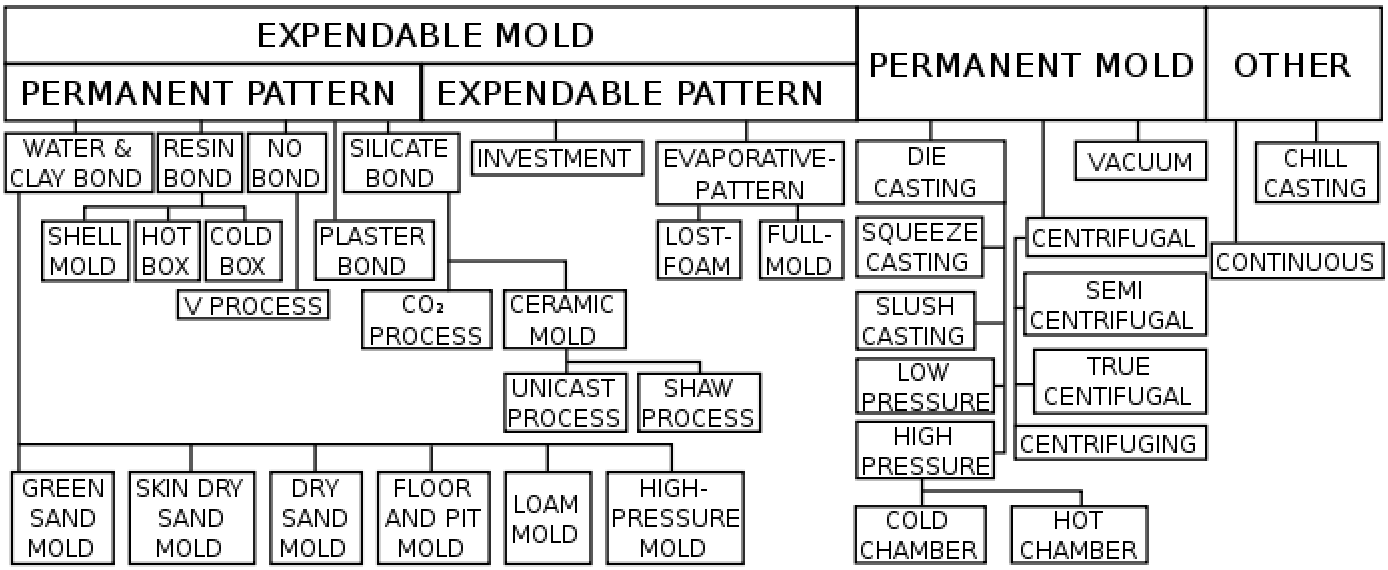
In metalworking, **casting** involves pouring liquid metal into a mold, which contains a hollow cavity of the desired shape, and then allowing it to cool and solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods.

Casting processes have been known for thousands of years, and widely used for sculpture, especially in bronze, jewellery in precious metals, and weapons and tools. Traditional techniques include lost-wax casting, plaster mold casting and sand casting.

The modern casting process is subdivided into two main categories: expendable and non-expendable casting. It is further broken down by the mold material, such as sand or metal, and pouring method, such as gravity, vacuum, or low pressure.

Expendable mold casting

Expendable mold casting is a generic classification that includes sand, plastic, shell, plaster, and investment (lost-wax technique) moldings. This method of mold casting involves the use of temporary, non-reusable molds.



Sand casting

Sand casting is one of the most popular and simplest types of casting, and has been used for centuries. Sand casting allows for smaller batches than permanent mold casting and at a very reasonable cost. Not only does this method allow manufacturers to create products at a low cost, but there are other benefits to sand casting, such as very small-size operations. From castings that fit in the palm of your hand to train beds (one casting can create the entire bed for one rail car), it can all be done with sand casting. Sand casting also allows most metals to be cast depending on the type of sand used for the molds. Sand casting requires a lead time of days, or even weeks sometimes, for production at high output rates (1–20 pieces/hr-mold) and is unsurpassed for large-part production. Green (moist) sand has almost no part weight limit, whereas dry sand has a practical part mass limit of 2,300–2,700 kg (5,100–6,000 lb). Minimum part weight ranges from 0.075–0.1 kg (0.17–0.22 lb). The sand is bonded together using clays, chemical binders, or polymerized oils (such as motor oil). Sand can be recycled many times in most operations and requires little maintenance.

Plaster mold casting

Plaster casting is similar to sand casting except that plaster of paris is substituted for sand as a mold material. Generally, the form takes less than a week to prepare, after which a production rate of 1–10 units/hr·mold is achieved, with items as massive as 45 kg (99 lb) and as small as 30 g (1 oz) with very good surface finish and close tolerances. Plaster casting is an inexpensive alternative to other molding processes for complex parts due to the low cost of the plaster and its ability to produce near net shape castings. The biggest disadvantage is that it can only be used with low melting point non-ferrous materials, such as aluminium, copper, magnesium, and zinc.

Shell molding

Shell molding is similar to sand casting, but the molding cavity is formed by a hardened "shell" of sand instead of a flask filled with sand. The sand used is finer than sand casting sand and is mixed with a resin so that it can be heated by the pattern and hardened into a shell around the pattern. Because of the resin and finer sand, it gives a much finer surface finish. The process is easily automated and more precise than sand casting. Common metals that are cast include cast iron, aluminium, magnesium, and copper alloys. This process is ideal for complex items that are small to medium sized.

Investment casting

Investment casting (known as lost-wax casting in art) is a process that has been practiced for thousands of years, with the lost-wax process being one of the oldest known metal forming techniques. From 5000 years ago, when beeswax formed the pattern, to today’s high technology waxes, refractory materials and specialist alloys, the castings ensure high-quality components are produced with the key benefits of accuracy, repeatability, versatility and integrity.

Investment casting derives its name from the fact that the pattern is invested, or surrounded, with a refractory material. The wax patterns require extreme care for they are not strong enough to withstand forces encountered during the mold making. One advantage of investment casting is that the wax can be reused.The process is suitable for repeatable production of net shape components from a variety of different metals and high performance alloys. Although generally used for small castings, this process has been used to produce complete aircraft door frames, with steel castings of up to 300 kg and aluminium castings of up to 30 kg. Compared to other casting processes such as die casting or sand casting, it can be an expensive process, however the components that can be produced using investment casting can incorporate intricate contours, and in most cases the components are cast near net shape, so require little or no rework once cast.

Waste molding of plaster

A durable plaster intermediate is often used as a stage toward the production of a bronze sculpture or as a pointing guide for the creation of a carved stone. With the completion of a plaster, the work is more durable (if stored indoors) than a clay original which must be kept moist to avoid cracking. With the low cost plaster at hand, the expensive work of bronze casting or stone carving may be deferred until a patron is found, and as such work is considered to be a technical, rather than artistic process, it may even be deferred beyond the lifetime of the artist.

In waste molding a simple and thin plaster mold, reinforced by sisal or burlap, is cast over the original clay mixture. When cured, it is then removed from the damp clay, incidentally destroying the fine details in undercuts present in the clay, but which are now captured in the mold. The mold may then at any later time (but only once) be used to cast a plaster positive image, identical to the original clay. The surface of this plaster may be further refined and may be painted and waxed to resemble a finished bronze casting.

Evaporative-pattern casting

This is a class of casting processes that use pattern materials that evaporate during the pour, which means there is no need to remove the pattern material from the mold before casting. The two main processes are lost-foam casting and full-mold casting.

Lost-foam casting

Lost-foam casting is a type of evaporative-pattern casting process that is similar to investment casting except foam is used for the pattern instead of wax. This process takes advantage of the low boiling point of foam to simplify the investment casting process by removing the need to melt the wax out of the mold.

Full-mold casting

Full-mold casting is an evaporative-pattern casting process which is a combination of sand casting and lost-foam casting. It uses an expanded polystyrene foam pattern which is then surrounded by sand, much like sand casting. The metal is then poured directly into the mold, which vaporizes the foam upon contact.

Non-expendable mold casting

Non-expendable mold casting differs from expendable processes in that the mold need not be reformed after each production cycle. This technique includes at least four different methods: permanent, die, centrifugal, and continuous casting. This form of casting also results in improved repeatability in parts produced and delivers Near Net Shape results.

Permanent mold casting

Permanent mold casting is a metal casting process that employs reusable molds ("permanent molds"), usually made from metal. The most common process uses gravity to fill the mold, however gas pressure or a vacuum are also used. A variation on the typical gravity casting process, called slush casting, produces hollow castings. Common casting metals are aluminum, magnesium, and copper alloys. Other materials include tin, zinc, and lead alloys and iron and steel are also cast in graphite molds. Permanent molds, while lasting more than one casting still have a limited life before wearing out.

Die casting

The die casting process forces molten metal under high pressure into mold cavities (which are machined into dies). Most die castings are made from nonferrous metals, specifically zinc, copper, and aluminium based alloys, but ferrous metal die castings are possible. The die casting method is especially suited for applications where many small to medium sized parts are needed with good detail, a fine surface quality and dimensional consistency.

Casting is a solidification process, which means the solidification phenomenon controls most of the properties of the casting. Moreover, most of the casting defects occur during solidification, such as *gas porosity* and *solidification shrinkage*. Solidification occurs in two steps: *nucleation* and *crystal growth*. In the nucleation stage solid particles form within the liquid. When these particles form their internal energy is lower than the surrounded liquid, which creates an energy interface between the two. The formation of the surface at this interface requires energy, so as nucleation occurs the material actually undercools, that is it cools below its freezing temperature, because of the extra energy required to form the interface surfaces. It then recalescences, or heats back up to its freezing temperature, for the crystal growth stage. Note that nucleation occurs on a pre-existing solid surface, because not as much energy is required for a partial interface surface, as is for a complete spherical interface surface. This can be advantageous because fine-grained castings possess better properties than coarse-grained castings. A fine grain structure can be induced by *grain refinement* or *inoculation*, which is the process of adding impurities to induce nucleation. All of the nucleations represent a crystal, which grows as the heat of fusion is extracted from the liquid until there is no liquid left. The direction, rate, and type of growth can be controlled to maximize the properties of the casting. Directional solidification is when the material solidifies at one end and proceeds to solidify to the other end; this is the most ideal type of grain growth because it allows liquid material to compensate for shrinkage.

Shrinkage

There are three types of shrinkage: *shrinkage of the liquid*, *solidification shrinkage* and *patternmaker's shrinkage*. The shrinkage of the liquid is rarely a problem because more material is flowing into the mold behind it. Solidification shrinkage occurs because metals are less dense as a liquid than a solid, so during solidification the metal density dramatically increases. Patternmaker's shrinkage refers to the shrinkage that occurs when the material is cooled from the solidification temperature to room temperature, which occurs due to thermal contraction.

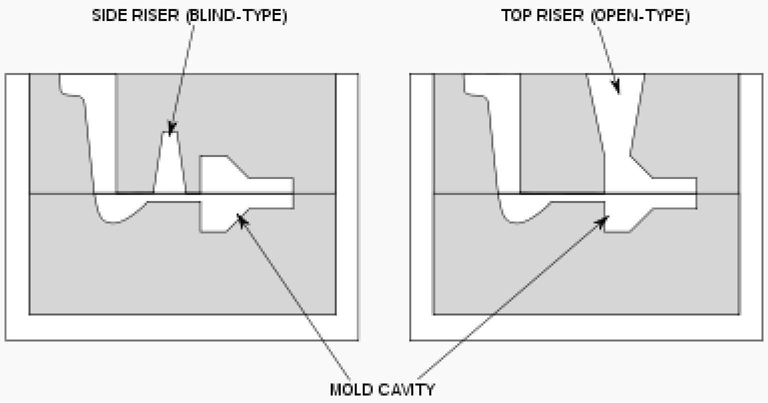
Solidification shrinkage Most materials shrink as they solidify, but, as the table to the right shows, a few materials do not, such as gray cast iron. For the materials that do shrink upon solidification the type of shrinkage depends on how wide the freezing range is for the material. For materials with a narrow freezing range, less than 50 °C (122 °F), a cavity, known as a *pipe*, forms in the center of the casting, because the outer shell freezes first and progressively solidifies to the center. Pure and eutectic metals usually have narrow solidification ranges. These materials tend to form a *skin* in open air molds, therefore they are known as *skin forming alloys*. For materials with a wide freezing range, greater than 110 °C (230 °F), much more of the casting occupies the *mushy* or *slushy* zone (the temperature range between the solidus and the liquidus), which leads to small pockets of liquid trapped throughout and ultimately porosity. These castings tend to have poor ductility, toughness, and fatigue resistance. Moreover, for these types of materials to be fluid-tight a secondary operation is required to impregnate the casting with a lower melting point metal or resin.

Solidification shrinkage of various metals[17][18]

Metal	Percentage
Aluminium	6.6
Copper	4.9
Magnesium	4.0 or 4.2
Zinc	3.7 or 6.5
Low carbon steel	2.5–3.0
High carbon steel	4.0
White cast iron	4.0–5.5
Gray cast iron	−2.5–1.6
Ductile cast iron	−4.5–2.7

For the materials that have narrow solidification ranges pipes can be overcome by designing the casting to promote directional solidification, which means the casting freezes first at the point farthest from the gate, then progressively solidifies towards the gate. This allows a continuous feed of liquid material to be present at the point of solidification to compensate for the shrinkage. Note that there is still a shrinkage void where the final material solidifies, but if designed properly this will be in the gating system or riser.

Risers and riser aids



Different types of risers

Risers, also known as *feeders*, are the most common way of providing directional solidification. It supplies liquid metal to the solidifying casting to compensate for solidification shrinkage. For a riser to work properly the riser must solidify after the casting, otherwise it cannot supply liquid metal to shrinkage within the casting. Risers add cost to the casting because it lowers the *yield* of each casting; i.e. more metal is lost as scrap for each casting. Another way to promote directional solidification is by adding chills to the mold. A chill is any material which will conduct heat away from the casting more rapidly that the material used for molding.

Risers are classified by three criteria. The first is if the riser is open to the atmosphere, if it is then its called an *open* riser, otherwise its known as a *blind* type. The second criterion is where the riser is located; if it is located on the casting then it is known as a *top riser* and if it is located next to the casting it is known as a*side riser*. Finally, if riser is located on the gating system so that it fills after the molding cavity, it is known as a *live riser* or *hot riser*, but if the riser fills with materials that's already flowed through the molding cavity it is known as a *dead riser* or *cold riser*.

Riser aids are items used to assist risers in creating directional solidification or reducing the number of risers required. One of these items are *chills* which accelerate cooling in a certain part of the mold. There are two types: external and internal chills. External chills are masses of high-heat-capacity and high-thermal-conductivity material that are placed on an edge of the molding cavity. Internal chills are pieces of the same metal that is being poured, which are placed inside the mold cavity and become part of the casting. Insulating sleeves and toppings may also be installed around the riser cavity to slow the solidification of the riser. Heater coils may also be installed around or above the riser cavity to slow solidification.

Mold cavity

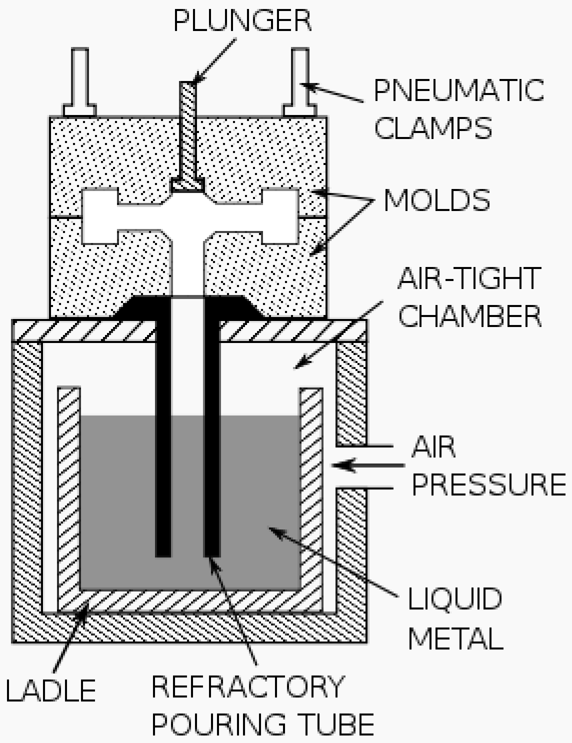
The mold cavity of a casting does not reflect the exact dimensions of the finished part due to a number of reasons. These modifications to the mold cavity are known as *allowances* and account for patternmaker's shrinkage, draft, machining, and distortion. In non-expendable processes, these allowances are imparted directly into the permanent mold, but in expendable mold processes they are imparted into the patterns, which later form the mold cavity. Note that for non-expendable molds an allowance is required for the dimensional change of the mold due to heating to operating temperatures.

For surfaces of the casting that are perpendicular to the parting line of the mold a draft must be included. This is so that the casting can be released in non-expendable processes or the pattern can be released from the mold without destroying the mold in expendable processes. The required draft angle depends on the size and shape of the feature, the depth of the mold cavity, how the part or pattern is being removed from the mold, the pattern or part material, the mold material, and the process type. Usually the draft is not less than 1%.

The machining allowance varies drastically from one process to another. Sand castings generally have a rough surface finish, therefore need a greater machining allowance, whereas die casting has a very fine surface finish, which may not need any machining tolerance. Also, the draft may provide enough of a machining allowance to begin with.

The distortion allowance is only necessary for certain geometries. For instance, U-shaped castings will tend to distort with the legs splaying outward, because the base of the shape can contract while the legs are constrained by the mold. This can be overcome by designing the mold cavity to slope the leg inward to begin with. Also, long horizontal sections tend to sag in the middle if ribs are not incorporated, so a distortion allowance may be required. Cores may be used in expendable mold processes to produce internal features. The core can be of metal but it is usually done in sand.

Filling



Schematic of the low-pressure permanent mold casting process

There are a few common methods for filling the mold cavity: *gravity*, *low-pressure*, *high-pressure*, and *vacuum*. Vacuum filling, also known as *counter-gravity* filling, is more metal efficient than gravity pouring because less material solidifies in the gating system. Gravity pouring only has a 15 to 50% metal yield as compared to 60 to 95% for vacuum pouring. There is also less turbulence, so the gating system can be simplified since it does not have to control turbulence. Plus, because the metal is drawn from below the top of the pool the metal is free from dross and slag, as these are lower density (lighter)

PRACTICAL TASKS

Литье

- технологический процесс изготовления отливок, заключающийся в заполнении форм расплавленным материалом и дальнейшей обработке полученных изделий

TEXT A. **CHANGES IN MATERIALS TECHNOLOGY**

Since the technology of any age is founded upon the materials of the age, the era of new materials will have a profound effect on engineering of the future.

Not only new materials, but related, and equally important, new and improved and less wasteful processes for the shaping, treating and finishing of both traditional and new materials are continuously being developed.

It is important that an engineer should be familiar with them. These include casting, injection molding and rotational molding of components of ever increasing size, complexity and accuracy; manufacture of more complex components by powder metallurgy techniques; steel forming and casting processes based on new, larger and more mechanized machines, giving reduced waste and closer tolerances; the avoidance of waste in forging by the use of powder metallurgy or cast press forms and new finishing processes for metals and plastics, just to name a few. A high proportion of these processes is aimed at the production of complex, accurate shapes with a much smaller number of operations and with far less waste than the traditional methods of metal manufacture.

Joining techniques have developed to unprecedented level of sophistication and are also providing opportunities for economies. It is necessary to mention that these newer techniques allow the manufacture of complicated parts by welding together simpler sub-units requiring little machining; such assemblies can be made from a variety of materials. The methods can also be used effectively for assembly, allowing savings to be made in both materials and machine utilization.

The brief review of new processes above has indicated that a new materials technology is rapidly emerging, providing new opportunities and challenges for imaginative product design and for more efficient manufacture.

Language Study

1. Give the meanings of the words. Check yourselves according to the dictionary.

technology, era, to have **an effect,** process, **finishing,** traditional materials, manufacture, complex component, mechanized machine, press form, **accurate** shape, joining **technique, assemblies, assembly,** to indicate.

2. Finish the table:

Process				Result - product	
to cast	отливать	casting	литьё	casting	отливка
to forge	ковать	forging	ковка	forging	
to assemble	собирать	assembly	сборка	assembly	
to mold	формовать, отливать в форму	molding	формовка, прессование в формах	molding	

3. Fill in the text modal verbs should/ought to, will/would, can/could, may/might, must:

Corrosion

Corrosion attacks all engineering materials, especially metals.

No material... be completely corrosion-resistant. Even stainless steels ... corrode. Engineers ..., however, fight corrosion. For example, they ... use high-purity metals because these metals are more resistant than alloys. They... also make sure that two dissimilar metals are not allowed to touch each other. Finally, engineers ... protect the surfaces of the metals in many different ways. One of the most common methods ... be to paint them.

Active Vocabulary

Область применения	**Существительные и сочетания с существительными**	**Глаголы и глагольные сочетания**	**Прилагательные**	**Наречия**
1. Технологические процессы и методы	**shaping** **treating** **finishing** **casting** **injection/** **rotational** **molding** **powder metallurgy techniques** **forging** **joining techniques** **welding**	**to shape** **to treat** **to finish** **to cast** **to mold** **to forge** **to join** **to weld** **to machine** **to assemble**		

	machining **assembly**			
2.Характеристика и результат технологического	**complexity** **accuracy waste** **close tolerance** **economy** **saving**	**to reduce waste to** **avoid waste to** **require little** **machining** **to make savings**	**profound** **accurate** **efficient** **complex**	**effecti** **vely** **equall**

Read the text B and find in it the information about the machines and materials' characteristics of future:

TEXT B. WORKING WITH NEW MATERIALS

A successful design is almost always a compromise among highest performance, attractive appearance, efficient production, and lowest cost. Achieving the best compromise requires satisfying the mechanical requirements of the part, utilizing the most economical material that will perform satisfactorily, and choosing a manufacturing process compatible with the part design and material choice. Stating realistic requirements for each of these areas is of the utmost importance.

The rapidity of change in materials technology is typified by the fact that plastics, a curiosity at the turn of the 20th century, are now being used in volumes which have for many years exceeded those of all the non-ferrous metals put together, and which are beginning to rival steel.

The changes which are taking place are, of course, not only quantitative. They are associated with radical changes in technology — in the range and nature of the materials and processes available to the engineer.

The highest specific strength (i.e. the strength available from unit weight of material) now available comes from non-metals, such as fibreglass, and from metals, such as berillium and titanium, and new ultra-high strength steels.

Fibre technology, in its modern form, is of more recent origin than plastics, but composites based on glass and/or on carbon fibres are already being applied to pressure vessels, to lorry cabs and to aircraft engines, and may well replace aluminium for the skin and structure of aircraft. An all-plastic car has been exhibited: nearly the whole car, except the engine and transmission is of plastics or reinforced plastics.

It is not only plastics and their reinforcement which are changing the materials scene. Ceramics too are gaining an increasing foothold. Their impact as tooling materials in the form of carbides, nitrides and oxides is also well known — cutting tools made of these materials are allowing machining rates which had previously been considered quite impossible.

Silicon nitride seems to offer particular promise for a wide variety of applications. Among these is liquid metal handling. Pumps for conveying liquid aluminium are now on trial which could revolutionize the foundry industry. Silicon nitride is also being tested for the bearing surfaces of the Wankel rotary engines which are being developed as potential replacements for the conventional piston engines of our motor cars. And ceramic magnets have replaced the traditional steel pole-piece plus copper field coil for providing the engineering field for many electric motors.

It is clear that the number of combinations of all kinds of original trends in the production of new materials is practically unlimited. This, in turn, opens new realms for the designing of still cheaper, effective and unthinkably perfected, compared to that we have today, machines and mechanisms.

TASKS

1. Make the table with:

- the materials' names applying in engineering;
- their characteristics;
- applying field of these materials.

2. Make the reports using the information from the made table.

Read the Text A and find in it:

- the definition of **CASTING**;
- the casting applying;
- the process of making casting.

<u>TEXT A.</u> METAL CASTING - A BASIC MANUFACTURING PROCESS

One of the basic processes of the metalworking industry is the production of metal castings. A casting may be defined as "a metal object obtained by allowing molten metal to solidify in a mold", the shape of the object being determined by the shape of the mold cavity. A foundry is a commercial establishment for producing castings.

Numerous methods have been developed through the ages for reducing metal castings but the oldest method is that of making sand castings in the foundry. Primarily, work consists of melting metal in a furnace and pouring it into suitable sand molds where it solidifies and assumes the shape of the mold.

Most castings serve as details or component parts of complex machines and products. In most cases they are used only when they are machined and finished to specified manufacturing tolerances providing easy and proper assembly of the product.

At present the foundry industry is going through a process of rapid transformation, owing to modern development of new technological methods, new machines and new materials. Because of the fact that casting methods have advanced rapidly owing to the general mechanical progress of recent years there is today no comparison between the quality of castings, the complexity of the patterns produced and the speed of manufacture with the work of a few years ago.

Language Study

1. Write out the English words and word combinations for the defying the main processes in the casting from the 1st paragraph of the Text A.

Процесс		Место протекания	
1 . production of metal castings	производство металлических отливок	in the foundry	в литейном цехе
2. melting the metal			
3. pouring		into the mold	
4.	затвердение металла		

2. Find the English equivalents in the text:

Быстро развиваться, обрабатывать механически, качественные отливки, правильная сборка, до установленных допусков, служить деталями, сложные модели, обрабатывать начисто.

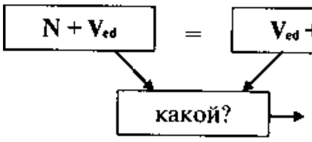
3. Translate the words paying attention to the "wrong friends of translator". Check their meanings according to the dictionary:

Basic process, metal object, **commercial** establishment, numerous methods, to serve as details and component parts, **complex** machines and products, proper **assembly**, rapid transformation, technological methods, **general** mechanical progress.

4. Find the pairs of words with close meanings:

to define, to progress, nowadays, proper, parts, to produce, quick, details, to advance, to manufacture, rapid, to determine, suitable, at present

5. a) Study the scheme with Participle II:



переводится русским причастием на *–ный, -тый,-мый*

b) Translate the next word combinations:

1. ...a metal object *obtained by*... 2. ...the *poured* mold... 3. ...*machined and finished* castings... 4. ...*specified* tolerances... 5. ...the complexity of patterns *produced*...

c) Compare the next patterns with Participle I and II:

1. developed methods — developing methods
2. solidified castings — solidifying castings
3. melted (molten) cast iron — melting cast iron
4. machined parts — machining parts

TEXT STUDY

1. Finish the sentences by choosing the necessary part:

1. A foundry is a commercial establishment for...
2. A casting is a metal object obtained by...
3. The shape of the casting is determined by...
4. Sand casting production is ...
5. This method consists of...
6. Then the metal solidifies and assumes...
7. Most castings serve as details or component parts of...
8. But at first they are machined and finished to...

a) the shape of the mold cavity,
b) one of the oldest methods for producing metal castings,
c) the shape of the sand mold.
d) allowing molten metal to solidify in a mold.
e) complex machines and products.
f) producing castings,
g) specified tolerances.
h) melting metal in a furnace and pouring it into sand molds.

2. Read the text and write in a sentence the main point of it:

How a Casting Is Made

The process of making an iron casting can simply be described as the pouring of hot liquid or molten iron into a mold of a desired shape. Molten iron is poured from the ladles (ковш) into the sand molds. The iron travels along a series of passageways (зд. отверстие) in the molds to the cavities. It then falls from the bottom to top. The iron in the molds is allowed to cool for some time and the casting solidifies and hardens (отверждаться). At this time the casting is separated from the mold and the raw (зд. необработанный) casting is born.

Then the casting undergoes cleaning and checking before final processing.

TASKS

Answer the questions:

1.What is a foundry? 2. What is a casting? 3. Is the shape of the casting determined by the shape of the mold cavity? 4. What basic processes does sand casting production consist of? 5. Where is the metal melted? 6. In what molds is it poured then? 7. Does the metal assume the shape of the mold? 8. Can most castings be used as parts of machines immediately following their solidification? 9. What operations should a casting be subjected to?

Read the text and find the next information in it:

-casting methods of choice;

-the technology of making metal castings of forming a cavity in sand

-advantages and disadvantages of sand casting

Sand Casting

Selection of a casting method depends primarily upon: 1) quantity of parts, 2) size of the part, 3) tolerances and finish, 4) physical characteristics, 5) part configuration, 6) the metal to be cast.

The oldest commercial method of making metal castings consists of forming a cavity in sand and filling the cavity with molten metal. After the metal solidifies, the sand is broken away, and the casting is removed, trimmed, and cleaned.

Sand molds are made in two or more sections: bottom (drag), top (cope), and intermediate sections (cheeks) when required. Joints between sections are the parting lines. The sand is contained in flasks, made of metal or sometimes wood.

Molten metal is poured into the sprue, and connecting runners conduct the metal to the casting cavity. Riser cavities in the cope sand over heavy sections of the casting serve as metal reservoirs. They fill with molten metal as the cavity is filled and, as the casting solidifies and shrinks, the risers feed molten metal to the heavy, slowly solidifying sections, thus minimizing porosity in the part. Slag floats to the top of the risers and thus is not incorporated into the casting. Sprue, runner, and risers are trimmed from the casting after it is removed from the sand.

Cores are hard shapes of sand placed in the mold to produce hollow castings. Patterns of wood or metal are used to prepare the mold.

Extremely large or heavy castings are made by floor molding. Here, the mold is made in the floor of the foundry using the earth as the flask. Advantages and disadvantages: Sand casting offers the least expensive method for producing general-purpose castings. Pattern equipment is relatively inexpensive and long lasting.

Sand castings are more subject to human control than parts made by other casting processes. More material must be left on a sand casting to permit machining for a finished surface. Thin sections cannot be cast (1/3 in is generally considered a practical minimum).

bottom = drag – нижняя полуформа
top = **cope** - верхняя полуформа
intermediate sections = cheeks runner – щечки (промежуточные секции)
parting line – линии разъема
flask - опока
sprue – стояк

runner – литниковый ход (канал)
to conduct – зд. подводить
riser – прибыль (отливки)
to shrink – давать усадку
to float - всплывать
to trim - обрубать

Fill in the next tables:

Часть литниковой системы		Назначение	
англ.	русск.	англ.	русск.
1. sprue			
2. runner			
3. riser			

Вид литейного оборудования		Материал		Назначение	
англ.	русск.	англ.	русск.	англ.	русск.
1. mold					
2. flask					
3. core					
4. pattern					

Active Vocabulary

Область применения	Существительные и сочетания	Глаголы	Прилагательные	Коннекторы
1. Место изготовления отливок	**foundry**			
2. Оборудование и продукция литейного производства	**(sand) casting** **mold** **mold cavity furnace** **pattern**			**owing to** **because of**
3. Технологические процессы		**to melt** **to pour** **to solidify** **to form** **to machine** **to finish**		**in case** **in most cases**
4. Характеристика и результат технологического процесса	**tolerance** **quality** **shape**		**molten suitable** **proper** **rapid complex** **easy**	
5. Классификация, спецификация изделий, процессов		**to define to determine** **to specify**		

UNIT 2 FORGING

THEORY

Forging is a manufacturing process involving the shaping of metal using localized compressive forces. Forging is often classified according to the temperature at which it is performed: "cold", "warm", or "hot" forging. Forged parts can range in weight from less than a kilogram to 580 metric tons. Forged parts usually require further processing to achieve a finished part. Today, forging is a major world-wide industry that has significantly contributed to the development of the manufacturing cycles.

History

Forging is one of the oldest known metalworking processes. Traditionally, forging was performed by a smith using hammer and anvil, though introducing water power to the production and working of iron in the 12th century drove the hammer and anvil into obsolescence. The smithy or forge has evolved over centuries to become a facility with engineered processes, production equipment, tooling, raw materials and products to meet the demands of modern industry. In modern times, industrial forging is done either with presses or with hammers powered by compressed air, electricity, hydraulics or steam. These hammers may have reciprocating weights in the thousands of pounds. Smaller power hammers, 500 lb (230 kg) or less reciprocating weight, and hydraulic presses are common in art smithies as well. Some steam hammers remain in use, but they became obsolete with the availability of the other, more convenient, power sources.

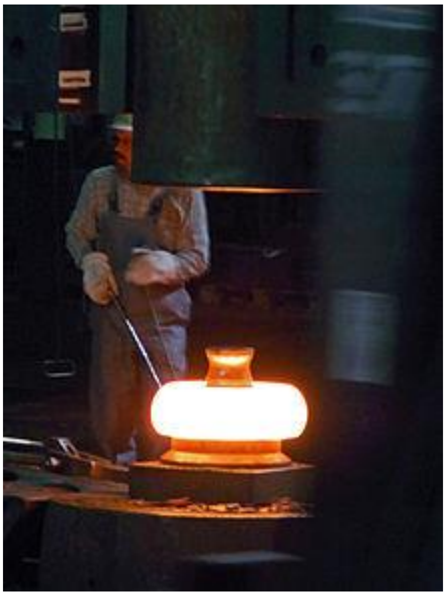
Advantages and disadvantages

Forging can produce a piece that is stronger than an equivalent cast or machined part. As the metal is shaped during the forging process, its internal grain deforms to follow the general shape of the part. As a result, the grain is continuous throughout the part, giving rise to a piece with improved strength characteristics.

Some metals may be forged cold, but iron and steel are almost always hot forged. Hot forging prevents the work hardening that would result from cold forging, which would increase the difficulty of performing secondary machining operations on the piece. Also, while work hardening may be desirable in some circumstances, other methods of hardening the piece, such as heat treating, are generally more economical and more controllable. Alloys that are amenable to precipitation hardening, such as most aluminium alloys and titanium, can be hot forged, followed by hardening.

Production forging involves significant capital expenditure for machinery, tooling, facilities and personnel. In the case of hot forging, a high-temperature furnace (sometimes referred to as the forge) is required to heat ingots or billets. Owing to the massiveness of large forging hammers and presses and the parts they can produce, as well as the dangers inherent in working with hot metal, a special building is frequently required to house the operation. In the case of drop forging operations, provisions must be made to absorb the shock and vibration generated by the hammer. Most forging operations use metal-forming dies, which must be precisely machined and carefully heat-treated to correctly shape the workpiece, as well as to withstand the tremendous forces involved.

Processes



There are many different kinds of forging processes available, however they can be grouped into three main classes

- Drawn out: length increases, cross-section decreases
- Upset: length decreases, cross-section increases
- Squeezed in closed compression dies: produces multidirectional flow

Common forging processes include: roll forging, swaging, cogging, open-die forging, impression-die forging, press forging, automatic hot forging and upsetting.

Temperature

All of the following forging processes can be performed at various temperatures, however they are generally classified by whether the metal temperature is above or below the recrystallization temperature. If the temperature is above the material's recrystallization temperature it is deemed *hot forging*; if the temperature is below the material's recrystallization temperature but above 30% of the recrystallization temperature (on an absolute scale) it is deemed *warm forging*; if below 30% of the recrystallization temperature (usually room temperature) then it is deemed *cold forging*. The main advantage of hot forging is that as the metal is deformed work hardening effects are negated by the recrystallization process. Cold forging typically results in work hardening of the piece.

Drop forging

Drop forging is a forging process where a hammer is raised and then "dropped" onto the workpiece to deform it according to the shape of the die. There are two types of drop forging: *open-die drop forging* and *closed-die drop forging*. As the names imply, the difference is in the shape of the die, with the former not fully enclosing the workpiece, while the latter does.

Open-die drop forging

Open-die drop forging (with two dies) of an ingot to be further processed into a wheel

Open-die forging is also known as *smith forging*. In open-die forging, a hammer strikes and deforms the workpiece, which is placed on a stationary anvil. Open-die forging gets its name from the fact that the dies (the surfaces that are in contact with the workpiece) do not enclose the workpiece, allowing it to flow except where contacted by the dies. Therefore the operator, or a robot, needs to orient and position the workpiece to get the desired shape. The dies are usually flat in shape, but some have a specially shaped surface for specialized operations. For example, a die may have a round, concave, or convex surface or be a tool to form holes or be a cut-off tool. Open die forgings can be worked into shapes which include discs, hubs, blocks, shafts (including step shafts or with flanges), sleeves, cylinders, flats, hexes, rounds, plate, and some custom shapes. Open-die forging lends itself to short runs and is appropriate for art smithing and custom work. In some cases, open-die forging may be employed to rough-shape ingots to prepare them for subsequent operations. Open-die forging may also orient the grain to increase strength in the required direction.

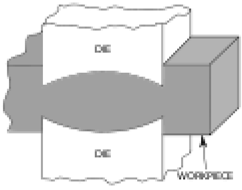
Advantages of Open-Die Forging

- Reduced chance of voids
- Better fatigue resistance
- Improved microstructure

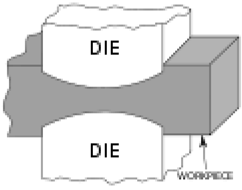
- Continuous grain flow
- Finer grain size

Greater strength *Cogging* is successive deformation of a bar along its length using an open-die drop forge. It is commonly used to work a piece of raw material to the proper thickness. Once the proper thickness is achieved the proper width is achieved via *edging*. *Edging* is the process of concentrating material using a concave shaped open die. The process is called edging because it is usually carried out on the ends of the workpiece. *Fullering* is a similar process that thins out sections of the forging using a convex shaped die. These processes prepare the workpieces for further forging processes.

Edging



Fullering



A cross-section of a forged connecting rod that has been etched to show the grain flow

Impression-die forging

Impression-die forging is also called closed-die forging. In impression-die forging, the metal is placed in a die resembling a mold, which is attached to the anvil. Usually, the hammer die is shaped as well. The hammer is then dropped on the workpiece, causing the metal to flow and fill the die cavities. The hammer is generally in contact with the workpiece on the scale of milliseconds. Depending on the size and complexity of the part, the hammer may be dropped multiple times in quick succession. Excess metal is squeezed out of the die cavities, forming what is referred to as *flash*. The flash cools more rapidly than the rest of the material; this cool metal is stronger than the metal in the die, so it helps prevent more flash from forming. This also forces the metal to completely fill the die cavity. After forging, the flash is removed. In commercial impression-die forging, the workpiece is usually moved through a series of cavities in a die to get from an ingot to the final form. The first impression is used to distribute the metal into the rough shape in accordance to the needs of later cavities; this impression is called an *edging*, *fullering*, or *bending* impression. The following cavities are called *blocking* cavities, in which the piece is working into a shape that more closely resembles the final product. These stages usually impart the workpiece with generous bends and large fillets. The final shape is forged in a *final* or *finisher* impression cavity. If there is only a short run of parts to be done, then it may be more economical for the die to lack a final impression cavity and instead machine the final features. Impression-die forging has been improved in recent years through increased automation which includes induction heating, mechanical feeding, positioning and manipulation, and the direct heat treatment of parts after forging. One variation of impression-die forging is called *flashless forging*, or *true closed-die forging*. In this type of forging, the die cavities are completely closed, which keeps the workpiece from forming flash. The major advantage to this process is that less metal is lost to flash. Flash can account for 20 to 45% of the starting material. The disadvantages of this process include additional cost due to a more complex die design and the need for better lubrication and workpiece placement.

There are other variations of part formation that integrate impression-die forging. One method incorporates casting a forging *preform* from liquid metal. The casting is removed after it has solidified, but while still hot. It is then finished in a single cavity die. The flash is trimmed, then the part is quench hardened. Another variation follows the same process as outlined above, except the preform is produced by the spraying deposition of metal droplets into shaped collectors (similar to the Osprey process).

Closed-die forging has a high initial cost due to the creation of dies and required design work to make working die cavities. However, it has low recurring costs for each part, thus forgings become more economical with more volume. This is one of the major reasons closed-die forgings are often used in the automotive and tool industry. Another reason forgings are common in these industrial sectors is that forgings generally have about a 20 percent higher strength-to-weight ratio compared to cast or machined parts of the same material.

Design of impression-die forgings and tooling

Forging dies are usually made of high-alloy or tool steel. Dies must be impact resistant, wear resistant, maintain strength at high temperatures, and have the ability to withstand cycles of rapid heating and cooling. In order to produce a better, more economical die the following rules should be followed. The dies should part along a single, flat plane if at all possible. If not, the parting plane should follow the contour of the part.

- The parting surface should be a plane through the center of the forging and not near an upper or lower edge.
- Adequate draft should be provided; a good guideline is at least 3° for aluminum and 5° to 7° for steel.
- Generous fillets and radii should be used.
- Ribs should be low and wide.
- The various sections should be balanced to avoid extreme difference in metal flow.
- Full advantage should be taken of fiber flow lines.
- Dimensional tolerances should not be closer than necessary.

The dimensional tolerances of a steel part produced using the impression-die forging method are outlined in the table below. The dimensions across the parting plane are affected by the closure of the dies, and are therefore dependent on die wear and the thickness of the final flash. Dimensions that are completely contained within a single die segment or half can be maintained at a significantly greater level of accuracy.

Dimensional tolerances for impression-die forgings

Mass [kg (lb)]	Minus tolerance [mm (in)]	Plus tolerance [mm (in)]
0.45 (1)	0.15 (0.006)	0.46 (0.018)
0.91 (2)	0.20 (0.008)	0.61 (0.024)
2.27 (5)	0.25 (0.010)	0.76 (0.030)
4.54 (10)	0.28 (0.011)	0.84 (0.033)

9.07 (20)	0.33 (0.013)	0.99 (0.039)
22.68 (50)	0.48 (0.019)	1.45 (0.057)
45.36 (100)	0.74 (0.029)	2.21 (0.087)

A lubricant is used when forging to reduce friction and wear. It is also used as a thermal barrier to restrict heat transfer from the workpiece to the die. Finally, the lubricant acts as a parting compound to prevent the part from sticking in the dies.

Press forging

Press forging works by slowly applying a continuous pressure or force, which differs from the near-instantaneous impact of drop-hammer forging. The amount of time the dies are in contact with the workpiece is measured in seconds (as compared to the milliseconds of drop-hammer forges). The press forging operation can be done either cold or hot. The main advantage of press forging, as compared to drop-hammer forging, is its ability to deform the complete workpiece. Drop-hammer forging usually only deforms the surfaces of the work piece in contact with the hammer and anvil; the interior of the workpiece will stay relatively undeformed. Another advantage to the process includes the knowledge of the new part's strain rate. We specifically know what kind of strain can be put on the part, because the compression rate of the press forging operation is controlled.

There are a few disadvantages to this process, most stemming from the workpiece being in contact with the dies for such an extended period of time. The operation is a time-consuming process due to the amount and length of steps. The workpiece will cool faster because the dies are in contact with workpiece; the dies facilitate drastically more heat transfer than the surrounding atmosphere. As the workpiece cools it becomes stronger and less ductile, which may induce cracking if deformation continues. Therefore heated dies are usually used to reduce heat loss, promote surface flow, and enable the production of finer details and closer tolerances. The workpiece may also need to be reheated.

When done in high productivity, press forging is more economical than hammer forging. The operation also creates closer tolerances. In hammer forging a lot of the work is absorbed by the machinery, when in press forging, the greater percentage of work is used in the work piece. Another advantage is that the operation can be used to create any size part because there is no limit to the size of the press forging machine. New press forging techniques have been able to create a higher degree of mechanical and orientation integrity. By the constraint of oxidation to the outer layers of the part, reduced levels of microcracking occur in the finished part. Press forging can be used to perform all types of forging, including open-die and impression-die forging. Impression-die press forging usually requires less draft than drop forging and has better dimensional accuracy. Also, press forgings can often be done in one closing of the dies, allowing for easy automation.

Upset forging

Upset forging increases the diameter of the workpiece by compressing its length. Based on number of pieces produced, this is the most widely used forging process. A few examples of common parts produced using the upset forging process are engine valves, couplings, bolts, screws, and other fasteners.

Upset forging is usually done in special high-speed machines called *crank presses*, but upsetting can also be done in a vertical crank press or a hydraulic press. The machines are usually set up to work in the horizontal plane, to facilitate the quick exchange of workpieces from one station to the next. The initial workpiece is usually wire or rod, but some machines can accept bars up to 25 cm (9.8 in) in diameter and a capacity of over 1000 tons. The standard upsetting machine employs split dies that contain multiple cavities. The dies open enough to allow the workpiece to move from one cavity to the next; the dies then close and the heading tool, or ram, then moves longitudinally against the bar, upsetting it into the cavity. If all of the cavities are utilized on every cycle, then a finished part will be produced with every cycle, which makes this process advantageous for mass production.

These rules must be followed when designing parts to be upset forged: The length of unsupported metal that can be upset in one blow without injurious buckling should be limited to three times the diameter of the bar.

- Lengths of stock greater than three times the diameter may be upset successfully, provided that the diameter of the upset is not more than 1.5 times the diameter of the stock.
- In an upset requiring stock length greater than three times the diameter of the stock, and where the diameter of the cavity is not more than 1.5 times the diameter of the stock, the length of unsupported metal beyond the face of the die must not exceed the diameter of the bar.

Automatic hot forging

The automatic hot forging process involves feeding mill-length steel bars (typically 7 m (23 ft) long) into one end of the machine at room temperature and hot forged products emerge from the other end. This all occurs rapidly; small parts can be made at a rate of 180 parts per minute (ppm) and larger can be made at a rate of 90 ppm. The parts can be solid or hollow, round or symmetrical, up to 6 kg (13 lb), and up to 18 cm (7.1 in) in diameter. The main advantages to this process are its high output rate and ability to accept low-cost materials. Little labor is required to operate the machinery.

There is no flash produced so material savings are between 20 and 30% over conventional forging. The final product is a consistent 1,050 °C (1,920 °F) so air cooling will result in a part that is still easily machinable (the advantage being the lack of annealing required after forging). Tolerances are usually ±0.3 mm (0.012 in), surfaces are clean, and draft angles are 0.5 to 1°. Tool life is nearly double that of conventional forging because contact times are on the order of 0.06 second. The downside is that this process is only feasible on smaller symmetric parts and cost; the initial investment can be over $10 million, so large quantities are required to justify this process. The process starts by heating the bar to 1,200 to 1,300 °C (2,190 to 2,370 °F) in less than 60 seconds using high-power induction coils. It is then descaled with rollers, sheared into blanks, and transferred through several successive forming stages, during which it is upset, preformed, final forged, and pierced (if necessary). This process can also be coupled with high-speed cold-forming operations. Generally, the cold forming operation will do the finishing stage so that the advantages of cold-working can be obtained, while maintaining the high speed of automatic hot forging. Examples of parts made by this process are: wheel hub unit bearings, transmission gears, tapered roller bearing races, stainless steel coupling flanges, and neck rings for LP gas cylinders. Manual transmission gears are an example of automatic hot forging used in conjunction with cold working.

Roll forging

Roll forging is a process where round or flat bar stock is reduced in thickness and increased in length. Roll forging is performed using two cylindrical or semi-cylindrical rolls, each containing one or more shaped grooves. A heated bar is inserted into the rolls and when it hits a stop the rolls rotate and the bar is progressively shaped as it is rolled through the machine. The piece is then transferred to the next set of grooves or turned around and reinserted into the same grooves. This continues until the desired shape and size is achieved. The advantage of this process is there is no flash and it imparts a favorable grain structure into the workpiece.

Examples of products produced using this method include axles, tapered levers and leaf springs.

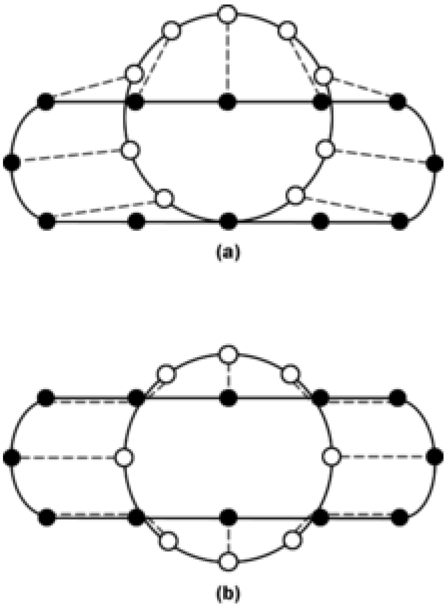
Net-shape and near-net-shape forging

This process is also known as *precision forging*. It was developed to minimize cost and waste associated with post-forging operations. Therefore, the final product from a precision forging needs little or no final machining. Cost savings are gained from the use of less material, and thus less scrap, the overall decrease in energy used, and the reduction or elimination of machining. Precision forging also requires less of a draft, 1° to 0°. The downside of this process is its cost, therefore it is only implemented if significant cost reduction can be achieved.

Cost implications

To achieve a low-cost net shape forging for demanding applications that are subject to a high degree of scrutiny, i.e. non-destructive testing by way of a dye-penetrant inspection technique, it is crucial that basic forging process disciplines be implemented. If the basic disciplines are not met, subsequent material removal operations will likely be necessary to remove material defects found at non-destructive testing inspection. Hence low-cost parts will not be achievable.

Example disciplines are: die-lubricant management (Use of uncontaminated and homogeneous mixtures, amount and placement of lubricant). Tight control of die temperatures and surface finish / friction.



(a) Material flow of a conventionally forged disc;

(b) Material flow of an impactor forged disc

Induction forging

Unlike the above processes, induction forging is based on the type of heating style used. Many of the above processes can be used in conjunction with this heating method.

Equipment

Hydraulic drop-hammer

The most common type of forging equipment is the hammer and anvil. Principles behind the hammer and anvil are still used today in *drop-hammer* equipment. The principle behind the machine is simple: raise the hammer and drop it or propel it into the workpiece, which rests on the anvil. The main variations between drop-hammers are in the way the hammer is powered; the most common being air and steam hammers. Drop-hammers usually operate in a vertical position. The main reason for this is excess energy (energy that isn't used to deform the workpiece) that isn't released as heat or sound needs to be transmitted to the foundation. Moreover, a large machine base is needed to absorb the impacts. To overcome some shortcomings of the drop-hammer, the *counterblow machine* or *impactor* is used. In a counterblow machine both the hammer and anvil move and the workpiece is held between them. Here excess energy becomes recoil. This allows the machine to work horizontally and have a smaller base. Other advantages include less noise, heat and vibration. It also produces a distinctly different flow pattern. Both of these machines can be used for open-die or closed-die forging.

Forging presses

A *forging press*, often just called a press, is used for press forging. There are two main types: mechanical and hydraulic presses. Mechanical presses function by using cams, cranks and/or toggles to produce a preset (a predetermined force at a certain location in the stroke) and reproducible stroke. Due to the nature of this type of system, different forces are available at different stroke positions. Mechanical presses are faster than their hydraulic counterparts (up to 50 strokes per minute). Their capacities range from 3 to 160 MN (300 to 18,000 short tons-force). Hydraulic presses use fluid pressure and a piston to generate force. The advantages of a hydraulic press over a mechanical press are its flexibility and greater capacity. The disadvantages include a slower, larger, and costlier machine to operate. The roll forging, upsetting, and automatic hot forging processes all use specialized machinery.

List of large forging presses, by ingot size

Force (tonnes)	**Ingot size (tonnes)**	**Company**	**Location**
16,000	600	China National Erzhong Group	Deyang, China
14,000	600	Japan Steel Works	Japan
15,000	580	China First Heavy Industries Group	Heilongjiang, China
13,000		Doosan	South Korea

List of large forging presses, by force

Force (tonnes)	**Force (tons)**	**Ingot size (tonnes)**	**Company**	**Location**
80,000	*(88,200)*	>150	China Erzhong	Deyang, China

75,000	*(82,690)*		VSMPO-AVISMA	Russia
65,000	*(71,660)*		Aubert & Duval	Issoire, France
(45,350)	50,000	20	Alcoa, Wyman Gordon	USA
40,000	*(44,100)*		Aubert & Duval	Pamiers, France
30,000	*(33,080)*	8	Wyman Gordon	Livingston, Scotland
30,000	*(33,070)*		Weber Metals, Inc.	California, USA
30,000	*(30,108)*		Firth Rixson	Georgia, USA

PRACTICAL TASKS

Read the Text B. What does the process of forging mean?

TEXT B. **THE FUNDAMENTALS OF FORGING**

Forging is the oldest known metalworking process. It is believed to have begun when early man discovered he could beat pieces of ore into useful shapes. History tells us that forging was widely practiced at the time when written records first appeared.

The blacksmith was one of the first to realize thee advantages of forging. Although he did not know why, he knew that hammering a piece of hot metal not only resulted in a usable shape, it improved its strength. It is this inherent improvement in strength of metal that has placed forgings in the most highly stressed applications in machines.

To understand why forging improves the mechanical properties of metal, it is important to recognize that metal is made up of grains. Each grain is an individual crystal, and when the grains are large, cracks can occur and propagate along the grain boundaries. Therefore, it is desirable to minimize the grain size in metal.

Reducing the metal’s grain size is one of the things forging does so well. Forging breaks down a coarse-grained structure producing a chemically homogeneous wrought structure with much smaller grains by controlled plastic deformation. In forging controlled plastic deformation whether at elevated temperature or cold (at room temperature) results in greater metallurgical soundness and improved mechanical properties of the metal.

Metal shaping by controlled plastic deformation is the basis for all forging operations. Because of the diversity of forging end-use applications, however, a wide range of processes and equipment have been developed to produce forging. Some processes are ideally suited to make large parts, others, small parts, and still others, rings. Modern forging is not only carried out in virtually all metals, it is done at temperatures

ranging from more than 2500°F to room temperature. Part configuration generally determines the forging method chosen.

To fill in the scheme:

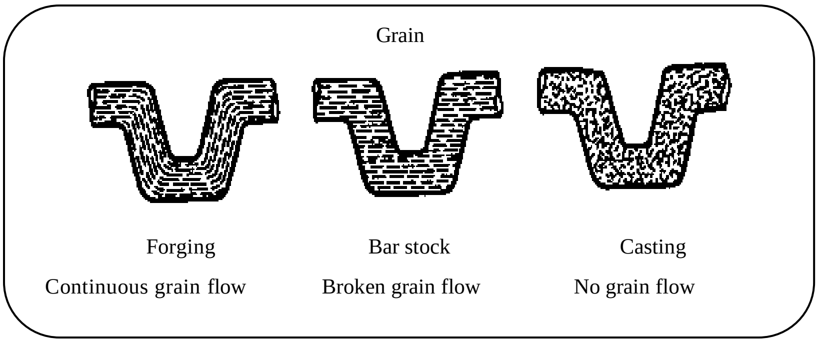
I. Определение процесса ковки

II. Наиболее важная характеристика процесса ковки

III. Вывод о необходимости уменьшения размера зерна кристаллической решетки металла

IV. Результат пластической деформации при ковке

V. Вывод о важности процесса пластической деформации



Representation of grain flow in a forging (above left), machined bar stock (above center) and casting (above right).

Read the Text 4 and determine what method of plastic deformation gives such a grain flow:

In forging, controlled plastic deformation, whether at elevated temperature or cold (at room temperature) results in greater metallurgical soundness and improved mechanical properties of the metal. Most forging grade metal is pre-worked to remove defects. This pre-working results in directional alignment of grain flow, which when properly forged, produces directional properties in strength, ductility and resistance to impact. The figure below shows the continuous grain flow in a forged crankshaft, the broken grain flow of a crankshaft machined from bar stock, and the complete absence of grain flow in a casting. Continuous grain flow around the part shape is most desirable. Since bar stock and plate have unidirectional grain flow, any change in contour from machining will cut flow lines, exposing grain ends and leaving the metal sensitive to stress corrosion and fatigue failure. Most castings have no grain flow or directional strength.

The increased emphasis on optimizing the efficiency of all kinds of consumer and industrial products has increased the service requirements for mechanical parts. Forging makes metal parts stronger than other metalworking methods. Thus forging has become more than just a way of making metal parts, it has become an indispensable method of making high strength metal components. To the designer, the structural integrity of forgings means realistic safety factors based on materials that will respond predictably to the environment without costly special processing.

Since virtually all metals can be forged, the range of physical and mechanical properties available from forged products spans the entire 'spectrum of ferrous and non-ferrous metallurgy. Whether a designer is looking for impact strength, corrosion resistance, high tensile strength, or long fatigue life, there is an alloy appropriate to the application that can be forged.

to result in – приводить к, давать в результате

metallurgical soundness – структура металла

improved - улучшенные

grain flow – направление волокон

cross-section – поперечное сечение

absence - отсутствие

bar stock – заготовка в виде прутка

plate – заготовка в виде плиты

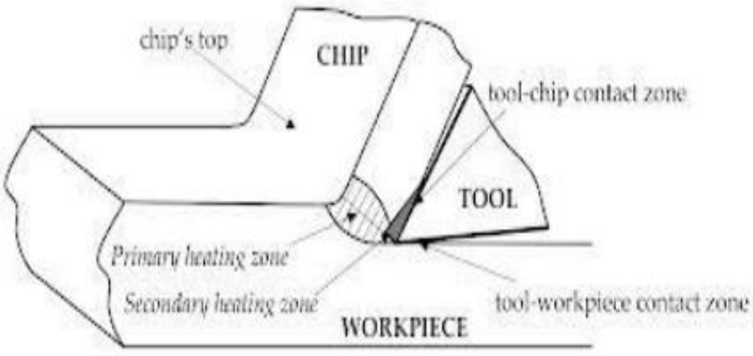
Explain the saying:

Forging makes metal parts stronger than other metalworking methods.

THEORY

Machining: Term applied to all material-removal processes. Metal cutting: The process in which a thin layer of excess metal (chip) is removed by a wedge-shaped single-point or multipoint cutting tool with defined geometry from a work piece, through a process of extensive plastic deformation.
Metal cutting: The process in which a thin layer of excess metal (chip) is removed by a wedge-shaped single-point or multipoint cutting tool with defined geometry from a work piece, through a process of extensive plastic deformation

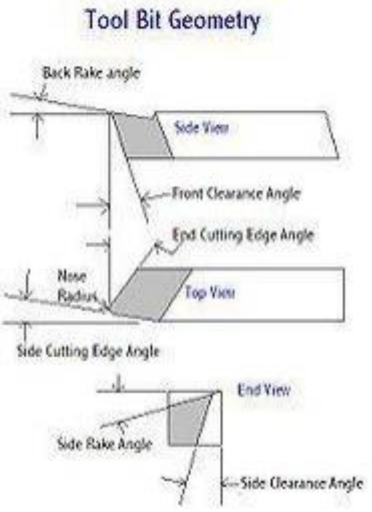
MECHANICS OF CHIP FORMATION



The cutting itself is a process of extensive plastic deformation to form a chip that is removed afterward. The basic mechanism of chip formation is essentially the same for all machining operations. Assuming that the cutting action is continuous, we can develop so-called continuous model of cutting process. The cutting model shown above is oversimplified. In reality, chip formation occurs not in a plane but in so-called primary and secondary shear zones, the first one between the cut and chip, and the second one along the cutting tool face.

Single-point cutting tool, As distinguished from other cutting tools such as a The cutting edge is ground to suit a particular machining operation and may be re sharpened or reshaped as needed. The ground tool bit is held rigidly by a tool holder while it is cutting.

Back Rake is to help control the direction of the chip, which naturally curves into the work due to the difference in length from the outer and inner parts of the cut. It also helps counteract the pressure against the tool from the work by pulling the tool into the work.



Side Rake along with back rake controls the chip flow and partly counteracts the resistance of the work to the movement of the cutter and can be optimized to suit the particular material being cut. Brass for example requires a back and side rake of 0 degrees while aluminum uses a back rake of 35 degrees and a side rake of 15 degrees. Nose Radius makes the finish of the cut smoother as it can overlap the previous cut and eliminate the peaks and valleys that a pointed tool produces. Having a radius also strengthens the tip, a sharp point being quite fragile.

All the other angles are for clearance in order that no part of the tool besides the actual cutting edge can touch the work. The front clearance angle is usually 8 degrees while the side clearance angle is 10-15 degrees and partly depends on the rate of feed expected. Minimum angles which do the job required are advisable because the tool gets weaker as the edge gets keener due to the lessening support behind the edge and the reduced ability to absorb heat generated by cutting. The Rake angles on the top of the tool need not be precise in order to cut but to cut efficiently there will be an optimum angle for back and side rake.

Cutting tool materials. **Requirements**. The cutting tool materials must possess a number of important properties to avoid excessive wear, fracture failure and high temperatures in cutting, the following characteristics are essential for cutting materials to withstand the heavy conditions of the cutting process and to produce high quality and economical parts:

Hardness at elevated temperatures (so-called hot hardness) so that hardness and strength of the tool edge are maintained in high cutting temperatures:

Toughness: ability of the material to absorb energy without failing. Cutting if often accompanied by impact forces especially if cutting is interrupted, and cutting tool may fail very soon if it is not strong enough.

Wear resistance: although there is a strong correlation between hot hardness and wear resistance, later depends on more than just hot hardness. Other important characteristics include surface finish on the tool, chemical inertness of the tool material with respect to the work material, and thermal conductivity of the tool material, which affects the maximum value of the cutting temperature at tool-chip interface.

Cutting tool materials

Carbon Steels. It is the oldest of tool material. The carbon content is 0.6~1.5% with small quantities of silicon, Chromium, manganese, and vanadium to refine grain size. Maximum hardness is about HRC 62. This material has low wear resistance and low hot hardness. The use of these materials now is very limited.

High-speed steel (HSS). First produced in 1900s. They are highly alloyed with vanadium, cobalt, molybdenum, tungsten and Chromium added to increase hot hardness and wear resistance. Can be hardened to various depths by appropriate heat treating up to cold hardness in the range of HRC 63-65. The cobalt component give the material a hot hardness value much greater than carbon steels. The high toughness and good wear resistance make HSS suitable for all type of cutting tools with complex shapes for relatively low to medium cutting speeds. The most widely used tool material today for taps, drills, reamers, gear tools, end cutters, slitting, broaches, etc.

Cemented Carbides. Introduced in the 1930s. These are the most important tool materials today because of their high hot hardness and wear resistance. The main disadvantage of cemented carbides is their low toughness. These materials are produced by powder metallurgy methods, sintering grains of tungsten carbide (WC) in a cobalt (Co) matrix (it provides toughness). There may be other carbides in the mixture, such as titanium carbide (TiC) and/or tantalum carbide (TaC) in addition to WC.

Ceramics. Ceramic materials are composed primarily of fine-grained, high-purity aluminum oxide (Al2O3), pressed and sintered with no binder. Two types are available: white, or cold-pressed ceramics, which consists of only Al2O3 cold pressed into inserts and sintered at high temperature. Black, or hot-pressed ceramics, commonly known as cermets (from ceramics and metal). This material consists of 70% Al2O3 and 30% TiC. Both materials have very high wear resistance but low toughness; therefore they are suitable only for continuous operations such as finishing turning of cast iron and steel at very high speeds. There is no occurrence of built-up edge, and coolants are not required.

Cubic boron nitride (CBN) and synthetic diamonds**.** Diamond is the hardest substance ever known of all materials. It is used as a coating material in its polycrystalline form, or as a single-crystal diamond tool for special applications, such as mirror finishing of non-ferrous materials. Next to diamond, CBN is the hardest tool material. CBN is used mainly as coating material because it is very brittle. In spite of diamond, CBN is suitable for cutting ferrous materials.

Cutting fluids. Cutting fluid (coolant) is any liquid or gas that is applied to the chip and/or cutting tool to improve cutting performance. A very few cutting operations are performed dry, i.e., without the application of cutting fluids. Generally, it is essential that cutting fluids be applied to all machining operations. Cutting fluids serve three principle functions:

To remove heat in cutting: the effective cooling action of the cutting fluid depends on the method of application, type of the cutting fluid, the fluid flow rate and pressure. The most effective cooling is provided by mist application combined with flooding. Application of fluids to the tool flank, especially under pressure, ensures better cooling that typical application to the chip but is less convenient.

To lubricate the chip-tool interface: cutting fluids penetrate the tool-chip interface improving lubrication between the chip and tool and reducing the friction forces and temperatures.

To wash away chips: this action is applicable to small, discontinuous chips only. Special devices are subsequently needed to separate chips from cutting fluids.

Methods of application

Manual application. Application of a fluid from a can manually by the operator. It is not acceptable even in job-shop situations except for tapping and some other operations where cutting speeds are very low and friction is a problem. In this case, cutting fluids are used as lubricants.

Flooding. In flooding, a steady stream of fluid is directed at the chip or tool-workpiece interface. Most machine tools are equipped with a recirculating system that incorporates filters for cleaning of cutting fluids. Cutting fluids are applied to the chip although better cooling is obtained by applying it to the flank face under pressure

Coolant-fed tooling. Some tools, especially drills for deep drilling, are provided with axial holes through the body of the tool so that the cutting fluid can be pumped directly to the tool cutting edge.

Mist applications. Fluid droplets suspended in air provide effective cooling by evaporation of the fluid. Mist application in general is not as effective as flooding but can deliver cutting fluid to inaccessible areas that cannot be reached by conventional flooding.

Types of cutting fluid

Cutting Oils.Cutting oils are cutting fluids based on mineral or fatty oil mixtures. Chemical additives like sulphur improve oil lubricant capabilities. Areas of application depend on the properties of the particular oil but commonly, cutting oils are used for heavy cutting operations on tough steels.

Soluble Oils. The most common, cheap and effective form of cutting fluids consisting of oil droplets suspended in water in a typical ratio water to oil 30:1. Emulsifying agents are also added to promote stability of emulsion. For heavy-duty work, extreme pressure additives are used. Oil emulsions are typically used for aluminum and cooper alloys.

Chemical fluids. These cutting fluids consist of chemical diluted in water. They possess good flushing and cooling abilities. Tend to form more stable emulsions but may have harmful effects to the skin.

Machinability. Machinability is a term indicating how the work material responds to the cutting process. In the most general case good machinability means that material is cut with good surface finish, long tool life, low force and power requirements, and low cost.

Machinability of different materials. Steels Leaded steels: lead acts as a solid lubricant in cutting to improve considerably machinability.

Resulphurized steels: sulphur forms inclusions that act as stress raisers in the chip formation zone thus increasing machinability.

Difficult-to-cut steels: a group of steels of low machinability, such as stainless steels, high manganese steels, precipitation-hardening steels.

Other metals. Aluminum: easy-to-cut material except for some cast aluminum alloys with silicon content that may be abrasive. Cast iron: gray cast iron is generally easy-to-cut material, but some modifications and alloys are abrasive or very hard and may cause various problems in cutting.

Cooper-based alloys: easy to machine metals. Bronzes are more difficult to machine than brass.

Selection of cutting conditions

For each machining operation, a proper set of cutting conditions must be selected during the process planning. Decision must be made about all three elements of cutting conditions,

- Depth of cut; - Fee; - Cutting speed

There are two types of machining operations: - Roughing operations: the primary objective of any roughing operation is to remove as much as possible material from the work piece for as short as possible machining time. In roughing operation, quality of machining is of a minor concern.

- Finishing operations: the purpose of a finishing operation is to achieve the final shape, dimensional precision, and surface finish of the machined part. Here, the quality is of major importance. Selection of cutting conditions is made with respect to the type of machining operation. Cutting conditions should be decided in the order depth of cut - feed - cutting speed.

PRACTICAL TASKS

Read the text A and find the next information:

- the classification of metal cutting machines;
- the technology of metal cutting;
- the operations are made on the metal cutting machines;
- the kinds of metal cutting products.

TEXT A. **METAL CUTTING**

Cutting is one of the oldest arts practiced in the stone age, but the cutting of metals was not found possible until the 18th century, and its detailed study started about a hundred years ago. Now in every machine-shop you may find many machines for working metal parts, these cutting machines are generally called machine-tools and are extensively used in many branches of engineering. Fundamentally all machine-tools remove metal and can be divided into the following categories:

1. Turning machines (lathes).
2. Drilling machines.
3. Boring machines.
4. Milling machines.
5. Grinding machines.

Machining of large-volume production parts is best accomplished by screw machines. These machines can do turning, threading, facing, boring and many other operations. Machining can produce symmetrical shapes with smooth surfaces and dimensional accuracies not generally attainable by most fabrication methods.

Screw-machined parts are made from bar stock or tubing fed intermittently and automatically through rapidly rotating hollow spindles. The cutting tools are held on turrets and tool slides convenient to the cutting locations. Operations are controlled by cams or linkages that position the work, feed the tools, hold them in position for the proper time, and then retract the tools. Finished pieces are automatically separated from the raw stock and dropped into a container.

Bushings, bearings, nuts, bolts, studs, shafts and many other simple and complex shapes are among the thousands of products produced on screw machines. Screw machining is also used to finish shapes produced by other forming and shaping processes.

Most materials and their alloys can be machined — some with ease, others with difficulty. Machinability involves three factors: 1. Ease of chip removal. 2. Ease of obtaining a good surface finish. 3. Ease of obtaining good tool life.

Language Study

1. Write out the names of metal cutting machines;

Fill in the next table by model:

Название станка		**Операция**	
1. lathe (turning machine)	**токарный станок**	**turning**	**обточка**
2.		**drilling**	
3.			**расточка**
4. grinding machine			
5.	**винторезный станок**		
6.		**milling**	
7. cutting machine			

2. Write out the words determined the screw-machined parts:

Название узлов, частей станка		**Назначение**	
1.			
2.			
3.			

3. Find the English equivalents to the next Russian words and word combinations:

Срок службы, прутковая заготовка, гладкая поверхность, размерная точность, снимать стружку, удобный (подходящий), массовое производство, достижимый, отделка поверхности

4. Translate the words paying attention to the "wrong friends of translator". Check their meanings according to the dictionary:

detailed study, **fundamentally,** *symmetrical* shapes, **generally, fabrication** *methods,* hollow *spindle,* cutting *location,* **to control** *operations, to position* the work, *to separate,* to drop into *a container,* to involve *a factor*

5. Find the pairs of words with close meanings:
to work, proper, to produce, convenient, location, to fabricate, to machine, position

6. Find the pairs of words with opposite meanings:

raw, simple, to feed, difficulty, complex, finished, ease, to retract

7. Translate the word combinations built by the next models: Ved (какой) + N, N + Ved (какой).
detailed study, screw-machined parts, finished pieces, products produced on screw machines, shapes produced by other processes

8. Determine what sentences are referred to the point of the text:

1. All machine-tools employed for removing metal are divided into five general categories. 2. Screw-machined parts can't be made from bar stock. 3. Cutting tools held on turrets and tool slides are used for machining metal parts. 4. The workpiece placed on the spindle doesn't rotate. 5. Cams and linkages designed for controlling cutting operations position the work, feed, hold in position and retract the tools. 6. Metal parts worked on machine-tools have smooth surfaces and high dimensional accuracies. 7. Finished parts are of symmetrical shapes.

TEXT STUDY

Finish the sentences by choosing the necessary part:

1. There are ...
2. They are...
3. These machine-tools can perform...
4. Finished parts possess...
5. A lot of simple and complex shapes...
6.Screw-machining is also used...
7.Most engineering materials can be machined...

a) symmetrical shapes, high dimensional accuracies and smooth surfaces.
b) for finishing operations.
c) five general categories of machine-tools.
d)can be produced on screw machines.
e) turning, milling, grinding, boring, etc. operations,
f) by machine-tools.
g) lathes, drilling, boring, milling and grinding machines.

TASKS

Answer the questions:

1. When did the study of metal cutting start? 2. What is the purpose of metal cutting? 3. What machines are called "machine-tools"? 4. List the general categories of machine-tools. 5. What is the function of the spindle? 6. Where are cutting tools held? 7. By what means are cutting operations controlled? 8. List products produced on screw machines. 9. What are the general advantages of machining over other fabrication methods?

Before reading the text B, look through the next new lexis of the text. Study them, please:

Tool edge – режущая кромка инструмента**, skin finish = surface finish, machining allowance** – припуск на обработку**, rigidity of setup** – жёсткость наладки **, rate of metal removal** – скорость резания**, nodular iron** – чугун с шаровидным графитом**, flake-graphite iron** – чугун с чешуйчатым графитом**, rather than** – а не… **, abrasive action** – истирающее воздействие**.**

Read the text and then tell:

- about the main factors of the edge of a cutting tool;

- how many factors are;

- what property of what material is there?

<u>TEXT B.</u> FACTORS AFFECTING MACHINABILITY

Machinability is generally assumed to be a function of fool edge life. The main factors which influence the behavior, and thus the life of the edge of a cutting tool, are:

-the mechanical characteristics of the material being machined, such as its strength, hardness and metallurgical structure;

-the state of the casting, involving the skin finish, critical dimensions, machining allowances, slag inclusions, the presence of scabs, rust, dirt, etc.;

-the nature of the machining techniques being used;

-the characteristics of the machine-tool being used, such as machine efficiency, available power, and the rigidity of the setup.

Other factors aside, it is primarily the structure of the metal which determines its resistance to the cutting action of the tool, i. e. the potential rate of metal removal, and the resulting abrasion on the tool, i. e. the life of the cutting edge.

Structure, strength and machinability are interrelated to some extent — in general, increased strength implies reduced machinability. This basic relationship must be understood, otherwise difficulties may be experienced in the machine shop if the designer has specified a material with a higher strength than is necessary. Nevertheless, care should be taken in rating machinability on the basis of strength. For example, nodular irons are normally considerably stronger than flake-graphite types, but are likely to he easier to machine. It is therefore recommended that structure, rather than strength, be adopted as the basis for machining practice.

Hardness provides a more reliable guide to machinability than does strength, for hardness depends mainly on the matrix structure of the casting. Again, however, the relation is of a general nature only, for it is possible to have a metal which exhibits a low hardness value, but which has a very abrasive action on the cutting tool. For example, the presence of hard phosphide particles embedded in a soft, ferritic matrix reduces tool life considerably.

TASKS

Answer the questions:

1. What are the main factors influencing the tool edge life? 2. Does the structure of the material influence machinability? In what way? 3. What does increased strength result in? 4. Why is hardness more reliable in determining machinability of a material than strength?

Read the Text 5 and make its outline:

Machine-Tools

These are the machines used in engineering to shape metals and other materials.

Before the machine age this work was done with hardened hand tools, in particular, the chisel and hammer.

It took a long time to obtain the necessary quality and accuracy. The metal was first given roughly its right shape by being either hammered when red hot or cast in a mold. Then the final shape was obtained by further hammering and by chiseling.

A great advance was made with the introduction of the file, a hardened steel tool, used to smooth the relatively rough surfaces left by the chisel.

Nowadays, these hand tools are normally used only for final fitting and adjustment of parts made on machine-tools.

The various complicated machine-tools now used by engineers are designed to do the same jobs as the hammer, the chisel and the file, but very much more quickly and efficiently, and with much wider range of application. The vastly increased production of modern times would never have been possible without these machines to take the place of hand work, nor could the hand-worker ever produce the precision now needed.

The machine-tools which have replaced the chisel and file and which shape the metal by removing parts of it are shapers, planers, milling machines, drilling and boring machines, grinders and lathes and those which have replaced the hammer and which press the metal into the required shape are steam hammers, forging and pressing machines and sheetmetal work tools.

chisel зубило, долото	**range of application** диапазон применения
hammer молоток	**shaper** поперечно-строгальный станок
file напильник	**planer** продольно-строгальный станок

rough грубый
roughly грубо
sheetmetal work tool машина для листовой штамповки

Read the Text 6 and list the main objects and parts of lathe

Metal-Cutting Machines. The Lathe

The most useful and versatile machine in the workshop is a turning machine (lathe). As the name shows, it is used for turning different objects and parts. However, besides turning many other operations can be performed on a lathe, such as drilling, reaming, tapping and by employing suitable adapters operations of milling and grinding may be carried out without difficulty.

The lathe consists of the following basic parts: the bed, the headstock, the tailstock, the saddle (or carriage) with the tool-post and the driving and gear mechanism.

The bed is a base for supporting and aligning the components of the machine. At the opposite ends of the bed there is a headstock and a tailstock.

The headstock carries a pair of bearings in which the spindle rotates. The spindle holds the workpiece and rotates with it. The headstock also incorporates the driving and gear mechanism. The parts of this mechanism are the feed shaft and the change gear box. The feed shaft is designed for driving the tool-post, and the change gear box drives the spindle of the lathe at various speeds. Tapered centres in the nose of the spindle and of the tailstock hold the work firmly between them. The tool-post is driven along the saddle either forwards or backwards at a fixed and uniform speed. That is why the operator is capable of making accurate cuts and giving the work a good finish.

There are many types of lathes but all of them operate on the same basic principle: the workpiece is revolved by power and a cutting tool is brought against it, removing metal in the form of chips.

The other principle of operation is that used in milling, grinding and drilling machines. In these machines the tool is fixed and the work is moved to and fro against it in a horizontal plane.

to support – поддерживать
to align – центрировать
feed shaft – вал подачи
change gear box – коробка перемены скоростей
tapered centre – конический центр
to drive (drove, driven) – приводить в действие
to move forwards or backwards / to and fro двигаться вперед-назад

What of these sentences are true or false?

1. The main components of the lathe are: the bed, the headstock, the saddle and the driving and gear mechanism, 2. The headstock and the tailstock are located at one end of the bed. 3. The tool-post is mounted on the bed. 4. The tool-post carries the tool. 5. The spindle holds and rotates the work. 6. The function of the change gear box is driving the headstock spindle. 7. The tool-post is driven by the feed shaft. 8. All lathes operate on the same principle: the tool is fixed and the work is moved to and fro against it in a horizontal plane.

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