English for ...

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MECHANICAL ENGINEERING

Selected texts for students and PhD students

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WYDAWNICTWO POLITECHNIKI GDAŃSKIEJ

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GDAŃSK 2012

RECENZENT
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PROJEKT OKŁADKI
Katarzyna Olszonowicz

Wydanie I – 2007

Wydano za zgodą
Rektora Politechniki Gdańskiej

Publikacja dostępna tylko w wersji elektronicznej

ISBN 978-83-7348-439-9

WYDAWNICTWO POLITECHNIKI GDAŃSKIEJ

Wydanie II. Ark. wyd. 4,8, ark. druku 7,5, 999/735

Contents

Introduction

In this new edition the glossary section has been extended and enriched. Additionally, some texts and descriptions of the in-text illustrations have been corrected.

This book has been written for students and PhD students of Mechanical Faculty, who would like to enlarge their vocabulary in the subject matter of their studies. The goal of the book is also for the students to practice using the new words through a variety of exercises. The material presented is intended for students of intermediate and upper intermediate level of English. Each unit provides a selection of texts illustrating the problems connected with mechanical engineering.

The aim is to provide students with vocabulary which might be useful in their future studies and professional career. The book consists of 13 units, each containing a text and comprehension and vocabulary exercises. A variety of exercises check the understanding, and practise vocabulary. The exercises are structured in such a way as to help students use the presented vocabulary creatively and memorize it.

The answer key to the exercises, mathematical tables and weights and measures are included at the back of the book.

Acknowledgments

We would especially like to thank Antoni Neyman, Jan Kłopocki and Michał Wasilczuk for their valuable comments and assistance throughout the writing process of this book.

Unit 1

Iron Ore

To make iron, you start with iron ore. Iron ore is simply rock that happens to contain a high concentration of iron.

One thing that gave certain countries an edge between the 15 th and 20 th centuries was the availability of iron ore deposits. For example, England, the United States, France, Germany, Spain and Russia all have good iron ore deposits. When you think of the historical importance of all of these countries, you can see the correlation!

Fig. 1.1. Hematite, a common iron ore

Common iron ores include:

Hematite	–	Fe_2O_3	–	70 percent iron
Magnetite	–	Fe_3O_4	–	72 percent iron
Limonite	–	$Fe_2O_3 + H_2O$	–	50 percent to 66 percent iron
Siderite	–	$FeCO_3$	–	48 percent iron

Usually, you find these minerals mixed into rocks containing silica.

Making Iron

All of the iron ores contain iron combined with oxygen. To make iron from iron ore, you need to eliminate the oxygen to create pure iron.

The most primitive facility used to refine iron from iron ore is called a bloomery. In a bloomery, you burn charcoal with iron ore and a good supply of oxygen (provided by a bellows or blower). Charcoal is essentially pure carbon. The carbon combines with oxygen to make carbon dioxide and carbon monoxide (releasing lots of heat in the process). Carbon and carbon monoxide combine with the oxygen in the iron ore and carry it away, leaving iron metal.

In a bloomery, the fire does not get hot enough to melt the iron completely, so you are left with a spongy mass containing iron and silicates from the ore. By heating and hammering the bloom, the glassy silicates mix into the iron metal to create wrought iron. Wrought iron is tough and easy to work, making it perfect for creating tools in a blacksmith shop.

The more advanced way to smelt iron is in a blast furnace. A blast furnace is charged with iron ore, charcoal or coke (coke is charcoal made from coal) and limestone (CaCO3). Huge quantities of air are blast in at the bottom of the furnace. The calcium in the limestone combines with the silicates to form slag. At the bottom of the blast furnace, liquid iron collects along with a layer of slag on top. Periodically, you let the liquid iron flow out and cool.

The liquid iron typically flows into a channel in a bed of sand. Once it cools, this metal is known as pig iron.

To create a ton of pig iron, you start with 2 tons of ore, 1 ton of coke and half-ton of limestone. The fire consumes 5 tons of air. The temperature reaches almost 3000 degrees F (about 1600 degrees C) at the core of the blast furnace!

Pig iron contains 4 percent to 5 percent carbon and is so hard and brittle that it is almost useless. You do one of two things with pig iron:

You melt it, mix it with slag and hammer it to eliminate most of the carbon (down to 0.3 percent) and create wrought iron. Wrought iron is the stuff a blacksmith works with to create tools, horseshoes and so on. When you heat wrought iron, it is malleable, bendable, weldable and very easy to work with.

Creating Steel

Steel is iron that has most of the impurities removed. Steel has a concentration of carbon from 0.5 to 1.5 percent. Impurities like silica, phosphor and sulfur weaken steel tremendously, so they must be eliminated. The advantage of steel over iron is its greatly improved strength.

The open hearth method is one way to create steel from pig iron. The pig iron, limestone and iron ore go into an open hearth furnace. It is heated to about 871ºC. The limestone and ore form a slag that floats on the surface. Impurities, including carbon, are oxidized and float out of the iron into the slag. When the carbon content is right, you have carbon steel.

Another way to create steel from pig iron is the Bessemer process.

The Bessemer process is an industrial process for the manufacture of steel from molten pig iron. The principle involved is that of oxidation of the impurities in the iron by the oxygen of air that is blown through the molten iron; the heat of oxidation raises the temperature of the mass and keeps it molten during the operation. The process is carried on in a large container called the Bessemer converter, which is made of steel and has a lining of silica and clay or of dolomite. The capacity is from 8 to 30 tons of molten iron; the usual charge is 15 or 18 tons. The converter is egg-shaped. At its narrow upper end it has an opening through which the pig-iron is put in and the finished product is poured out. The wide end, or bottom, has a number of perforations through which the air is forced upward into the converter during operation. The container is set on pivots so that it can be tilted at an angle to receive the charge, turned upright during the “blow” and inclined for pouring the molten steel after the operation is complete. As the air passes upward through the molten pig iron, impurities such as silicon, manganese, and carbon unite with the oxygen in the air to form oxides; the carbon monoxide burns off with a blue flame and the other impurities form slag. Dolomite is used as the converter lining when the phosphorus content is high; the process is then called basic Bessemer. The silica and clay lining is used in the acid Bessemer process, in which phosphorus is not removed. In order to provide the elements necessary to give the steel the desired properties, another substance (an iron-carbon-manganese alloy) is usually added to the molten metal after the oxidation is completed. The converter is then emptied into ladles from which the steel is poured into moulds; the slag is left behind. The whole process is completed in 15 to 20 min. The Bessemer process was superseded by the open-hearth process.

Most modern steel plants use what is called a basic oxygen furnace to create steel. The advantage is that it is a rapid process - about 10 times faster than the open hearth furnace.

A variety of metals might be alloyed with the steel at this point to create different properties. For example, the addition of 10 percent to 30 percent chromium creates stainless steel, which is very resistant to rust. The addition of chromium and molybdenum creates chrome-moly steel, which is strong and light.

By testing a metal under a load one can define what mechanical properties it has. One can determine strength, elasticity, plasticity, hardness and other properties of the metal. In order to have a clear conception of the metal properties, it is subjected to tests on special devices and machines. Let us consider some of the mechanical properties of metals.

Strength of materials is the property of some materials, mainly metals, to be subjected to the influence of external forces without incurring damage and without changing their shape. If a load acts upon a surface of unit area, it is called a unit force.

Elasticity is the ability of a material to change its shape under the influence of external loads and return to its original form upon removal of the load. All materials are elastic but the range of elasticity varies for different materials. For determining the elasticity of metals some machines may be used, among them a rupture machine.

Plasticity is that property of a material which under the influence of loads may elongate while its cross-section decreases. So plasticity is the ability of material to change its form without breaking under the influence of a load and preserve this changed form after removal of the load. For determining the plasticity of metals a rupture machine may be used too.

Hardness is the characteristic of a solid material expressing its resistance to permanent deformation. Hardness is the most important mechanical property of metals. Hardness can be measured on various scales.

Exercises

1. Match the words from the text with their Polish equivalents:

1) availability	a) topnieć
2) century	b) łączyć
3) deposits	c) gąbczasty
4) bloomery	d) wytapiać
5) combine	e) dostępność
6) melt	f) wiek
7) spongy	g) złoża
8) smelt	h) piec fryszerski
9) tool	i) narzędzie

2. Find in the text the English equivalents for the words:

1) węgiel drzewny
2) węgiel
3) tlenek
4) żelazo
5) kęsisko
6) miechy
7) dmuchawa
8) piec
9) wapień
10) żużel, szlaka

3. Find the English equivalents for the expressions:

1) gąbczasta masa zawierająca żelazo,
2) jest załadowywany rudą żelaza,
3) łączy się z krzemianami tworząc żużel,
4) metal ten zwany jest surówką,
5) jest jego znacznym wzmocnieniem,
6) utlenianie zanieczyszczeń w żelazie.

4. Put in the missing articles: *a*, *an*, *the* or nothing:

1. As ……. air passes upward through ……. molten pig iron, impurities such as silicon, manganese, and carbon unite with ……. oxygen in ……. air to form oxides.
2. Most modern steel plants use what is called ……. basic oxygen furnace to create ……. steel.
3. Steel is ……. iron that has most of ……. impurities removed.
4. ……. advantage of ……. steel over ……. iron is its greatly improved strength.
5. ……. process is carried on in ……. large container called ……. Bessemer converter, which is made of steel and has ……. lining of silica and clay or of ……. dolomite.

5. Translate the sentences into English:

1. Zanieczyszczenia takie jak krzemionka, fosfor i siarka znacznie osłabiają stal.
2. Do pieca Martenowskiego wkłada się surówkę, wapienie oraz rudę żelaza.
3. Proces ten zachodzi w dużym zbiorniku zwanym konwertorem Bessemera.
4. Zbiornik jest ustawiony na sworzniach tak, że może być pochylony o kąt potrzebny do pobrania wsadu.
5. Większość nowoczesnych hut do produkcji stali używa zasadowego konwertera tlenowego.

6. Make adjectives from the following nouns:

Nouns	Adjectives
industry	
strength	
welding	
quantity	
glass	
combination	
creation	
purity	
importance	
history	

Comprehension

1. Answer the following questions:

1. Do all iron ores contain oxygen?
2. How is slag formed?
3. What happens when we heat wrought iron?
4. What is the advantage of steel over iron?
5. What do we call a container in which the Bessemer process is carried on?
6. In what way can we determine what mechanical properties a metal has?

2. Match the terms with their definitions:

Charcoal	Calcium combined with the silicates
Slag	Iron with impurities removed
Steel	Impurity weakening steel
Sulfur	Pure carbon

Unit 2

Hand tools

Clamping devices

Clamping devices are employed to hold and position material while it is being worked. Several types are used in machining.

Vises

The machinist's or bench vise (fig. 2.1) is designed for numerous holding tasks. It should be mounted far enough out on the bench edge to permit clamping long work in a vertical position. It may be a solid base vise, or a swivel base type, which allows the vise to be rotated.

Small precision parts may be held in a small bench vise. This type vise can be rotated and tilted to any desired position. Vise size is determined by the width of the jaws.

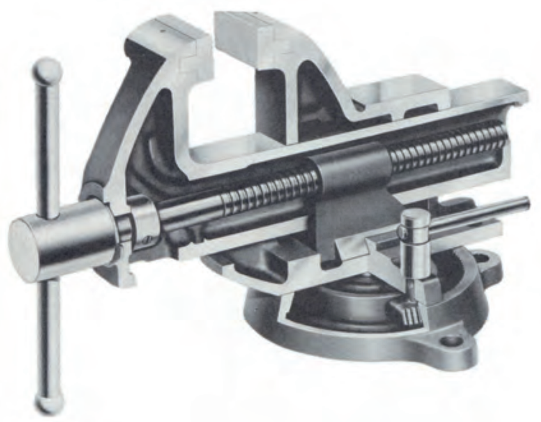


Fig. 2.1. Bench vise

A vise's clamping action is obtained from a power screw turned by a handle. The handle is long enough to apply ample pressure for any work that will fit the vise. Under no circumstances should the vise handle be hammered tight, nor should additional pressure be applied using pipes for leverage.

Vise jaws are hardened. Unless covered with soft copper, brass, or aluminum caps, the jaws should not be employed to clamp work that would be damaged or marred by the jaw serrations.

Clamps

The C-clamp and the parallel clamp hold parts together while they are worked on.

The C-clamp is made in many sizes. Jaw opening determines clamp size.

A parallel clamp is ideal for holding small work. For maximum clamping action, the jaw faces must be parallel.

Pliers

The combination or slip-joint pliers are widely used for holding operation. The slip-joint permits the pliers to be opened wider at the hinge pin to grip larger size work. The size of the pliers indicates the overall length of the tool.

Some combination pliers are made with cutting edges for clipping wire or small metal sections to needed lengths.

Diagonal pliers are another widely utilized tool for light cutting tasks. The cutting edges are at an angle to permit the pliers to cut flush with the work surface.

Side-cutting pliers are capable of cutting heavier wire and pins. Some of them have a wire stripping groove and insulated handles.

Round-nose pliers are helpful when forming wire and pieces made of light metal. Their jaws are smooth and will not mar metal being worked.

Needle-nose pliers, (both straight and curved-nose), are handy when work space is limited and for holding small work. They will reach into cramped places.

Tongue and groove pliers have aligned teeth for flexibility in gripping different size work. Jaw opening size can be adjusted easily. They are made in many different sizes.

Adjustable clamping pliers are a relatively new addition to the pliers family. Jaw opening can be adjusted through a range of sizes. After fitting on the work, a squeeze of the hand can lock the jaws onto the work with more than 9 kN. Jaw pressure can be relieved by opening the quick release on the handle. These pliers are made in many sizes with straight, curved, or long-nose jaws.

Wrenches

Torque limiting wrenches. Torque (often called a moment) can informally be thought of as “rotational force” or “angular force” which causes a change in rotational motion. This force is defined by linear force multiplied by a radius. The SI units for torque are newton metres.

Adjustable wrenches. The term “adjustable wrench” is a misnomer (not named properly). Other wrenches, such as the "monkey wrench" and pipe wrench, are also adjustable. However, the wrench that is somewhat like an open-end wrench, but with an adjustable jaw, is commonly referred to as an" adjustable wrench".

As the name implies, the wrench can be adjusted to fit a range of bolt head and nut sizes. Although convenient at times, the adjustable wrench is not intended to take the place of open-end, box, and socket wrenches.

The pipe wrench is a wrench that will grip round stock. However, the jaws always leave marks on the work.

Open-end wrenches are usually double ended, with two different size openings. They are made about 0.13 mm oversize to permit them to easily slip on bolt heads and nuts of the wrench size. Openings are angled with the wrench body so they can be applied in close quarters.

Box wrenches. The body or jaw of the box wrench completely surrounds the bolt head or nut. A properly fitted box wrench will not normally slip. It is preferred for many jobs. Box wrenches are available in the same sizes as open-end wrenches and with straight and offset handles.

Socket wrenches. Socket wrenches are box-like and are made with a detachable tool head-socket that fits many types of handles (either solid bar or ratchet type). A typical socket wrench set contains various handles and a wide range of socket sizes. Many sets include both standard and metric sockets.

Spanner wrenches are special wrenches with drive lugs; they are usually furnished with machine tools and attachments. Spanner wrenches are designed to flush and recessed type threaded fittings. The fittings have slots or holes to receive the wrench end.

A hook spanner is equipped with a single lug that is placed in a slot or notch cut in the fitting.

An end spanner has lugs on both faces of the wrench for better access to the fitting. The lugs fit notches or slots machined into the face of the fitting.

Allen wrenches. The wrench, used with socket-headed fasteners, is more commonly known as an allen wrench. It is manufactured in many sizes to fit fasteners of various standard and metric dimensions.

Screwdrivers

Screwdrivers are manufactured with many different tip shapes. Each shape has been designed for a particular type of fastener. The standard and Philips type screwdrivers are familiar to all shop workers.

A standard screwdriver has a flattened wedge-shaped tip that fits into the slot in a screw head. The shank diameter, and the width and thickness of the tip are proportional with the length. Screwdriver length is measured from blade tip to the handle. The blade is heat-treated to provide the necessary hardness and toughness to withstand the twisting pressures.

The Philips screwdriver has an X-shaped tip for use with Philips recessed head screws. They are manufactured in the same general styles as the standard screwdriver.

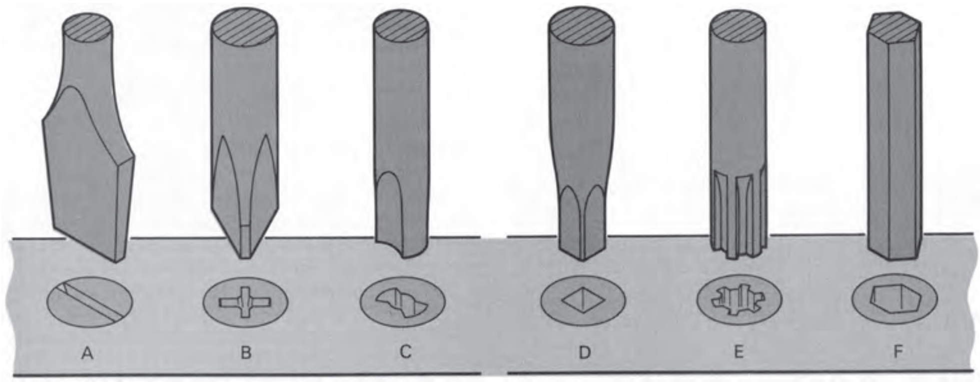


Fig. 2.2. Screwdriver tips. A – Standard, B – Philips, C – Clutch, D – Square, E – Torx, F – Hex

Hand cutting tools

Not all cutting in metalworking is done by machine. There are several basic hand tools that are cutting implements. These tools, when in good condition, sharp, and properly handled, are safe to use.

Chisels

Chisels are tools used mostly to cut cold metal, hence the term "cold" chisels.

The work to be cut will determine how the chisel should be sharpened. A chisel with a slightly curved cutting edge will work better when cutting on a flat plate. A curved edge will help prevent the chisel from cutting unwanted grooves in the surrounding metal, as when shearing rivet heads. If it is to be used to shear metal held in a vise, the cutting edge should be straight.

The chisel is frequently employed to chip surplus metal from castings. Chipping is started by holding the chisel at an angle. The angle must be great enough to cause the cutting edge to enter the metal.

Sawing metal by hand

The typical hacksaw is composed of a frame with a handle and a replaceable blade. Almost all hacksaws made today are adjustable to accommodate several different blade lengths. They are also made so the blade can be installed in either a vertical or horizontal position.

Files

A file is used for hand smoothing and shaping operations. The modern file is made from high grade carbon steel and is heat treated to provide the necessary hardness and toughness.

Files are classified by their shape. The shape is the general outline and cross section. The outline is either tapered or blunt. Files are also classified according to the cut of the teeth: single-cut, double-cut, rasp, and curved tooth, and to the coarseness of the teeth: rough, coarse, bastard, second-cut, smooth, and dead smooth.

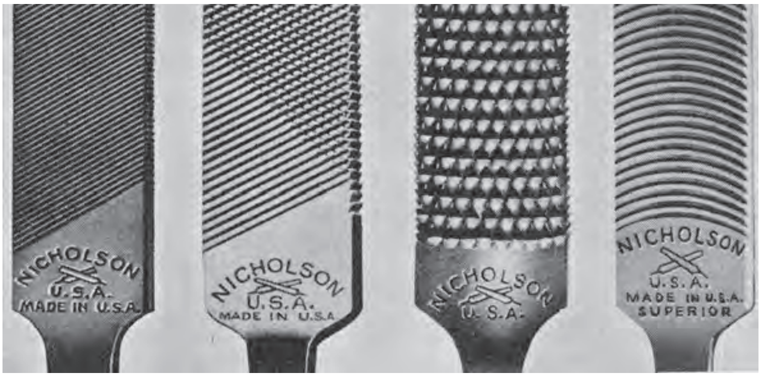


Fig. 2.3. Files. A – single-cut, B – double-cut, C – rasp, D – curved-tooth

There is almost no limit to the number of different kinds, shapes, and cuts of files that are manufactured.

Files have three distinct characteristics: length, kind and cut. The file length is always measured from the heel to the point. The tang is not included in the measurement.

The file type refers to its shape, such as flat , mill, half-round, square, etc. The file cut indicates the relative coarseness of the teeth.

Single-cut files are usually used to produce a smooth surface finish. They require only light pressure to cut.

Double-cut files remove metal much faster than single-cut files. They require heavier pressure and they produce a rougher surface finish.

Rasps are best for working wood or other soft materials where a large amount of stock must be removed in a hurry.

A curved-tooth file is used to file flat surfaces of aluminum and steel sheet.

Some files have safe edges which denotes that the file has one or both edges without teeth. This permits filing corners without danger to the portion of the work that is not to be filed.

Many factors must be considered in selecting the file if maximum cutting efficiency is to be attained:
— the nature of the work (flat, concave, convex, notched, etc.)
— kind of material.
— amount of the material to be removed.
— surface finish and accuracy demanded.

Of the many file shapes available, the most commonly used are flat, pillar, square, 3-square, knife, half-round, round, and crossing. Each shape is available in many sizes and degrees of coarseness.

Exercises

1. Find the English equivalents for these words:

1) obróbka skrawaniem
2) imadło
3) mosiądz
4) szczęki
5) ciśnienie
6) wypusty
7) rączka
8) okoliczności, warunki
9) miedź
10) szczypce
11) elastyczność
12) osiować
13) kołek
14) zakrzywiony
15) chwytać
16) nakrętka
17) gniazdo, oprawka
18) dodatki
19) zaciskanie, mocowanie
20) śruba, wkręt

2. Match the words from the text with their Polish equivalents:

1) torque
2) thread
3) misnomer

a) znaki
b) niewłaściwa nazwa
c) śruba

4) range — d) zakres
5) marks — e) zapadka
6) ratchet — f) moment obrotowy
7) bolt — g) gwint

4) range	d) zakres
5) marks	e) zapadka
6) ratchet	f) moment obrotowy
7) bolt	g) gwint

3. Match the words from the list with their English equivalents:

1) powierzchnia	a) smoothing
2) szorstki	b) shaping
3) wklęsły	c) rough
4) nacięcie pilnika	d) file cut
5) wycięcie, karb	e) surface
6) kształtowanie	f) concave
7) wygładzanie	g) notch

4. Match the words from the text in column A with their synonyms in column B:

A	B
convenient	let
permit	kinds
apply	different
proper	use
types	situated
various	helpful
placed	a little bit
slightly	right, slightly

5. Insert the, a, an, or – where no article is necessary:

1. Small precision parts may be held in ……. small bench vise. This type vise can be rotated and tilted to any desired position. ……. vise size is determined by ……. width of ……. jaws.
2. ……. vise's clamping action is obtained from ……. heavy screw turned by ……. handle. ……. handle is long enough to apply ……. ample pressure for any work that will fit ……. vise. Under no circumstances should ……. vise handle be hammered tight, nor should additional pressure be applied using ……. length of pipe for leverage.
3. ……. combination or ……. slip-joint pliers are widely used for holding operation. ……. slip-joint permits ……. pliers to be opened wider at ……. hinge

pin to grip larger size work. ……. size of ……. pliers indicates ……. overall length of ……. tool.

6. Complete the sentences with prepositions:

1. A vise's clamping action is obtained ……. a power screw turned ……. a handle.
2. The size ……. the pliers indicates the overall length ……. the tool.
3. They will reach ……. cramped places.
4. These pliers are made ……. many sizes with straight, curved, or long-nose jaws.
5. Box wrenches are available ……. the same sizes as open-end wrenches and ……. straight and offset handles.
6. A hook spanner is equipped ……. a single lug that is placed ……. a slot or notch cut ……. the fitting.
7. Each shape has been designed ……. a particular type ……. fastener.

7. Fill in the correct words from the list below:

finish, surplus, hardness, characteristics, cut, edges, frame, carbon

1. Files are also classified according to the ……. of the teeth.
2. Files have three distinct …….: length, kind and cut.
3. They require heavier pressure and they produce a rougher surface ……..
4. Some files have safe ……. which denotes that the file has one or both edges without teeth.
5. The chisel is frequently employed to chip ……. metal from castings.
6. The typical hacksaw is composed of a ……. with a handle and a replaceable blade.
7. The modern file is made from high grade ……. steel and is heat treated to provide the necessary ……. and toughness.

Comprehension

1. Choose the best item:

1. Torque is the product of:
   a) the speed times the force of the arm.
   b) the force divided by the length arm.

c) the force applied, times the length of the arm.
d) the force applied, times the width of the lever arm.

2. A standard screwdriver has:
   a) a flattened wing-shaped tip.
   b) a round wedge-shaped tip.
   c) a flattened wedge-shaped tip.
3. Chipping action by chisels is started by:
   a) holding the chisel straight.
   b) holding the chisel at an angle.
   c) holding the chisel in a perpendicular position.

2. Answer the following questions.

1. What are the files classified by?
2. What is a wrench used with socket-headed fastener known as?
3. Which wrenches are double ended?
4. What is the vise size determined by?
5. Are vise jaws hardened?

Unit 3

Measurement

Without some form of accurate measurement, modern industry could not exist. The science that deals with systems of measurement is called metrology.

Today, industry makes measurements accurately to one-millionth of the inch. This is known as a microinch. One-millionth of a meter is called a micrometer. If a microinch were as thick as a dime, an inch would be as high as four Empire State Buildings.

The rule

The steel rule, often incorrectly referred to as a scale, is the simplest of the measuring tools found in the shop. There are three basic types of rule graduations: metric, fractional, and decimal.

The micrometer caliper

A Frenchman, Jean Palmer, devised and patented a measuring tool that made use of a screw thread, making it possible to read measurements quickly and accurately without calculations.

It incorporated a series of engraved lines on the sleeve and around the thimble. The device, called "Systeme Palmer" is the basis for the modern micrometer caliper – fig. 3.1.

Fig. 3.1. Micrometer caliper

The micrometer caliper, also known as a “mike”, is a precision measuring tool capable of measuring to 1/100(0.01) mm. When fitted with a Vernier scale, it will read to 2/1000 (0.002) mm.

Micrometers are made in a large variety of models. A few of the more commonly used are:

— An outside micrometer, measures external diameters and thicknesses.
— An inside micrometer, measures internal diameters of cylinders and rings, widths of slots, etc. There are two general styles of inside micrometers: the conventional inside micrometer, whose range is extended by fitting longer rods to the micrometer head, and the jaw-type inside micrometer, whose range is limited to 25 mm.
— A direct reading micrometer is read directly from the numbers appearing in the readout opening in the frame. An electronic digital readout micrometer senses the spindle position on the work and indicates the measurement on the digital display.
— A micrometer depth gage will measure the depths of holes, slots, projections, etc. The measuring range can be increased by changing to spindles of longer lengths.
— A screw thread micrometer has a pointed spindle and a double “V” anvil, both correctly shaped to contact the screw thread. It measures the pitch diameter of the thread, which equals the outside diameter of the thread minus the depth of one thread.

Reading a metric Vernier micrometer

Metric Vernier micrometers (fig. 3.2) are used like those graduated in hundredths of a millimeter (0.01 mm). However, using the Vernier scale on the sleeve, an additional reading of two-thousandths of a millimeter can be obtained.

The important thing is to hold a micrometer properly when making a measurement. The work is placed into position, and the thimble rotated until the part is clamped lightly between the anvil and spindle. Guard against excessive pressure. It will cause erroneous reading. The correct contact pressure will be applied if a “mike” with a ratchet stop is used. This device is used to rotate the spindle. When the pressure reaches a predetermined amount, the ratchet stop slips and prevents further turning of the spindle. Uniform contact pressure with the work is assured even if different people use the same micrometer. Some micrometers are fitted with a friction thimble. It is a friction control built into the upper section of the thimble.

When several identical parts are to be gaged, lock the spindle into place with the lock ring. Gaging parts with a micrometer locked at the proper setting is an easy way to determine whether the pieces are oversize, correct size, or undersize.

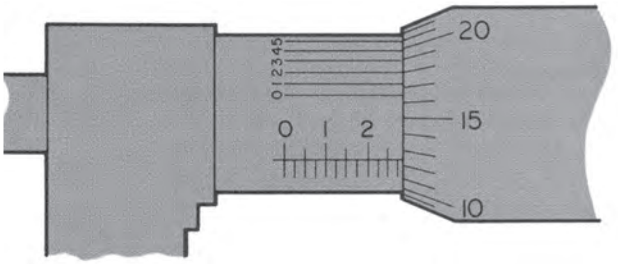


Fig. 3.2. Metric Vernier micrometer scale

Reading an inside micrometer

To get a correct reading with an inside micrometer, it is important that the tool be held square across the diameter of the work. It must be positioned so that it will measure across the diameter on exact center.

Measurement is made by holding one end of the tool in place and then ”feeling” for the maximum possible setting by moving the other end from left to right, and then in and out of the opening. The measurement is made when no left or right movement is felt, and a slight drag is noticeable on the in and out swing. It may be necessary to take several readings and average them.

Reading a micrometer depth gage

Be sure to read a micrometer depth gage correctly. Unlike an outside micrometer, the graduations on this measuring tool are in REVERSE ORDER. That is: they read 0,9,8,7, etc.

Vernier measuring tools

The Vernier principle of measuring was named for its inventor, Pierre Vernier (1580−1637), a French mathematician.

The Vernier caliper, unlike the micrometer caliper, can make both inside and outside measurements. The design of the tool permits measurements to be made over a large range of sizes. The Vernier caliper can make accurate measurements to 1/50 or 2/100 (0.02) mm.

The following measuring tools also utilize the Vernier principle:

— the Vernier height gage is designed for use in tool rooms and inspection departments, for layout work, checking hole or pin location, etc.,
— the Vernier depth gage is ideal for measuring the depth of holes, slots, and recesses,
— a gear tooth Vernier caliper is needed to measure gear teeth, form and threading tools,

— a universal Vernier bevel protractor is designed for the precision layout and measurement of angles. Angles are measured in degrees, minutes, and seconds.

Vernier measuring tools, with the exception of the Vernier bevel protractor, consist of a graduated beam with fixed jaw, and a Vernier slide assembly. The Vernier slide assembly is composed of a movable jaw, Vernier plate, and clamping screws. The slide moves as a unit along the beam. Unlike other Vernier measuring tools, the beam of the 'Vernier caliper is graduated on both sides. One side is for making OUTSIDE measurements, the other for INSIDE measurements. Many of the newer Vernier measuring tools are graduated to make both inch and millimeter measurements.

Universal Vernier bevel protractor

There are many times when angles must be measured with great accuracy. A universal Vernier bevel protractor can measure angles accurately to 1/12 degrees or 5 minutes. A quick review of the circle, angles, and units of measurement associated with them will help in understanding how to read this instrument.

Degree − A circle, no matter what size, contains 360° degrees. Angles are also measured by degrees.

Minute − If a degree were divided into 60 equal parts, each part would be one minute. The minute is utilized to represent a fractional part of a degree.

Second − There are 60 seconds in one minute. An angular measurement written in degrees, minutes, and seconds would be 36° 18' 22" .This would read 36 degrees, 18 minutes, and 22 seconds.

The universal bevel protractor fig. 3.3 is a finely made tool with a dial graduated into degrees, a base, and a sliding blade that can be extended in either direction or set at any angle to the stock. The blade can be locked against the dial by tightening the blade clamp nut. The blade and dial can be rotated as a unit to any desired position, and locked by tightening the dial clamp nut.

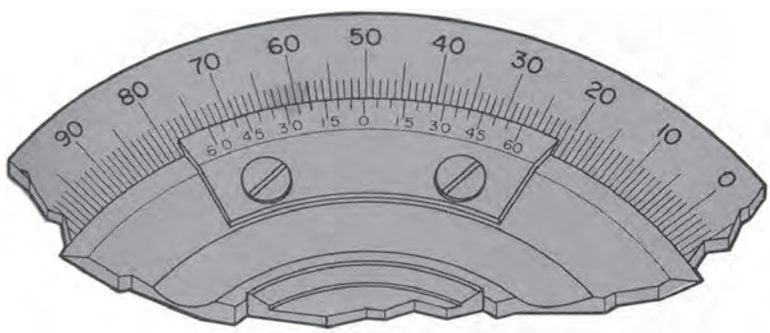


Fig. 3.3. Universal Vernier bevel protractor

The protractor dial, graduated into 360 degrees reads 0-90 degrees and 90-0 degrees. Every ten degrees is numbered, and each 5 degrees is indicated by a fine line longer than those on either side. The Vernier scale is divided into twelve equal parts on each side of the “0”. Every third graduation is numbered 0, 15, 30, 45, and 60, representing minutes. Each division equals 5 minutes. Since each degree is divided into 60 minutes, each division is equal to 5/60 of a degree. To read the protractor, note the number of degrees that can be read up to the “0” on the Vernier plate. To this, add the number of minutes indicated by the line beyond the ”0” on the Vernier plate that aligns exactly with a line on the dial.

Gages

It is impractical to check every dimension on every manufactured part with conventional measuring tools. For rapid checking, plug, ring, and snap gages, precision gage blocks, dial indicators and other electronic, optical and laser gages are employed. These gaging devices can quickly determine whether the dimensions of a manufactured part are within specified limits of tolerances.

Gaging, which is the term used when checking parts with various gages, differs somewhat from measuring. Measuring requires the skillful use of precision measuring tools to determine the exact geometric size of the piece. Gaging, on the other hand, simply shows whether the piece is made within the specified tolerances.
When great numbers of an item, with several critical dimensions, are manufactured ,it may not be possible to check each piece. It therefore becomes necessary to decide how many pieces, picked at random, must be checked to assure satisfactory quality and adherence to specifications. This technique is called statistical quality control.
Several types of gages have been developed. Each has been devised to do a specific job.

Plug gages are used to check whether hole diameters are within specified tolerances. The double end cylindrical plug gage fig. 3.4, has two gaging members known as GO and NO-GO plugs. The GO plug should enter the hole with little or no interference. The NO-GO plug should NOT enter if the opening is made to specifications.
The GO plug is made LONGER to distinguish it from the NO-GO plug. A progressive or step plug gage is able to check the GO and NO-GO dimensions in one motion.

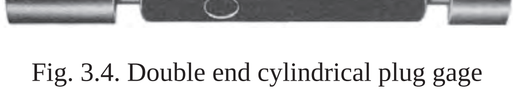


Fig. 3.4. Double end cylindrical plug gage

Ring gage. External diameters are checked with ring gages fig. 3.5. The GO and NO-GO ring gage are separate units, that can be distinguished from each other by a groove cut on the knurled outer surface of the NO-GO gage.

On ring gages, the gage tolerance is OPPOSITE to that applied to the plug gage. The opening of the GO gage is larger than the NO-GO gage.

Fig. 3.5. Ring gages

A snap gage functions much the same as a ring gage. It is made in three general types:

The adjustable snap gage, which can be adjusted through a range of sizes.

The nonadjustable snap gage fig. 3.6, which is made for one specific size.

The dial indicator snap gage, on which plus or minus tolerances are read directly from the indicator. The dial face has a double row of graduations reading in opposite directions from zero. MINUS graduations are in red and PLUS graduations are in black.

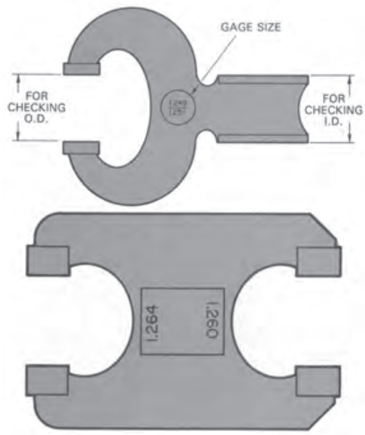


Fig. 3.6. Top – Combination internal – external nonadjustable snap gage. Bottom – Nonadjustable type external snap gage

Thread gages. Gages similar to those just described are used to check screw thread fits and tolerances and are known as thread plug gages fig. 3.7 and thread ring gages fig. 3.9, and thread roll snap gages.

Fig. 3.7. Thread plug gage

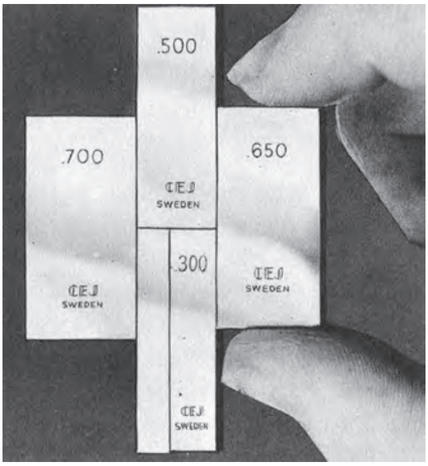


Fig. 3.8. Gage blocks

Gage blocks (fig. 3.8) are super accurate steel measuring standards commonly known as Jo-blocks. They are accepted by major world powers as standards of accuracy for all types of manufacturing.

Gage blocks are used widely to check and verify the accuracy of master gages; as working gages for toolroom work; and for laying out and setting up work for machining where extreme accuracy is required.

Gage blocks can be purchased in various combinations or sets ranging from a few carefully selected blocks that meet conditions found in many shops, to a complete set of 121 blocks.

Dial indicators

Much use is made of dial indicators for centering and aligning work on machine tools, checking for eccentricity, and visual inspection of work.

Dial indicators are made like fine watches with shockproof movements and jeweled bearings. They are either of the balanced type, where the figures read in both directions from ”0”, and the continuous type, that reads from “0” in a clockwise direction.

Fig. 3.9. Thread ring gage

The hand on the dial is actuated by a sliding plunger. Place the plunger lightly against the work until the hand moves. The dial face is turned until the “0” line coincides with the hand. As the work or unit touching the plunger is slowly moved, the indicator hand will measure this movement. For example, it might show the difference between the high and low points or the total run-out of the piece in a lathe. When machining, adjustments are made until there is little or no indicator movement.

Electronic gage. Another gage that can make extremely close measurements is the electronic gage. It is a comparison type gage and must be calibrated by means of master gauge blocks

The laser is a device that produces a very narrow beam of extremely intense light that can be utilized for communication, medical, and industrial applications. Laser is the abbreviation for Light Amplification by Stimulated Emission of Radiation. The laser is another area of technology that has moved from the laboratory into the shop. When employed for inspection purposes, it can check the accuracy of critical areas in machined parts quickly and accurately. Laser gage is shown in fig. 3.10.

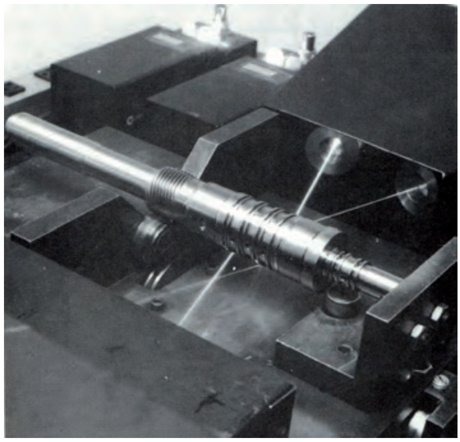


Fig. 3.10. Laser gage

The optical comparator uses magnification as a means for production inspection. An enlarged image of the part is projected upon a screen for inspection. The part image is superimposed upon an enlarged accurate drawing of the correct shape and size. The comparison is made visually. Variations as small as 0.012 mm can be noted by a skilled operator.

Optical flats are precise measuring instruments that use light waves as a measuring standard. The flats are made of quartz with one face ground and polished to optical flatness. When this face is placed on a machined surface and a special light passes through it, light bands appear on the surface. The shape of these bands indicate to the inspector the accuracy of the measurement in millionths, ten millionths, and hundred millionths of a mm.

Exercises

1. Find in the text the English equivalents to the following Polish words:

1) moneta dziesięciocentowa
2) podziałka
3) dziesiętny
4) liczyć
5) obmyśleć
6) dokładnie
7) mechanizm zapadkowy
8) bębenek, nasadka
9) piasta
11) tuleja, bęben
12) układ
13) czujnik
14) rzut
15) sprawdzian szczękowy
16) trzpień pomiarowy
17) średnica podziałowa
18) odczyt wskazań przyrządu
19) mikrometr

2. Find synonyms to the following words in the above text:

1) skilled
2) show
3) place
4) go up
5) limits
6) get
7) correctly
8) turn around
9) same

3. Complete the table:

Verb	Noun	Adjective
		measurable
*****		possible
*****		capable
*****	precision	
		general
direct		
	appearance	*****
indicate		
	notice	
*****		accurate

4. Insert *the a*, *an* or – where no article is necessary:

1. One-millionth of ……. meter is called ……. micrometer.
2. ……. distance of ……. measurement is determined by counting ……. number of ……. millimeters.
3. ……. direct reading micrometer is read directly from ……. numbers appearing in ……. readout opening in ……. frame.
4. It measures ……. pitch diameter of ……. thread, which equals ……. outside diameter of ……. thread minus ……. depth of one thread.
5. To get ……. correct reading with ……. inside micrometer, it is important that ……. tool be held square across ……. diameter of ……. work.
6. ……. universal bevel protractor is ……. finely made tool with ……. dial graduated into ……. degrees, ……. base, and ……. sliding blade that can be extended in either ……. direction or set at any angle to ……. stock.

5. Complete the sentences using a word from the box below:
accurate, device, measurements, pressures, setting, average, angle

1. They found a useful ………. for detecting electrical activity.
2. The builders made careful ………..
3. The gas containers burst at high ………..
4. The freezer is already on its highest ………..
5. I suppose I ………. about five cups of coffee a day.
6. The cutter is ………. to within half a millimetre.
7. This drawing of the monastery was done from an unusual ………..

6. Put the verbs in brackets into the correct tense and voice form:

1. The Vernier slide assembly is ………. (compose) a movable jaw, Vernier plate, and clamping screws.
2. Unlike other Vernier measuring tools, the beam of the Vernier caliper ………. (graduate) on both sides.
3. The minute ………. (utilize) to represent a fractional part of a degree.
4. The blade can ………. (lock) against the dial by tightening the blade clamp nut.
5. When great numbers of an item, with several critical dimensions, ………. (manufacture), it may not be possible to check each piece.
6. The adjustable snap gage, which can ………. (adjust) through a range of sizes.
7. They ………. (accept) by major world powers as standards of accuracy for all types of manufacturing.
8. It must ………. (position) so that it ………. (measure) across the diameter on exact center.
9. It may be necessary to take several readings and ………. (average) them.

7. Complete the sentences with prepositions:

1. It is a friction control built ………. the upper section ……….the thimble.
2. Guard ………. excessive pressure.
3. A micrometer depth gage will measure the depths ………. holes, slots, projections, etc.
4. Micrometers are made ………. a large variety ………. models.
5. There are three basic types ………. rule graduations: metric, fractional, and decimal.

6. The science that deals ………. systems ………. measurement is called metrology.
7. Variations as small as 0.012 mm can be noted ………. a skilled operator.

Comprehension

1. Answer the following questions:

1. What are basic types of rule graduations?
2. What is the distance of the measurement determined by?
3. What device is the basis for the modern micrometer caliper?
4. Which micrometer measures widths of slots?
5. What is necessary to measure a full range of thread pitches?

2. Match the words with their definitions:

Micrometer caliper	Technique checking items to assure satisfactory quality and adherence to specifications.
Optical flats	A precision measuring tool capable of measuring to 1/100 mm.
Statistical quality control	Measuring instruments that use light waves as a measuring standard

Unit 4

Lasers

Lasers (Light Amplification by Stimulated Emission of Radiation) are used in practically every major industry, from medicine and computers, to entertainment and construction. A power rating, usually in watts, determines the strength of the laser. Some lasers can cut through metal, while others merely read tiny bits of information without damaging the surface. Basically, the application of lasers can be divided into marking, etching and cutting, or reading and scanning.

In the medical industry, carbon dioxide lasers are used in many types of surgery because they are more precise and sensitive than scalpels. Lasers remove tattoos without needing skin grafts, as well as painlessly clearing rot out of teeth. These less invasive lasers result in faster recuperation from surgeries such as removing certain tumors and correcting vision by reforming the eyeball lens. Damage to surrounding tissue, as well as bleeding, has been reduced by using lasers.

In many home or office devices lasers are used. CD, DVD and Blue-Ray players use lasers to read the audio and video information on the disc, the way a needle used to read the groove of a record. CD, DVD and Blue-Ray recorders have stronger lasers that can burn the information onto the surface of the disc, either temporarily or permanently. Laser printers utilize lasers to change the surface of the paper and to display text and graphics. Even at the grocery store, lasers scan the barcode on your packages to tell the computerized register what you're buying and how much it costs.

Lasers of the appropriate strength can etch surfaces from plastic to rock. Some companies inscribe a minute identification number on diamonds to keep track of them. Tombstones made of granite or limestone are carved with powerful lasers. Numerous metal pieces can be precisely cut out, drilled, and welded together to make a finished product using lasers capable of melting metal. Even though the first laser was made in a laboratory back in 1960, it took several decades to apply this tool to various technologies. Now lasers are indispensable to our daily lives. Visible lasers have even replaced strings, levels, and stakes in surveying equipment. Everyone should be treated to a laser show inside a planetarium, where coloured lasers of all widths simulate the night sky.

Exercises

1. Find the English equivalents:

1) przemysł
2) rozrywka

3) powierzchnia
4) zastosowanie
5) trawienie
6) dwutlenek węgla
7) rekuperacja
8) soczewka
9) wykorzystywać
10) mały, drobny

2. Match the words from the text with their Polish equivalents:

1) major	a) niezbędne
2) determine	b) tkanka
3) strength	c) chirurgia
4) invasive	d) główny
5) surgery	e) określać
6) tissue	f) inwazyjny
7) display	g) siła
8) barcode	h) wyświetlać
9) inscribe	i) kod kreskowy
10) indispensable	j) wyryć, wypisać

3. Translate the following sentences into Polish:

1. Some lasers can cut through metal, while others merely read tiny bits of information without damaging the surface.
2. In the medical industry, carbon dioxide lasers are used in many types of surgery because they are more precise and sensitive than scalpels.
3. Laser printers utilize lasers to change the surface of the paper and to display text and graphics.
4. Lasers of the appropriate strength can etch surfaces from plastic to rock.
5. Even though the first laser was made in a laboratory back in 1960, it took several decades to apply this tool to various technologies.

4. Find in the text synonyms for the following words:

1) amusement, fun
2) define, specify
3) little, small
4) use
5) fundamentally
6) take away, clear away
7) piece, chunk
8) recovery

9) show, demonstration
10) necessary

5. Find the opposites to these words:

1) minor
2) big
3) multiply
4) inaccurate
5) fix
6) more
7) weaker
8) invisible
9) outside
10) inner

6. Put in the missing articles: a, an, the or nothing:

1. ……. power rating, usually in watts, determines ……. strength of ……. laser.
2. ……. damage to surrounding tissue, as well as ……. bleeding, has been reduced by using ……. lasers.
3. CD, DVD and Blue-Ray players use lasers to read ……. audio and video information on ……. disc, ……. way ……. needle used to read ……. groove of ……. record.
4. Laser printers utilize lasers to change ……. surface of ……. paper and to display text and ……. graphics.
5. Even though ……. first laser was made in ……. laboratory back in 1960, it took several decades to apply this tool to various technologies.

Comprehension

1. Answer the following questions:

1. Why are carbon dioxide lasers used in surgery?
2. What surfaces can lasers of the appropriate strength etch?
3. What types of devices can read the audio and video information using lasers?
4. What can remove tattoos without a skin graft operation?
5. Why do lasers scan the barcodes on packages?
6. In what units is lasers' power rating given?
7. Can we find lasers that do not damage the surface while reading small bits of information?

Unit 5

Lathe

The lathe operates on the principle of the work being rotated against the edge of a cutting tool. It is one of the oldest and most important machine tools. The lathe with its main parts is shown in fig. 5.1. The cutting tool is controllable and can be moved lengthwise on the lathe bed and into any desired angle across the revolving work. Lathe size is determined by the swing and length of the bed. The swing indicates the largest diameter that can be turned over the ways: a flat or v shaped bearing surface that aligns and guides the movable part of machine. Bed length is the entire length of the ways.

Bed length must not be mistaken for the maximum length of the work that can be turned between centers. The longest piece that can be turned is equal to the length of the bed minus the distance taken up by the headstock and tailstock.

The chief function of any lathe, no matter how complex it may appear to be, is to rotate the work against a controllable cutting tool. Each of the lathe parts falls into one of the following categories:

1. Driving the lathe.
2. Holding and rotating the work.
3. Holding, moving, and guiding the cutting tool.

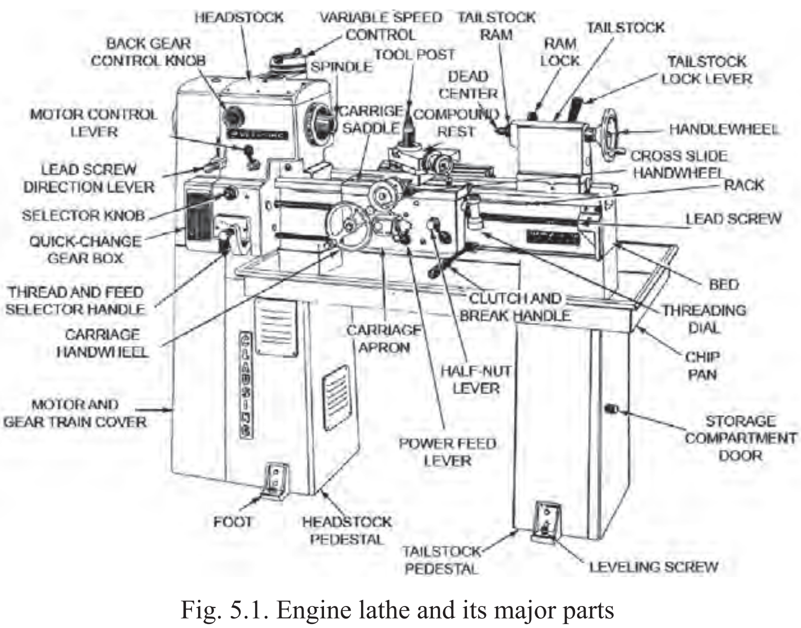


Fig. 5.1. Engine lathe and its major parts

Driving the lathe

Power is transmitted to the various drive mechanisms by belt drive or gear train. Spindle speed can be varied by:

1. Shifting to a different gear ratio.
2. Adjusting a split pulley to another position.
3. Controlling the speed hydraulically.

Holding and rotating the work

The headstock contains the spindle to which the various work holding attachments are fitted.

The spindle revolves in heavy duty bearings and is rotated by belts, gears, or a combination of both. It is hollow with the front tapered internally to receive tools and attachments with taper shanks. The hole permits long stock to be turned without dangerous overhang. It also allows use of a knockout bar to remove taper shank tools.

Externally, on the front end, a spindle is threaded or fitted with one of two types of tapered spindle noses to receive work holding attachments.

A threaded spindle nose permits mounting an attachment by screwing it directly on the threads until it seats on the spindle flange.

The cam-lock spindle nose has a short taper that fits into a tapered recess on the back of the work holding attachment. A series of camlocking studs, located on the back of the attachment, are inserted into holes in the spindle nose. The studs are locked by tightening the cams located around the spindle nose.

A long taper key spindle is fitted with a long taper and key that fits into a corresponding taper and keyway in the back of the work holding device. Mounting is done by rotating the key until it is on the top. The keyway in the back of the work holding attachment is slid over the key to support the device until the threaded spindle collar can be engaged with the threaded section on the back of the chuck, faceplate, etc., and tightened. Work is held in the lathe by a chuck, faceplate, collet or between centers.

The outer end of the work is often supported by the tailstock. It can be adjusted along the ways to accommodate different lengths of work. The tailstock mounts the dead center ,and can be fitted with tools for drilling, reaming, and threading. The tailstock is locked on the ways by tightening a clamp bolt nut or binding lever. The tailstock spindle is positioned by rotating the handwheel and can be locked in position by tightening a binding lever.

Holding, moving and guiding the cutting tool

The bed is the foundation of a lathe. All other parts are fitted to it. Ways are integral with the bed. The V-shape maintains precise alignment of the headstock and tailstock, and serves as rails to guide the travel of the carriage. The carriage controls and supports the cutting tool. Power is transmitted to the carriage through the feed mechanism, which is located at the left of the lathe. Power is transmitted through a train of gears to the quick change gear box which regulates the amount of tool travel per revolution of the spindle. The gear train also contains gears for reversing tool travel. The quick change gear box is arranged between the spindle and the lead screw. It contains gears of various ratios, which makes it possible to machine various pitches of screw threads. Longitudinal (back-and-forth) travel and cross (in-and-out) travel is controlled in the same manner.

Exercises

1. Find the English equivalents for these words:

1) narzędzie tnące
2) zasada
3) prowadnice
4) materiał obrabiany
5) konik
6) uchwyt obrotowy
7) koło pasowe
8) wrzeciono
9) łożysko, panewka
10) chwyt stożkowy
11) wypychacz
12) wrzeciennik
13) kołnierz
14) gwintowanie
15) śruba dwustronna
16) zderzak
17) tuleja
18) suport wzdłużny
19) kieł stały
20) oprawka pierścieniowa
21) pokrętło
22) skrzynka przekładniowa

2. Fill in the correct preposition:

1. Ways are integral ……. the bed.
2. The bed is the foundation ……. a lathe.
3. The gear train also contains gears ……. reversing tool travel.

4. The outer end ……. the work is often supported ……. the tailstock.
5. Power is transmitted ……. the carriage ……. the feed mechanism, which is located ……. the left ……. the lathe.

3. Rewrite the following sentences in the passive:

1. We can move a cutting tool lengthwise on the lathe bed.
2. The swing and length of the bed determines lathe size.
3. The longest piece that we can turn.
4. A belt drive transmits power to the various drive mechanisms.
5. Belts and gears rotate the spindle.
6. We lock the studs by tightening the cams located around the spindle nose.
7. Chuck, faceplate or collet hold work in the lathe.

4. Complete the table:

Verb	Noun
move	
	indication
revolve	
	engagement
align	
	service
contain	
	rotation

5. Match the words from the text in column A with their synonyms in column B:

A	B
desire	every
rotation	main
chief	want
appear	purpose
each	put in order
major	situation
use	turning
position	seem
arrange	important

6. Find in the text the English equivalents for the expressions:

1) które może być obracane nad prowadnicami,
2) niezależnie od tego jak skomplikowana może się wydawać,

3) albo kombinacja obu,
4) aż usadowi się na kołnierzu wrzeciona,
5) spełnia funkcję,
6) ustawione między wrzecionem a śrubą pociągową.

7. Supply the missing words:

1. Bed length is e………. length of the ways.
2. Lathe size is determined by the s………. and length of the bed.
3. Power is transmitted to the various d………. mechanisms.
4. The hole permits long s………. to be turned without dangerous o………..
5. Mounting is done by rotating the k………. until it is on the top.

Comprehension

1. Answer the following questions:

1. Can the cutting tool of a lathe be controlled?
2. What is the lathe size determined by?
3. Can the spindle speed be varied by controlling the speed hydraulically?
4. What is a knockout bar used for?
5. What is the work in the lathe held by?
6. Can the tailstock be fitted with tools for reaming?
7. What is the function of the carriage?

2. Say whether the following statements are true or false?

1. The cutting tool is uncontrollable and can't be moved lengthwise on the lathe bed.
2. Lathe's bed length is not the entire length of the ways.
3. Work holding attachments may be mounted on the lathe.
4. The outer end of the work is often supported by the carriage apron.
5. The V-shape of the lathe's bed serves as rails to guide the travel of the carriage.

Unit 6

Milling Machines

A milling machine rotates a multitooth cutter into the work (fig. 6.1). A wide variety of cutting operations can be performed on milling machines. They are capable of machining flat or contoured surfaces, slots, grooves, recesses, threads, gears, spirals, and other configurations.

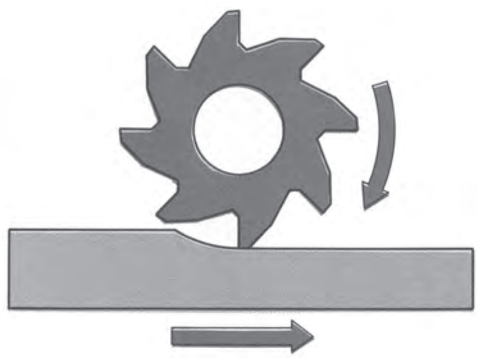


Fig. 6.1. Milling

There are more variations of milling machines available than any other family of machine tools. Milling machines are well suited for computer controlled operations. As mentioned, metal is removed in milling by means of turning a multitooth cutter into the work. Each tooth of the cutter removes a small individual chip of material. Work may be clamped directly to the machine table, held in a fixture, or mounted in or on one of the numerous work-holding devices available for milling machines.

Types of milling machines

It is difficult to classify the various categories of milling machines because their designs tend to merge with one another. However, for practical purposes, milling machines may be grouped into two large families:

1. Fixed-bed type.
2. Column and knee type.

Both groups are made with horizontal or vertical spindles. On a horizontal spindle milling machine, the cutter is fitted onto an arbor mounted in the machine on an axis parallel with the work table. The cutter on a vertical spindle milling machine is normally perpendicular or at a right angle to the work table. However, on many vertical spindle machines, it can be tilted to perform angular cutting operations.

Fixed-bed milling machines

Fixed-bed or bed-type milling machines are characterized by very rigid work table construction and support. The work table moves only in a longitudinal direction (back and forth/X-axis) and can vary in length from 3 to 30 ft. (0.9 to 9.0m). Vertical (up and down/Z-axis) and cross (in and out/Y-axis) movements are obtained by cutter head movements. The type of bed permits heavy cutting on large, heavy work. Bed-type milling machines can be further classified as horizontal, vertical, or planer type machines.

Column and knee milling machines

The column and knee type milling machine fig. 6.2 is so named because the parts that provide movement to the work consist of a column that supports and guides the knee in vertical movement (up and down/Z-axis). The knee supports the mechanism for obtaining traverse (in and out/Y-axis) and longitudinal (back and forth/X-axis) table movements.

There are three basic types of knee and column type milling machines:

1. Plain (horizontal spindle) milling machine.
2. Universal (horizontal spindle) milling machine.
3. Vertical spindle milling machine.

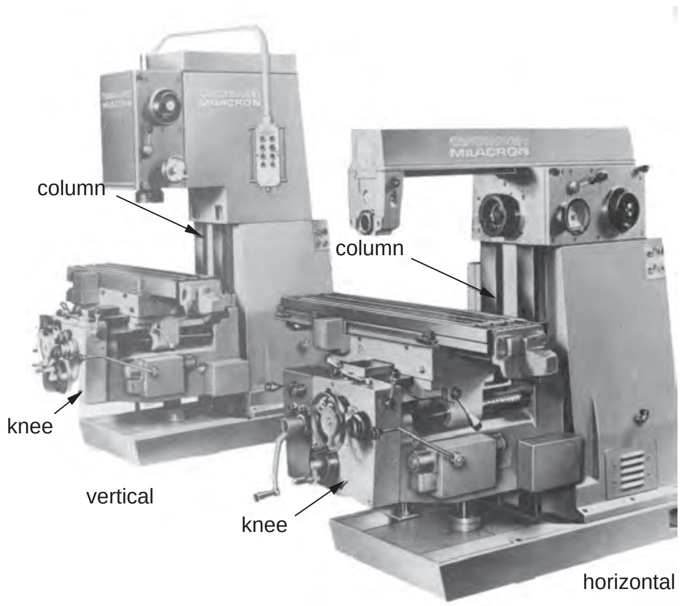


Fig. 6.2. Column and knee type milling machines

Plain milling machine

The work table on the plain milling machine has three movements: vertical, cross, and longitudinal (X-,Y-, and Z-axes).The cutter spindle projects horizontally from the column.

Universal milling machine

A universal milling machine is similar to the plain milling machine but the table has a forth movement. On this type of machine ,the table can be swiveled on the saddle through an angle of 45 degrees or more. This makes it possible to produce spiral gears, spiral splines, and similar work.

Vertical spindle milling machine

A vertical spindle milling machine differs from the plain and universal machines by having the cutter spindle in a vertical position, at a right angle to the top of the work table. The cutter head can be raised and lowered by hand or by power feed. This type milling machine is best suited for an end mill or face mill cutter. Vertical mills include swivel head, sliding head, and rotary head types. On a swivel head milling machine, the spindle can be swiveled for angular cuts.

On the sliding head milling machine, the spindle head is fixed in a vertical position. The head can be moved in a vertical direction by hand or under power.

The spindle on the rotary head milling machine can be moved vertically and in circular arcs of adjustable radii about a vertical center line. It can be adjusted manually or under power feed.

Methods of milling machine control

The method employed to control table movement is another way of classifying milling machines, and all machine tools in general. Basically, there are four methods of control.

1. Manual-All movements are made by hand lever control.
2. Semi-automatic-Movements are controlled by hand or power feeds.
3. Fully automatic-A complex hydraulic feed arrangement follows two or three dimensional templates to guide the cutter automatically.
4. Computerized (CNC)-Machining coordinates are entered into a master computer or computer on the machine using a special programming language. Computer instructions electronically guide the cutter through the required machining sequence.

Adjusting milling cutting speed and feed

Depending upon the milling machine make, cutting speed (cutter rpm) and rate of feed (table movement speed) may be changed by:

1. ShiftingV-belts.
2. Adjusting variable speed pulleys.
3. Utilizing a quick change gear box and shifting or dialing to the required speed and feed setting. On some machines, speed and feed changes are made hydraulically or electronically.

There are two main categories of milling operations.

1. Face milling is done when the surface being machined is parallel with the cutter face. Large, flat surfaces are machined with this technique.
2. Peripheral milling is done when the surface being machined is parallel with the periphery of the cutter.

Milling cutters

The typical milling cutter is circular in shape with a number of cutting edges (teeth) located around the circumference. A milling cutter is manufactured in a large number of stock shapes, sizes, and kinds, because it cannot be economically ground for a particular job as can a lathe cutter bit.

Types of milling cutters

There are two general types of milling cutters:

1. A solid cutter has the shank and body made in one piece.
2. The inserted tooth cutter has teeth made of special cutting material, which are brazed or clamped in place. Worn and broken teeth can be replaced easily instead of discarding the entire cutter.

Milling cutters are frequently classified by the method used to mount them on the machine.

1. Arbor cutters have a suitable hole for mounting to an arbor.
2. Shank cutters are fitted with either a straight or taper shank that is an integral part of the cutter. They are held in the machine by collets or special sleeves.
3. Facing cutters can be mounted directly to a machine’s spindle nose or on a stub arbor.

The following are the more commonly used milling cutters with a summary of the work to which they are best suited.

End milling cutters are designed for machining slots, keyways, pockets, and similar work. The cutting edges are on the circumference and end. Solid end mills may have straight or helical flutes and straight or taper shanks. Straight shank end mills are available in single and double end styles.

Face milling cutters are intended for machining large flat surfaces parallel to the face of the cutter. The teeth are designed to make the roughing and finishing cuts in one operation. Because of their size, most face milling cutters have inserted cutting edges.

Plain milling cutters are cylindrical, with teeth located around the circumference. Plain milling cutters less than 20 mm diameter are made with straight teeth. Wider plain cutters, called slab cutters, are made with helical teeth.

Side milling cutters. Cutting edges are located on the circumference and on one or both sides of side milling cutters. They are made in solid form or with inserted teeth.

Metal slitting saws are thin milling cutters that resemble circular saw blades. They are employed for narrow slotting and cutoff operations. Slitting saws are available in diameters as small as 60 mm and as large as 200 mm.

Formed milling cutters are employed to accurately duplicate a required contour. A wide range of shapes can be machined with standard cutters available. Included in this cutter classification are the concave cutter, convex cutter, corner rounding cutter, and gear cutter.

Exercises

1. Put in the missing articles: a, an, the or nothing:

1. ……. wide variety of cutting operations can be performed on ……. milling machines.
2. As mentioned, ……. metal is removed in milling by means of turning ……. multitooth cutter into ……. work.
3. On ……. horizontal spindle milling machine, ……. cutter is fitted onto ……. arbor mounted in ……. machine on ……. axis parallel with ……. work table.
4. ……. universal milling machine is similar to ……. plain milling machine but ……. table has ……. forth movement.
5. On ……. swivel head milling machine, ……. spindle can be swiveled for angular cuts.

2. Make adjectives from the following nouns.

Noun	Adjective
circle	
periphery	
variety	
capability	
availability	
individuality	
longitude	
power	

3. Find the Polish equivalents to the following English words:

1) multitooth cutter
2) recess
3) arbor
4) spline
5) face – mill
6) fixture
7) pocket
8) flute
9) roughing
10) keyway
11) finishing
12) taper shank
13) sleeve
14) spindle nose
15) stub arbor
16) rotary head
17) template
18) chart
19) adjusting
20) shifting

4. Match the words from column A with their antonyms in column B:

A	B
wide	general
capable	narrow
small	slow
direct	incapable
difficult	different
heavy	simple, uncomplicated
similar	easy
complex	light
quick	big
particular	indirect

5. Put the verbs in brackets into the correct tense and voice form:

1. A milling machine (rotate) ………. a multitooth cutter into the work.
2. As mentioned, metal (remove) ………. in milling by means of turning a multitooth cutter into the work.
3. Work may (clamp) ………. directly to the machine table.
4. However, for practical purposes, milling machines may (group) ………. into two large families.
5. However, on many vertical spindle machines, it can (tilt) ………. to perform angular cutting operations.
6. The work table (move) ………. only in a longitudinal direction.
7. This (make) ………. it possible to produce spiral gears, spiral splines, and similar work.
8. On a swivel head milling machine, the spindle can (swivel) ………. for angular cuts.

6. Find in the text English equivalents for the expressions:

1) dla operacji kontrolowanych komputerowo,
2) różne kategorie frezarek,
3) albo pod kątem prostym do stołu roboczego,
4) mogą być dalej sklasyfikowane jako poziome, pionowe, ...,
5) o kąt 45°,
6) ręcznie albo automatycznie,
7) dwu bądź trójwymiarowe wzorniki.

Comprehension

1. Answer the following questions:

1. Which milling cutters are employed to duplicate a required contour?
2. Which cutters may have straight or helical flutes?
3. What may the cutting speed and rate of feed be changed by?
4. Enumerate two main categories of milling operations.
5. What is the difference between a universal milling machine and plain milling machine as regards the table movement?
6. What surfaces and configurations are milling machines capable of machining?

2. Multiple choice:

1. They (line 100) refers to:
   a) taper shanks
   b) straight shanks
   c) integral parts of the cutter
   d) shank cutters
2. It (line 27) refers to:
   a) stock shape
   b) milling cutter
   c) stock size
   d) large number
3. It (line 63) refers to:
   a) vertical center line
   b) rotary head
   c) the spindle
   d) circular arc
4. It (line 89) refers to:
   a) the cutter
   b) work table
   c) vertical spindle machine
5. They (line 2) refers to:
   a) milling machines
   b) cutting operations
   c) multitooth cutters

Unit 7

Drilling

Common drills are known as twist drills because most are made by forging or milling rough flutes, and then twisting them to a spiral shape. After twisting, the drills are milled and ground to approximate size. Then, they are heat treated and ground to exact size.

Most drills are made of high speed steel or carbon steel. High speed steel drills can be operated at much higher cutting speeds than carbon steel drills without danger of burning and drill damage.

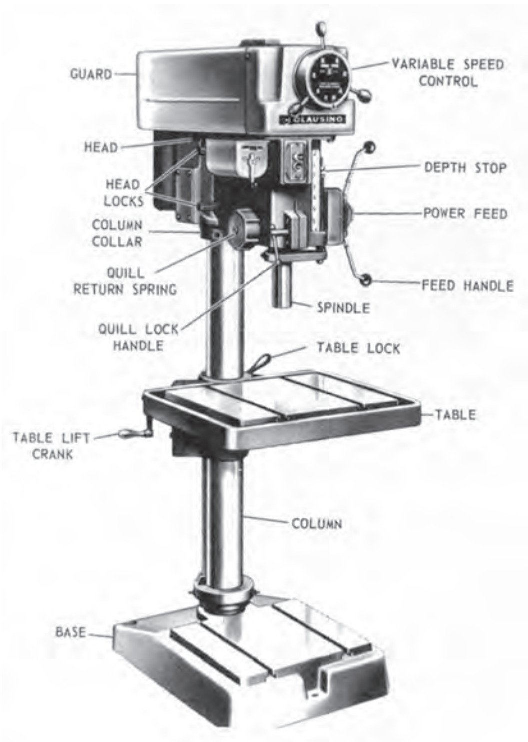


Fig. 7.1. Floor model drilling machine

Types of drills

Industry utilizes special drills to improve the accuracy of a drilled hole, to speed production, and to improve drilling efficiency.

The straight flute gundrill is designed for ferrous and nonferrous metals. It is usually fitted with a carbide cutting tip.

An oil hole drill has coolant holes through the body to permit fluid or air to be forced to the point to remove heat. The pressure of the fluid or air also ejects the chips from the hole while drilling.

Three-and four-flute core drills are used to enlarge core holes in casting.

Special step drills permit the elimination of one or more drilling operations in production work.

Combination drills and reamer drills also speed up production by eliminating one operation.

Spade drills have replaceable cutting tips, usually of tungsten carbide.

Most drills are available with straight or taper shanks and with tungsten carbide tips. Coating drills with Titanium Nitride greatly increases tool life.

Parts of a drill

The twist drill has been scientifically designed to be an efficient cutting tool. It is composed of three principle parts: point, shank, and body (fig. 7.2).

The point is the cone-shaped end that does the cutting. The point consists of the following:

— dead center refers to the sharp edge at the extreme tip of the drill. This should always be in the exact center of the drill axis,
— the lips are the cutting edges of the drill,
— the heel is the portion of the point back from the lips or cutting edges.

The body is the portion of the drill between the point and the shank. It consists of:

— flutes are two or more spiral grooves that run the length of the drill body. The flutes do four things:
  – help form the cutting edges of the drill point,
  – curl the chip tightly for easier removal,
  – form channels through which the chips can escape as the hole is drilled,
  – allow coolant and lubricant to get down to the cutting edges.

The margin is the narrow strip extending back the entire length of the drill body. Body clearance refers to the part of the drill body that has been reduced in order to lower friction between the drill and the wall of the hole.

The web is the metal column that separates the flutes. It gradually increases in thickness toward the shank for added strength.

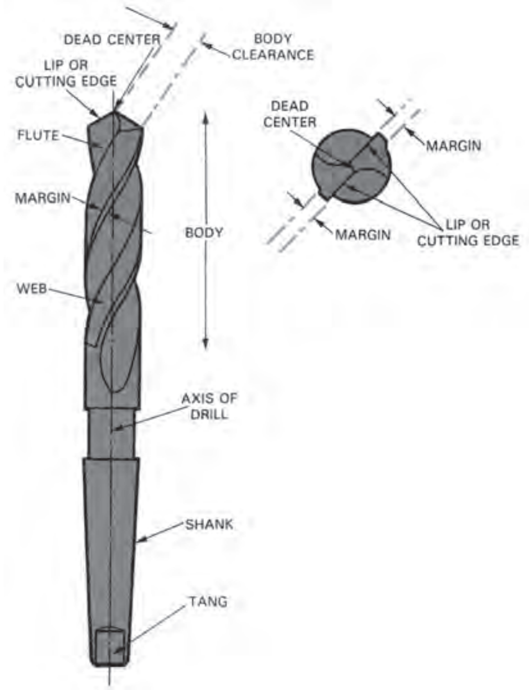


Fig. 7.2. Parts of a twist drill

Holding drills in drill press

A drill is held in the drill press by either of the following methods:

Chuck: Movable jaw mechanism for drills with straight shanks.

Tapered spindle: Tapered opening for drills with taper shanks. Drill chucks with taper shanks make it possible to use straight shank drills when the drill press is fitted with a taper spindle opening.

Exercises

1. Match the words from the text with their Polish equivalents:

1) diameter	a) stożek
2) forging	b) oś
3) carbon steel	c) precyzja
4) damage	d) wióry
5) pressure	e) ostrze
6) accuracy	f) trzonek
7) casting	g) kucie

8) chips
9) tip
10) shank
11) cone
12) axis

h) średnica
i) stal węglowa
j) odlew
k) ciśnienie
l) uszkodzenie

2. Find in the text words for:

1) kieł stały
2) skręcać
3) chłodziwo
4) rowek
5) smar
6) krawędź
7) pasek
8) uchwyt
9) prosty
10) wiertarka pionowa

3. Translate these sentences into English:

1. Po skręceniu, wiertła są frezowane i szlifowane do odpowiedniego rozmiaru.
2. Przemysł używa specjalnych wierteł do poprawienia precyzji wykonywanych otworów.
3. Ciśnienie cieczy lub powietrza również wyrzuca wióry podczas wiercenia.
4. Wiertła piórkowe mają wymienialne ostrza zwykle wykonane z węgliku wolframu.
5. Żebro usztywniające jest metalową kolumną, która oddziela rowki.

4. Complete the chart:

Infinitive	Past simple	Past participle
do		
	knew	
		got
	sped	
		made
run		
	held	

5. Fill in the correct word from the list below:

chip, heat, drill, pressure, utilizes, twisted

1. She ……… the wire into the shape of a star.
2. The ……… of the water caused the glass to shatter.
3. This is a heating system that ……… solar energy.
4. The ……… of the water turns the wheel.
5. The Saudi government has announced plans to ……… for water in the desert.
6. These cheap plates ……… really easily.

Comprehension

1. Answer the following questions:

1. What are drills made of?
2. Which drills have replaceable cutting tips?
3. What parts is a twist drill composed of?
4. What part of a drill does the cutting?
5. What is a movable jaw mechanism for drills with straight shanks called?
6. What is a straight flute gundrill fitted with?

2. Match the terms with their definitions:

Margin	Drills having replaceable cutting tips of tungsten carbide
Spade drills	A narrow strip extending back the entire length of the drill body
Web	The portion of the drill between the point and the shank
Heel	A metal column that separates the flutes
Body	The portion of the point back from the lips or cutting edges

Unit 8

Precision Grinding

Grinding, like milling, drilling, sawing, planing, and turning, is a cutting operation. However, grinding makes use of an abrasive tool composed of thousands of cutting edges. The grinding wheel might be compared to a many toothed milling cutter as each of the abrasive particles is actually a separate cutting edge. In precision grinding, each abrasive grain removes a relatively small amount of material permitting a smooth, accurate surface to be generated. It is also one of the few machining operations that can produce a smooth, accurate surface on material regardless of its hardness. Grinding is frequently a finishing operation. Different variations of planer type surface grinder are shown in fig. 8.1.

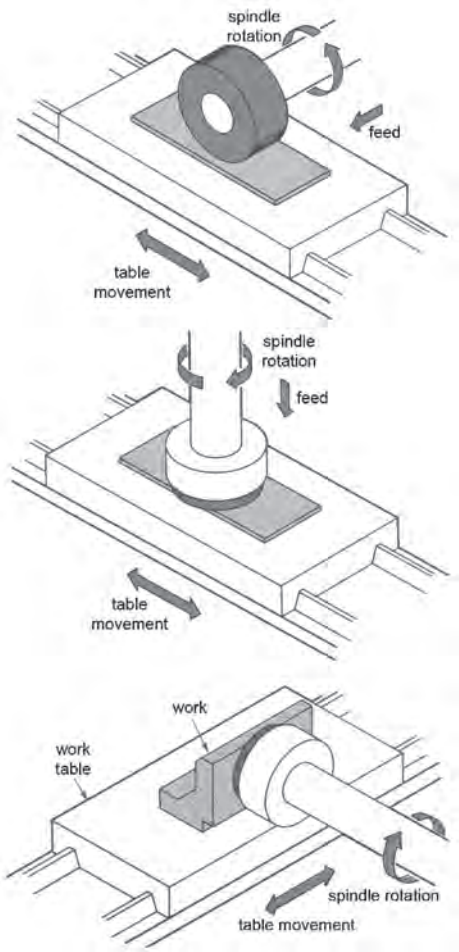


Fig. 8.1. Three variations of planer type surface grinder

Types of surface grinders

While all grinding operations might be called surface grinding because all grinding is done on the surface of the material, industry classifies surface grinding as the grinding of flat surfaces.

There are two basic types of surface grinding machines:

Planer type surface grinders make use of a reciprocating motion to move the work table back and forth under the grinding wheel

Rotary type surface grinders have circular work tables that revolve under the rotating grinding wheel fig. 8.2.

The planer type surface grinder is frequently found in training centers. It slides the work back and forth under the edge of the grinding wheel. Table movement can be controlled manually or by means of a mechanical or hydraulic drive mechanism.

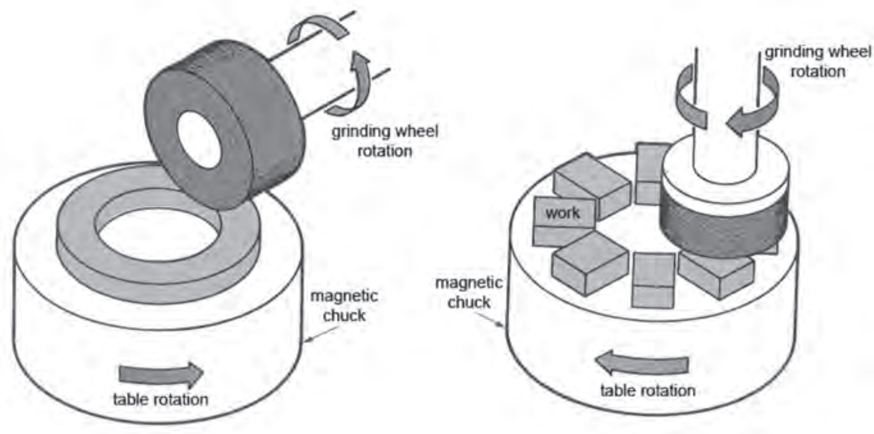


Fig. 8.2. Two variations of rotary type surface grinder

Work holding devices

Much work done on a surface grinder is held in position by a magnetic chuck. This holds the work by exerting a magnetic force. A magnetic chuck makes use of a permanent magnet.

An electromagnetic chuck utilizes an electric current to create the magnetic field. Frequently, work mounted on a magnetic chuck becomes magnetized and must be demagnetized before it can be used. A demagnetizer may be employed to neutralize the piece. Other ways to mount work on a surface grinder are:

1. A universal vise.
2. An indexing head with centers.
3. Clamps to hold the work directly on worktable.
4. Double-faced masking tape can be used to hold thin sections of nonmagnetic materials.

Grinding wheels

Each abrasive particle in a grinding wheel is a cutting tooth. As the wheel cuts, the metal chips dull the abrasive grains and wear away the bonding material(material that holds abrasive particles together).The ideal grinding wheel, of course, would be one in which the bonding medium wears away slowly enough to get maximum use from the individual abrasive grains. However, it would also wear rapidly enough to permit dulled abrasive particles to drop off and expose new particles.

Because so many factors govern grinding wheel efficiency, the wheel eventually dulls and must be dressed with a diamond dressing tool. Only manufactured abrasives are suitable for modern high-speed grinding wheels. The properties and spacing of abrasive particles and composition of the bonding medium can be controlled to get the desired grinding performance.

Cutting fluids (coolants)

Cutting fluids are an important factor in lessening wear on the grinding wheel. They help to maintain accurate dimensions and are important to the quality of the surface finish produced. As a coolant, it is equally important for it to remove the heat generated during the grinding operation. Heat must be removed as fast as it is generated.

Several types of grinding fluids are utilized:

Water-soluble chemical fluids are solutions that take advantage of the excellent cooling ability of water. They are usually transparent and include a rust inhibitor, water softeners, detergents to improve the cleaning ability of water, and bacteriostasis (substance that regulates and controls growth of bacteria).

Polimers are added to improve lubricating qualities.

Water-soluble oil fluids are coolants that take advantage of the excellent cooling qualities of water. They are usually milky white. They are also less expensive than most chemical type fluids. Bacteriostases are also added to control bacteria growth.

The coolant can be applied by flooding the grinding area. The fluid recirculates by means of a pump and holding tank built into the machine.

Centerless grinding

The work does not have to be supported between centers in centerless grinding (fig. 8.3) because the work is rotated against the grinding wheel. Instead, the piece is positioned on a work support blade. The workpiece is fed automatically between a regulating or feed wheel and a grinding wheel. Primarily, the regulating wheel causes the piece to rotate, and the grinding wheel does the cutting. Feed through the wheel is obtained by setting the regulating wheel at a slight angle.

There are four variations of centerless grinding:

Through feed grinding can only be employed to produce simple cylindrical shapes. Work is fed continuously by hand, or from a feed hopper into the gap between the grinding wheel and the regulating wheel. The finished pieces drop off the work support blade.

Infeed grinding is a centerless grinding technique that feeds the work into the wheel gap until it reaches a STOP. The piece is ejected at the completion of the grinding operation. Work diameter is controlled by regulating the width of the gap between the regulating wheel and grinding wheel.

End feed grinding is a form of centerless grinding ideally suited for grinding short tapers and spherical shapes. Both wheels are dressed to the required shape and work is fed in from the side of the wheel to an end stop. The finished piece is ejected automatically.

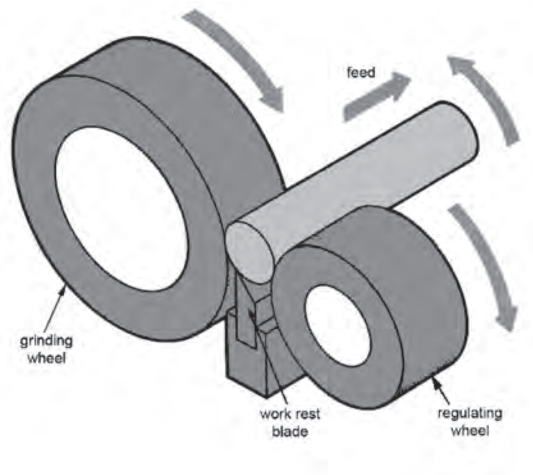


Fig. 8.3. Centerless grinding

Internal centerless grinding minimizes distortion in finishing thin-wall work and eliminates reproduction of hole-size errors and waviness in the finish.

Centerless grinding is utilized when large quantities of the same part are required. Production is high and costs are relatively low because there is no need to drill center holes nor to mount work in a holding device. Almost any material can be ground by this technique.

Form grinding

In form grinding, the grinding wheel is shaped to produce the required contour on the work.

Thread grinding is an example of form grinding. A form of template guides the diamond particle wheel that grinds the required thread shape.

Exercises

1. Add the correct prefixes to make the opposite of these words (de-, dis-, in-, non-, un-):

1) separable
2) magnetic
3) magnetize
4) suitable
5) controlled
6) advantage
7) expensive

8) regulate
9) finished
10) mount

2. Match the words from the text with their Polish equivalents:

1) abrasive	a) wydajność
2) grinding wheel	b) zbiornik
3) sawing	c) powierzchnia
4) particles	d) gładki
5) smooth	e) zużywać się
6) surface	f) chłodziwo
7) drive mechanism	g) ściernica
8) wear away	h) piłowanie
9) efficiency	i) cząsteczki
10) coolant	j) mechanizm napędowy
11) tank	k) ścieralny

3. Fill in the correct words from the list below:
smooth, wheels, efficiency, mechanical, magnetic field, particles

1. Do you like the new ……… in my car?
2. Two phenomena which both waves and ……… appear to undergo are reflection and refraction.
3. The stone steps had been worn ……… by centuries of visitors.
4. The pump shut off as a result of a ……… failure.
5. The space round a magnet in which it exerts a force is known as ……….
6. The improvements in ……… have been staggering.

4.Complete the sentences with the correct prepositions:

1. However, grinding makes use ……. an abrasive tool composed ……. thousands ……. cutting edges.
2. It is also one ……. the few machining operations that can produce a smooth, accurate surface ……. material regardless ……. its hardness.
3. Table movement can be controlled manually or ……. means ……. a mechanical or hydraulic drive mechanism.
4. A magnetic chuck makes use ……. a permanent magnet.
5. Only manufactured abrasives are suitable ……. modern high-speed grinding wheels.

6. Water-soluble oil fluids are coolants that take advantage ……. the excellent cooling qualities ……. water.

5. Make nouns from the following verbs:

Verb	Noun
vary	
soften	
improve	
employ	
eject	
operate	
complete	
form	
exert	
electrify	

6. Find in the text the English equivalents for the expressions:

1) złożony z tysięcy krawędzi tnących,
2) usuwa względnie małą część materiału,
3) bez względu na swoją twardość,
4) wykorzystują ruch postępowo zwrotny,
5) i odsłania nowe cząsteczki,
6) pod małym kątem.

Comprehension

1. Answer the following questions:

1. What is bacteriostasis?
2. What might the grinding wheel be compared to?
3. Is grinding a finishing operation?
4. What type of grinders make use of a reciprocating motion?
5. What holds work on a surface grinder in position?
6. What should be done when the wheel eventually dulls?
7. What is important in lessening wear on the grinding wheel?
8. What causes the workpiece to rotate in centerless grinding?
9. Which form of centerless grinding is ideal for grinding short tapers and spherical shapes?

10. In which type of grinding is the grinding wheel shaped to produce the required contour on the work?

2. Match the terms with their definitions:

Grinding	An example of form grinding
Infeed grinding	Important factor in lessening wear on the grinding wheel
Cutting fluid	A Centerless grinding technique that feeds the work into the wheel gap until it reaches a stop
Thread grinding	Cutting operation making use of an abrasive tool composed of thousands of cutting edges

Unit 9

Welding

Welding is the most common way of permanent joining metal parts. In this process, heat is applied to metal pieces, melting and fusing them to form a permanent bond. Because of its strength, welding is used in shipbuilding, automobile manufacturing and repair, aerospace applications, and thousands of other manufacturing activities. Welding is also used to join beams when constructing buildings, bridges, and other structures, and to join pipes in pipelines, power plants, and refineries.

Welders use many types of welding equipment set up in a variety of positions, such as flat, vertical, horizontal, and overhead. They may perform manual welding, in which the work is entirely controlled by the welder, or semiautomatic welding, in which the welder uses machinery, such as a wire feeder, to perform welding tasks.

Arc welding is the most common type of welding. Standard arc welding involves two large metal alligator clips that carry a strong electric current. One clip is attached to any part of the workpiece being welded. The second clip is connected to a thin welding rod. When the rod touches the workpiece, a powerful electric circuit is created. The massive heat created by the electrical current causes both the workpiece and the steel core of the rod to melt together, cooling quickly to form a solid bond. During welding, the flux that surrounds the rod's core vaporizes, forming an inert gas that serves to protect the weld from atmospheric elements that might weaken it. Welding speed is important. Variations in speed can change the amount of flux applied, weakening the weld, or weakening the surrounding metal.

Two common but advanced types of welding are Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) welding. TIG welding is often used to join stainless steel or aluminum. While TIG uses welding rods, MIG uses a spool, which continuously feeds wire, which allows the welder to join longer stretches of metal without stopping to replace the rod. In TIG welding, the welder holds the welding rod in one hand and an electric torch in the other hand. The torch is used to simultaneously melt the rod and the workpiece. In MIG welding, the welder holds the wire feeder, which functions like the alligator clip in arc welding. Instead of using gas flux surrounding the rod, TIG and MIG protect the initial weld from the environment by blowing inert gas onto the weld.

Like arc welding, soldering and brazing use molten metal to join two pieces of metal. However, the metal added during the process has a melting point lower than that of the workpiece, so only the added metal is melted, not the workpiece. Soldering uses metals with a melting point below 800 degrees Fahrenheit; brazing uses metals with a higher melting point. Because soldering and brazing do not melt the workpiece, these processes normally do not create the distortions or weaknesses in the workpiece that can occur during welding. Soldering is commonly used to join electrical, electronic, and other small metal parts. Brazing produces a stronger joint than does soldering, and is often used to join metals other than steel, such as brass. Brazing can also be used to apply coatings to parts to reduce wear and protect against corrosion.

Brazing

Brazing joins two pieces of base metal when a melted metallic filler flows across the joint and cools to form a solid bond. Similarly to soldering, brazing creates an extremely strong joint, usually stronger than the base metal, without melting or deforming the components. Two different metals, or base metals such as silver and bronze, are perfect for brazing.

The process of brazing is the same as soldering, although metals and temperatures differ. You can braze pipes, rods, flat metals, or any other shape as long as the pieces fit neatly against each other without large gaps. Brazing handles more unusual configurations with linear joints, whereas most welding makes spot welds on simpler shapes.

The torch uses fuels like acetylene and hydrogen to create an extremely high temperature, often between 800° F and 2000° F (430 – 1100° C). The temperature must be low enough so as not to melt base metal, yet high enough to melt the braze.

Brazing has many advantages over spot welding or soldering. For instance, a brazed joint is smooth, creating an airtight and watertight bond for piping that can be easily plated so the seam disappears. It also conducts electricity like the base alloys. Only brazing can join dissimilar metals, such as bronze, steel, aluminum, wrought iron, and copper, with different melting points.

Soldering

Soldering joins two pieces of metal, such as electrical wires, by melting them together with another metal to form a strong, chemical bond. In a delicate procedure, a special material, called solder, flows over two pre-heated pieces and attaches them through a process similar to welding or brazing.

The solder, or soldering wire, often an alloy of aluminum and lead, needs a lower melting point than the metal you're joining. Finally, you need rosin called flux that ensures the joining pieces are incredibly clean. Flux removes all the oxides from the surface of the metal that would interfere with the molecular bonding, allowing the solder to flow into the joint smoothly.

Various metals can be soldered together, such as gold and sterling silver in jewellery, brass in watches and clocks, copper in water pipes, or iron in leaded glass windows. All these metals have different melting points, and therefore use different solder. Soft solder, with a low melting point, is perfect for wiring a circuit board. Hard solder, such as for making a bracelet, needs a torch rather than a soldering iron to get a hot enough temperature.

Exercises

1. Find in the text the words for:

1) stały, trwały
2) ciepło
3) topić
4) zgrzewać
5) belka
6) rura
7) różnorodność
8) płaski
9) wyposażenie
10) podajnik
11) powszechny
12) zacisk
13) spoiwo
14) otulina, topnik
15) otaczać
16) nierdzewny
17) szpula
18) zastąpić

2. Complete the table:

Verb	Noun
apply	
	form
strengthen	
	feeder
electrify	
	welding
accelerate	
	protection

3. Put in the missing articles: a, an, the or nothing:

1. They may perform ……. manual welding, in which ……. work is entirely controlled by ……. welder, or semiautomatic welding, in which ……. welder uses machinery, such as ……. wire feeder, to perform welding tasks.
2. When ……. rod touches ……. workpiece, ……. powerful electrical circuit is created.
3. Variations in ……. speed can change ……. amount of flux applied, weakening ……. weld, or weakening ……. surrounding metal.
4. ……. massive heat created by ……. electrical current causes both ……. workpiece and ……. steel core of ……. rod to melt together.
5. In TIG welding, ……. welder holds ……. welding rod in one hand and ……. electric torch in ……. other hand.

4. Find in the text the English equivalents for the expressions:

1) żeby stworzyć bardzo wysoką temperaturę,
2) chociaż metale i temperatury różnią się od siebie,
3) jednak wystarczająco wysoką żeby stopić lutowinę,

4) i dlatego też używają innego lutu,
5) tworzy się potężny obwód elektryczny,
6) więc jedynie dodany metal jest topiony.

5. Complete the sentences with words from the list below:
speed, joint, common, brazing, electricity, equipment, circuit

1. Arc welding is the most …….type of welding.
2. Welders use many types of welding ……. set up in a variety of positions.
3. When the rod touches the workpiece, a powerful electrical ……. is created.
4. Variations in ……. can change the amount of flux applied, weakening the weld, or weakening the surrounding metal.
5. Brazing produces a stronger ……. than does soldering, and is often used to join metals other than steel, such as brass.
6. The process of ……. is the same as soldering, although metals and temperatures differ.
7. It also conducts ……. like the base alloys.

6. Match the words with their synonyms:

1) handle	a) waterproof
2) create	b) connect
3) watertight	c) deal with
4) attach	d) thus
5) therefore	e) essential
6) important	f) invent
7) involve	g) fix
8) join	h) include

Comprehension

1. Answer the following questions:

1. What happens in the process of welding?
2. What machinery does a welder use in semiautomatic welding?
3. When is an electric circuit created in arc welding?
4. What happens with the flux that surrounds the rod's core during welding?
5. Which process is used to join brass?
6. Which metals are perfect for brazing?
7. Does the solder need a lower melting point than the metal you're joining?

Unit 10

Car Engine

Have you ever opened the hood of your car and wondered what was going on in there? A car engine can look like a big confusing jumble of metal, tubes and wires to the uninitiated.

The Basics

The purpose of a gasoline car engine is to convert gasoline into motion so that your car can move. Currently the easiest way to create motion from gasoline is to burn the gasoline inside an engine. Therefore, a car engine is an internal combustion engine - combustion takes place internally.

A steam engine in old-fashioned trains and steam boats is the best example of an external combustion engine. The fuel (coal, wood, oil, whatever) in a steam engine burns outside the engine to create steam, and the steam creates motion inside the engine. Internal combustion is a lot more efficient (takes less fuel per mile) than external combustion, plus an internal combustion engine is a lot smaller than an equivalent external combustion engine.

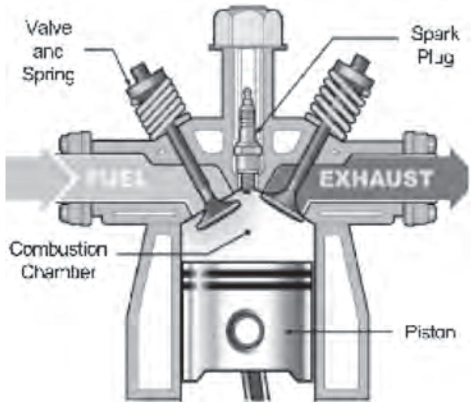


Fig. 10.1. Engine

Almost all cars today use a reciprocating internal combustion engine because this engine is:

Relatively efficient (compared to an external combustion engine)

Relatively inexpensive (compared to a gas turbine)

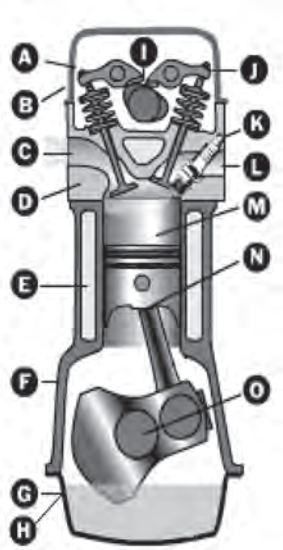
Relatively easy to refuel (compared to an electric car)

Almost all cars currently use what is called a four-stroke combustion cycle to convert gasoline into motion. The four strokes are illustrated in fig. 10.1. They are: intake stroke, compression stroke, combustion stroke, exhaust stroke.

Here is what happens as the engine goes through its cycle.

The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take air and gasoline into a cylinder. This is the intake stroke. Then the piston moves back up to compress this fuel/air mixture. Compression makes the explosion more powerful.

When the piston reaches the top of its stroke, the spark plug emits a spark to ignite the gasoline. The gasoline charge in the cylinder explodes, driving the piston down.



A) Intake Valve
B) Valve Cover
C) Intake Port
D) Head
E) Coolant
F) Engine Block
G) Oil Pan
H) Oil Sump
I) Camshaft
J) Exhaust Valve
K) Spark Plug
L) Exhaust Port
M) Piston
N) Connecting Rod
O) Crankshaft

Fig. 10.2. Structure of engine

Once the piston hits the bottom of its stroke, the exhaust valve opens and the exhaust leaves the cylinder to go out the tail pipe.

Now the engine is ready for the next cycle, so it intakes another charge of air and gas.

Notice that the motion that comes out of an internal combustion engine is rotational, while the motion produced by a piston is linear (straight line). In an engine the linear motion of the pistons is converted into rotational motion by the crank shaft.

The combustion chamber is the volume where compression and combustion take place. As the piston moves up and down, you can see that the size of the combustion chamber changes. It has maximum volume as well as a minimum volume. The difference between the maximum and minimum is called the displacement and is measured in liters or CCs (Cubic Centimeters, where 1,000 cubic centimeters equals a litre).

The spark plug supplies the spark that ignites the air/fuel mixture so that combustion can occur. The spark must happen at just the right moment for things to work properly.

Valves. The intake and exhaust valves open at the proper time to let in air and fuel and to let out exhaust. Note that both valves are closed during compression and combustion so that the combustion chamber is sealed.

A piston is a cylindrical piece of metal that moves up and down inside the cylinder. It is responsible for the change of the cylinder volume.

Piston rings provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. The rings serve two purposes:
They prevent the fuel/air mixture and exhaust in the combustion chamber from leaking into the sump during compression and combustion.
They keep oil in the sump from leaking into the combustion area, where it would be burned and lost.

The connecting rod connects the piston to the crankshaft. It can rotate at both ends so that its angle can change as the piston moves and the crankshaft rotates.

The crank shaft turns the piston's up and down motion into circular motion just like a crank on a jack-in-the-box does.

The sump surrounds the crankshaft. It contains some amount of oil, which collects in the bottom of the sump (the oil pan).

Exercises

1. Find in the text the words for:

1) maska silnika
2) plątanina
3) przekształcić
4) wewnętrzny
5) para
6) zewnętrzny
7) wydajny
8) niedrogi
9) względnie
10) wynaleźć
11) tłoki
12) obrotowy
13) wał korbowy
14) spalanie
15) komora
16) iskra
17) występować
18) zawór
19) sprężanie
20) pierścień

2. Complete the sentences with a preposition:

1. The purpose ….. a gasoline car engine is to convert gasoline ….. motion so that your car can move.
2. A steam engine ….. old-fashioned trains and steam boats is the best example ….. an external combustion engine.
3. The gasoline charge ….. the cylinder explodes, driving the piston …...
4. Now the engine is ready ….. the next cycle, so it intakes another charge ….. air and gas.
5. ….. an engine the linear motion ….. the pistons is converted ….. rotational

motion ….. the crank shaft.

6. A piston is a cylindrical piece ….. metal that moves ….. and ….. inside the cylinder.

3. Find in the text the English equivalents for the expressions:

1) najłatwiejszy sposób tworzenie ruchu z paliwa,
2) jest najlepszym przykładem silnika o spalaniu zewnętrznym,
3) dużo bardziej wydajne niż spalanie zewnętrzne,
4) w porównaniu do silnika o spalaniu zewnętrznym,
5) jest również znane jako,
6) więc pobiera następną porcję powietrza i paliwa,
7) tak żeby spalanie mogło nastąpić.

4. Complete the sentences with the words given:

capacity, steam, air, motion, combustion, sump, charge, gasoline, displacement, drop, cycle

1. The fuel in a ……. engine burns outside the engine to create steam, and the steam creates …….inside the engine.
2. Almost all cars currently use what is called a four-stroke combustion …….to convert …….into motion.
3. Only a tiny …….of gasoline needs to be mixed into the …….for it to work.
4. Now the engine is ready for the next cycle, so it intakes another …….of air and gas.
5. The combustion chamber is the …….where compression and ……. take place.
6. The difference between the maximum and minimum is called the ……..
7. They keep oil in the ……. from leaking into the combustion area.

5. Match the words from the text in column A with their synonyms in column B:

A	B
gasoline	tiny
current	present
motion	petrol
old-fashioned	movement
small	out of date
inexpensive	commence
illustrate	cheap
start	show

6. Translate these sentences into Polish:

1. Compression makes the explosion more powerful.
2. Then the piston moves back up to compress this fuel/air mixture.
3. Now the engine is ready for the next cycle, so it intakes another charge of air and gas.
4. The combustion chamber is the capacity where compression and combustion take place.

7. Put in the missing articles: a**,** an**,** the **or nothing:**

1. Now ……. engine is ready for ……. next cycle, so it intakes another charge of air and ……. gas.
2. In ……. engine ……. linear motion of ……. pistons is converted into rotational motion by ……. crank shaft.
3. ……. piston starts at ……. top, …….intake valve opens, and ……. piston moves down to let ……. engine take air and gasoline in ……. cylinder.
4. ……. steam engine in old-fashioned trains and steam boats is …….best example of …….external combustion engine.
5. Almost all cars currently use what is called ……. four-stroke combustion cycle to convert ……. gasoline into motion.

Unit 11

Gears

Gears are used in tons of mechanical devices. They do several important jobs, but most important, they provide a gear reduction in motorized equipment. This is key because, often, a small motor spinning very fast can provide enough power for a device, but not enough torque. For instance, an electric screwdriver has a very large gear reduction because it needs high torque to turn screws, but the motor only produces a low amount of torque at a high speed. With a gear reduction, the output speed can be reduced while the torque is increased.

Fig. 11.1. Spur gear

Spur Gears

Spur gears fig. 11.1 are the most common type of gears. They have straight teeth, and are mounted on parallel shafts. Sometimes, many spur gears are used at once to create very large gear reductions.

Spur gears are used in many devices, like the electric screwdriver, windup alarm clock, washing machine and clothes dryer.

Fig. 11.2. Helical gears

Helical Gears

The teeth on helical gears fig. 11.2 are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement.

This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears. For this reason, helical gears are used in almost all car transmissions.

Because of the angle of the teeth on helical gears, they create a thrust load on the gear when they mesh. Devices that use helical gears have bearings that can support this thrust load.

Fig. 11.3. Crossed helical gears

One interesting thing about helical gears is that if the angles of the gear teeth are proper, they can be mounted on perpendicular shafts fig. 11.3.

Bevel Gears

Bevel gears fig. 11.4 are useful when the direction of a shaft's rotation needs to be changed. They are usually mounted on shafts that are positioned at 90 degrees to each other, but can be designed to work at other angles as well.

The teeth on bevel gears can be straight, spiral (fig. 11.5) or hypoid (fig. 11.6). Straight bevel gear teeth actually have the same problem as straight spur gear teeth – as each tooth engages, it impacts the corresponding tooth all at once.

Fig. 11.4. Bevel gears

Fig. 11.5. Spiral bevel gears

Just like with spur gears, the solution to this problem is to curve the gear teeth. These spiral teeth engage just like helical teeth: the contact starts at one end of the gear and progressively spreads across the whole tooth.

On straight and spiral bevel gears, the shafts must be perpendicular to each other, but they must also be in the same plane. The hypoid gear, on the other hand, can engage with the axes in different planes.

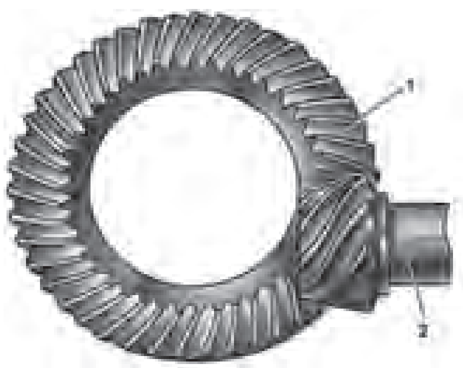


Fig. 11.6. Hypoid bevel gears in a car differential: 1 – ring gear, 2 – pinion gear

This feature is used in many car differentials. The ring gear of the differential and the input pinion gear are both hypoid. This allows the input pinion to be mounted lower than the axis of the ring gear. Figure 11.6 shows the input pinion engaging the ring gear of the differential. Since the drive shaft of the car is connected to the input pinion, this also lowers the drive shaft. This means that the drive shaft doesn't intrude into the passenger compartment of the car as much, making more room for people and cargo.

Worm Gears

Worm gears fig. 11.7 are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater.

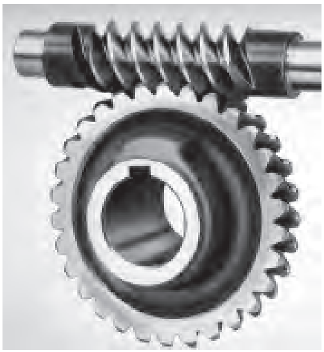


Fig. 11.7. Worm gear

Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm. This is because the angle on the worm is so shallow that when the gear tries to spin it, the friction between the gear and the worm holds the worm in place.

This feature is useful for machines such as conveyor systems, in which the locking feature can act as a brake for the conveyor when the motor is not turning.

Rack and Pinion Gears

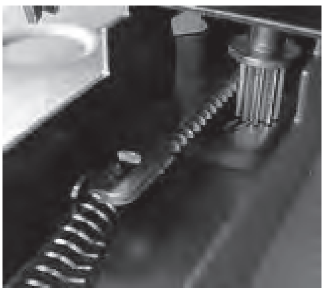


Fig. 11.8. Rack and pinion gears from a household scale

Rack and pinion gears fig. 11.8 are used to convert rotation into linear motion. A perfect example of this is the steering system in many cars. The steering wheel rotates a gear which engages the rack. As the gear turns, it moves the rack either to the right or left, depending on which way you turn the wheel.

Rack and pinion gears are also used in some scales to turn the dial that displays your weight.

Planetary Gearsets & Gear Ratios

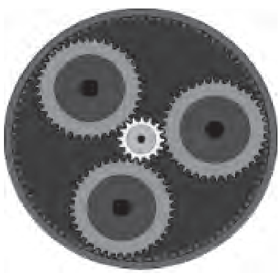


Fig. 11.9. Planetary Gears

Any planetary gearset has three main components:

1. The sun gear
2. The planet gears
3. The ring gear

Each of these three components can be the input, the output or can be held stationary. Choosing which piece plays which role determines the gear ratio for the gearset.

Exercises

1. Find in the text words for:

1) wyposażenie
2) obracać się, wirować
3) moment obrotowy
4) śrubokręt
5) koło walcowe
6) zazębienie
7) gładki
8) obciążenie wzdłużne
9) łożysko
10) osadzać
11) prosty
12) zakrzywić
13) płaszczyzna
14) oś
15) wałek zębaty
16) wał napędowy
17) przedział pasażerski
18) kąt

2. Find in the text the English equivalents for the expressions:

1) umożliwiają redukcję przełożenia
2) mały silnik obracający się bardzo szybko
3) są osadzone na równoległych wałach
4) stopniowo rozchodzi się podczas obrotu kół
5) posiadają łożyska, które dają opór obciążeniu wzdłużnemu
6) rozwiązaniem tego problemu jest zakrzywienie zębów

3. Fill in the correct words from the list bellow:

reduction, component, friction, compartment, property, motion, rack, converting, determine, conveyer

1. He is the …………… of good news.
2. Put the ice cream back in the freezer …………… .
3. There was a slight …………… in the price.
4. Check your rope frequently as …………… against the rock can wear it down.
5. That's my personal …………… .
6. He summoned the waiter with a …………… of his hand.
7. The dishes are on the plate …………… .
8. This is part of the process of …………… iron into steel.
9. The repair shop sells electrical …………… .
10. Your parents' income is used to …………… your level of financial aid.

4. Find in the text the opposites to the given words:

1) disconnect
2) higher

3) inproper
4) finish
5) decrease
6) slow
7) insignificant
8) rough

5. Find in the text synonyms for the following words:

1) essential
2) rotate
3) quantity
4) same, similar
5) step by step
6) effect, influence
7) cover, stretch out
8) quality, charactristic

6. Make nouns from the following adjectives:

Adjectives	Nouns
mechanical	
fast	
electric	
high	
smooth	
proper	
progressive	
different	
shallow	
perfect	

7. Complete the sentences with the correct prepositions:

1. They do several important jobs, but most important, they provide a gear reduction ……. motorized equipment.
2. A perfect example ……. this is the steering system ……. many cars.
3. This means that the drive shaft doesn't intrude ……. the passenger compartment ……. the car as much, making more room ……. people and cargo.
4. Bevel gears are useful when the direction ……. a shaft's rotation needs to be changed.

5. The teeth ……. helical gears are cut ……. an angle ……. the face ……. the gear.
6. Because ……. the angle ……. the teeth ……. helical gears, they create a thrust load ……. the gear when they mesh.
7. For instance, an electric screwdriver has a very large gear reduction because it needs high torque to turn screws, but the motor only produces a low amount ……. torque ……. a high speed.

Comprehension

1. Answer the following questions:

1. What happens when a gear reduction occurs?
2. What types of gears do you know?
3. In what devices are spur gears used?
4. What gears can be found in almost all car transmissions?
5. What types of gears are used to convert rotation into linear motion?

2. Match the terms with their definitions:

Spur Gears	Gears which are usually mounted on shafts that are positioned at 90 degrees to each other
Helical Gears	Types of gears with large reductions that are positioned at 90 degrees to each other
Bevel Gears	Types of gears in which teeth are cut at an angle to the face of the gear
Worm Gears	Gears having straight teeth, which are mounted on parallel shafts

Unit 12

Heat energy transfer mechanisms

Heat conduction

Heat conduction is the transmission of heat across matter.

Heat transfer is always directed from a higher to a lower temperature. Denser substances are usually better conductors; metals are excellent conductors.

The law of heat conduction also known as Fourier's law states that the time rate of heat flow Q through a slab (or a portion of a perfectly insulated wire, as shown in fig. 12.1) is proportional to the gradient of temperature difference:

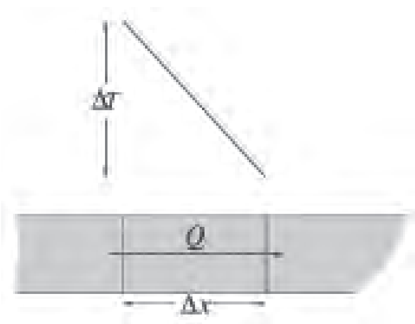


Fig. 12.1. Heat conduction

$$Q = KA\frac{\Delta T}{\Delta x} \qquad (1)$$

A is the transversal surface area, Δx is the thickness of the body of matter through which the heat is passing, K is a conductivity constant dependent on the nature of the material and its temperature, and ΔT is the temperature difference through which the heat is being transferred. This law forms the basis for the derivation of the heat equation.

Convection

Convection is the transfer of heat by the motion of a fluid. It may arise from temperature differences either within the fluid or between the fluid and its boundary, other sources of density variations (such as salinity variable), or from the application of an external motive force. It is one of the three primary mechanisms of heat transfer, the others being conduction and radiation. Convection occurs in atmosphere, oceans, and planetary mantles.

Free and forced convection

Free convection (fig. 12.2) is the convection in which motion of the fluid arises solely due to the temperature differences existing within the fluid. Example: hot air rising off the surface of a radiator.

Heated matter becomes more buoyant and “rises”; while cooler material “sinks”. Free convection occurs in any liquid or gas which expands or contracts in response to changing temperatures when it is exposed to multiple temperatures in an acceleration field such as gravity or a centrifuge. The local changes in density result in buoyancy forces that cause currents to come into being in the fluid.

Forced convection happens when motion of the fluid is imposed externally (such as by a pump or fan).

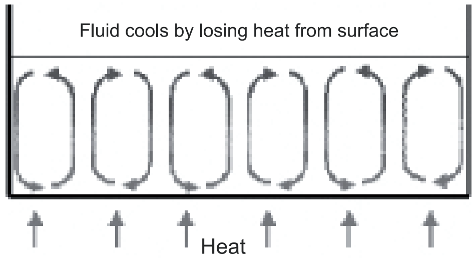


Fig. 12.2. Free convection

Radiation

Radiation is a means of heat transfer. Radiative heat transfer is the only form of heat transfer that can occur in the absence of any form of medium and as such is the only means of heat transfer through a vacuum. Thermal radiation is a direct result of the movements of atoms and molecules in a material. Since these atoms and molecules are composed of charged particles (protons and electrons), their movements result in the emission of electromagnetic radiation, which carries energy away from the surface. At the same time, the surface is constantly bombarded by radiation from the surroundings, resulting in the transfer of energy to the surface. Since the amount of emitted radiation increases with increasing temperature, there is a transfer of energy from higher temperatures to lower temperatures.

For room temperature objects (~300 K), the majority of photons emitted (and involved in radiative heat transfer) are in the infrared spectrum, but this is by no means the only frequency range involved in radiation. The frequencies emitted are partially related to black-body radiation.

Heat transfer coefficient

The heat transfer coefficient is used as a factor in calculating heat transfer in thermodynamics. The heat transfer coefficient is often calculated from the Nusselt number (a dimensionless number). Below is an example where it is used to find the heat lost from a hot tube to the surrounding area.

$$Q = \alpha A \Delta T \tag{2}$$

Where: Q – power input or heat loss [W],
α – overall heat transfer coefficient [W/m^{2}K],
A – outside surface area of tube [m^2],
ΔT – difference in temperature between tube surface and surrounding area [K].

There are different heat transfer relations for different liquids, flow conditions, and thermodynamic conditions. A common example pertinent to thermal hydraulic calculations is the Dittus-Boelter heat transfer correlation, valid for water in a circular pipe with Reynolds numbers between 100 000 and 120 000 and Prandtl numbers between 0.7 and 120. An example is shown below, where it is used to calculate the heat transfer from a tube wall to water.

$$\alpha = \frac{k_w \cdot N_u}{D_H} \tag{3}$$

where: $N_u = 0.024 \cdot R_e^{0.8} \cdot P_r^{0.4}$ – Dittus-Boelter correlation,

$\mathrm{Re} = \dfrac{\dot{m} \cdot D_H}{\mu \cdot A}$ – Reynolds number,

$\mathrm{Pr} = \dfrac{C_p \cdot \mu}{k_w}$ – Prandtl number,

N_u – Nusselt number,
k_w – thermal conductivity of water [W/mK],
D_H – hydraulic diameter [m],
$\dot{m}$ – mass flow rate [kg/m^{2}s],
μ – water viscosity [Pas],
C_p – heat capacity at constant pressure [J/kgK],
A – cross-sectional area of flow [m^2].

Exercises

1. Read the text and find the English equivalents for the Polish words:

1) przewodzenie
2) tempo
3) płyta
4) izolowany
5) linia poprzeczna
6) grubość
7) wyprowadzenie (wzoru)
8) brzeg
9) gęstość
10) źródło
11) osłona izolacyjna
12) wyporowy
13) przyspieszenie

14) rozszerzać się
15) ilość

2. Complete the table:

Noun	Verb	Adjective
		conductive
	transmit	*****
thickness		
	form	*****
		applicable
		different
density		
	occur	*****

3. Match the words from the text with their Polish equivalents.

1) constant, — a) całkowity
2) thickness — b) opór
3) resistance — c) stała
4) valid — d) przynależny
5) calculations — e) obliczenia
6) pertinent — f) ważny
7) overall — g) warunki
8) factor — h) czynnik
9) coefficient — i) współczynnik
10) conditions — j) grubość

4. Which of these words can be used both as a noun and a verb without any change in form.

heat, tube, form, change, become, force, flow, transfer, find, result, object, water, derivation

5. Find in the text the English equivalents for the expressions.

1) jest w kierunku od wyższej do niższej temperatury
2) metale są wspaniałymi przewodnikami
3) fragment bardzo dobrze zaizolowanego drutu
4) może powstać z różnic temperatur
5) który rozszerza się i kurczy się przy zmieniającej się temperaturze
6) bezpośredni rezultat ruchu atomów

7) większość fotonów emitowanych
8) jest używany jako czynnik w przekazywaniu ciepła

6. Match the two parts of the sentences:

1. Heat conduction	a) involved in radiation.
2. The local changes in density	b) is rising off the surface of a radiator.
3. Denser substances	c) is a direct result of the movements of atoms and molecules.
4. There is transfer of energy	d) is the transmission of heat across matter.
5. This is by no means the only frequency range	e) result in buoyancy forces.
6. Hot air	f) for different liquids.
7. There are different heat transfer relations	g) are usually better conductors.
8. Thermal radiation	h) from higher temperatures to lower temperatures.

Comprehension

1. Answer the following questions:

1. What is the heat transfer coefficient calculated from?
2. What is thermal radiation?
3. When does forced convection occur?
4. Does convection occur in oceans?
5. What is Dittus – Boelter heat transfer correlation?

2. Match the words with their definitions:

Conduction	the transfer of heat by the motion of particles of a fluid
Convection	movements of atoms in a material.
Radiation	energy in the form of heat sent out as waves

Unit 13

The History of the Automobile

The Internal Combustion Engine and Early Gas-Powered Cars

The very first self-powered road vehicles were powered by steam engines and by that definition Nicolas Joseph Cugnot of France built the first automobile in 1769 fig. 13.1 - recognized by the British Royal Automobile Club and the Automobile Club de France as being the first. So why do so many history books say that the automobile was invented by either Gottlieb Daimler or Karl Benz? It is because both Daimler and Benz invented highly successful and practical gasoline-powered vehicles that ushered in the age of modern automobiles. Daimler and Benz invented cars that looked and worked like the cars we use today. However, it is unfair to say that either man invented "the" automobile.

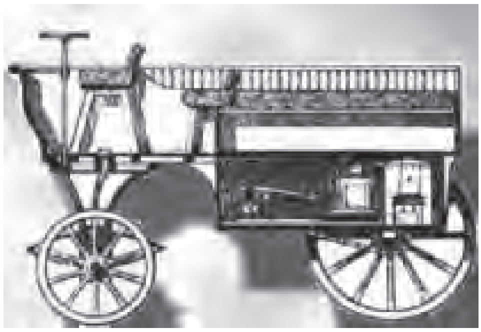


Fig. 13.1. First automobile with internal combustion. engine

History of the Internal Combustion Engine – The Heart of the Automobile

An internal combustion engine is any engine that uses the explosive combustion of fuel to push a piston within a cylinder – the piston's movement turns a crankshaft that then turns the car wheels via a chain or a drive shaft. The different types of fuel commonly used for car combustion engines are gasoline (or petrol), diesel, and kerosene.

A brief outline of the history of the internal combustion engine includes the following highlights:

1680 – Dutch physicist, Christian Huygens designed (but never built) an internal combustion engine that was to be fueled with gunpowder.

1807 – Francois Isaac de Rivaz of Switzerland invented an internal combustion engine that used a mixture of hydrogen and oxygen for fuel. Rivaz designed a car for his engine - the first internal combustion powered automobile. However, his was a very unsuccessful design.

1824 – English engineer, Samuel Brown adapted an old Newcomen steam engine to burn gas, and he used it to briefly power a vehicle up Shooter's Hill in London.

1858 – Belgian-born engineer, Jean Joseph Étienne Lenoir invented and patented (1860) a double-acting, electric spark-ignition internal combustion engine fueled by coal gas. In 1863, Lenoir attached an improved engine (using petroleum and a primitive carburettor) to a three-wheeled wagon that managed to complete an historic fifty-mile road trip.

1862 – Alphonse Beau de Rochas, a French civil engineer, patented but did not build a four-stroke engine (French patent #52,593, January 16, 1862).

1864 – Austrian engineer, Siegfried Marcus, built a one-cylinder engine with a carburettor, and attached his engine to a cart for a rocky 500-foot drive. Several years later, Marcus designed a vehicle that briefly ran at 10 mph.

1873 – George Brayton, an American engineer, developed an unsuccessful two-stroke kerosene engine (it used two external pumping cylinders). However, it was considered the first safe and practical oil engine.

1866 – German engineers, Eugen Langen and Nikolaus August Otto improved on Lenoir's and de Rochas' designs and invented a more efficient gas engine.

1876 – Nikolaus August Otto invented and later patented a successful four-stroke engine, known as the "Otto cycle".

1876 – The first successful two-stroke engine was invented by Sir Dougald Clerk.

1883 – French engineer, Edouard Delamare-Debouteville, built a single-cylinder four-stroke engine that ran on stove gas. It is not certain if he indeed build a car, however, Delamare-Debouteville's designs were very advanced for the time - ahead of both Daimler and Benz in some ways at least on paper.

1885 – Gottlieb Daimler invented what is often recognized as the prototype of the modern gas engine – with a vertical cylinder, and with gasoline injected through a carburettor (patented in 1887). Daimler first built a two-wheeled vehicle the "Reitwagen" (Riding Carriage) with this engine and a year later built the world's first four-wheeled motor vehicle.

1886 – On January 29, Karl Benz received the first patent (DRP No. 37435) for a gas-fueled car.

1889 – Daimler built an improved four-stroke engine with mushroom-shaped valves and two V-slant cylinders.

1890 – Wilhelm Maybach built the first four-cylinder, four-stroke engine.

Engine design and car design were integral activities, almost all of the engine designers mentioned above also designed cars, and a few went on to become major manufacturers of automobiles. All of these inventors and more made notable improvements in the evolution of the internal combustion vehicles.

Famous Automobile Makers

Nicolaus August Otto

Nicolaus August Otto invented the gas motor engine in 1876.

Gottlieb Daimler
In 1885, Gottlieb Daimler invented a gas engine that allowed for a revolution in car design.

Karl Benz (Carl Benz)
Karl Benz was the German mechanical engineer who designed and in 1885 built the world's first practical automobile to be powered by an internal-combustion engine.

John Lambert
America's first gasoline-powered automobile was the 1891 Lambert car invented by John W. Lambert.

Duryea Brothers
They founded America's first company to manufacture and sell gasoline-powered vehicles.

Henry Ford
Henry Ford improved the assembly line for automobile manufacturing (Model-T), invented a transmission mechanism, and popularized the gas-powered automobile.

Rudolf Diesel
Rudolf Diesel invented the diesel-fueled internal combustion engine.

Charles Franklin Kettering
Charles Franklin Kettering invented the first automobile electrical ignition system and the first practical engine-driven generator.

Exercises

1. Find in the text the words for:

1) pojazd
2) zapoczątkować
3) wynaleźć
4) nowoczesny
5) wewnętrzny
6) spalanie
7) tłok
8) wał korbowy
9) nafta
10) zarys
11) wodór
12) projekt
13) gaz węglowy
14) gaźnik
15) czterosuw

2. Complete the table:

Adjective	Noun	Verb
		invent
high		
explosive		
	movement	
		drive
		design
	mixture	
electric		
successful		

3. Match the words with their synonyms:

1) vehicle	a) unharmed
2) internal	b) petrol
3) type	c) kind
4) gasoline	d) inner
5) mixture	e) effective
6) attach	f) car
7) complete	g) composition
8) brief	h) connect, join
9) safe	i) short
10) practical	j) total

4. Put in the missing articles: a**,** an**,** the **or nothing:**

1. Rivaz of Switzerland invented ……. internal combustion engine that used ……. mixture of hydrogen and oxygen for ……. fuel.
2. ……. very first self-powered road vehicles were powered by ……. steam engines and by that definition Nicolas Joseph Cugnot of France built ……. first automobile.
3. All of these inventors and more made notable improvements in ……. evolution of ……. internal combustion vehicles.
4. ……. internal combustion engine is any engine that uses ……. explosive combustion of fuel to push ……. piston within ……. cylinder.

Unit 14

The Dewar flask

The Dewar flask

The Dewar flask – fig. 14.1 (invented by James Dewar) is a container designed for storage of cold or hot liquids for long period of time. It is a Pyrex glass vessel and has a design as shown in the diagram below.

It has two walls with vacuum in between to minimize energy transfer by conduction and convection.

The surfaces of the wall are coated with silver (a very good reflector with low emissivity) to minimize energy transfer by radiation.

Fig. 14.1. The Dewar flask

Key to exercises

Unit 1

1. Match the words from the text with their Polish equivalents:
   1) *e*, 2) *f*, 3) *g*, 4) *h*, 5) *b*, 6) *a*, 7) *c*, 8) *d*, 9) *i*

2. Find in the text the English equivalents for the words:
   1. węgiel drzewny – *charcoal*
   2. węgiel – *carbon*
   3. tlenek – *monoxide*
   4. żelazo – *iron*
   5. kęsisko – *bloom*
   6. miechy – *bellows*
   7. dmuchawa – *blower*
   8. piec – *furnace*
   9. wapień – *limestone*
   10. żużel, szlaka – *slag*

3. Find the English equivalents for the expressions:
   1) spongy mass containing iron,
   2) furnace is charged with iron ore,
   3) combines with the silicates to form slag,
   4) this metal is known as pig iron,
   5) is its greatly improved strength,
   6) oxidation of the impurities in the iron.

4. Put in the missing articles: *a*, *an*, *the* or nothing:
   1. As *the* air passes upward through *the* molten pig iron, impurities such as silicon, manganese, and carbon unite with *the* oxygen in *the* air to form oxides.
   2. Most modern steel plants use what is called *a* basic oxygen furnace to create steel.
   3. Steel is iron that has most of *the* impurities removed:
   4. *The* advantage of steel over iron is its greatly improved strength.
   5. *The* process is carried on in *a* large container called *the* Bessemer converter, which is made of steel and has *a* lining of silica and clay or of dolomite.

5. Translate the sentences into English:
   1. Impurities like silica, phosphor and sulfur weaken steel tremendously.
   2. The pig iron, limestone and iron ore go into an open hearth furnace

3. The process is carried on in a large container called the Bessemer converter.
4. The container is set on pivots so that it can be tilted at an angle to receive the charge.
5. Most modern steel plants use what is called a basic oxygen furnace to create steel.

6. Make adjectives from the following nouns:

Nouns	Adjectives
industry	*industrial*
strength	*strong*
welding	*weldable*
quantity	*quantitative*
glass	*glassy*
combination	*combined*
creation	*creative*
purity	*pure*
importance	*important*
history	*historic/historical*

Comprehension

1. Answer the following questions:
   1. All of the iron ores contain iron combined with oxygen.
   2. The calcium in the limestone combines with the silicates to form slag.
   3. When you heat wrought iron, it is malleable, bendable, weldable and very easy to work with.
   4. The advantage of steel over iron is its greatly improved strength.
   5. The process is carried on in a large container called the Bessemer converter.
   6. By testing a metal under a load one can define what mechanical properties it has.

2. Match the terms with their definitions:

Charcoal	*Pure carbon*
Slag	*Calcium combined with the silicates*
Steel	*Iron with impurities removed*
Sulfur	*Impurity weakening steel*

Unit 2

1. Find the English equivalents for these words:
   1) obróbka skrawaniem – *machining*
   2) imadło – *vice*

3) mosiądz – *brass*
4) szczęki – *jaws*
5) ciśnienie – *pressure*
6) wypusty – *serrations*
7) rączka – *handle*
8) okoliczności, warunki – *circumstances*
9) miedź – *copper*
10) szczypce – *pliers*
11) elastyczność – *flexibility*
12) osiować – *align*
13) kołek – *pin*
14) zakrzywiony – *curved*
15) chwytać – *grip*
16) nakrętka – *nut*
17) gniazdo, oprawka – *socket*
18) dodatki – *attachments*
19) zaciskanie, mocowanie – *clamping*
20) śruba, wkręt – *screw*

2. Match the words from the text with their Polish equivalents:
1) *f*, 2) *g*, 3) *b*, 4) *d*, 5) *a*, 6) *e*, 7) *c*

3. Match the words from the list with their English equivalents:
1) *e*, 2) *c*, 3) *f*, 4) *d*, 5) *g*, 6) *b*, 7) *a*

4. Match the words from the text in column A with their synonyms in column B:

A	B
convenient	*helpful*
permit	*let*
apply	*use*
proper	*right, suitable*
types	*kinds*
various	*different*
placed	*situated*
slightly	*a little bit*

5. Insert *the*, *a*, *an*, or – where no article is necessary:

1. Small precision parts may be held in *a* small bench vise. This type vise can be rotated and tilted to any desired position. vise size is determined by *the* width of *the* jaws.
2. A vise's clamping action is obtained from *a* heavy screw turned by *a* handle. *The* handle is long enough to apply ample pressure for any work that will fit *the* vise. Under no circumstances should *the* vise handle be hammered tight, nor

should additional pressure be applied using *a* length of pipe for leverage.

3. *The* combination or slip-joint pliers are widely used for holding operation. *The* slip-joint permits *the* pliers to be opened wider at *the* hinge pin to grip larger size work. *The* size of *the* pliers indicates *the* overall length of *the* tool.

6. Complete the sentences with prepositions:
   1. A vise's clamping action is obtained *from* a heavy screw turned *by* a handle.
   2. The size *of* the pliers indicates the overall length *of* the tool.
   3. They will reach *into* cramped places.
   4. These pliers are made *in* many sizes *with* straight, curved, or long-nose jaws.
   5. Box wrenches are available *in* the sizes as open-end wrenches and *with* straight and offset handles.
   6. A hook spanner is equipped *with* a single lug that is placed in a slot or notch cut in the fitting.
   7. Each shape has been designed *for* a particular type *of* fastener.

7. Fill in the correct words from the list below:
   1. Files are also classified according to the *cut* of the teeth.
   2. Files have three distinct *characteristics*: length, kind and cut.
   3. They require heavier pressure and they produce a rougher surface *finish*.
   4. Some files have safe *edges* which denotes that the file has one or both edges without teeth.
   5. The chisel is frequently employed to chip *surplus* metal from castings.
   6. The typical hacksaw is composed of a *frame* with a handle and a replaceable blade.
   7. The modern file is made from high grade *carbon* steel and is heat treated to provide the necessary *hardness* and toughness.

Comprehension

1. Choose the best item:

   1) *c*, 2) *c*, 3) *b*

2. Answer the following questions:
   1. Files are classified by the shape and cut of the teeth.
   2. A wrench used with socket headed fastener is known as allen wrench.
   3. Open-end wrenches are usually double ended.
   4. The vise size is determined by the width of the jaws.
   5. Yes, they are.

Unit 3

1. Find in the text the English equivalents to the following Polish words:

   1) moneta dziesięciocentowa − *dime*

2) podziałka – *graduation*
3) dziesiętny – *decimal*
4) liczyć – *count*
5) obmyśleć – *devise*
6) dokładnie – *accurately*
7) mechanizm zapadkowy – *ratchet*
8) bębenek, nasadka – *thimble*
9) piasta – *hub*
11) tuleja, bęben – *barrel*
12) układ – *layout*
13) czujnik – *dial indicator*
14) rzut – *projection*
15) sprawdzian szczękowy – *snap gauge*
16) trzpień pomiarowy – *plunger*
17) średnica podziałowa – *pitch diameter*
18) odczyt wskazań przyrządu – *readout*
19) mikrometr – *micometer caliper*

2. Find synonyms to the following words in the above text:

1) capable
2) appear
3) position
4) increase
5) range
6) obtain
7) properly
8) rotate
9) uniform

3. Complete the table:

Verb	Noun	Adjective
measure	*measurement*	measurable
*****	*possibility*	*possible*
*****	*capability*	capable
*****	precision	*precise*
generalize	*generality*	general
direct	*direction*	*direct*
appear	appearance	*****
indicate	*indication*	*indicative*
notice	notice	*noticeable*
*****	*accuracy*	accurate

4. Insert *the*, *a*, *an* or – where no article is necessary:
   1. One-millionth of *a* meter is called *a* micrometer.
   2. *The* distance of *the* measurement is determined by counting *the* number of millimeters.
   3. *A* direct reading micrometer is read directly from *the* numbers appearing in *the* readout opening in *the* frame.
   4. It measures *the* pitch diameter of *the* thread, which equals *the* outside diameter of the thread minus *the* depth of one thread.
   5. To get *a* correct reading with *an* inside micrometer, it is important that *the* tool be held square across *the* diameter of *the* work.
   6. *A* universal bevel protractor is *a* finely made tool with *a* dial graduated into degrees, *a* base, and *a* sliding blade that can be extended in either direction or set at any angle to *the* stock.

5. Complete the sentences using a word from the box below:
   1. They found a useful *device* for detecting electrical activity.
   2. The builders made careful *measurements*.
   3. The gas containers burst at high *pressures*.
   4. The freezer is already on its highest *setting*.
   5. I suppose I *average* about five cups of coffee a day.
   6. The cutter is *accurate* to within half a millimeter
   7. This drawing of the monastery was done from an unusual *angle*.

6. Put the verbs in bold into the correct tense and voice form:
   1. The Vernier slide assembly is *composed of* a movable jaw, Vernier plate, and clamping screws.
   2. Unlike other Vernier measuring tools, the beam of the Vernier caliper *is graduated* on both sides.
   3. The minute is *utilized* to represent a fractional part of a degree.
   4. The blade can *be locked* against the dial by tightening the blade clamp nut.
   5. When great numbers of an item, with several critical dimensions, *are manufactured*, it may not be possible to check each piece.
   6. The adjustable snap gage, which can *be adjusted* through a range of sizes.
   7. They *are accepted* by major world powers as standards of accuracy for all types of manufacturing.
   8. It must *be positioned* so that it *will* measure across the diameter on exact center.
   9. It may be necessary to take several readings and *average* them.

7. Complete the sentences with prepositions:
   1. It is a friction control build *into* the upper section of the thimble.
   2. Guard *against* excessive pressure.
   3. A micrometer depth gage will measure the depths *of* holes, slots, projections, etc.

4. Micrometers are made *in* a large variety of models.
5. There are three basic types *of* rule graduations: metric, fractional, and decimal.
6. The science that deals *with* systems *of* measurement is called metrology.
7. Variations as small as 0.012 mm can be noted *by* a skilled operator.

Comprehension

1. Answer the following questions:
   1. There are three basic types of rule graduations: metric, fractional, and decimal.
   2. The distance of the measurement is determined by counting the number of millimeters.
   3. The device, called "Systeme Palmer" is the basis for the modern micrometer caliper.
   4. An inside micrometer measures the widths of slots.
   5. A set of thread micrometers are necessary to measure a full range of thread pitches.

Unit 4

1. Find the English equivalents:
   1) industry
   2) entertainment
   3) surface
   4) application
   5) etching
   6) carbon dioxide
   7) recuperation
   8) lens
   9) utilize
   10) minute

2. Match the words from the text with their Polish equivalents:
   1) *d*, 2) *e*, 3) *g*, 4) *f*, 5) *c*, 6) *b*, 7) *h*, 8) *i*, 9) *j*, 10) *a*

3. Translate the following sentences into Polish:
   1. Niektóre lasery potrafią przeciąć metal, podczas gdy inne po prostu czytają małe skrawki informacji, nie niszcząc przy tym powierzchni.
   2. W medycynie, lasery gazowe na dwutlenku węgla są używane w wielu rodzjach chirurgii, ponieważ są bardziej precyzyjne i czułe niż skalpele.

3. Drukarki laserowe wykorzystują lasery, aby zmienić powierzchnię papieru oraz żeby pokazać tekst i grafikę.
4. Lasery o odpowiedniej sile mogą wytrawić powierzchnie od plastiku po skałę.
5. Chociaż pierwszy laser został zrobiony w laboratorium w1960, zastosowanie tego urządzenia w różnych technologiach zabrało niemało czasu.

4. Find in the text synonyms for the following words:
   1) entertainment
   2) determine
   3) tiny
   4) application
   5) basically
   6) remove
   7) bit
   8) recuperation
   9) display
   10) indispensable

5. Find the opposites to these words:
   1) major
   2) tiny
   3) divide
   4) precise
   5) damage
   6) less
   7) stronger
   8) visible
   9) inside
   10) surrounding

6. Put in the missing articles: a, an, the or nothing:
   1. *A* power rating, usually in watts, determines *the* strength of the laser.
   2. Damage to surrounding tissue, as well as bleeding, has been reduced by using lasers
   3. CD, DVD and Blue-Ray players use lasers to read *the* audio and video information on *the* disc, *the* way *a* needle used to read *the* groove of *a* record.
   4. Laser printers utilize lasers to change *the* surface of *the* paper and to display text and graphics.
   5. Even though *the* first laser was made in *a* laboratory back in 1960, it took several decades to apply this tool to various technologies.

Unit 5

1. Find the English equivalents for these words:

1) narzędzie tnące – *cutting tool*
2) zasada – *principle*
3) prowadnice – *ways*
4) materiał obrabiany – *workpiece*
5) konik – *tailstock*
6) uchwyt obrotowy – *chuck*
7) koło pasowe – *pulley*
8) wrzeciono – *spindle*
9) łożysko, panewka – *bearing*
10) chwyt stożkowy – *taper shank*
11) wypychacz – *knockout bar*
12) wrzeciennik – *headstock*
13) kołnierz – *flange*
14) gwintowanie – *threading*
15) śruba dwustronna – *studs*
16) zderzak – *dog*
17) tuleja – *sleeve*
18) suport wzdłużny – *carriage*
19) kieł stały – *dead center*
20) oprawka pierścieniowa – *collet*
21) pokrętło – *handwheel*
22) skrzynka przekładniowa – *gear box*

2. Fill in the correct preposition:

1. Ways are integral *with* the bed.
2. The bed is the foundation *of* a lathe.
3. The gear train also contains gears *for* reversing tool travel.
4. The outer end *of* the work is often supported *by* the tailstock.
5. Power is transmitted *to* the carriage *through* the feed mechanism, which is located *at* the left *of* the lathe.

3. Rewrite the following sentences in the passive:

1. A cutting tool can be moved lengthwise on the lathe bed.
2. Lathe size is determined by the swing and length of the bed.
3. The longest piece that can be turned.
4. Power is transmitted to the various drive mechanisms by belt drive.
5. The spindle is rotated by belts and gears.
6. The studs are locked by tightening the cams located around the spindle nose.
7. Work is held in the lathe by a chuck, faceplate or collet.

4. Complete the table:

Verb	Noun
move	*movement*
indicate	indication
revolve	*revolution*
engage	engagement
align	*alignment*
serve	service
contain	*container*
rotate	rotation

5. Match the words from the text in column A with their synonyms in column B:

A	B
desire	want
rotation	turning
chief	main
appear	seem
each	every
major	important
use	purpose
position	situation
arrange	put in order

6. Find in the text the English equivalents for the expressions:

1) that can be turned over the ways,
2) no matter how complex it may appear to be,
3) or a combination of both,
4) until it seats on the spindle flange,
5) serves as,
6) arranged between the spindle and the lead screw.

7. Supply the missing words:

1. Bed length is entire length of the ways.
2. Lathe size is determined by the swing and length of the bed.
3. Power is transmitted to the various drive mechanisms.
4. The hole permits long stock to be turned without dangerous overhang.
5. Mounting is done by rotating the key until it is on the top.

Comprehension

1. Answer the following questions:
   1. The cutting tool is controllable.
   2. Lathe size is determined by the swing and length of the bed.
   3. Spindle speed can be varied by controlling the speed hydraulically.
   4. A knockout bar is used to remove taper shank tools.
   5. Work is held in the lathe by a chuck, faceplate, collet or between centers.
   6. The tailstock can be fitted with tools for reaming.
   7. The carriage controls and supports the cutting tool.

Unit 6

1. Put in the missing articles: a, an, the or nothing:
   1. *A* wide variety of cutting operations can be performed on milling machines.
   2. As mentioned, metal is removed in milling by means of turning *a* multitooth cutter into *the* work.
   3. On *a* horizontal spindle milling machine, *the* cutter is fitted onto *an* arbor mounted in *the* machine on *an* axis parallel with *the* work table.
   4. *A* universal milling machine is similar to *the* plain milling machine but *the* table has *a* forth movement.
   5. On *a* swivel head milling machine, *the* spindle can be swiveled for angular cuts.

2. Make adjectives from the following nouns:

Noun	Adjective
circle	*circular*
periphery	*peripheral*
variety	*various*
capability	*capable*
availability	*available*
individuality	*individual*
longitude	*longitudinal*
power	*powerful*

3. Find the Polish equivalents to the following English words:
   1) multitooth cutter – *frez wieloostrzowy*
   2) recess – *wybranie*
   3) arbor – *trzpień*
   4) spline – *wypust*
   5) face – mill – *frez czołowy*

6) fixture – *uchwyt mocujący*
7) pocket – *zagłębienie*
8) flute – *rowek*
9) roughing – *obróbka zgrubna*
10) keyway – *rowek klinowy*
11) finishing – *wygładzanie*
12) taper shank – *chwyt stożkowy*
13) sleeve – *tuleja*
14) spindle nose – *końcówka wrzeciona*
15) stub arbor – *krótki trzpień*
16) rotary head – *głowica obiegowa*
17) template – *wzornik*
18) chart – *tabela*
19) adjusting – *regulacja*
20) shifting – *przesunięcie*

4. Match the words from column A with their antonyms in column B:

A	B
wide	*narrow*
capable	*incapable*
small	*big*
direct	*indirect*
difficult	*easy*
heavy	*light*
similar	*different*
complex	*simple, uncomplicated*
quick	*slow*
particular	*general*

5. Put the verbs in bold into the correct tense and voice form:
1. A milling machine *rotates* a multitooth cutter into the work.
2. As mentioned, metal *is removed* in milling by means of turning a multitooth cutter into the work.
3. Work may *be clamped* directly to the machine table.
4. However, for practical purposes, milling machines may *be grouped* into two large families.
5. However, on many vertical spindle machines, it can *be tilted* to perform angular cutting operations.
6. The work table *moves* only in a longitudinal direction
7. This *makes* it possible to produce spiral gears, spiral splines, and similar work.
8. On a swivel head milling machine, the spindle can *be swiveled* for angular cuts.

6. Find in the text the English equivalents for the expressions:
   1) for computer controlled operations,
   2) various categories of milling machines,
   3) or at a right angle to the work table,
   4) can be further classified as horizontal, vertical …,
   5) through an angle of 45 degrees,
   6) by hand or under power,
   7) two or three dimensional templates.

Unit 7

1. Match the words from the text with their Polish equivalents:
   1) *h*, 2) *g*, 3) *i*, 4) *l*, 5) *k*, 6) *c*, 7) *j*, 8) *d*, 9) *e*, 10) *f*, 11) *a*, 12) *b*

2. Find in the text words for:
   1) dead center – *kieł stały*
   2) curl – *skręcać*
   3) coolant – *chłodziwo*
   4) flute – *rowek*
   5) lubricant – *smar*
   6) margin – *krawędź*
   7) strip – *pasek*
   8) chuck – *uchwyt*
   9) straight – *prosty*
   10) drill press – *wiertarka pionowa*

3. Translate these sentences into English:
   1. After twisting, the drills are milled and ground to approximate size.
   2. Industry utilizes special drills to improve the accuracy of a drilled hole.
   3. The pressure of the fluid or air also ejects the chips from the hole while drilling.
   4. Spade drills have replaceable cutting tips, usually of tungsten carbide.
   5. The web is the metal column that separates the flutes.

4. Complete the chart:

Infinitive	Past simple	Past participle
do	*did*	*done*
know	knew	*known*
get	*got*	got
speed	sped	*sped*
make	*made*	made
run	*ran*	*run*
hold	held	*held*

5. Fill in the correct word from the list below:
   1. She *twisted* the wire into the shape of a star.
   2. The *heat* of the water caused the glass to shatter.
   3. This is a heating system that *utilizes* solar energy.
   4. The *pressure* of the water turns the wheel.
   5. The Saudi government has announced plans to *drill* for water in the desert.
   6. These cheap plates *chip* really easily.

Comprehension

1. Answer the following questions:
   1. Most drills are made of high speed steel or carbon steel.
   2. Spade drills have replaceable cutting tips.
   3. It is composed of three principle parts: point, shank, and body.
   4. The point does.
   5. Chuck
   6. It is usually fitted with a carbide cutting tip.

Unit 8

1. Add the correct prefixes to make the opposite of these words (de-, dis-, in-, non-, un-):
   1) inseparable
   2) non-magnetic
   3) demagnetize
   4) unsuitable
   5) uncontrolled
   6) disadvantage
   7) inexpensive
   8) deregulate
   9) unfinished
   10) dismount

2. Match the words from the text with their Polish equivalents:
   1) *k*, 2) *g*, 3) *h*, 4) *i*, 5) *d*, 6) *c*, 7) *j*, 8) *e*, 9) *a*,10) *f*, 11) *b*

3. Fill in the correct words from the list below:
   1. Do you like the new *wheels* in my car?
   2. Two phenomena which both waves and *particles* appear to undergo are reflection and refraction.
   3. The stone steps had been worn *smooth* by centuries of visitors.
   4. The pump shut off as a result of *a mechanical* failure.
   5. The space round a magnet in which it exerts a force is known as *magnetic field.*

6. The improvements in *efficiency* have been staggering.

4. Complete the sentences with the correct prepositions:
   1. However, grinding makes use *of* an abrasive tool composed *of* thousands *of* cutting edges.
   2. It is also one *of* the few machining operations that can produce a smooth, accurate surface *on* material regardless *of* its hardness.
   3. Table movement can be controlled manually or *by* means *of* a mechanical or hydraulic drive mechanism.
   4. A magnetic chuck makes use *of* a permanent magnet.
   5. Only manufactured abrasives are suitable *for* modern high-speed grinding wheels.
   6. Water-soluble oil fluids are coolants that take advantage *of* the excellent cooling qualities *of* water.

5. Make nouns from the following verbs:

Verb	Noun
vary	*variation*
soften	*softness*
improve	*improvement*
employ	*employment*
eject	*ejection*
operate	*operation*
complete	*completion*
form	*form*
exert	*exertion*
electrify	*electricity*

6. Find in the text the English equivalents for the expressions:
   1) composed of thousands of cutting edges,
   2) removes a relatively small amount of material,
   3) regardless of its hardness,
   4) make use of a reciprocating motion,
   5) and exposes new particles,
   6) at a slight angle.

Comprehension

1. Answer the following questions:
   1. It is a substance that regulates and controls the growth of bacteria.
   2. The grinding wheel might be compared to a many toothed milling cutter.
   3. Grinding is frequently a finishing operation.

4. Planer type surface grinders make use of a reciprocating motion.
5. Workpiece on a surface grinder is held in position by a magnetic chuck.
6. It must be dressed with a diamond dressing tool.
7. Cutting fluids are an important factor in lessening wear on the grinding wheel.
8. The regulating wheel causes the piece to rotate.
9. End feed grinding is a form of centerless grinding ideally suited for grinding short tapers and spherical shapes.
10. In form grinding ,the grinding wheel is shaped to produce the required contour on the work.

2 Match the terms with their definitions:

Grinding	*Cutting operation making use of an abrasive tool composed of thousands of cutting edges*
Infeed grinding	*A Centerless grinding technique that feeds the work into the wheel gap until it reaches a stop*
Cutting fluid	*Important factor in lessening wear on the grinding wheel*
Thread grinding	*An example of form grinding*

Unit 9

1. Find in the text the words for:

1) stały, trwały – *permanent*
2) ciepło – *heat*
3) topić – *melt*
4) zgrzewać – *fuse*
5) belka – *beam*
6) rura – *pipe*
7) różnorodność – *variety*
8) płaski – *flat*
9) wyposażenie – *equipment*
10) podajnik – *feeder*
11) powszechny – *common*
12) zacisk – *clip*
13) spoiwo – *bond*
14) otulina, topnik – *flux*
15) otaczać – *surround*
16) nierdzewny – *stainless*
17) szpula – *spool*
18) zastąpić – *replace*

2. Complete the table:

Verb	Noun
apply	*application*
form	form
strengthen	*strength*
feed	feeder
electrify	*electricity*
weld	welding
accelerate	acceleration
protect	protection

3. Put in the missing articles: *a*, *an*, *the* or nothing:
   1. They may perform manual welding, in which *the* work is entirely controlled by *the* welder, or semiautomatic welding, in which *the* welder uses machinery, such as *a* wire feeder, to perform welding tasks.
   2. When *the* rod touches *the* workpiece, a powerful electrical circuit is created.
   3. Variations in speed can change *the* amount of flux applied, weakening *the* weld, or weakening *the* surrounding metal.
   4. The massive heat created by *the* electrical current causes both *the* workpiece and *the* steel core of *the* rod to melt together.
   5. In TIG welding, *the* welder holds *the* welding rod in one hand and *an* electric torch in *the* other hand.

4. Find in the text the English equivalents for the expressions:
   1) to create an extremely high temperature,
   2) although metals and temperatures differ,
   3) yet high enough to melt the braze,
   4) and therefore use different solder,
   5) a powerful electrical circuit is created,
   6) so only the added metal is melted.

5. Complete the sentences with words from the list below:
   1. Arc welding is the most *common* type of welding.
   2. Welders use many types of welding *equipment* set up in a variety of positions.
   3. When the rod touches the workpiece, a powerful electrical *circuit* is created.
   4. Variations in *speed* can change the amount of flux applied, weakening the weld, or weakening the surrounding metal.
   5. Brazing produces a stronger *joint* than does soldering, and is often used to join metals other than steel, such as brass.
   6. The process of *brazing* is the same as soldering, although metals and temperatures differ.
   7. It also conducts *electricity* like the base alloys.

6. Match the words with their synonyms:
   1) *c*, 2) *f*, 3) *a*, 4) *b*, 5) *d*, 6) *e*, 7) *h*, 8) *g*

Comprehension

1. In the process of welding, heat is applied to metal pieces, melting and fusing them to form a permanent bond.
2. A welder uses a wire feeder, to perform welding tasks in semiautomatic welding.
3. When the rod touches the workpiece, a powerful electric circuit is created.
4. During welding, the flux that surrounds the rod's core vaporizes.
5. Brazing is often used to join metals other than steel, such as brass.
6. Silver and bronze are perfect for brazing.
7. Yes, the solder needs a lower melting point than the metal you're joining.

Unit 10

1. Find in the text the words for:
   1) maska silnika – *hood*
   2) plątanina – *jumble*
   3) przekształcić – *convert*
   4) wewnętrzny – *internal*
   5) para – *steam*
   6) zewnętrzny – *external*
   7) wydajny – *efficient*
   8) niedrogi – *inexpensive*
   9) względnie – *relatively*
   10) wynaleźć – *invent*
   11) tłoki – *pistons*
   12) obrotowy – *rotational*
   13) wał korbowy – *crank shaft*
   14) spalanie – *combustion*
   15) komora – *chamber*
   16) iskra – *spark*
   17) występować – *occur*
   18) zawór – *valve*
   19) sprężanie – *compression*
   20) pierścień – *ring*

2. Complete the sentences with a preposition:
   1. The purpose *of* a gasoline car engine is to convert gasoline *into* motion so that your car can move.

2. A steam engine *in* old-fashioned trains and steam boats is the best example *of* an external combustion engine.
3. The gasoline charge *in* the cylinder explodes, driving the piston *down*.
4. Now the engine is ready *for* the next cycle, so it intakes another charge *of* air and gas.
5. *In* an engine the linear motion *of* the pistons is converted *into* rotational motion *by* the crank shaft.
6. A piston is a cylindrical piece *of* metal that moves *up* and *down* inside the cylinder.

3. Find in the text the English equivalents for the expressions:

1) the easiest way to create motion from gasoline,
2) is the best example of an external combustion engine,
3) a lot more efficient than external combustion,
4) compared to an external combustion engine,
5) is also known as,
6) so it intakes another charge of air and gas,
7) so that combustion can occur.

4. Complete the sentences with the words given:

1. The fuel in a *steam* engine burns outside the engine to create steam, and the steam creates *motion* inside the engine.
2. Almost all cars currently use what is called a four-stroke combustion *cycle* to convert *gasoline* into motion.
3. Only a tiny *drop* of gasoline needs to be mixed into the *air* for it to work.
4. Now the engine is ready for the next cycle, so it intakes another *charge* of air and gas.
5. The combustion chamber is the *capacity* where *compression* and *combustion* take place.
6. The difference between the maximum and minimum is called the *displacement*.
7. They keep oil in the *sump* from leaking into the combustion area.

5. Match the words from the text in column A with their synonyms in column B:

A	B
gasoline	*petrol*
current	*present*
motion	*movement*
old-fashioned	*out of date*
small	*tiny*
inexpensive	*cheap*
illustrate	*show*
start	*commence*

6. Translate these sentences into Polish:
    1. Sprężanie sprawia, że wybuch jest mocniejszy.
    2. Następnie tłok porusza się z powrotem do góry w celu sprężenia mieszanki paliwowo – powietrznej.
    3. Teraz silnik jest gotowy do następnego cyklu, więc pobiera następną ilość powietrza i paliwa.
    4. Komora spalania jest objętością gdzie ma miejsce sprężanie i spalanie.

7. Put in the missing articles: *a*, *an*, *the* or nothing:
    1. Now *the* engine is ready for *the* next cycle, so it intakes another charge of air and gas.
    2. In an engine *the* linear motion of *the* pistons is converted into rotational motion by *the* crank shaft.
    3. The piston starts at *the* top, *the* intake valve opens, and *the* piston moves down to let *the* engine take air and gasoline in *a* cylinder.
    4. *A* steam engine in old-fashioned trains and steam boats is *the* best example of *an* external combustion engine.
    5. Almost all cars currently use what is called *a* four-stroke combustion cycle to convert gasoline into motion.

Unit 11

1. Find in the text words for:

1) equipment	10) mount
2) spin	11) straight
3) torque	12) curve
4) screwdriver	13) plane
5) spur gear	14) axis
6) meshing	15) pinion
7) smooth	16) drive shaft
8) thrust load	17) passenger compartment
9) bearing	18) angle

2. Find in the text the English equivalents for the expressions:
    1) they provide a gear reduction
    2) small motor spinning very fast
    3) mounted on parallel shafts
    4) gradually spreads as the gears rotate
    5) have bearings that can support this thrust load
    6) the solution to this problem is to curve the gear teeth

3. Fill in the correct words from the list bellow:
    1. He is the *conveyer* of good news.

2. Put the ice cream back in the freezer *compartment*.
3. There was a slight *reduction* in the price.
4. Check your rope frequently as *friction* against the rock can wear it down.
5. That's my personal *property*.
6. He summoned the waiter with a *motion* of his hand.
7. The dishes are on the plate *rack*.
8. This is part of the process of *converting* iron into steel.
9. The repair shop sells electrical *components*.
10. Your parents' income is used to *determine* your level of financial aid.

4. Find in the text the opposites to the given words:

1) connect
2) lower
3) proper
4) start
5) increase
6) fast
7) important
8) smooth

5. Find in the text synonyms for the following words:

1) important
2) spin
3) amount
4) common
5) gradually
6) impact
7) spread
8) feature

6. Make nouns from the following adjectives:

Adjectives	Nouns
mechanical	*mechanics, mechanism*
fast	*speed*
electric	*electricity*
high	*height*
smooth	*smoothness*
proper	*property*
progressive	*progression*
different	*difference*
shallow	*shallowness*
perfect	*perfectionism, perfectionist*

7. Complete the sentences with the correct prepositions:
   1. They do several important jobs, but most important, they provide a gear reduction *in* motorized equipment.
   2. A perfect example *of* this is the steering system *in* many cars.
   3. This means that the drive shaft doesn't intrude *into* the passenger compartment *of* the car as much, making more room *for* people and cargo.
   4. Bevel gears are useful when the direction *of* a shaft's rotation needs to be changed.
   5. The teeth *on* helical gears are cut *at* an angle *to* the face *of* the gear.
   6. Because *of* the angle *of* the teeth *on* helical gears, they create a thrust load *on* the gear when they mesh.
   7. For instance, an electric screwdriver has a very large gear reduction because it needs high torque to turn screws, but the motor only produces low amount *of* torque *at* a high speed.

Comprehension

1. With a gear reduction, the output speed can be reduced while the torque is increased.
2. spur gears,
   helical gears,
   bevel gears,
   hypoid bevel gears,
   worm gears,
   rack and pinion gears
   planetary gears
3. Spur gears are used in many devices, like the electric screwdriver, windup alarm clock, washing machine and clothes dryer.
4. Helical gears are used in almost all car transmissions.
5. Rack and pinion gears are.

Unit 12

1. Read the text and find the English equivalents for the Polish words.
   1) conduction
   2) rate
   3) slab
   4) insulated
   5) transversal
   6) thickness
   7) derivation
   8) boundary

9) density
10) source
11) mantle
12) buoyant
13) acceleration
14) expand
15) amount

2. Complete the table:

Noun	Verb	Adjective
conduction	*conduct*	conductive
transmission	transmit	*****
thickness	*thicken*	*thick*
form	form	*****
application	*apply*	applicable
difference	*differ*	different
density	*condense*	*dense*
occurence	occur	*****

3. Match the words from the text with their Polish equivalents:
1) *c*, 2) *j*, 3) *b*, 4) *f*, 5) *e*, 6) *d*, 7) *a*, 8) *h*, 9) *i*; 10) *g*

4. Which of these words can be used both as a noun and a verb without any change in form:
heat, form, change, force, flow, transfer, result, object, water

5. Find in the text the English equivalents for the expressions:
1) is directed from a higher to a lower temperature,
2) metals are excellent conductors,
3) a portion of a perfectly insulated wire,
4) It may arise from temperature differences,
5) expands or contracts in response to changing temperatures,
6) a direct result of the movements of atoms,
7) the majority of photons emitted,
8) is used as a factor in calculating heat transfer

6. Match the two parts of the sentences:
1) *d*, 2) *e*, 3) *g*, 4) *h*, 5) *a*, 6) *b*, 7) *f*, 8) *c*

Comprehension

1. Answer the following questions:
   1. The heat transfer coefficient is often calculated from the Nusselt number.
   2. Thermal radiation is a direct result of the movements of atoms and molecules

in a material.
3. Forced convection happens when motion of the fluid is imposed externally (such as by a pump or fan).
4. Yes, it does.
5. Thermal hydraulic calculation is the Dittus-Boelter heat transfer correlation.

Unit 13

1. Find in the text the words for:
   1) vehicle
   2) usher
   3) invent
   4) modern
   5) intrnal
   6) combustion
   7) piston
   8) crankshaft
   9) kerosene
   10) outline
   11) hydrogen
   12) design
   13) coal gas
   14) carburettor
   15) four-stroke

2. Complete the table:

Adjective	Noun	Verb
inventive	*invention*	invent
high	*height*	*****
explosive	*explosion*	*explode*
*****	movement	*move*
*****	*driver*	drive
*****	*design*	design
*****	mixture	*mix*
electric	*electrician*	*electrify*
successful	*success*	*succeed*

3. Match the words with their synonyms:
   1) *f*, 2) *d*, 3) *c*, 4) *b*, 5) *g*, 6) *h*, 7) *j*, 8) *i*, 9) *a*, 10) *e*

4. Put in the missing articles: *a*, *an*, *the* or nothing:
   1. Rivaz of Switzerland invented *an* internal combustion engine that used *a*

mixture of hydrogen and oxygen for fuel.

2. *The* very first self-powered road vehicles were powered by steam engines and by that definition Nicolas Joseph Cugnot of France built *the* first automobile.
3. All of these inventors and more made notable improvements in *the* evolution of *the* internal combustion vehicles.
4. *An* internal combustion engine is any engine that uses *the* explosive combustion of fuel to push *a* piston within *a* cylinder.

Glossary

A

acid bessemer process – process bessemerowski
adherence – przyleganie, przyczepność
adjust – nastawiać,regulować
adjustable wrench – klucz nastawny
adjusting – regulacja
aligned – ustawione w linii
allen wrench – klucz do wkrętów z sześciokątnym gniazdem
alligator clip – zacisk szczękowy
ample – wystarczający
anvil – kowadełko
apron – skrzynka suportowa
arbor – trzpień
arc welding – spawanie łukowe
at close quaters – z bliska
attachment – nasadka

B

back gear control knob – pokrętło sterowania biegiem wstecznym
bar – pręt
barrel – bębęn, tuleja
base metal – metal rodzimy, metal nieszlachetny
basic oxygen furnace – zasadowy konwertor tlenowy
basic process – process konwertorowy
bastard – równiak
beam – belka dźwigar
bearing – łożysko
bearing surface – powierzchnia nośna
bed – łoże
bed of sand – warstwa piaskowa
bellows – miechy
bench – ława
bench lathe – tokarka stołowa
bench vice – imadło warsztatowe
bevel gear – przekładnia zębata stożkowa
bevel protractor – kątomierz
binding lever – dźwignia zaciskowa
blade – ramię dłuższe kątownika
blast – wdmuchiwać
bloomery – piec fryszerski
bloom – kęsisko
blower – dmuchawa
blunt – tępy
body – część robocza wiertła, korpus
body clearance – skraj trzpienia
bold head – łeb śruby
bond – spoiwo
boring – wytaczanie
box wrench – klucz oczkowy
brass – mosiądz
braze – lutowina
brazed – lutowany na twardo
braze – lutowina twarda
brazing – lutowanie twarde
brittle – kruchy
buoyant – wyporowy
butt welding – spawanie stykowe

C

caliper – sprawdzian szczękowy
cam – krzywka
camlock nose – końcówka wrzeciona tokarki
car transmission – napęd samochodowy
carriage – suport wzdłużny
carriage handwheel – pokrętło suportu tokarki
carriage saddle – sanie wzdłużne suportu tokarki
casting – odlew
centers – kły
centrifuge – wirówka

charcoal – węgiel drzewny
charge – wsad
chart – tabela
chip pan – wanna na wióry
chipping – dłutowanie
chisel – dłuto
chuck – uchwyt obrotowy
circuit board – płytka drukowana
clad – platerowany
clamp – zacisk
clamping device – urządzenie mocujące
clamping pliers – szczypce zaciskowe
clumps – grudki
clutch and break handle – dźwignia włączenia i wyłączenia napedu tokarki
coal gas – gaz węglowy
coalescence – oddziaływanie
coarse – zdzierak
coefficient – współczynnik
coke – koks
collet – tuleja zaciskowa
combination pliers – szczypce uniwersalne (kombinerki)
combustible – palny
concave – wklęsły
conductivity – przewodność
contoured surface – powierzchnia kształtowa
convex – wypukły
coordinates – współrzedne
core – rdzeń
countersunk hole – otwór z pogłebieniem stożkowym
cramp – zacisk, klamra
crankshaft lathe – tokarka do wałów korbowych
cross section – przekrój poprzeczny
cross slide handwheel – pokrętło suportu poprzecznego
crossed gear – przekładnia kątowa
crossing – z krzyżowymi nacięciami
cross-slide – suport poprzeczny, sanie
cut – nacięcie
cut flush – ciąć równo z powierzchnią
cutter bit – nóż do struga

D

dead center – kieł stały, poprzeczna krawędź skrawająca wiertła krętego
dead-smooth – jedwabnik
depth stop – ogranicznik głębokości wiercenia
derivation – pochodzenie
diagonal pliers – obcinaki
dial clamp nut – nakrętka dociskowa
dial-indicator – czujnik zegarowy
differential – różniczka
distortion – odkształcenie, zniekształcenie
dog – zderzak
dresser – obciągacz ściernic
drive lug – uchwyt pędny (lug – wypust)
dull – tępić

E

eccentricity – niewspółosiowość
edge – przewaga
emissivity – emisyjność
end spanner – klucz płaski
end-feed grinding – szlifowanie bezkłowe do oporu
end-milling cutter – frez walcowo-czołowy
energize – zasilić
engage – zazębiać się
engine lathe – tokarka uniwersalna
etching – trawienie
exhaust port – szczelina wylotowa

F

face – powierzchnia czołowa
face mill – frez czołowy
face plate – tarcza tokarska
facility – urządzenie
facing – toczenie czoła, planowanie
fastener – łącznik
fasteners – elementy łączące
feature – właściwość
feature – być wyposażonym w
feed handle – pokrętło do posuwu ręcznego
feed mechanism – mechanizm posuwowy
filler metal – spoiwo
fillet – zaokrąglenie
finishing – wygładzanie

fitting – dopasowywanie
fittings – osprzęt
fixture – uchwyt mocujący
flange – kołnierz
flat metal – blacha
fluid – płyn
flute – rowek
flux – topnik
fluxing –uplastycznienie
foot – stopka, nóżka (maszyny)
forming – kucie
form grinding – szlifowanie kształtowe
form tool – nóż kształtowy
free – swobodny

G

gage – mierzyć precyzyjnie, przyrząd pomiarowy
gage (gauge) – przyrząd pomiarowy
gage block – płytka wzorcowa
gear ratio – przełożenie przekładni zębatej
gear tooth caliper – suwmiarka do kół zębatych
gear train – przekładnia zębata
go-not-go gauge – sprawdzian dwugraniczny
graduation – podziałka
grind – szlifować
guard – osłona

H

half-nut lever – dźwignia pół-nakrętki
handle – trzonek (imadła)
handlewheel – pokrętło
headstock – wrzeciennik
heat capacity – pojemność cieplna
heat flux – strumień cieplny
heavy-duty – wysokowydajny, przystosowany do dużych obciążeń
heel – wierzchołek, krawędź powierzchni przyłożenia u podstawy noża
helical – śrubowy, spiralny
high grade steel – stal wysokiej jakości
hinge pin – sworzeń zawiasy
hollow shaft – wał drążony
hook spanner – klucz do nakrętek okrągłych, pazurowy
hub – piasta
hypoid – hipoidalny

I

implements – narzędzia
indentations – wycięcia
index plate – tarcza podziałowa
indexing head – podzielnica
inert gas – gaz obojętny
in-feed grinding – szlifowanie bezkłowe wgłębne
input gear – zębnik
input pinion gear – wejście zębnika
inside micrometer – mikrometr do pomiarów wewnętrznych
integral – nierozdzielny
intermediate shaft – wał pośredni
internal centerless grinding – bezkłowe szlifowanie otworów
internal grinding – szlifowanie otworów

J

jaw – szczęka; kieł (sprzęgła kłowego dwukierunkowego)
jig – przyrząd obróbkowy
jeweled bearing – łożysko kamienne (w mechanizmach precyzyjnych)

K

Kerosene – nafta
key – klucz
key spindle – klin wzdłużny wrzeciona
keyways – rowki
knee-type – wspornikowy
knife file – pilnik nożowy
knockout bar – wypychacz
knurled – radełkowany

L

ladle – kadź
lathe – tokarka
layout – układ
lead screw – śruba pociągowa
lead screw direction lever – dźwignia

sterownia kierunkiem obrotów śruby pociągowej
leveling screw – śruba poziomująca
level – niwelator
leverage – działanie, przełożenie, układ dźwigni
limestone – kamień wapienny
lip – krawędź tnąca
liquid – ciecz
long-nose jaw – szczypce z długim noskiem
lug – wypust

M

machinist – operator maszyny, ślusarz
malleable – ciągliwy, kowalny
mantle – płaszcz ochronny
mar – uszkodzić powierzchnię
margin – krawędź
marking – oznaczanie
mass flow – strumień masy
master gauge – przeciwsprawdzian
mesh – zazębiać się
metal slitting saw – frez tarczowy, frez piłkowy
micrometer caliper – mikrometr
MIG – Metal Inert Gas welding – spawanie metodą o łuku zwartym
mill – z nacięciem na krawędziach (frez)
milling machine – frezarka
monkey wrench – klucz nastawny/ rozsuwalny pojedynczy
motive – napędowy
motor and gear train cover – osłona przekladni i silnika
motor control lever – dźwignia sterownia silnikiem
mould – forma odlewnicza
mount – mocować, osadzać

N

needle-nose plies – szczypce igłowe
notched – karbowany
nozzle – dysza
nut – nakrętka

O

offset – przesunięty, wygięty
oiled paper – bibuła
oil-fluid – emulsja chłodząca (chłodziwo)
open-end wrench – klucz (maszynowy) płaski
open-hearth – piec martenowski
open-hearth method – metoda martenowska
optical comparator – komparataor porównawczy
optical flat – płytka płasko-równoległa
outline – kontur
overhang – nawis, część wystająca
overhead – nagórny

P

pedestal – podstawa, stojak
peripheral mill – powierzchnia obrotowa
periphery – krawędź, brzeg narzędzia
pertinent – odnoszący się do
petroleum – ropa naftowa
pig iron – surówka
pillar file – pilnik zegarmistrzowski (swiss pattern)
pin – sworzeń,kołek, końcowka
pin spanner – klucz sworzniowy, klucz do nakrętek okrągłych z wcięciami (na obwodzie nakrętki)
pinion gear – mniejsze koło w przekładni zębatej
pipe wrench – klucz do rur
pitch – skok śruby
pitch diameter – średnica podziałowa
pivot – czop
plain milling cutter – frez walcowy
plane – strugać
planer type – frezarka pozioma
planet wheel – koło obiegowe
plate – powierzchnia
plated – platerowany
plug gauge – sprawdzian trzpieniowy
plunger – trzpień pomiarowy
pocket – zagłębienie
point – ostrze
power feed – posuw automatyczny

power feed lever – dźwignia włączenia posuwu mechanicznego
premise – przesłanka logiczna
projection – rzut
prong – ząb,grot
protractor dial – podziałka tarczowa kątomierza
pulley – koło pasowe
pyrex glass – szkło pyreksowe

Q

quick-change gear box – przekładnia szybkozmienna
quill – tuleja
quill lock – blokada tulei
quill return spring – sprężyna powrotna tulei

R

rack – zębatka
rack and pinion – listwa zębata
ram lock – blokada tulei konika
rasp – tarnik
ratchet – mechanizm zapadkowy
rate – wartość
readout – odczyt wskazań przyrządu
reaming – rozwiercanie
recess – wybranie
reciprocating motion – ruch prostoliniowy postępowo-zwrotny
resilient – sprężynujący
respectively – odpowiednio
rest – podtrzymka
retracted – cofany
ring gear – koło koronowe przekładni obiegowej
ring gear – wieniec (koła talerzowego)
rivet – nit
rod – element przedłużający w postaci pręta, pręt
rosin – kalafonia
rotary head – głowica obiegowa
rough – zgrubny
roughing – zdzieranie
round-nose pliers – szczypce okrągłe krótkie
rule – miarka
run-out – bicie
rupture machine – maszyna wytrzymałościowa

S

saddle – sanie wzdłużne
salinity – stopień zasolenia
scale – przymiar rysunkowy, linijka z podziałką
screw – śruba
screw-thread micrometer – śruba mikrometryczna
second-cut – półgładzik
selector knob – pokrętło
serrations – ząbki
shank – trzonek narzędzia
shearing – ścinanie
shifting – zmiana, przesunięcie
SI – międzynarodowy układ jednostek miar – systeme international
side mill – frez tarczowy trzystronny
side-cutting pliers – szczypce z bocznymi nożami
silica – krzemionka
slab – płyta; walcowy
slab mill – frez walcowy
slag – żużel, szlaka
sleeve – tuleja
slide assembly – prowadnica
sliding head – głowica suwakowa
slip joint – połączenie przesuwne
slip-joint pliers – szczypce nastawne
smelt – wytapiać
snap gage/gauge – sprawdzian szczękowy
socket – gnizdo, oprawka
socket wrench – klucz nasadowy
socket-headed – z łbem gniazdowym
solder – lut
soldering – lutowanie miękkie
soldering iron – lutownica typu kolba
solely – wyłącznie
solid – lity, masywny
spanner wrench – kluch trzpieniowy, sześciokątny fajkowy
sparing – odstęp

spatial – przestrzenne
spatter – rozprysk
spindle – wrzeciono
spindle nose – końcówka wrzeciona
spline – wypust
split pulley – koło pasowe dzielone
spot welding – zgrzewanie punktowe, spawanie punktowe
spur gear – koło zębate walcowe o zębach prostych
squeegee – wycieraczka gumowa
stagecoach – dyliżans
sterling silver – srebro standardowe
stock – dyby, materiał obrabiany
storage compartment – schowek
stress – naprężenie
stub arbor – krótki trzpień
stud – śruba dwustronna
sun gear – koło słoneczne przekładni obiegowej
superimposed – nałożony
surveying – miernictwo
swing – wahać, kołysać, średnica toczenia
swivel head – głowica skrętna
swivel vice – imadło obracalne

T

tailstock – konik
tailstock lock lever – dźwignia blokująca przesuw konika
tailstock ram – tuleja konika
tang – chwyt, płetwa wiertła
taper – stożek
taper bore – otwór zbieżny
taper shank – chwyt stożkowy, stożek morsa
tapered recess – stożkowe podebranie
template – wzornik
term – składnik
thermit – termitowe
thimble – bębenek, nasadka
thread – gwint
thread and feed selector handle – rączka nastawienia prędkości posuwu
thread ring gauge – sprawdzian do gwintów
threading – gwintowanie
threading dial – wskaźnik do gwintów
three-square – trójkątny zbieżny
through-feed grinding – szlifowanie bezkłowe przelotowe
thrust load – obciążenie wzdłużne
TIG – Tungsten Inert Gas welding – spawanie elektrodą wolframową w osłonie gazu obojętnego
tilt – przechył
tilt angle – kąt nachylenia
tilted – pochylony
tip – końcówka, ostrze wkrętaka
tongue-groove pliers – szczypce przesuwne
tool head – głowica narzędziowa
tool post – imak narzędziowy
tool rest – podtrzymka narzędziowa
torch – palnik
torque-limiting wrench – klucz z ogranicznikiem momentu
train of gears – przekładnia złożona
transducer – przetwornik
traverse movement – przesuw
true the surface – precyzyjnie wyszlifować powierzchnię
turning – toczenie
turret – głowica rewolwerowa

U

unity – jedność
utilize – wykorzystywać
utilizing – wykorzystywanie

V

variable speed control – urządzenie sterujące zmianą prędkość
vernier height gauge – wysokościomierz suwmiarkowy
vernier micrometer – mikrometr z noniuszem
vernier plate – podziałka z noniuszem/ płyta noniusza
vertical center line – wertykalna linia osiowa
v-slant – w układzie v

W

warp – *wypaczenie*
way – prowadnica
weakness – osłabienie materiału
wear – ścieranie, zużywanie
web – rdzeń wiertła
wedge-shaped – klinowy
wedge-shaped screwdriver – śrubokręt klinowy
welding rod – elektroda
wheel – tarcza
wheel lathe – tokarka do zestawów kołowych
wire feeder – podawarka drutu
wire stripping – zdejmowanie izolacji z drutu
wiring – odrutowanie
work support blade – listwa prowadząca
workpiece – przedmiot obrabiany
worm gear – przekładnia ślimakowa
wrought iron – żelazo zgrzewne

Appendix

Mathematics	
$3^2 = 9$	**Raising to a power** three squared (3): the power; 3: the base; 2: the exponent (index); 9: value of the power
$\sqrt[3]{8} = 2$	**Evolution(extracting a root)** Cube-root of 8: cube root; 8: the radical; 3: the index(degree) of the root; $\sqrt{\ }$: radical sign; 2: value of the root
$\sqrt{4 = 2}$	**Square root**
$3x + 2 = 12$	**Simple equation** 3, 2: coefficients; *x*: the unknown quantity
$\frac{4}{5} + \frac{2}{7} = \frac{38}{35}$	**Fractions of different denominations** 35: common denominator
$3 + 2 = 5$	**Addition (adding)** 3and 2: the terms of the sum; +: plus sign; =: equals sign; 5: the sum
$3 - 2 = 5$	**Subtraction(subtracting)** 3: the minuend; –: minus sign; 2: the subtrahend; 1: the remainder(difference)
$3 \cdot 2 = 6$ $3 \times 2 = 6$	**Multiplication(multiplying)** 3: the multiplicand; × : multiplication sign; 2: the multiplier; 2 and 3: factors; 6: the product

$6 \div 2 = 3$	**Division(dividing)** 6: the dividend; 2: the divisor; 3: the quotient:

Mathematical symbols			
$-$ subtraction	$+$ addition	$\times$ multiplication	$\div$ division
$=$ Is equal to	$\neq$ Is not equal to	$\approx$ Is approximately equal to	$\sim$ Is equivalent to
$\equiv$ Is identical with	$\not\equiv$ Is not identical with	$\pm$ Plus or minus	$\varnothing$ Empty set
$>$ Is greater than	$\geq$ Is equal to or greater than	$<$ Is less than	$\leq$ Is equal to or less than
$\cup$ Union	$\cap$ Intersection	$\subset$ Is contained in	% Percent
$\in$ Belongs to	$\notin$ Does not belong to	$\sqrt{}$ Square root of	Σ Sum
∞ Infinity	$\int$ Integral	! factorial	

Fractions and decimals			
$^1/_2$	A half	$^1/_3$	A\one third
$^1/_4$	A quarter	$^2/_5$	Two fifths
$^1/_8$	An\one eighth	$^7/_{12}$	Seven twelfths
$^1/_{10}$	A\one tenth	$1^1/_2$	One and a half
$^1/_{16}$	A\one sixteenth	$2^3/_8$	Two and three eighths
0.1	(nought) point one	1.75	One point seven five
0.25	(nought) point two five	3.976	Three point nine seven six
0.33	(nought) point three three		

Mathematical expressions			
+	Plus	3^2	Three squared
–	Minus	5^3	Five cubed
×	Times or multiplied by	6^{10}	Six to the power of ten
÷	Divided by		
=	Equals		
%	percent		

Weights and measures

Weight		
GB/US		Metric
	1 ounce(oz)	28.35 grams (g)
16 ounces	= 1 pound (lb)	0.454 kilograms (kg)
14 pounds	= 1 stone (st)	6.356 kilograms
20 hundredweight	= 1 ton (t)	1.016 tonnes

Length		
GB/US		Metric
12 inches	= 1 foot (ft)	= 30.48 centimetres (cm)
3 feet	= 1 yard (yd)	= 0.914 metre (m)
1 760 yards	= 1 mile	= 1.609 kilometres (km)
	1 inch(in)	= 25.4 millimetres (mm)

Area		
GB		Metric
	1 square inch (sq in)	= 6.452 square centimetres
144 square inches	= 1 square foot (sq ft)	= 929.03 square centimetres
9 square feet	= 1 square yard (sq yd)	= 0.836 square metre
4840 square yards	= 1 acre	= 0.406 hectare
640 acres	= 1 square mile	= 2.59 square kilometres or 259 hectares

Capacity			
GB		US	Metric
20 fluid ounces(fl oz)		= 1 pint (pt)	= 1.201 pints = 0.568 litre(l)
2 pints	= 1 quart(qt)	= 1.201 quarts	= 1.136 litres
4 quarts	= 1 gallon(gall)	= 1.201 gallons	= 4.546 litres

Cubic measure		
GB/US		Metric
	1 cubic inch (cu in)	= 16.39 cubic centimetres (cc)
1728 cubic inches	= 1 cubic foot (cu ft)	= 0.028 cubic metre (m^3)
27 cubic feet	= 1 cubic yard	= 0.765 cubic metre

Temperature		
Conversion from	to	Formula
Celsius	Fahrenheit	°F = °C × 1.8 + 32
Fahrenheit	Celsius	°C = (°F – 32) / 1.8
Celsius	kelvin	K = °C + 273.15
kelvin	Celsius	°C = K – 273.15

Numbers

Ordinal numbers	Cardinal numbers
1 one	1st first
2 two	2nd second
3 three	3rd third
4 four	4th fourth
5 five	5th fifth
6six	6th sixth
7seven	7th seventh
8 eight	8th eighth
9 nine	9th ninth
10 ten	10th tenth
11 eleven	11th eleventh
12 twelve	12th twelfth
13 thirteen	13th thirteenth
14 fourteen	14th fourteenth
15 fifteen	15th fifteenth
16 sixteen	16th sixteenth
17 seventeen	17th seventeenth
18 eighteen	18th eighteenth
19 nineteen	19th nineteenth
20 twenty	20th twentieth
21 twenty-one	21st twenty-first
22 twenty-two	22nd twenty-second

cd. tabeli

30 thirty	30th thirtieth
40 forty	40th fortieth
50 fifty	50th fiftieth
60 sixty	60th sixtieth
70 seventy	70th seventieth
80 eighty	80th eightieth
90 ninety	90th ninetieth
100 a\one hundred	100th hundredth
101 a\one hundred and one	101st hundred and first
200 two hundred	200th two hundredth
1 000 a\one thousand	1 000th thousandth
10 000 ten thousand	10 000th ten thousandth
100 000 a\one hundred thousand	100 000th hundred thousandth
1 000 000 a\one million	1 000 000 millionth

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