Lesson 1

1. shape – форма, формировать
2. rolling – прокатка
3. extrusion – экструзия, выдавливание
4. drawing – волочение
5. forging –ковка
6. sheet – лист
7. to subject – подвергать
8. amount – количество
9. perform – выполнять, проводить
10. to harden – затвердевать, упрочняться
11. at least – по крайней мере
12. billet – заготовка, болванка
13. orifice – отверстие
14. die – штамп, пуансон, матрица, фильера, волочильная доска
15. cross section – поперечное сечение
16. window frame – рама окна
17. hollow – полый
18. initial – первоначальный, начальный
19. mandrel – оправка, сердечник
20. impact –удар
21. loosely – свободно, с зазором
22. fitting – посадка
23. ram – пуансон, плунжер
24. gap – промежуток, зазор
25. to determine – устанавливать, определять

Text: METALWORKING PROCESSES

Metals are important in industry because they can be easily deformed into useful shapes. A lot of metalworking processes have been developed for certain applications. They can be divides into five broad groups:

1. rolling; 2. extrusion; 3. drawing; 4. forging; 5. sheet-metal forming.

During the first four processes metal is subjected to large amounts of strain (deformation). But if deformation goes at a high temperature, the metal will recrystallize – that is, new strain-free grains will grow instead of deformed grains. For this reason metals are usually rolled, extruded, draw, or forged above their recrystallization temperature. This is called hot working. Under these conditions there is no limit to the compressive plastic strain to which the metal can be subjected.

Other processes are performed below the recrystallization temperature. These are called cold working. Cold working hardens metal and makes the part stronger. However, there is a limit to the strain before a cold part cracks.

Rolling

Rolling is the most common metalworking process. More than 90 percent of the aluminum, steel and copper produced is rolled at least once in the course of production. The most common rolled product is sheet. Rolling can be done either hot or cold. If the rolling is finished cold, the surface will be smoother and the product stronger.

Extrusion

Extrusion is pushing the billet to flow through the orifice of a die. Products may have either a simple or a complex cross section. Aluminum window frames are the examples of complex extrusions.

Tubes or other hollow parts can also be extruded. The initial piece is a thick-walled tube, and the extruded part is shaped between a die on the outside of the tube and a mandrel held on the inside.

In impact extrusion (also called back-extrusion) (штамповка выдавливанием), the workpiece is placed in the bottom of a hole and a loosely fitting ram is pushed against it. The ram forces the metal to flow back around it, with the gap between the ram and the die determing the wall thickness. The examples of this process is the manufacturing of aluminum beer cans.

Lesson 2

1. to pull – тянуть
2. reduction – сокращение
3. to achieve – достигать
4. in series – серия, последовательно
5. beyond – выше, свыше
6. yield point – точка текучести металла
7. retain – сохранять, удерживать
8. to bend – гнуть
9. shearing – обрезка, отрезание
10. edge – край
11. to grip – схватывать
12. lower die – нижний штамп
13. upper die – верхний штамп
14. dimension – измерение, размеры
15. required – необходимый
16. increase – увеличение
17. open-die forging – ковка в открытом штампе
18. hammering – ковка, колотить
19. within – внутри, в пределах
20. to enclose – заключать
21. rod – прут, стержень
22. bar – прут, брусок
23. involved –включенный

24. tolerance – допуск
25. upsetting – высадка, выдавливание

Text: DRAWING

Drawing consists of pulling metal through a die. One type is wire drawing. The diameter reduction that can be achieved in one die is limited, but several dies in series can be used to get the desired reduction.

Sheet metal forming

Sheet metal forming (штамповка листового металла) is widely used when parts of certain shape and size are needed. It includes forging, bending and shearing. One characteristic of sheet metal forming is that the thickness of the sheet changes little in processing. The metal is stretched just beyond its yield point (2 to 4 percent strain) in order to retain the new shape. Bending can be done by pressing between two dies. Shearing is a cutting operation similar to that used cloth.

Each of these processes may be used alone, but often all three are used on one part. For example, to make the roof of an automobile from a flat sheet, the edges are gripped and the piece pulled in tension over a lower die. Next an upper die is pressed over the top, finishing the forming operation, and finally the edges are sheared off to give the final dimensions.

Forging

Forging is the shaping of a piece of metal by pushing with open or closed dies. It is usually done hot in order to reduce the required force and increase the metal's plasticity.

Open-die forging is usually done by hammering a part between two flat faces. It is used to make parts that are too big to be formed in a closed die or in cases where only a few parts are to be made. The earliest forging machines lifted a large hammer that was then dropped on the workpiece, but now air or steam hammers are used, since they allow greater control over the force and the rate of forming. The part is shaped by moving or turning it between blows.

Closed-die forging is the shaping of hot metal within the walls of two dies that come together to enclose the workpiece on all sides. The process starts with a rod or bar cut to the length needed to fill the die. Since large, complex shapes and large strains are involved, several dies may be used to go from the initial bar to the final shape. With closed dies, parts can be made to close tolerances so that little finish machining is required.

Two closed-die forging operations are given special names. They are upsetting and coining. Coining takes its name from the final stage of forming metal coins, where the desired imprint is formed on a metal disk that is pressed in a closed die. Coining involves small strains and is done cold. Upsetting involves a flow of the metal back upon itself. An example of this process is the pushing of a short length of a rod through a hole, champing the rod, and then hitting the exposed length with a die to form the head of a nail or bolt.

Lesson 3

1. to provide – обеспечивать
2. improvement – улучшение
3. property – свойство
4. to eliminate – ликвидировать, исключить
5. porosity – пористость
6. directional – направленный
7. to segregate – разделять
8. casting – отливка
9. elongated – удлиненный
10. to weaken – ослабевать, ослаблять
11. transverse – поперечный
12. flow – течение, поток
13. finished – отделанный
14. thinning – утончение
15. fracture – разрушение
16. strain hardening – деформационное упрочнение
17. brass – латунь
18. beverage – напиток
19. can – консервная банка
20. to exhibit – проявлять
21. flaws – недостатки, дефекты кристаллической решетки
22. inclusion – включение
23. trapped – зд. заключенный
24. refining – очищать, очистка
25. to avoid – избегать
26. to undergo – подвергаться
27. tensile ductility – пластичность при растяжении

Text: METALWORKING AND METAL PROPERTIES

An important feature of hot working is that it provides the improvement of mechanical properties of metals. Hot-working (hot-rolling or hot-forging) eliminates porosity, directionality and segregation that are usually present in metals. Hot-worked products have better ductility and toughness than the unworked casting. During the forging of a bar, the grains of the metal become greatly elongated in the direction of flow. As a result, the toughness of the metal is greatly improved in this direction and weakened in directions transverse to the flow. Good forging makes the flow lines in the finished part oriented so as to lie in the direction of maximum stress when the part is placed in service.

The ability of a metal to resist thinning and fracture during cold-working operations plays an important role in alloy selection. In operations that involve stretching, the best alloys are those which grow stronger with strain (are strain hardening) – for example, the copper-zinc alloy, brass, used for cartridges and the

aluminum-magnesium alloys in beverage cans, which exhibit greater strain hardening.

Fracture of the workpiece during forming can result from inner flaws in the metal. These laws often consists of nonmetallic inclusions such as oxides or sulfides that are trapped in the metal during refining. Such inclusions can be avoided by proper manufacturing procedures.

The ability of different metals to undergo strain varies. The change of the shape after one forming operation is often limited by the tensile ductility of the metal. Metals such as copper and aluminum are more ductile in such operations than other metals.

Lesson 4

1. bar – брусок, прут
2. compression – сжатие
3. creep – ползучесть
4. cross-sectional area – площадь поперечного сечения
5. cyclic stress – циклическое напряжение
6. decrease – уменьшение
7. elastic deformation – упругая деформация
8. elastic limit – предел упругости
9. to exceed – превышать
10. external forces – внешние силы
11. fatigue – усталость металла
12. fracture – перелом, излом
13. to loosen – ослаблять, расшатывать
14. remaining – оставшийся
15. shear – срез
16. simultaneously – одновременно
17. to stretch – растягивать
18. techniques – методы
19. tension – напряженность
20. to propagate – распространять(ся)
21. to bend – гнуть, согнуть
22. to extend – расширять, продолжаться
23. to meet the needs – отвечать требованиям
24. to occur – происходить
25. to respond to – отвечать, реагировать на
26. to suffer – страдать
27. torsion – кручение
28. twisting – закручивание, изгиб
29. volume – объем, количество
30. rupture – разрыв

Text: MECHANICAL PROPERTIES OF MATERIALS

Materials Science and Technology is the study of materials and how they can be fabricated to meet the needs of modern technology. Using the laboratory techniques and knowledge of physics, chemistry and metallurgy, scientists are finding new ways of using metals, plastics and other materials.

Engineering must know how materials respond to external forces, such as tension, compression, torsion, bending and shear. All materials respond to these forces by elastic deformation. That is, the materials return their original size and form when the external force disappears. The materials may also have permanent deformation or they may fracture. The results of external forces are creep and fatigue.

Compression is a pressure causing a decrease in volume. When a material is subjected to a bending, shearing or torsion (twisting) force, both tensile and compressive forces are simultaneously at work. When a metal bar is bent, one side of it is stretched and subjected to a tensional force, and the other side is compressed.

Tension is a pulling force; for example, the force in a cable holding a weight. Under tension, a material usually stretches, returning to its original length if the force does not exceed the material's elastic limit. Under larger tensions, the material does not return completely to its original condition, and under greater forces the material ruptures.

Fatigue is the growth of cracks under stress. It occurs when a mechanical part is subjected to a repeated or cyclic stress, such as vibration. Even when the maximum stress never exceeds the elastic limit, failure of the material can occur even after a short time. No deformation is seen during fatigue, but small localized cracks develop and propagate through the material until the remaining cross-sectional area support the maximum stress of the cyclic force. Knowledge of tensile stress, elastic limits and the resistance of materials to creep and fatigue are of basic importance in engineering.

Creep is a slow, permanent deformation that results from a steady force acting on a material. Materials at high temperatures usually suffer from this deformation. The gradual loosing of bolts and the deformation of components of machines and engines are all the examples of creep. In many cases the slow deformation stops because deformation eliminates the force causing the creep. Creep extended over a long time finally leads to the rupture of the material.

Lesson 5

1. ability – способность
2. amount – количество
3. to absorb – поглощать
4. application – применение
5. brittle – хрупкий, ломкий
6. constituent – компонент
7. crack – трещина

8. creep resistance – устойчивость к ползучести
9. definition - определение
10. density – плотность
11. gradual – постепенный
12. rigid –жесткий
13. square root – квадратный корень
14. stiffness – жесткость
15. strain – нагрузка, напряжение, деформация
16. tensile strength – прочность на разрыв
17. toughness – прочность, стойкость
18. yield strength – прочность текучести
19. Young modulus - модуль Юнга

Text: MECHANICAL PROPERTIES OF MATERIALS

Density (specific weight) is the amount of mass in a unit volume. It is measured in kilograms per cubic metre. The density of water is 1000 kg/m^3 but most materials have a higher density and sink in water. Aluminum alloys, with typical densities around 2800 kg/m^3 are considerably less dense than steels, which have typical densities around 7800 kg/m^3 . Density is important in any application where the material must not be heavy.

Stiffness (rigidity) is a measure of the resistance to deformation such as stretching or bending. The Young modulus is a measure of the resistance to simple stretching or compression. It is the ratio of the applied force per unit area (stress) to the fractional elastic deformation (strain). Stiffness is important when a rigid structure is to be made.

Strength is the force per unit area (stress) that a material can support without failing. The units are the same as those of stiffness, MN/m^2, but in this case the deformation is irreversible. The yield strength is the stress at which a material first deforms plastically. For a metal the yield strength may be less than the fracture strength, which is the stress at which it breaks. Many materials have a higher strength in compression than in tension.

Ductility is the ability of a material to deform without breaking. One of the great advantages of metals is their ability to be formed into the shape that is needed, such as car body parts. Materials that are not ductile are brittle. Ductile materials can absorb energy by deformation but brittle materials cannot.

Toughness is the resistance of a material to breaking when there is a crack in it. For a material of given toughness, the stress at which it will fail is inversely proportional to the square root of the size of the largest defect present. Toughness is different from strength: the toughest steels, for example, are different from the ones with highest tensile strength. Brittle materials have low toughness: glass can be broken along a chosen lone by first scratching it with a diamond. Composites can be designed to have considerably greater toughness than their constituent materials. The example of a very tough composite is fiberglass that is very flexible and strong.

Creep resistance is the resistance to a gradual permanent change of shape, and it becomes especially important at higher temperatures. A successful research has been made in materials for machine parts that operate at high temperatures and under high tensile forces without gradually extending, for example the parts of plane engines.

Lesson 6

1. machine tools – станки
2. electrically driven – с электроприводом
3. workpiece – деталь
4. accurate – точный
5. to allow – позволять, разрешать
6. interchangeable – взаимозаменяемый
7. facility – приспособление
8. fluid – жидкость
9. to lubricate – смазывать
10. spark erosion – электроискровая обработка
11. discharge – разряд
12. by means of – посредством
13. beam – луч
14. drilling – сверление
15. flexible – гибкий
16. range – ассортимент, диапазон

Text: MACHINE TOOLS

Machine tools are used to shape metals and other materials. The material to be shaped is called the workpiece. Most machine tools are now electrically driven. Machine tools with electrical drive are faster and more accurate than hand tools: they were an important element in the development of mass-production processes, as they allowed individual parts to be made in large numbers so as to be interchangeable.

All machine tools have facilities for holding both the workpiece and the tool, and for accurately controlling the movement of the cutting tool relative to the workpiece. Most machining operations generate large amounts of heat, and use cooling fluids (usually a mixture of water and oils) for cooling and lubrication.

Machine tools usually work materials mechanically but other machining methods have been developed lately. They include chemical machining, spark erosion to machine very hard materials to any shape by means of a continuous high-voltage spark (discharge) between an electrode and a workpiece. Other machining methods include drilling using ultrasound, and cutting by means of a laser beam. Numerical control of machine tools and flexible manufacturing systems have made it possible for complete systems of machine tools to be used flexibly for the manufacture of a range of products

Lesson 7

1. lathe – токарный станок
2. machine tool – станок
3. to produce – производить
4. to finish – обрабатывать начисто
5. workpiece – заготовка
6. to design – предназначать
7. to hold – держать
8. to revolve – вращаться
9. to subject – подвергать
10. cutting tool – резец
11. turning – точение, протачивание
12. facing – торцевание
13. boring – растачивание
14. drilling – сверление
15. threading – нарезание резьбы резцом
16. tapping – нарезание резьбы метчиком
17. adapter – приспособление, державка
18. grinding – шлифование
19. milling – фрезерование
20. to determine – определять
21. to swing (swung) – поворачиваться, вращаться
22. to mount – устанавливать
23. bench lathe – верстачный токарный станок
24. turret lathe – револьверный станок
25. chucking lathe – патронный токарный станок
26. automatic lathe – токарный автомат
27. to treat – обрабатывать

Text: METAL-CUTTING MACHINES

Lathes

A lathe is known to be essentially a machine tool for producing and finishing surfaces of workpiece. The machine is designed to hold and revolve work around an axis of rotation so that it may be subjected to the action of a cutting tool moving in a horizontal plane through the axis of the work. When the cutting tool moves in a longitudinal direction or parallel to the axis, the operation is known as “turning”; when it moves in a transverse direction, it is known as “facing”. In addition to turning and boring, which the machine is primarily designed for many other operations, such as drilling, threading, tapping, and by employing special adapters grinding and milling, may be performed on a lathe.

Lathes used in shop practice are known to be of different designs and sizes. These lathes fall into various types, either according to their characteristic constructional features, or according to the work for which they are designed. The size of a lathe is determined by the diameter and length of work that may be swung

between centres. lathes of comparatively small size which may be mounted on a bench, are termed bench lathes, and are intended for small work of considerable accuracy. Lathes provided with tools held in a revolvable turret are called “turret lathes”. Lathes in which workpieces to be treated are held in a chuck a known as “chucking lathes”. Lathes in which most of operations are performed automatically are named “automatic lathes”.

Lesson 8

1. wheel lathe – колесотокарный станок
2. crankshaft lathe – токарный станок для обработки коленчатых валов
3. screw-cutting lathe – токарно-винторезный станок
4. carriage - суппорт
5. engine lathe – универсальный токарный станок
6. to fit - снабжать
7. power-actuated – приводимый в движение механически
8. cross-slide – поперечные салазки
9. clamp – зажимать
10. bed – станина
11. headstock –передняя бабка
12. tailstock – задняя бабка
13. feed mechanism – механизм подачи
14. cross ribs – поперечные ребра
15. casting – отливка
16. to support – поддерживать
17. to align – центрировать
18. way, guide – направляющая
19. to bolt – закреплять болтами
20. bearing – подшипник
21. spindle – шпиндель
22. to rotate – вращаться
23. live (running) centre – вращающийся центр
24. dead (non-rotating, cup) centre – неподвижный центр
25. nose – конец шпинделя
26. change gearbox – коробка перемены скоростей
27. to incorporate – включать
28. speed change lever – рукоятка управления коробки скоростей
29. set – набор, комплект
30. in turn – в свою очередь

Text

Besides there are also many special-purpose lathes such as crankshaft lathes and wheel lathes for turning crankshafts or engine driving wheels respectively; screw-cutting lathes for threading screws, etc. The engine lathe used for metal-turning operations is fitted with a power-actuated carriage and cross-slide for

clamping and holding the cutting tool. In engine lathes the cutting tools are generally guided by the machine tool itself, in other words, they are operated mechanically, while in some lathes the cutting tools are guided by hand. The engine lathe consists essentially of the following basic parts: the bed, the headstock, the tailstock, the feed mechanism, and the carriage.

The bed is a rigid casting with two longitudinal walls firmly connected by cross ribs integral with the casting. The bed serves as a base to support and align the rest of the machine. The upper surface of the bed is provided with parallel V-type and flat ways or guides for accurate aligning of the sliding parts of the lathe – the carriage and the tailstock. The headstock: is located find firmly bolted to the left-hand side of the bed and carries a pair of bearings in which the spindle rotates. Many modern lathes have a motor built into the headstock with the spindle serving as the motor shaft. The spindle being one of the most important parts of the lathe, is a steel hollow shaft with a taper bore for the insertion of the live or running centre on which the place to be turned is placed. The other end of the work is supported by the non-rotating dead or cup centre. The nose of the spindle is accurately threaded for chucks to be screwed on it. The chucks in turn, hold and revolve workpieces together with the spindle. The headstock also incorporates the change gearbox driven by a set of speed change levers. The change gearbox serves for running the lathe at different speeds required in turning and boring workpieces of various diameters.

Lesson 9

1. sleeve – втулка, шпиндель
2. to carry - содержать, вмещать, пиноль
3. nut – гайка
4. to advance – подавать вперед
5. to retract – отводить назад
6. revolving screw – вращающийся винт
7. handwheel – маховичок ручного управления
8. inner bed ways – внутренние направляющие станины
9. flat ways – плоские направляющие
10. V-section – v-образное сечение
11. rectangular – прямоугольный
12. Morse taper hole – коническое отверстие с конусом типа Морзе
13. large area bearing – подшипник с большой площадью опоры
14. tapered tool shank – конический хвостовик инструмента
15. cone of gears – ступенчатая зубчатая передача
16. intermediate shaft – передаточный, промежуточный вал
17. splined shaft – шлицевой вал
18. tumbler gear – накидная шестерня
19. to drop – попадать, опускать
20. index plate – делительная пластинка
21. fine change shifter – механизм переключения

22. front and rear of the tailstock – передняя и задняя часть задней бабки
23. against the rear of the centre – в тыльную, хвостовую часть центра
24. by means of – посредством, при помощи

Text

The tailstock located at the right-hand side of the bed is a casting carrying a non-rotating sleeve, which together with the nut can be advanced or retracted by means of the tailstock revolving screw operated by the hand wheel. The tailstock may by moved anywhere along the lathe bed and can be clamped in place at any point. On changing the position, the tailstock slides along the two inner bed ways one of which named flat way is of rectangular cross-section and the other is of V-section. The tailstock sleeve mounts a hollow spindle with a standard taper bore for holding the lathe centres or tapered tool shanks.

The dead centre fits in a Morse taper hole in the sleeve and may be removed by retracting the sleeve, thereby bringing the end of the tailstock screw against the rear of the centre and forcing it out. The tailstock spindle has a large area bearing in doth the front and rear of the tailstock. To facilitate measurement of the spindle travel the tailstock spindle is graduated.

The feed mechanism for both longitudinal and cross feeds of the engine lathe is simple and easy to operate. It comprise a cone of gears, an intermediate shaft and a set of sliding gears. The fine change shifter slides on a spindle shaft and carries a tumbler gear which is dropped into engagement with a gear on the cone corresponding to the thread of feed selected on the index plate above it.

Lesson 10

1. reverse handle – рукоятка изменения хода
2. unit – узел
3. to shift – переключать
4. apron – фартук
5. feed shaft – валик подачи
6. lead screw – ходовой винт
7. to slide – скользить
8. tool rest – поворотная часть крестового суппорта
9. control lever – рычаг управления
10. to require – требовать
11. saddle – продольные салазки
12. cross-slide –поперечные салазки
13. to term – называть
14. by gearing or belting – с помощью зубчатой или ременной передачи
15. to drive –приводить в действие, движение
16. principal – основной
17. geared to the spindle – соединенный с помощью шестерен со шпинделем
18. engaging – зацепление, соединение
19. at right angle – под прямым углом

Text

Movement of the carriage and the cross-slide can be reversed either by reversing the feed mechanism with the reverse handle or by shifting the single lever located on the carriage apron. Suitable speed ratios between the spindle and the feed mechanism are provided by a change gearbox. The carriage is a unit intended for mounting the tool and capable along the two outer V-type ways, on which it is supported, in a direction parallel to the spindle axis.

For turning and facing operations the carriage is driven from the headstock spindle by gearing or belting through a feed shaft. For thread cutting, where a definite amount of carriage movement is required for every spindle rotation, a load screw, geared to the spindle, is used for motion of the carriage. The carriage is made up of two principle parts, one of which carries the saddle, which slides upon the bed and on which the cross-slide and the tool rest are mounted. The other part, termed the apron, represents the front wall of the carriage. It provides a support for the operating handwheel and control levers, as well as carries the mechanism for engaging the feed mechanism of the lathe to drive the carriage. The cross-slide mounted on the carriage can move at right angles to the spindle axis. It is operated by the cross-slide screw which turns in a nut fixed to the carriage.

Lesson 11

1. compound rest – крестовой суппорт
2. tool post – верхняя часть суппорта, резцедержатель
3. lapping – притирка, нахлестка
4. countersinking – зенкование
5. counterboring – зеркерование
6. upright (vertical) spindle drilling machine – вертикально-сверлильный станок
7. multiple-spindle drilling machine – многошпиндельный сверлильный станок
8. radial spindle drilling machine – радиально-сверлильный станок
9. drilling head – сверлильная головка
10. quill – втулка, полый вал
11. pinion – зубчатый валик, малое зубчатое колесо
12. worm shaft – червячный вал
13. worm gear – червячная шестерня
14. crank – кривошип
15. rachet lever – храповый рычаг
16. gearing – зубчатая передача
17. come pulley – ступенчатый шкив

DRILLING MACHINE

Drilling machines are very old machine tool mainly employed for drilling holes of different sizes in metal or any other solid material. In addition to drilling holes, such operations as tapping, reaming, lapping, countersinking and counterboring may be performed on the drilling machines. Since drilling machines are used for a great variety of operations, they fall into

various classes, the main of them being upright or vertical spindle, multiple-spindle, and radial spindle machines. In all three types, the drill spindle rotates in a sleeve or quill which does not rotate but is free to move axially to provide the necessary feed for the drill.

In vertical spindle drilling machines the spindle is in a vertical position. The upright column resting on a heavy base. The column equipped with a gearbox providing a wide range of speeds has a feed mechanism. The feed mechanism represents a feed shafts with its necessary gearing by which the drill is cut into the work at a proper speed. The feed shaft and the gearing provide a mechanical feed and any adjustment of both the drilling head mounted on the top of the column and the table for drilling operations. Since in the upright drilling machines the spindle sleeve supports are foxed, all adjustment for different classes of work is made by moving the table which accomplished by turning the crank. The table can be moved in horizontal plane, clamped at any point or, if desired, swung out of the way so that large work may be placed on the base. The machine is also equipped with a ratchet lever for hand feeding the drill. A hand wheel is fastened to a worm shaft whose worm engages a worm gear on the pinion feed shaft, giving a motion much finer than that obtained by using the hand lever. Speed changes in the upright drilling machines are effected either by cone pulleys or by a geared head.

Lesson 12

1. heave duty drilling machine – сверлильный станок для тяжелых работ
2. plain drilling machine – простой сверлильный станок
3. sensitive drilling machine – сверлильный станок повышенной точности
4. comparatively – сравнительно
5. delicate works – хрупкие заготовки
6. to save – экономить
7. considerable – значительный
8. simultaneous – одновременный
9. push button operation – кнопочное управление
10. drive gear – зубчатый привод

TEXT

The upright drilling machines, in turn, are classified, as: heavy duty, plain and sensitive. The heavy duty drilling machine is used for heavy drilling, the plain vertical spindle machine being employed for lighter work. The sensitive drilling machine is a vertical or upright machine of comparatively light construction adapted to very high speed of drilling holes in delicate works. The multiple-spindle drilling machines are built in both vertical and horizontal types. Saving considerable time and space this machine is used for simultaneous drilling of many holes in a large number of workpieces.

The machine may have a number of movable drills mounted on the cross way, all the spindles being driven from the same shaft by a worm gear. One of the types of the multiple-spindle machines is the full automatic multiple-spindle drill head

machine requiring only push button operation. The machine is provided with a large number of spindles ranging from four to a hundred or even more, which are driven by the same spindle gear in the same head.

Lesson 13

1. radial arm – радиальная траверса
2. bore – растачивать, расточка
3. Morse tape shank – конический хвостовик Морзе
4. flange – установочный фланец, закраина
5. alloy steel – легированная сталь
6. brass – латунь
7. ft. per min (foot (feet) per minute) – футов в минуту
8. per revolution – за оборот
9. 15°16" (15 feet 16 inches) – 15 футов 16 дюймов

Text

The radial drilling machine has a vertical column mounted on a cast iron base. The column carries a radial arm which moves not only in a horizontal plane with the column, but may also be moved an a vertical plane. A drilling head carrying the drill and power feed mechanism may be moved along horizontal ways of the arm. Bored to take a Morse taper shank, the spindle is driven by a reversing motor, flange mounted on top of the gearbox. The drill can be moved over the work to any desired position so that many holes may be drilled in the work without moving it from one place to another. The radial drilling machine is therefore adapted to heavy work where it is easier to move the drill than the work.

Spindle speed and feed changes are effected by gearing. Drilling speeds may vary from 40 ft. per min for cast and alloy steels to 300 ft. per min for brass and bronze, drilling feeds ranging from .002" per revolution for $^{1}/_{8}$" diameter drills to .15" per revolution for drills 1" in diameter and over.

Note to the text

Bored to take a Morse taper shank, the spindle is driven by a reversing motor, flange mounted on top of the gearbox – шпиндель, расточенный под конический хвостовик Морзе, приводится в движение реверсивным двигателем, а установочный фланец расположен наверху коробки скоростей.

Lesson 14

1. milling machine – фрезерный станок
2. to remove – удалять
3. multi-toothed rotating cutter – многозубная вращающаяся фреза
4. column and knee milling machine – консольно-фрезерный станок
5. bed milling machine – верстачный фрезерный станок
6. planer milling machine – продольно-фрезерный станок
7. rotary milling machine – ротационный (вращательный) фрезерный станок

8. horizontal plain milling machine – горизонтально-фрезерный станок
9. vertical milling machine – вертикально-фрезерный станок
10. universal spindle milling machine – универсально-фрезерный станок
11. to handle – управлять
12. cutting fluid – эмульсия, смазывающе-охлаждающая жидкость
13. coolant tank –охлаждающий резервуар
14. pad – прокладка, подушка
15. outlet nozzle – выпускное, выходное сопло, форсунка
16. valve – клапан, вентиль
17. streamlined – обтекаемой формы

Text: MILLING MACHINE

Milling machines are used for milling operations. Milling is the process of removing material from work with a multi-toothed rotating cutter. There are various classes and types of milling machines in use, from small hand-operated types to fully automatic ones, the main of them being: column and knee-type, bed type, planer type, and rotary type. Column- and knee-type milling machines are made in three styles: horizontal plain, vertical and universal spindle milling machines. They are used for both toolroom and manufacturing work because of the ease with which they may be handled. What are the essential features of the horizontal milling machine? The machine is provided with a massive streamlined column rising from a base which rests on a solid wooden or concrete floor which is sufficiently heavy to withstand the weight of the machine. The base, hollow inside, contains a coolant tank with cutting fluid that is delivered through piping by means of a motor-operated pump to the cutters and the place where the milling operation is performed. The centrifugal type pump is mounted on the pad located at the side of the base and is connected directly to the coolant tank. The cutting fluid flow can be regulated by means of valves connected to the outlet nozzles which can be swiveled for distributing a low pressure volume of cutting fluid to all diameter and types of cutters.

Lesson 15

1. supply – подача
2. to flood down – наполнять, заливать
3. power feed – механическая подача
4. feed gearbox – коробка подач
5. proper speed – надлежащая скорость
6. to house – заключать, вставлять
7. perforated pipe – перфорированная труба
8. to shift – переключать, перемещать
9. spindle speed change lever – рычаг переключения скорости шпинделя
10. train – зубчатая передача
11. antifriction bearing – подшипник качения
12. to space – располагаться

13. to attach – прикреплять
14. arbor – оправка (для крепления фрезы)
15. mandrel – оправка (для крепления обрабатываемого изделия)
16. overarm – поддерживающий рукав фрезерного станка
17. bearing bracket – консольный подшипник
18. knee – консоль
19. elevating screw – подъемный винт
20. with respect to – по отношению

Text

A constant supply of clear oil is pumped to the column top, distributed through perforated pipes and flooded down over all gears, shafts, and bearings throughout the entire column and feed gearbox. In the lower part of the column there is a motor for driving the spindle and the change gears for the power feed. A set of change gears for driving the spindle at a proper speed required for any work being done on the machine is housed in the upper part of the column. The change gears are shifted either manually by a spindle speed change lever located on the face of the column or by power to form various trains for providing the necessary cutting speeds.

The horizontal plain milling machine has a horizontal spindle rotating in antifriction bearings in the column. The spindle is a hardened, ground, hollow shaft spaced horizontally from the front to the back of the column. In operation, the milling cutters are either attached to the spindle nose or carried on an arbor. Secured to the top of the column is an overarm consisting of one or two heavy steel bars. The overarm is provided with bearing brackets for supporting arbors or mandrels. The knee which supports the table and saddle units is mounted on the face of the column and can be moved up and down by means of an elevating screw for adjusting workpieces with respect to cutters.

Lesson 16

1. to clamp – зажимать
2. rigidity – жесткость
3. dovetail guides – направляющие в виде «ласточкина хвоста»
4. semi-steel casting – отливка из сталистого чугуна
5. to fasten – закреплять, зажимать
6. pendulum milling – возвратно-поступательное фрезерование
7. backlash eliminator – ограничитель (отделитель) обратного хода
8. climb milling – фрезерование по подаче
9. conventional milling – фрезерование против подачи
10. to ensure – обеспечивать
11. reversal – обратный ход, реверсирование
12. to position – устанавливать
13. disengage – разъединять, выключать

Text

During each milling operation the knee should be clamped to the column, and in heavy-duty operations the knee is clamped to the overarm to ensure maximum rigidity. The upper part of the knee is provided with horizontal dovetail guides, which support the saddle unit mounted on them. The saddle, in turn, supports the table which is a heavy, semi-steel casting sliding in the dovetail guides on the saddle. The table has T-slots of ample depth serving to fasten work-holding devices. All the three elements, table, saddle, and knee, may be either power- or hand-fed by screw turning in fixed nuts. By means of a hand lever on the knee, the machine can be set for continuous pendulum milling, or for automatic cycle operation, with power feed movement of the table in either direction. The machine is provided with a backlash eliminator, which enables climb milling to be performed with both right- and left-hand cutters and is automatically disengaged upon reversal of the table. The eliminator can also be disengaged by movement of a lever when conventional milling is to be performed.

Vertical milling machines are similar to plain milling machines, but their spindle is positioned vertically.

Lesson 17

1. clamp bed – удерживающая плита
2. to swing – поворачиваться, вращаться
3. extend – проходить, тянуться
4. taper hole – конусное отверстие
5. bearing – опора, опорная поверхность
6. adjusting key – установочный клин
7. arbor shoulder – кромка оправки
8. pilot – направляющая цапфа
9. collar – кольцо, муфта
10. brace – крепление, стойка, подставка
11. feed rate – скорость подачи
12. fine feed – точная, мелкая подача
13. coarse feed – крупная подача
14. to result in – кончаться, иметь результат
15. to subject – подвергаться
16. in. per min = inch per minute – дюйм в минуту
17. 0.30" = 0.30 inch – 0,3 дюйма
18. intermediate – промежуточный, вспомогательный
19. arbor support – опора оправки
20. delicate (fragile) work – хрупкая, ломкая заготовка

Text

Universal milling machines are also similar to plain milling machines but the saddle is mounted on and swivels on a clamp bed which in turn slides on the knee

thus permitting the saddle to swing at an angle, and permitting table motion at other angles than 90^0 to the spindle axis.

Modern heavy-duty milling machines are equipped with a standardized spindle end which has a locating taper hole in the spindle. The arbor is seated by turning a draw-in-bolt which extends through a hole in the spindle, and screws into a threaded hole in the arbor. The arbor is driven by an adjusting key on the spindle nose which fits into slots in the arbor shoulder. The arbor support provides a cylindrical bearing for the pilot of the arbor and in many instances, an intermediate arbor support, serving as a bearing for an oversize collar, is employed. The arbor support is often connected to the knee by overarm braces for additional rigidity.

Cutting speeds on the milling machine depend upon the nature of the work, the type of cutter, the condition of the machine, and, in many instances, upon the experience and ability of the machine operator. Feed rates in milling are expressed in two ways: in. per min., or thousandths of an inch per revolution of the spindle. Delicate of fragile work requiring an accurate finish will need fine feeds, while heavy work, from which a considerable amount of metal is to be removed, can be subjected to coarse feeds. A good finish can usually be obtained by using a feed rate from 0.30" to 0.50" per revolution of the cutter. Finer feeds, such as 0.15" per revolution, will result in an excellent finish.

Note to the text

the arbor is seated by turning a draw-in-bolt – оправка устанавливается поворотом втяжного стержня

Lesson 18

1. planer –продольно-строгальный станок
2. shaper – поперечно-строгальный станок
3. slotter – долбежный станок
4. to generate – обрабатывать, производить
5. rectilinear – прямолинейный
6. stroke – ход
7. to plane – строгать
8. primarily – в основном
9. machining – механическая обработка
10. past – мимо, относительно
11. to finish – обрабатывать начисто
12. stationary tool – неподвижный резец
13. like parts – одинаковые детали
14. at one setting – за один раз, за одну установку
15. string planning – одновременное строгание партии изделий
16. in preference – преимущественно
17. jobbing shop – механический цех, ремонтная мастерская
18. production shop – производственный цех
19. double-housing planer – двухколонный продольно-строгальный станок
20. open-side planer – одноколонный продольно-строгальный станок

22. tandem planer – продольно-строгальный станок с двумя рабочими столами
23. rait planer – продольно-строгальный станок для строгания рельс
24. housing – стойка, колонна
25. roughing – черновая обработка
26. finishing – чистовая обработка
27. expensive – дорогостоящий

TEXT: PLANERS

Planers like shapers and slotters are machine tools that employ single-point tools to generate flat surfaces. In each of these the relative motion of the cutting tool and the work is rectilinear and either the tool or the work feeds in a direction perpendicular to the cutting stroke. All three machines finish surfaces in a similar manner, and their selection depends primarily upon the nature of the work. The planer is generally used for machining large work requiring long cuts. The work is held on a horizontal table and move a back and forth past a stationary tool. The planer is also known to be used when a large number of like parts are to be finished. In this case the parts are frequently placed on the planer table in rows, and a number of parts are planed at one setting. This operation is referred to as string planing.

Planers and shapers are used for machining surfaces to a high degree of accuracy, and in general require less power per cubic inch of metal removed than machine tools employing multi-toothed cutters. Planer and shaper tools are considerably less expensive than milling cutters; the planer may therefore be used in preference to a milling machine if the castings are poor and subject to hard spots. There are several standard types of planers that are in extensive use in jobbing and production shops such as double-housing planers; open-side planers; tandem planers, and rail planers. The double-housing planer has two vertical housings and is used for rapid roughing and finishing such works as engine and lathe beds, etc.

Note to the Text

If the castings are poor and subject to hard spots – если отливки плохие и имеют твердые места

Lesson 19

1. ample strength – достаточная прочность
2. to assure – обеспечивать
3. bracing – крепление
4. to key – закреплять шпонками
5. to bolt – скреплять болтами
6. cutter head – режущая головка
7. cross-rail – траверса, поперечина
8. side-feed – боковая подача
9. arrangement – приспособление
10. simultaneously – одновременно

11. otherwise – иначе, в противном случае
12. alloy iron – легированный чугун
13. to treat – обрабатывать
14. stop – упор, стопор, ограничитель
15. securely – надежно
16. lengthwise – в длину, вдоль
17. clamping block – разжимной блок
18. under side – обратная сторона
19. side-head – боковая головка
20. box-section – коробчатое сечение

TEXT

Ample strength and support of the housings are assured by their thick-walled, box-section internal bracing. The housings are keyed and bolted to the bed, forming a unit as rigid as a one-piece construction. The large-size planer of this type is provided with two cutter heads mounted on the cross-rail. The heads serve for holding two tools, which may cut material simultaneously, thus increasing the work capacity of the planer. In a planer with two cutter heads both vertical and side feeds, being independent of each other, are performed automatically. In addition, some planers are equipped with a side-head mounted on each housing. This arrangement makes it possible to machine simultaneously both the side and the top surface of a work to be treated.

The work to be planed is bolted or otherwise securely fastened to the table. The table is made of alloy iron and is of a box-section construction with top and bottom plates tied with side walls and the centre rib running the full length, and with cross-ribs. The upper part of the table has three or more tee slots running lengthwise, and numerous holes for inserting stops and clamping blocks, while the under side is provided with two accurately machined guides which slide in guide ways on the planer bed. The table moves between two housings against one or more cutting tools, which are held by the cross-rail and side-heads screwed to the housings, at a speed adapted to the material to be cut.

Note to the Text

the centre rib running the full length – центральная поперечина, проходящая по всей длине

Lesson 20

1. return stroke – обратный ход
2. to pass – определять
3. underneath – под, внизу
4. vice –тиски
5. strap – крепительная планка, зажим
6. projection portion – выступающая часть
7. gang planer tool – многорезцовая державка, набор фрез на одной оправке
8. tool bit – вставной резец

9. adjacent – смежный, соседний
10. chip – стружка, рубить, тесать
11. single-point cutting tool – резец с очень узким режущим лезвием

Text

The return stroke, during which no cutting takes place, is usually constant but is from two to four times as fast as the cutting stroke so as to economize on time. Planer size is determined by the maximum stroke of the table and the width and height of the work that will pass through the housings and underneath the cross-rail. A double housing 30 x 30 x 8" planer, for instance, will machine a part 30" high, 30" wide and 8" long. Open-side planers are classified by the cross-rail height and the length of stroke, and are generally used for handling work that is somewhat wider than its height. The open-side planer has but one vertical housing with the cross-rail attached to it. The tandem planer is equipped with two work tables sliding on the same bed. This permits to load one table while the other is in operation, or to use the two simultaneously when working on a large work-piece. The rail planer is a machine used for machining rails, which is provided with a narrow long table. Planer work may be held in a vice bolted to the planer table, or the work may be clamped directly to the table.

Castings can generally be clamped in place by using straps or clamps on projecting portions of the work. All planers are equipped with single-point cutting tools, which are similar to shaper tools, but are usually larger and stronger. In many cases, gang planer tools, carrying three or more tool bits closely adjacent, are used. As each chip is comparatively small, a planer equipped with a gang tool will carry a greater total feed and depth of cut than are possible with a single-point tool.

Notes to the Text

but is from two to four times as fast as the cutting stroke so as to economize on time – но в два-четыре раза быстрее хода резания для экономии времени

has but one vertical housing – имеет только вертикальную стойку

castings can generally be clamped in place – отливки обычно могут закрепляться на месте

Lesson 21

1. shaper – поперечно-строгальный станок
2. slotter – долбежный станок
3. reciprocating – возвратно-поступательное
4. to feed –подаваться
5. angular surface – угловая поверхность
6. curved surface – изогнутая поверхность
7. keyway – шпоночная канавка
8. square hole – квадратное отверстие
9. die opening – винторезное отверстие
10. ram – ползун
11. countershaft – контрпривод
12. to transmit – передавать
13. speed box drive shaft – ведущий вал коробки подач (скоростей)

14. crank-driven shaper – поперечно-строгальный станок с кулисным приводом ползуна
15. gear shaper – зубодолбежный станок
16. universal shaper – универсальный поперечно-строгальный станок
17. to derive – производить, получать, происходить
18. pivoted lever – поворотный рычаг
19. adjustable crank – регулирующий кривошип
20. mass production – поточное (серийное) производство

Text 3 Shapers and Slotters

Shapers and slotters are machine tools in which the work is fed to a reciprocating tool, while in planers the tool is fed to the work. The shaper is mainly designed to plane horizontal surfaces, but it is also possible to finish vertical and angular surfaces, and, with the application of the proper tools, even curved surfaces of workplaces of small and medium sizes. The slotter, which may be called a "vertical shaper", since its tool moves in a vertical direction past the stationary work, is used for machining flat surfaces which are difficult or inconvenient to machine because they are at right angles to the main dimensions of the part. The slotter is also employed for cutting internal keyways, square holes and die openings. Both the shapers and slotters are not used in mass production since they are rather slow in operation.

The size of the shaper is determined by the maximum stroke of its ram. The largest standard shaper has a stroke of 36 in. That is why the shaper is employed to perform planing operations on comparatively small work, the planer being, used on large work. Shapers are driven by belt from b countershaft, by direct connected motor, or by hydraulic power. When driven by motor, the power from the motor is transmitted by a belt or silent chain to the speed box drive shaft.

Shapers are subdivided into several classes such as crank-driven shapers. gear shapers, universal shapers, etc. The crank-driven shaper or crank shaper derives its cutting motion from a pivoted lever, which is driven by an adjustable crank.

Lesson 22

1. drive mechanism – приводной механизм
2. elevating screw – подъемный винт
3. swivel-base vice – тиски с поворотным основанием
4. tool head – резцедержатель, инструментальная головка
5. toolslide – инструментальные салазки
6. downfeed – механизм вертикальной подачи
7. clapper box – резцедержатель
8. lead screw – ходовой винт
9. bearing surface – опорная (несущая) поверхность
10. to guide – направлять
11. return stroke – обратный ход
12. to enable – позволять, давать возможность
13. cutting stroke – ход резания

Text

The shaper has a hollow column rising from a base pieced on the floor. The column houses a part of the drive mechanism for the machine. Mounted on the front of the column, which is machined so as to provide vertical bearing surfaces. is the cross-rail. The cross-rail, together with the saddle and the table which it supports, may be adjusted up or down for various heights on the face of the column with an elevating screw. The box-section table which is designed to carry the work is fastened to tile front of the saddle, and feeds in a direction perpendicular to the toot motion. The table is provided with T-slots on the top and sides for clamping the work. The work may be clamped either by means of bolts, or in a vice which are held in the T-slots.

A swivel-base vice being mounted on the top of the shaper table, the vice may be rotated about a vertical axis to set workpieces at an angle in the horizontal plane. The top of the shaper column is machined to form ways for supporting and guiding a ram which can slide along these ways forward and backward both in a cutting and return stroke cycle.

The ram supports a tool head mounted on the front end of the rain, and a toolslide with a swivel base. The tool head carries the down feed mechanism for the tool. The downfeed mechanism consists of a load screw and a handle for feeding the clapper box, mounted on the toolslide, and the tool up and down by hand. The addition to the hand downfeed, most shapers are equipped with a power downfeed. The tool head can swivel about the centre of the rain to enable the tool to be fed at an angle.

Lesson 23

1. to incline – наклонять
2. tool post – верхняя часть суппорта, резцедержатель
3. inserted-bit tool – державка со вставным резцом
4. extension tool – удлиненный резец
5. splined hole – шпоночное отверстие
6. quick-return mechanism – реверсивный механизм
7. crank arm – плечо кривошипа
8. to pin – зашплинтовать, заштифтовать
9. slide block – ползун
10. oscillate – колебаться, качаться
11. yoke – зажим, хомутик
12. tangent – касательная
13. crank pin – палец кривошипа
14. crank angel – угол поворота кривошипа
15. tilting – поворотный, наклонный

16. linkage – рычажной механизм, связь
17. idle – холостой
18. idle time – время, затраченное на обратный холостой ход ползуна

Text

Owing to the swiveling of the clapper box on the tool head the tool may be inclined at an angle with the head m any position, the angular adjustment of the clapper box being smaller than that for the tool head. A tool post for holding the cutting tool is mounted in the clapper box. Shaper tools are similar to solid or inserted-bit lathe tools; extension tools are used for cutting keyways and square and splined holes. Since the shaper tool acts only during the forward stroke of the ram and is idle during the return stroke, it is necessary to minimize this idle time by using a quick-return mechanism. The mechanism represents a variation of a driving chain, which is one of the most common of linkages. A pinion engages a large gear to which is affixed a crank arm. The outer end of the crank is pinned to a slide block, which is free to slide on a long swinging arm As the crank revolves, this arm oscillates back and forth, and by means of yoke reciprocates a table on suitable ways. The work to be shaped is clamped to this table. The point at which the oscillating arm is tangent on either side to the crank pin circle separates the cutting from the return stroke. Since the crank .arm turns uniformly, time is proportional to crank angle. The return stroke is accomplished in a much smaller crank angle than the cutting stroke, and consequently consumes less time. Gear shapers are special machine tools used for machining gear teeth. Universal shapers are equipped with tilting or adjustable tables which may be set at an angle toward cither side of the machine.

Lesson 24

1. to reciprocate - двигаться взад и вперед
2. to guard - предохранять
3. to attempt - пытаться
4. loose - свободный
5. to tear (torn, torn) - рвать
6. sleeve - рукав
7. elbow - локоть
8. hazardous - опасный
9. fire extinguisher - огнетушитель
10. drowsiness - сонливость

SAFETY RULES FOR MACHINE TOOLS

Since different cutting tools are used on various machine tools, the safety precautions for each may vary. The following are general safety rules for any machine tool:

Gears, pulleys, belts, and other revolving or reciprocating parts should be guarded to a height of 6 feet above the floor.

Do not operate any machine tool without proper lighting.

Never attempt to operate any machine tool until you fully understand how it works and know how to stop it quickly.

Never wear loose or torn clothing long hair, since these items can become caught in revolving machine parts. Ties should be removed and shirt sleeves should be rolled up above the elbow.

Always stop the machine before cleaning it or taking measurements of the workpiece.

Always wear safety glasses while operating machine tools. Also, wear respiratory protection if operation creates hazardous dust. All persons in the area where power tools are being operated should also wear safety eye protection and respirators as needed.

Know where fire extinguishers are located in the shop area and how to use them.

Do not operate any machine tool while under the influence of drugs, alcohol, or any medication that could cause drowsiness.

Lesson 25

1. safety - безопасность
2. regulation - правило
3. precaution - предосторожность
4. chip - стружка
5. injury - повреждение
6. to harden - зд. закаливать (сталь)
7. to shatter - разлетаться
8. razor - бритва
9. stock - груз
10. supply - снабжение
11. toe - большой палец ноги
12. impact - удар
13. to expose - подвергаться
14. hazard - риск, опасность
15. adjustment - регулировка, исправление
16. circuit breaker - прерыватель цепи
17. pulley - шкив, блок

GENERAL SHOP SAFETY

All tools are dangerous if used improperly or carelessly. Working safely is the first thing the user or operator should learn because the safe way is the correct way. A

person learning to operate machine tools must first learn the safety regulations and precautions for each tool or machine. Most accidents are caused by not following prescribed procedures. Develop safe work habits rather than suffer the consequences of an accident.

Using eye protection in the machine shop is the most important safety rule of all. Metal chips and shavings can fly at great speeds and distances and cause serious eye injury. Safety glasses must be worn when working with handcutting tools, since most handcutting tools are made of hardened steel and can break or shatter when used improperly.

The floor in a machine shop is often covered with razor-sharp metal chips, and heavy stock may be dropped on the feet. Therefore, safety shoes or a solid leather shoe must be worn at all times. Safety shoes are available in the supply system. These have a steel plate located over the toe and are designed to resist impact.

Exposure to electrical hazard will be minimal unless the operator becomes involved with machine repair. The machine operator is mostly concerned with the on and off switch on the machine tool. However, if adjustments or repairs must be made, the power source should be disconnected. If the machine tool is wired permanently, the circuit breaker should be switched off and tagged with an appropriate warning statement. Most often the power source will not be disconnected for routine adjustment such as changing machine speeds. However, if a speed change involves a belt change, make sure that no other person is likely to turn on the machine while the operator's hands are in contact with belts and pulleys.

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