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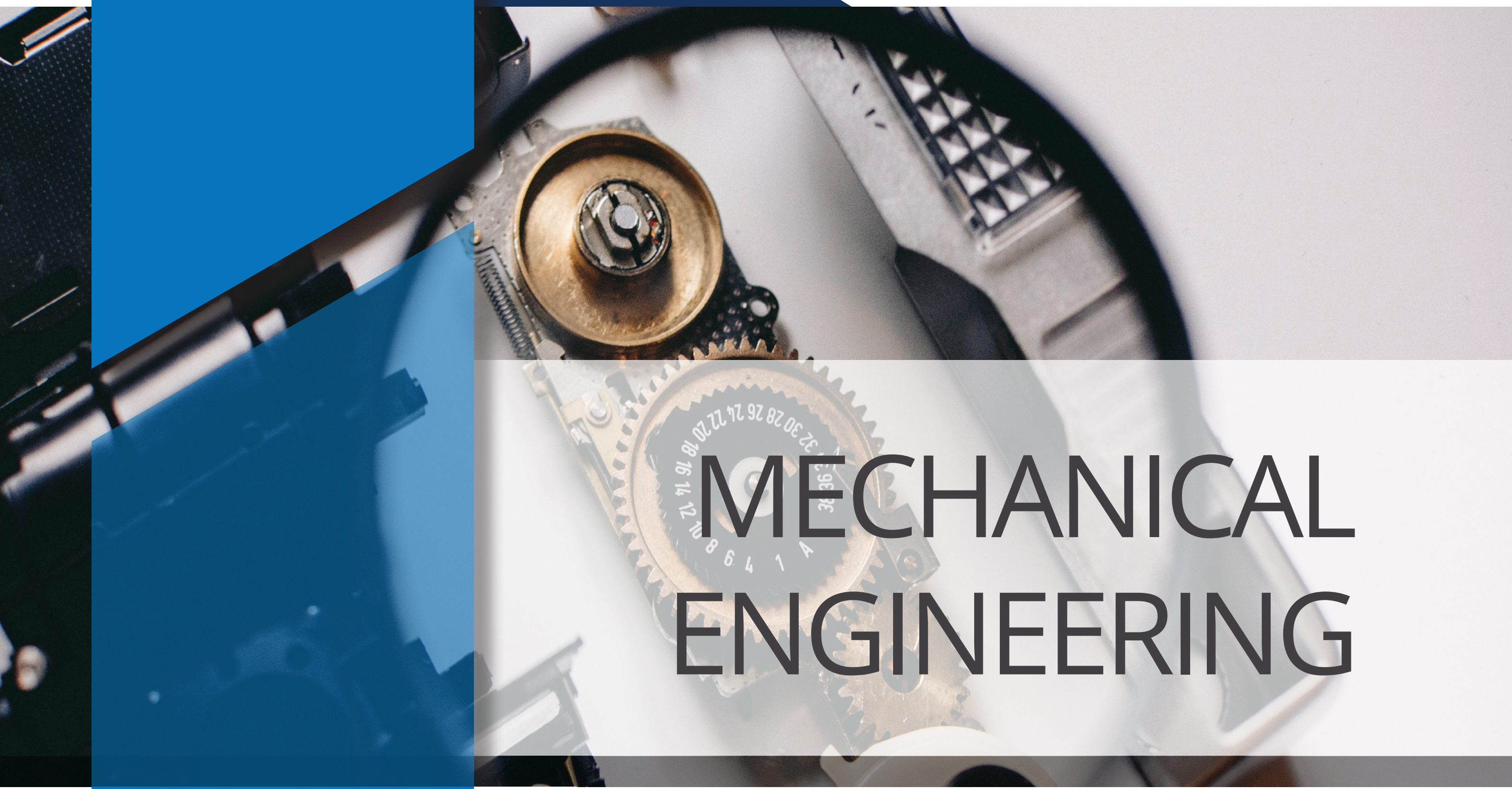

MECHANICAL ENGINEERING

Engineering technologies 1

UNIVERSITY OF APPLIED SCIENCES UPPER AUSTRIA
VŠTE
EUROPEAN UNION

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1. TECHNOLOGICAL PROCEDURES

Completing parts and assembling them into units takes place through certain activities. We call these activities a production process. The production process needs to be organized, planned, managed, implemented and controlled. The production process has three stages: preparation, implementation and control. In the production process, it is necessary to prescribe the order of each activity.

We designate individual manufacturing and assembly activities as a manufacturing process. If the work process is included in the production process during the production process, we call it a working procedure.

For the development of technological and working procedures, the technologist must have the following documents (Janáč, A. et al., 1994):

- production drawings of components, drawings of assemblies, subassemblies and whole machines,
- data on the number of machined pieces of products, including spare parts,
- data on the basic workshop funds,
- data on workshop equipment,
- data on the overall organization of workshop, operation, enterprise,
- data on the possibilities of cooperative relations with other workshops, factories, enterprises,
- Standards and norms (ISO, STN, CSN, EN, industry, enterprise) and the technical conditions of the product,
- Specific requirements of the ordering party.

The production process, as a basic rule for the production process, must meet these requirements (Janáč, A. et al., 1994):

- Determine the starting material or semi-finished product in terms of its dimensions and properties in terms of economy.
- Identify individual operations and their proper sequence.
- Determine the product's core technology.
- Identify and prescribe technical control operations prior to important technological operations and final operations.
- Identify universal, special and single-purpose machines. Single-purpose machines must be constructed and manufactured in advance.
- Identify special and communal tools and gauges.
- Identify special and dedicated products. Special preparations must be procured in advance, dedicated preparations must be constructed and manufactured in advance.
- Determine optimal technological conditions, heat treatment data, surface treatments.

- Identify and prescribe ancillary operations.
- Do not break the OSH technological and work process.
- Ensure that the production process is not inconsistent with the environmental aspect.
- Provide background for technical and economic indicators.

1.1. Requirements for the technological process

- Fulfillment of functional requirements given by specification, technical drawing and standards
- Manufacture of parts with minimal effort and minimal cost of production
- Maximize the capacity utilization of the proposed production facility
- Safeguarding work safety by the technological and work process
- Respecting ecological aspects

TD design approaches

- Preparation of the technological documentation:
- Man - Technologist without the use of PC technology
- Computer support
- PC support TD design:
- Group Technology Principle (Variant Approach)
    - Editing a technological process already in place for a component with similar features
- Exact principle (generative approach)
    - Mathematical modeling and generation of new techniques. Regardless of similarity

Depending on the type of production used, we divide the technological processes into:

- Framework (and working) technological process (small-lot and piece production) - contains only a list of operations without further division
- Detailed (and working) technological progress (serial and mass production) - contains all 12 of the items listed above. The procedure must be detailed because it is produced by workers with the lowest salary scales.

Manual approach to TD design

Use catalogs of tools, preparations, gauges, various tables, diagrams, nomograms to determine cutting conditions

Technologist processes:

- Component information
- Information on machinery and auxiliary equipment
- Information on production possibilities (technological methods, heat treatment, clamping)
- Based on the knowledge, knowledge and experience of the technology
- Techn. The procedures for a similar component can be distinguished by the order of operation used by the production equipment as well as the cutting parameters
- Small companies with a small assortment of manufactured components.

PC support TD design

Optimization of activities

- Speed up the design process
- Objective and flexible ways to respond to changing customer demands and changing manufacturing conditions
- CAPP (Computer Aided Process Planning)
- PC support for the following areas:
- Component Analysis - Analysis of the production profile
- Technical preparation of the production of production aids
- Database processing in pre-production stages
- Archiving digitized technologist. documentation
- Stop, edit, and modify texts in technology
- Calculation of Cutting Parameters

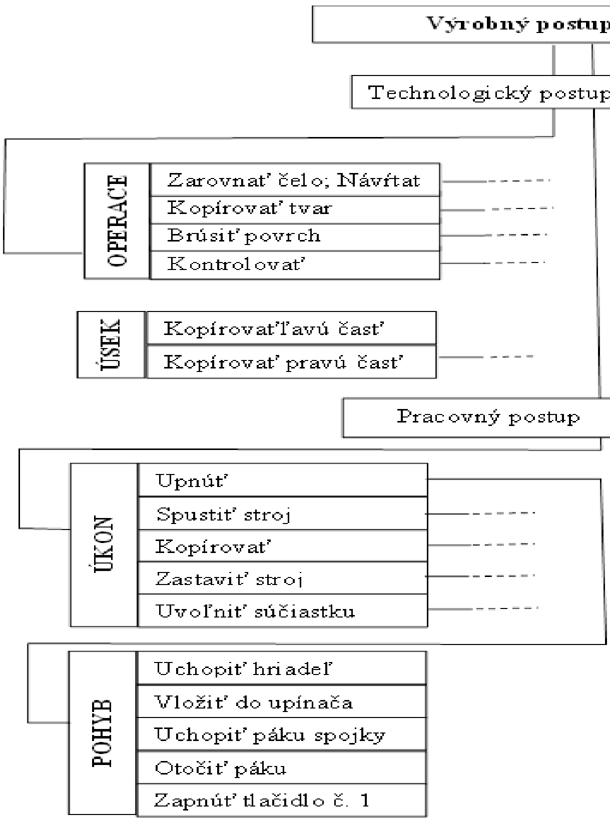
Advantages:

- Higher productivity of technologists
- Rationalization of TD design
- Greater clarity of TD
- Standardization of TD
- Objectivization of the technological process
- Optimizing TD
- Shortening running times for TD design
- Reducing boot time
- Integration with application programs and systems
- Greater flexibility to change the assortment
- Greater flexibility to change customer requirement

Economic benefits:

- Increased capacity utilization of existing machinery,
- Reduction of tools, preparations and aids
- Reducing bad products
- Reduction of workshop costs
- Reduction of labor
- Better use of material

1.2. Breakdown of the technological process



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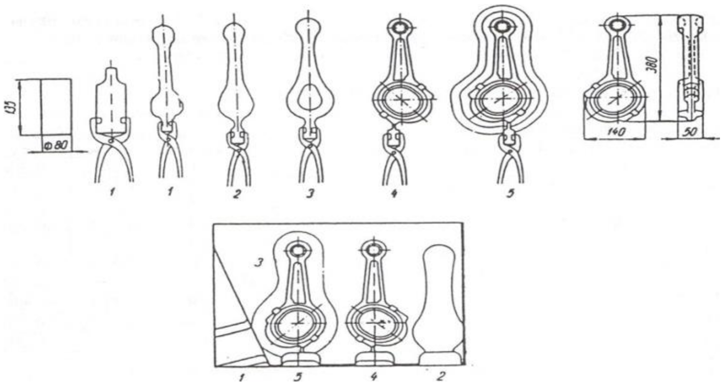
Legend: výrobný postup - production process, technologický postup - technological process
operace : zarovnať čelo, navrtat, kopírovat tvar, brúsit povrch, kontrolovat - operation: straighten the front, drill, copy the shape, grind the surface, check
úsek: kopírovat ľavú čast, kopírovať pravú časť, pracovný postup - section: copy the right part, copy the left part, workflow
úkol: upnúť, spustiť stroj, kopírovať, zastaviť stroj, uvoľnit súčiastku - task: clamp, start the machine, copy, stop the machine, release component
pohyb: uchopiť hriadeľ, vložit do upínača, uchopiť páku spojky, otočiť páku, zapnúť tlačidlo č. 1 - movement: grasp the shaft, clamp, grasp the clutch lever, turn the lever, switch the button 1
task: clamp, start the machine, copy, stop the machine, release the component

Technological processes for die forging

For the forging process, the process takes account of the economically and technically best manufacturing process. This procedure takes into account the sequence of the basic works, operations, sections, operations and movements needed to produce forgings. Further, we need to take into account further standardization and production data. These are data relating to material, semi-finished products, machines, tools, tools, tools, etc.

Picture technological process of forging buckets

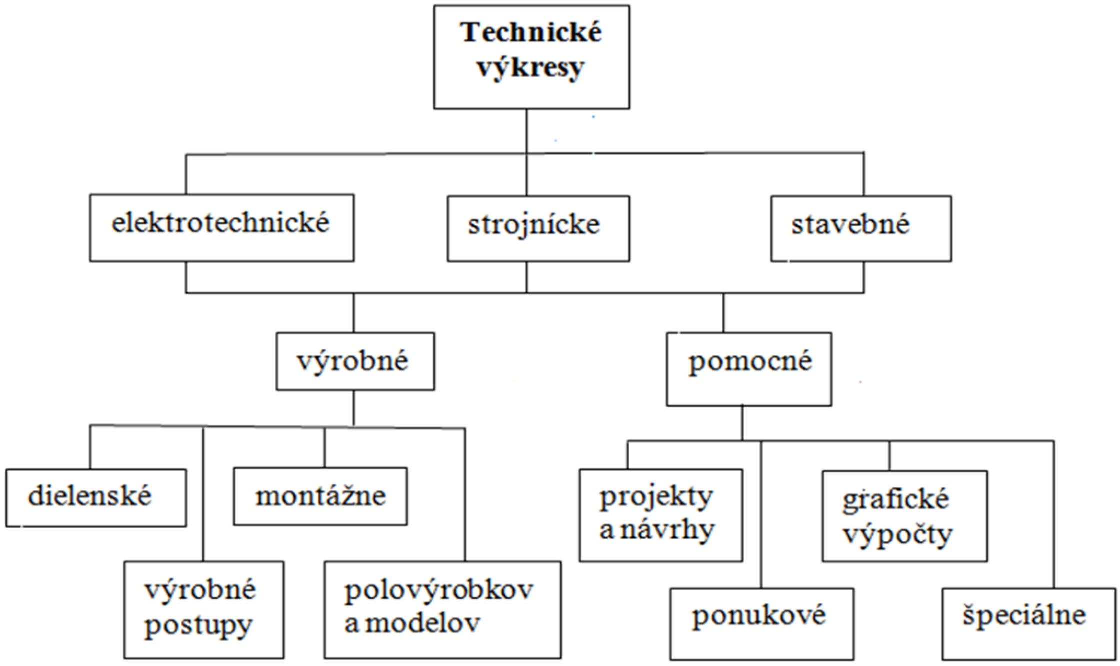


1.3. 2-Technological documentation

Technical drawing:

- Nose component of graphic documentation
- Design according to valid techn. Standards
- Applications in electrical engineering, engineering, construction

Divided technical drawings

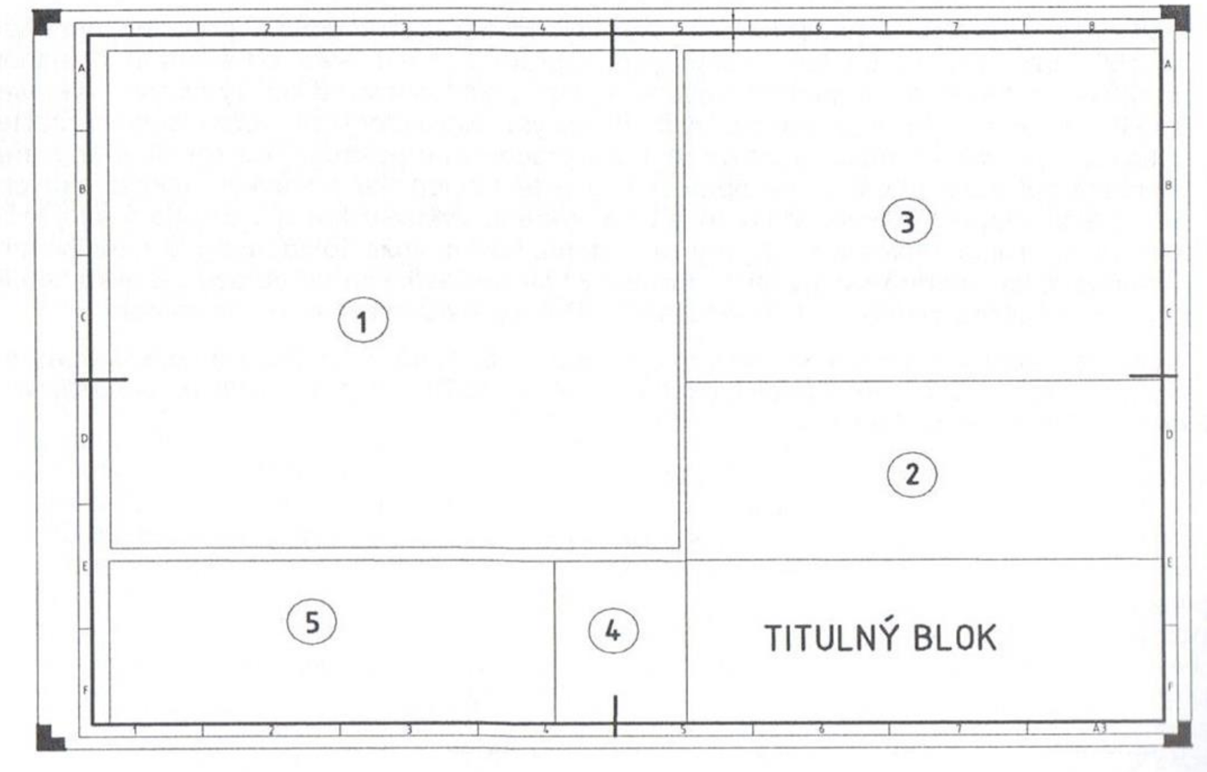


Legend: technické výkresy - technical drawings, elektrotechnické - electrical drawings, strojnícke - engineering drawings, stavebné construction drawings, výrobné production drawings, pomocné auxiliary drawings, dielenské - workshop drawings, montážne - assembly drawings, výrobné postupy production processes drawings, polovýrobkov a modelov - drawings of semi-finished products and models, projekty a návrhy - project drawings and designs, grafické výpočty - graphical calculations, ponukové - drawings at demand, špeciálne - special

Drawing formats:

Označenie formátu hlavné	Formát výkresu (orezaná kópia)	Orezaný originál (matrica, rematrica)	Výkresový list (najmenší dovolený rozmer)
A0	841 x 1189	851 x 1199	857 x 1205
A1	594 x 841	604 x 851	610 x 857
A2	420 x 594	430 x 604	436 x 610
A3	297 x 420	307 x 430	313 x 436
A4	210 x 297	220 x 307	226 x 313

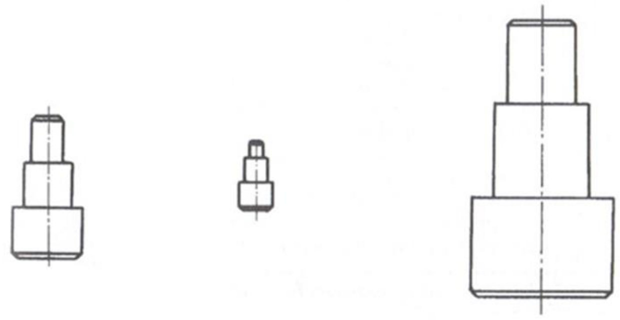
Legend: označenie formátu - format, hlavné - main, formát výkresu (orezaná kópia) - drawing format (trimmed copy), orezaný originál (matrica, rematrica) - trimmed original (matrix, rematrix), výkresový list (najmenší dovolený rozmer) - drawing sheet (the minimum allowed size)



Scale:

Determined by the ratio of the length element of the object shown in the drawing to the actual length dimension of the same element of the object

1st measure for true size - 1: 1
2. Magnification for - 2: 1
3rd reduction scale - 1: 2



a) mierka 1:1 b) mierka 1:2 c) mierka 2:1

Mierka strojníckych výkresov		
Skutočná veľkosť	Mierka zväčšenia	Mierka zmenšenia
1 : 1	2 : 1 5 : 1 10 : 1 20 : 1 50 : 1	1 : 2 1 : 200 1 : 5 1 : 500 1 : 10 1 : 1000 1 : 50 1 : 5000 1 : 100 1 : 10000

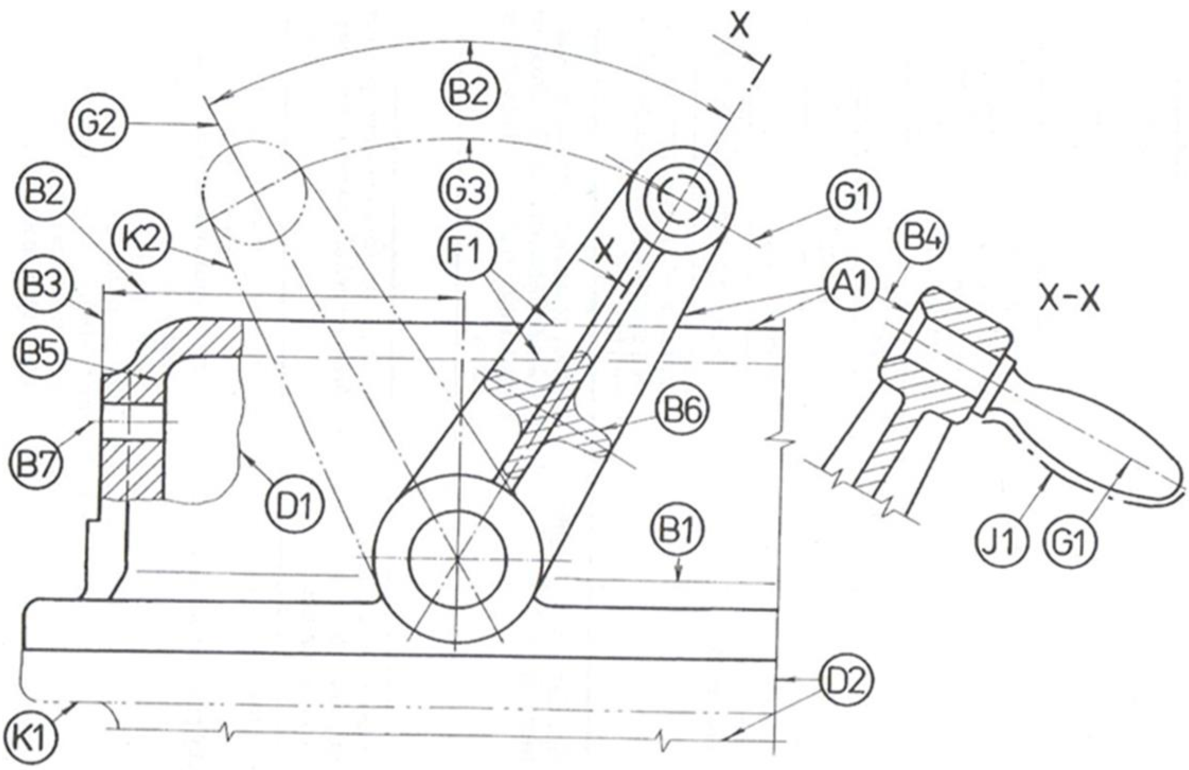
Legend: mierka - measuring scale, mierka strojnických výkresov - engineering drawings measuring scale, skutočná velkost - actual size, mierka zvačsenia - magnification rate, mierka zmenšenia - reduction rate

Types of drawings on technical drawings:

číslo	zobrazenie	popis
01.1	Súvislá tenká čiara	Používa sa na kreslenie: -pomocných kótovacích čiar, kótovacích čiar -odkazových čiar, šrafovania -ohraničenia podrobností -čiar sietí
	Súvislá tenká čiara kreslená od ruky	Používa sa na: -prednostne na ručné zobrazenie ohraničenia prerušovaných alebo čiastočných pohľadov -na zobrazenie rezov a prierezov, ak to nie je os súmernosti
	Súvislá tenká čiara so zalomením	Používa sa na: -zobrazenie ohraničenia čiastočných alebo prerušovaných pohľadov -zobrazenie rezov a prierezov, ak ohraničením nie je os súmernosti
01.2	Súvislá hrubá čiara	Používa sa na kreslenie: -viditeľné obrysy a hrany, -čiar chrbtov závitov s plnou hrúbkou profilu -zobrazenie grafov, diagramov -zobrazenia osových dĺžok priečkovej konštrukcie
02.1	Čiarkovaná tenká čiara	Používa sa na: -zakrytie hrán a obrysov
02.2	Čiarkovaná hrubá čiara	Používa sa na: -označenie úpravy povrchu
04.1	Čiara tenká s dlhou čiarou a bodkou	Používa sa na: -osi, čiary na označenie súmernosti -rozstupová čiara ozubení -rozstupová čiara dier
04.2	Čiara hrubá s dlhou čiarou a bodkou	Používa sa na: -označenie rovín rezu -deliacich rovín v obrazoch rezov
05.1	Tenká čiara s dlhou čiarkou a dvoma bodkami	Používa sa na kreslenie: -označenie susediacich súčiastok -ťažiskové osi -posunuté tolerančné pole

Number	Line	Description
01.1	Continuous thin line	Used for drawing: - auxiliary dimensioning lines, dimensioning lines - hatching - details borders - network lines
	Continuous hand-made line	Manually display a border of broken or partial views To display cross-sections and cross-sections if it is not an axis of symmetry
	Continuous thin line with wrap	Manually display a border of broken or partial views To display cross-sections and cross-sections if it is not an axis of symmetry
01.2	Continuous thick line	Visible outlines and edges Thread back line with full profile thickness graphs, diagrams axial lengths of crossbar construction
02.1	Dashed thin line	Cover edges and outlines
02.2	Dashed thick line	Marking surface treatment
04.1	Thin line with long line and dot	Axes, lines to mark symmetry Spacing of gearing Spacing of hole
04.2	Thick line with long line and dot	Marking section levels Partition in section
05.1	Thin line with long dash and two dots	Designation of adjacent components Centre of gravity Sifted tolerance field

Practical examples of use:



Základné typy čiar	Hrúbka čiary	Používanie a označenie čiary
01 súvislá	hrubá	viditeľné obrysy a hrany A1
	tenká	neurčené hrany B1, pomocné a kótovacie čiary B2 až B4, vyznačenie materiálu súčiastky v reze B5, obrysy vykreslených prierezov B6, krátka os B7
01 súvislá od ruky	tenká	prerušenie obrazu D1
01 súvislá zo zalomením	tenká	prerušenie obrazu D2
02 čiarkovaná	tenká/hrubá	zakryté obrazy a hrany F1
04, 08, 10 čiara s dlhou čiarkou a bodkou	hrubá	vyznačenie vynášaných častí alebo plôch J1
	tenká	os rotácie G1, os súmernosti a stopy rovín súmernosti G2, trajektórie G3 a stopy rovín rezov
05, 09, 12 čiara s dlhou čiarkou a dvoma bodkami	tenká	obrysy susedných predmetov K1, krajné polohy pohyblivých častí K2, ťažnice, východzie alebo konečné obrysy

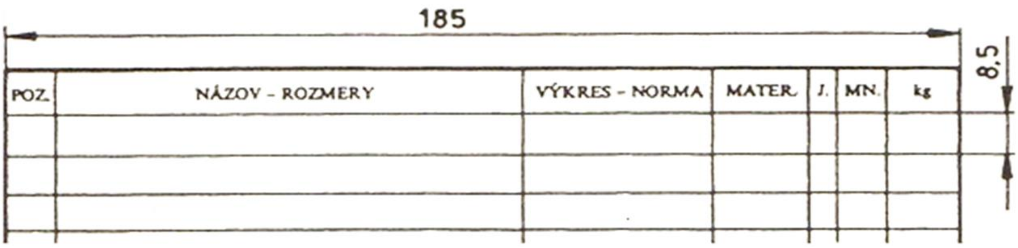
Basic types of lines	Line thick-ness	use
01 continuous	Thick Thin	Visible outlines and edges A1 Undetermined edges B1, auxiliary and dimensional lines B2 – B4, material of component in section B5, outlines of sections B6, short axis B7
01 continuous, hand-made	Thin	Image interruption D1
01 continuous with wrap	Thin	Image interruption D2
02 dashed	Thin/thick	Covered images and edges F1
04, 08, 10 line with long dash and dot	Thick Thin	Marking areas J1 Rotation axis G1, symmetry axis G2, trajectory G3, section planes
05, 09, 12 line with long line and two dots	thin	Outlines of adjacent object K1, positions of movable parts K2, medians, starting or resulting outlines

Production drawing requirements

- Production as small as possible
- Arrangement - main assembly, assemblies, subassemblies, component drawings
- Title block (description field)
- Item List (BOM)

Title block:

Legend: pol.- item, názov - name, čap - pin, č. výkresu - number of drawing, č. normy - standard, materiál - material, množ. - quantity, hmotn. - mass, vypracoval - prepared, kontroloval - checked by, datum vyhotovenia - date of preparation, rozmer, polotovar, norma - dimension, semi-finished product, standard, hodnotenie stavu povrchu - evaluation of surface, všeob. tolerance - general tolerance, metóda zobrazovania - display method, mierka - measuring scale, zmena - change, dátum - date, podpis - signature



Item list:

Legend: pozn. - note, názov - rozmery - name / dimensions, výkres - norma - drawing / standard, materl - material, mn. - quatity

Component Drawings:

- A separate drawing for each component
- Appropriate display and shape of the component
- Copying parts
- Roughness and surface treatment
- Heat treatment
- Tolerance of dimensions and geometric shapes
- Technical requirements in the description field
- Table of data for gears
- Description field including the dimensions of the blank, material type, data for inspection, production and material testing

Drawings of semi-finished products:

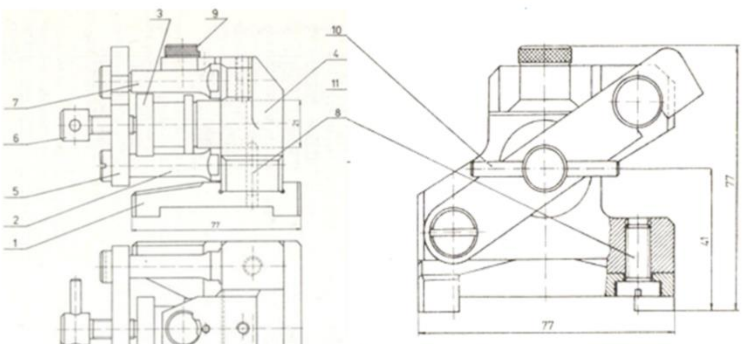
- Kind of material
- Properties and quality of the material
- The initial state of the material - in the form of a semi-finished product
- The number of the relevant standard

Casting drawings:

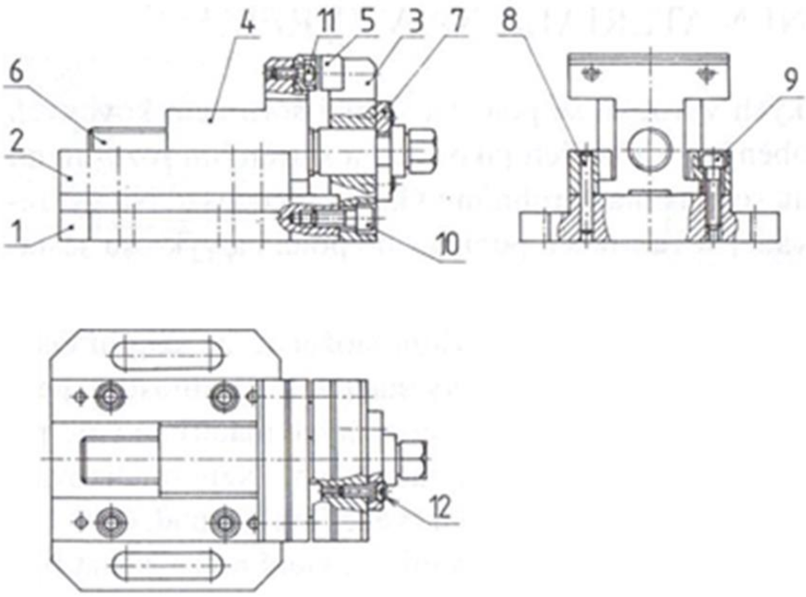
- Data for drawing a model drawing plot and for working in a model room and a lavatory
- Technological accuracy when casting
- Properly designed material
- Simple dimensional control and simple machinability
- Required degree of accuracy (above the field of description)
- Design and technology rounding
- Connecting walls, holes in castings

Drawing drawings:

- View assembly assembly in assembled state
- Dimensioning of the main dimensions
- Position of the assembly unit components
- Data on bonded, soldered and other joints



12							
11	SKRUTKA M8x16	STN 02 1131			11 500		0,28
10	PÁKA ø 5x45	16-16-06					
9	VŔTACIE PÚZDRO	STN 02 2150					
8	KOLÍK 5x25	26-15-13			11 600		0,09
7	SKRUTKA M 10x65	28-33-14					
6	POHYBOVÁ SKRUTKA	12-26-06					
5	DOSKA 95x15	16-05-04					
4	TEKESO	11-22-07					
3	VRETENO	17-20-40					
2	SKRUTKA M 10X8	13-12-15					
1	ZÁKL. PLATŇA PLECH10	11-17-04				1	
Poz	NÁZOV-ROZMER	Č.VÝK-Č.NOR	MATER	[illegible]	MATER	MN	HMOT
Popisové pole							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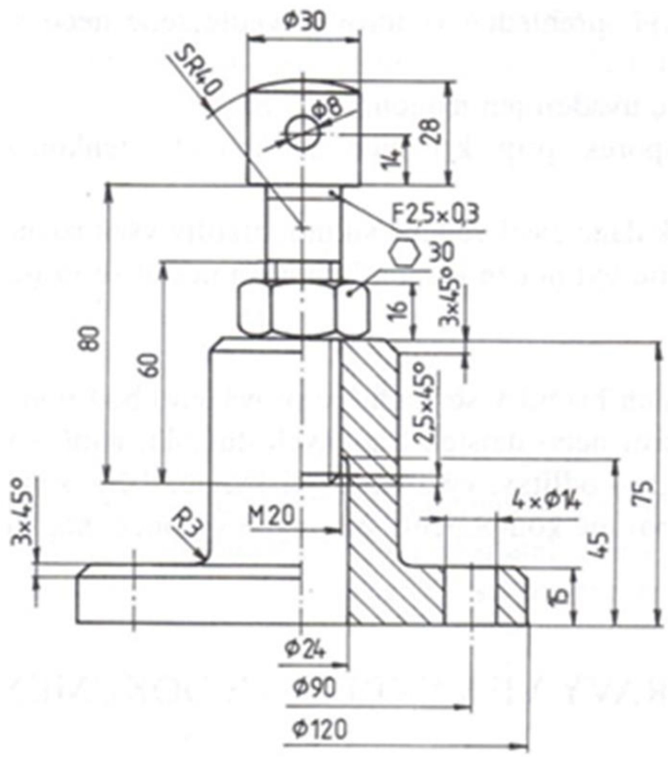

Ø30
SR40
Ø8
28
14
F2,5×0,3
30
80
60
16
3×45°
2,5×45°
75
4×Ø14
M20
R3
3×45°
45
15
Ø24
Ø90
Ø120

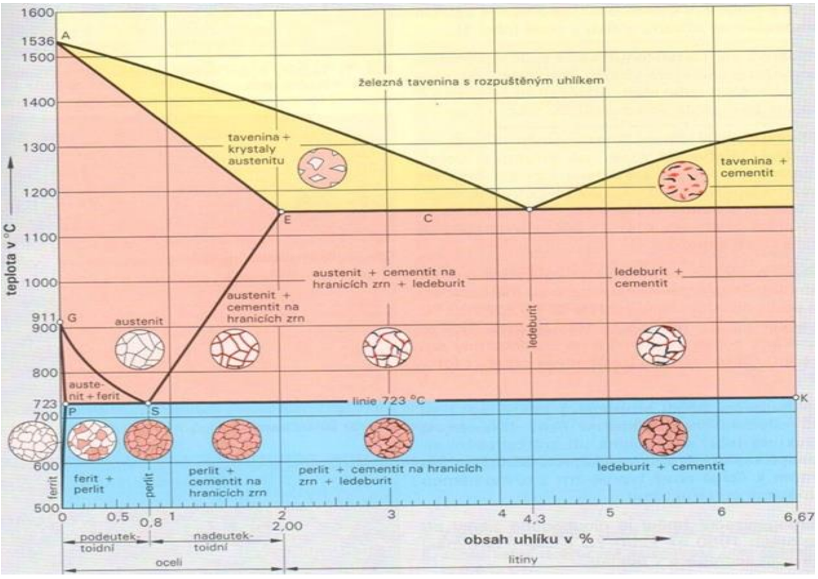
2. HEAT TREATMENT

The technological processes of heat treatment of metals used in technical practice can be divided into four basic groups

- Procedures in which we get a more balanced structure compared to the baseline. They are used with different concrete targets for all metallic materials. These procedures are referred to by the general annealing name.
- The processes in which we create structures of a degree of imbalance. For steel, such processes are hardening and tempering. In aluminum castings (or other non-ferrous alloys) a process known as curing is used.
- Procedures in which, in addition to structural changes, the chemical composition of the surface layers of the material, i.e. the chemical-heat treatment, changes.
- Procedures in which the desired change in properties is achieved by a combination of intensive molding and heat treatment, i.e. thermomechanical processing.

(Skočovský, P. et al., 2006)

Diagram of iron alloys with carbon and structural regions of materials with different C content



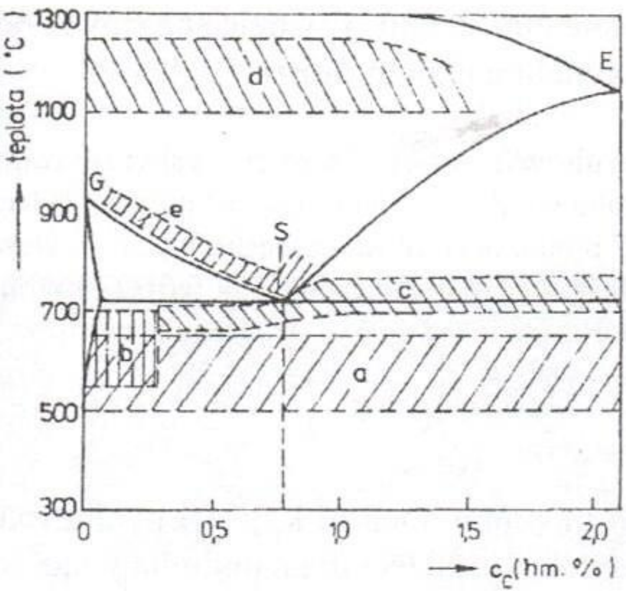
2.1. Annealing

Annealing is a method of heat treatment. In this way, we want the component to achieve a steady state. The principle of annealing is the uniform heating of the component to the annealing temperature, the stamina at that temperature for a certain period of time and, consequently, the slow cooling is generally followed.

Overview of steel annealing processes

	Way Annealing	Annealing temperature [°C]	Mark the first additional digit after the steel mark
Without recrystallization	-softboiled -recrystallisation -prote flake - For removal Fragility - For removal Internal stresses	680 – 720°C 550 - 700°C 650 – 700°C 200 – 300°C 500 – 650°C	1X XXX.3 - - - -
With recrystallization	-normalization -homogenizing -isothermic	750 – 900°C 1000 – 1200°C 600 – 750°C	1X XXX.1 - -

Areas of annealing temperatures in the equilibrium diagram

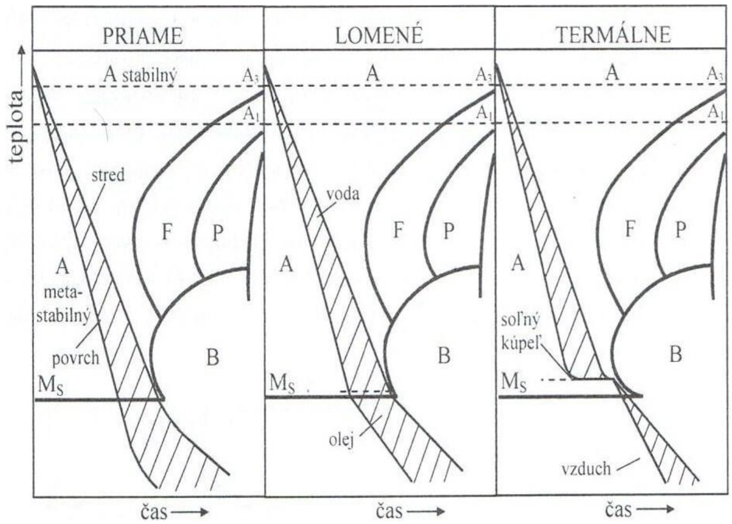


2.2. Hardening and tempering

Fertility is the ability of steel to achieve higher hardness. Tempering is the heating of the steel to the recrystallization temperature, the stamina at that temperature and subsequent cooling at a higher rate, such as the lower critical cooling rate. The most moderate and economically most conducive environment is air.

The aim of quenching is to achieve a different state such as the equilibrium state.

Types of hardening



Legend: priame - direct, lomené - angled, termálne - thermal, teplota - temperature, čas - time,stabilný - stabile, stred - centre, povrch - surface, olej - oil, solný kupel - saline bath, vzduch - air

- Direct quenching - we cool off the temperature of Austenitisation. In carbon steel, it is usually water, with small parts in steel.

- Angled hardening - Austenitic components that are normally soaked in water are cooled in two environments.

- Thermal quenching - the component is cooled at a greater speed than critical in an environment with a temperature above the Ms of the respective steel, where it remains for the time required to equalize temperatures throughout the cross section.

- The tempering is the heating of turbid steel with a martensitic structure at temperatures A1 in order to create structures closer to the equilibrium. From a technological point of view, we distribute tempering tempering at low temperatures (up to 300 ° C) and at high temperatures (above 400 ° C).

2.3. Chemical-heat treatment

The techniques of diffusion saturation of the surface of the components by some elements include chemical-heat treatment. The objective of chemical-heat treatment is to induce changes in the mechanical, chemical and physical properties of the elements. We understand these processes by diffusion saturation of the steel surface by various elements such as Al, B, C, N, C + N, Si and others. They are both metals and non-metals.

Depending on when we invoke the desired properties, we divide the processing methods into:

- Nitriding (during diffusion layer formation),
- Cementing, nitrocementing (after heat treatment of the saturated surface).

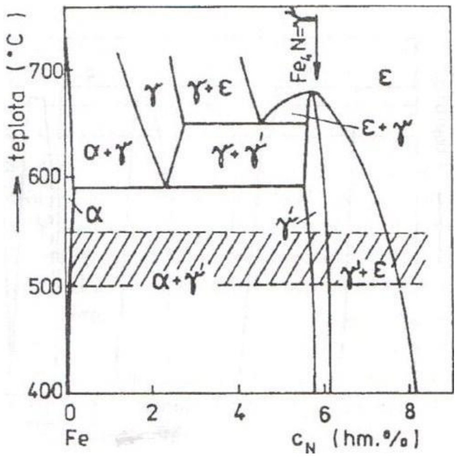
2.4. Cementing

Surface of carbon, low alloy and alloyed steels with low carbon content (up to 0, 25% C) with a carbon network for eutectic or, respectively, Nadeutectoid concentration 0.8-1% wt. Carbon).

After cementation, the parts must be dusted. We use several ways of quenching:

- Direct hardening of the curing temperature,
- Direct quenching with subcooling - after cementation, the batch in the furnace is cooled to 840-850 ° C) and becomes turbid from this temperature,
- Simple tempering after heating - the cooling of the component is used to room temperature, then the new heating to the temperature between AC1 and AC3 (840 - 850 ° C), the core of the component will melt and the structure will form ferrite and martensite,
- Double quenching after heating - the first hardening of the austenitizing core temperature (above AC3 - 880 - 900 ° C) and the second quench from the hardening temperature of the layer (above AC1 - 780 - 820 ° C).

2.5. Nitriding



Basic idea of structure of nitriding
Can be obtained from the equilibrium Fe-N diagram

Nitrite in a gaseous or liquid environment.

In the gaseous environment, ammonia is the source of nitrogen. This decomposes in contact with the surface of the component. We can formulate the equation:

$2NH_3 \rightarrow 2N + 3H_2$

Nitriding usually takes 12 to 60 hours. The rate of nitriding increases with increasing temperature.

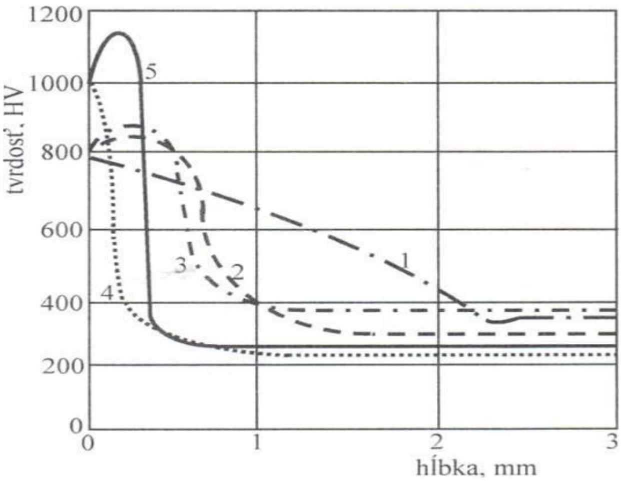
A liquid environment is created by a nitrided salt bath. This bath consists of a mixture of sodium cyanide (NaCN) and potassium cyanate (KCNO). In the salt bath, the nitriding time is shorter than in the gas (0.5-4).

Other methods of chemical-thermal processing

- Nitro-cementation - surface saturation with carbon and nitrogen at temperatures around AC3,
- Carbonitriding - surface saturation with carbon and nitrogen at temperatures around 650-750 ° C,
- Sulphonitriding - surface saturation with sulfur and nitrogen in a gaseous or liquid medium (elephant bath - 95% sodium cyanide and 5% sodium sulphite)
- Sulfonating - saturation of the surface of the components by sulfur. It is a process similar to sulfonitriding,
- Diffusion plating - chromium (diffusion chromium), silicon, aluminum (alloying, alumination) - corrosion resistant and corrosion, boron increases the hardness of the surface layer and resistance to wear.

The course of hardness in different layers

1-surface hardening, 2-cementation, 3-nitro-cementing, 4-carbo-nitriding, 5-nitriding

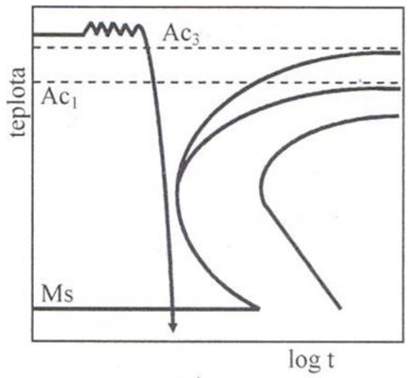


Legend: tvrdosť - hardness, hlbka – depth

2.6. Thermal-mechanical management

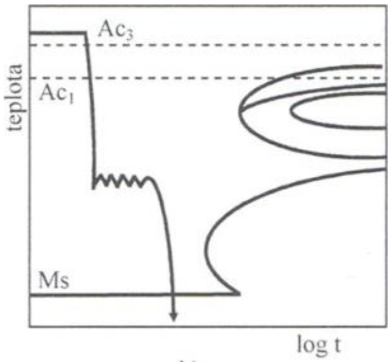
The methods of thermo-mechanical treatment are most often divided according to the molding temperature:

Low temperature thermomechanical processing



a)

High temperature thermomechanical processing



b)

Other methods of thermo-mechanical processing

- **Isoforming** - rapid cooling from the austenitic temperature to the perlite area,
- **Dynamic deformation aging of martensite** - deformation follows hardening, applied at temperature (150-200 ° C).

3. TECHNOLOGICAL PROCEDURES WITH COMPUTER SUPPORT

The constant pressure of competition forces designers and technology to work on new solutions and tackle new challenges. Cutting down production times, improving quality, changing the production program quickly, and other necessary changes are just some of the issues that need to be addressed. The starting point for dealing with complex situations that are very common in practice is the use of integrated computer production

CAD Systems (Computer Aided Design) are program tools designed to be used in the initial stages of the manufacturing process, in the development, construction and technological preparation of production. The CAD area is just one part of the deployment of computing technology in the industry. In summary, this deployment is marked with CA technology.

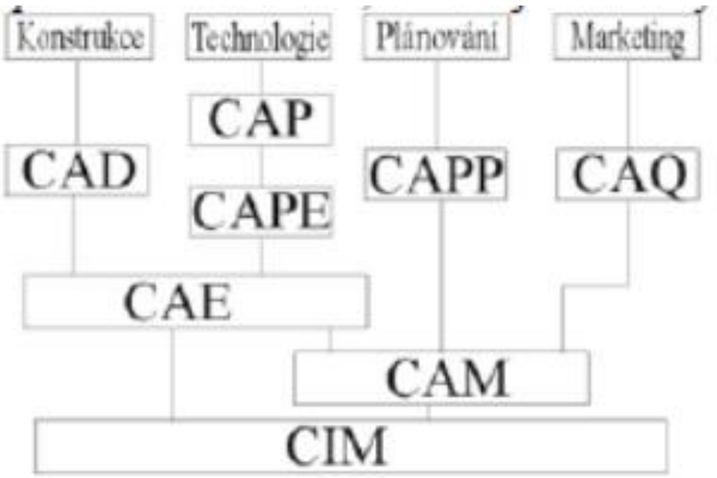
CAx stands for Computer Aided. CAx technology means the use of computing technology (technical and software) to promote the creative approach

Users (designers, technologists, calculators, and other professions) to solve tasks related to the production process.

CAx technologies can be divided into the following areas:

- CIM – Computer Intergarted Manufacturing
- CAM – Computer Aided manufacturing
- CAE – Computer Aided Engineering
- CAD – Computer Aided Design
- CAPE – Computer Aided Production Engineering
- CAP – Computer Aided Programming
- CAPP – Computer Aided Process Planning
- CAQ – Computer Aided Quality
- CMR - Customer Management Relationship - Customer Relationship Management System
- PDM - Product Data Management - product data management
- PLM - Product Lifecycle Management - product lifecycle management - an information platform that includes technical, product and marketing data on the product. The manufacturing company needs a production management system, a vendor management system, a customer relationship management system, a quality management system, and a system for engineering and innovation. PLM unifies these systems and creates a consolidated set of product information.

3.1. Relationship between different areas of CA technologies



Obr.1 Zařazeni CAD do oblasti CA technologii

CAD Abbreviation - Computer Design Support, includes all program tools designed for the design process. This means that it is designed and optimized for the design solution.

The CAD area itself can be further subdivided into areas such as:

- CADD - Computer Aided Design and Drawing
- CAPD - Computer Aided Pipe Design
- FEM - Finite Element Method (in this case, the abbreviation CAE - Computer Aided Engineering
- GIS - Geographic Information System
- Computer Aided Manufacturing

All CAD systems are tools. That is why they need to be accessed as well. The knowledge of any CAD system in no way assures that a system engineer will be a good designer. Implementation of CAD technology has brought a qualitative shift in design methodology. CAD systems have gone through several development stages

All stages were driven by the development of computing:

- mainframe computers allowed to create two-dimensional drawing documentation
- workstations have been able to draw three-dimensional objects on the vector screen whose shapes have been entered with the coordinates of the keyboard
- the possibility of creating drawing documentation was made accessible by the PC
- improvement of PC performance was made possible by three-dimensional modeling,

transfer of models into drawing documentation
- visualization and animation, internet connection

Designing processes make full use of CAD systems, providing the following benefits:

- easy collaboration amongst the stakeholders
- easy creation of a large number of variants and design modifications
- using optimization methods
- a perfect information system

Activities to be carried out by the design in the design process:

- assignment of technical task and processing of technical conditions
- preliminary calculations with the design of the project
- normalization and technical and economic assessment of the proposal
- making assembly drawings and production drawings, wiring diagrams
- making bills, control assemblies, and assembly drawings
- participation in the production of the prototype or directly at the start of production, repair of the drawing documentation
- proposals for external orders, materials for packing and transport of the product
- instructions for use and use of the product, creation of leaflets

The design process can be divided into the following steps:

- examining the request
- definition of the problem
- synthesis
- analysis and optimization
- evaluation
- implementation of the project

CAD modules can be divided into four categories:

- geometric modeling
- engineering analysis
- design assessment
- drawing up and drawing up the drawings

CAD systems can be divided into four categories:

- lower
- medium
- higher

- large

The following criteria are used to determine which category falls into:

- drawing and modeling tools available
- purchase price
- product support and reseller support

CAD systems such as AutoCAD LT, TurboCAD Delux can be included with CAD systems of lower class CAD systems. These are systems that support the creation of two-dimensional objects (models) and enable the drawing documentation to be generated. Some systems provide the possibility of creating a simple three-dimensional construction using a wire modeller.

CAD systems of the middle class can be represented by AutoCAD, Microstation, TurboCAD Professional, KeyCreator (CADKEY). All of these systems include three-dimensional modeling tools, including visualization tools. They are suitable both for drawing drawing documentation and for creating the documentation for the marketing department as a three-dimensional representation of the finished product. The advantage of these systems is their openness, making it possible to create special programs - superstructures, according to the requirements of the designers.

Large CAD systems are fully three-dimensional systems that require the creation of a three-dimensional model for drawing documentation. The model then creates assemblies or drawing documentation. One of the advantages of higher-end CAD systems is that they have parametric modellers. For users this means that the drawing model is always connected, and any changes made in any part will be reflected in both the drawing and the model. Also, these systems are open and allow the creation of superstructures according to user requirements.

3.2. Interface between computer and human

- DOS - text mode
- MS Windows - Graphical working environment
- Virtual reality - superstructure over the operating system
- Virtual Reality (VR) is the latest step in the development of a human-to-computer communication interface.

The development of the communication interface has taken place around the following stages:

- 1st punch tape and print output - past
- 2. Keyboard and Monitor - Present. For the comprehensible communication, a graphical communication environment was created - GUI - Graphics User Interface (icon menu, distribution of GUI into any number of panels - windows)
- 3. Virtual reality - a near future

The CoR can cover the following areas of human activity:

- modeling
- communication
- driving
- fun

Three levels of VR are currently distinguished:

- passive
- active
- interactive

Passive VR - is characterized by the fact that we can observe, listen, feel, but it is not possible to control the movements.

Active VR - Provides the ability to explore the environment, the possibility of moving in a virtual environment (flying, walking, swimming ...). At this stage, walks are done through buildings or through the viewing of virtual artworks.

Interactive VR - Allows you to familiarize yourself with the environment, explore it and change it according to our ideas (grab a book and scroll through it).

We perceive the virtual world in three ways:

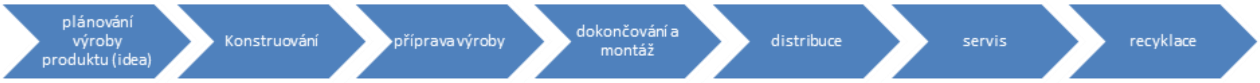
- vision
- 2nd hearing
- 3rd Hmat

Vision - The VR system respects basic imaging patterns, ie perspective and illumination (imaging was the first method of entering the VR).´

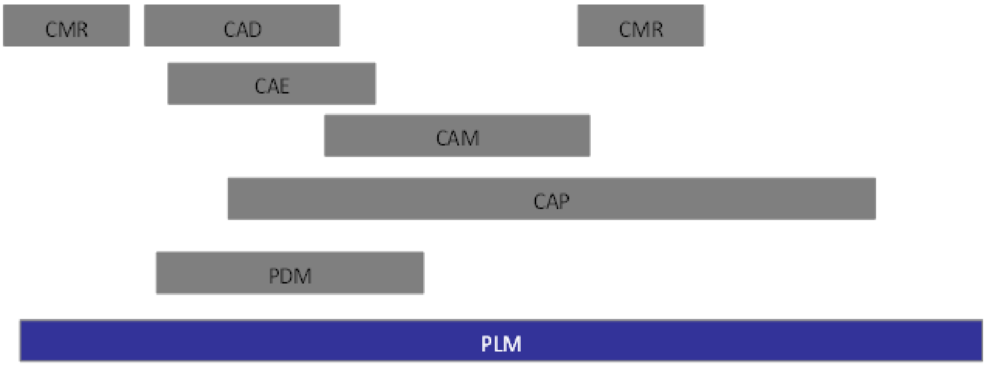
Hearing - sound perceptions help to understand VR - today is the usual "surround"

Touch - a very important opportunity to understand the facts in the CoR.

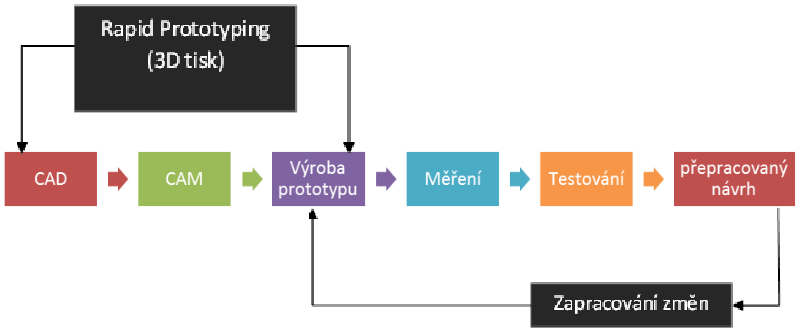
Manufacturing company management process using PLM and CAD / CAM integration:



Legend: plánování výroby produktu - planning manufacturing of product, konstruování - construction, příprava výroby - production preparation, dokončování a montáž - finishing and assembly, distribuce - distribution, servis - service, recyklace – recyclation

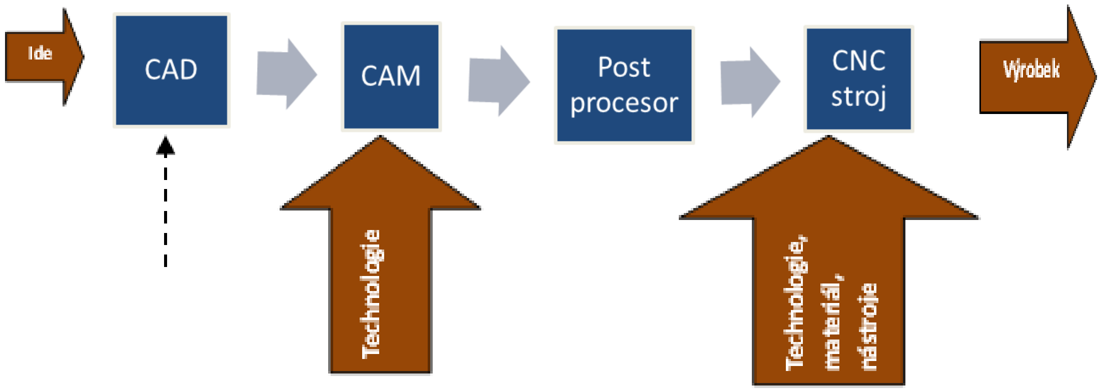


Product development process using CAD / CAM:



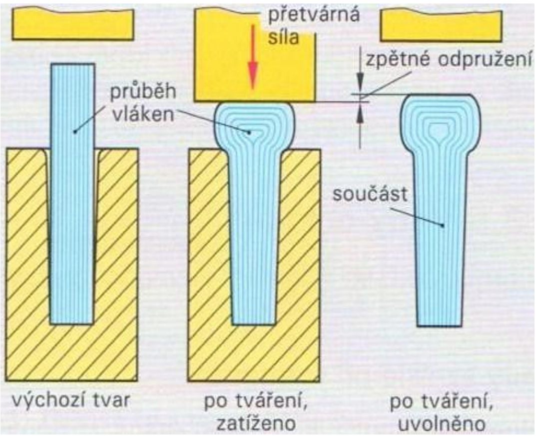
Legend: výroba prototypu - prototype manufacturing, měření - measuring, testování - testing, přepracovaný návrh - changed design, zapracování změn - including changes
Legend: post procesor - post processor, CNC stroj - NC machine, výrobek -product, technologie - technology, materiál - material, nástroje - tools

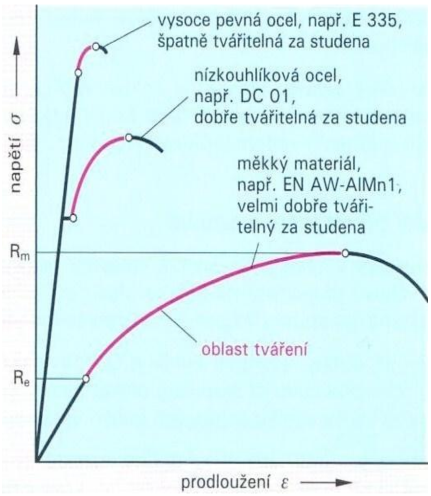
Process of production of components using CAD / CAM systems:



4. COLD FORMING

Forming is a part of engineering technology where we change properties, dimensions and shape by external forces. The shape change occurs by the transfer of the metal particles based on plasticity. It is the most important property of metals and strength and flexibility. The structure of the material remains preserved and improves the strength.





Legend: průběh vláken - course of fibres, výchozí tvar - initial shape, přetvárná síla - forming force, zpětné odpružení - backward suspension, součást - component, po tváření zatíženo - loaded after forming, po tváření uvolněno - released after forming
Legend: napětí - stress, prodloužení - extension, vysoce pevná ocel, např. E335, špatně tvářitelná za studena - high strength steel, e.g. E335, not suitable for cold forming, nízkouhlíková ocel, např. DC 01, dobře tvářitelná za studena - low carbon steel, e.g. DC 01, suitable for cold forming, měkký materiál, apř. EN AW AlMn1, velmi dobře tvářitelný za studena - soft material, e.g. EN AW alMn1, suitable for cold forming, oblast tváření - forming area

We can divide the processes by:

- Temperature
- Cold forming (the process takes place at a temperature lower than T≤ 0, 3T1)
  - T - block temperature in K
  - T1 - the melting point of the metal in K
- Hot forming (the process takes place at temperatures at which the recrystallization proceeds in the molding process so quickly that the reinforcement obtained by the deformation is traversed during the molding process (temperatures are higher than T ≤ 0.7 T1))
- Thermal effect - the molding temperature is not fully utilized, the block process proceeds with the efficiency ε = A_d / E,
- Adformation work used for the deformation process
- E - energy of the machine at the beginning of molding.

We can divide the processes into:

- Isothermal - the developed heat is drawn to the surroundings, the metal temperature is constant, the metal deformation is reversible or irreversible
- Adiabatic - developed heat remains in the metal, consumed to increase temperature
- The polytropic-extruded heat is partially discharged into the environment, part remains in the metal, recrystallization does not occur because the rate of deformation process is higher than the rate of recrystallization.
- Degree of deformation reached - the highest degree of deformation determines the magnitude of the change in shape and dimensions of the molded product.

Laws of molding

- The law of constantity (volume constant)
- The law of residual and supplementary stresses
- The law of the least resistance
- The law of constant (constant) potential energy of shape change
- The law of similarity
- Law of non-compliances of elastic stresses (deformations)
- The law of consolidation
- Law frightened

4.1. Cold forming

Cold forming is the technological processing of the material. During this processing the temperature is below the recrystallization temperature. The recrystallization temperature Tr is different and depends on the material and is therefore generally referred to as the melting point Tt. For most metals, the relationship applies:

Tr=0,4 Tt [K]

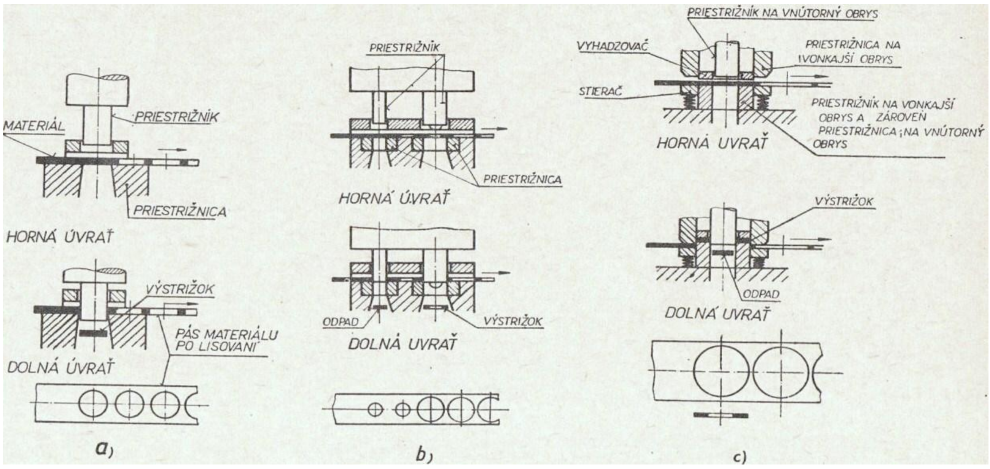
Pressing technique according to ČSN 226201 means the processing of metal and other semi-products and materials by cutting or shaping. We can use both ways to make a piece or semi-product of the required size and shape. In the pressing technology we talk about the following basic parks:

- Cutting material - gradual or simultaneous separation of the material by cutting tools
- Shaping (material displacement) - Mechanical processing by moving its part by pulling and pressing

We divide the crimping tools by one stroke as follows:

- Simple - one working stroke per operation (figure 6 13a),
- Progressive - two or more tasks - carried out one tool in a row (Figure 6 13b),
- Associated - tools that associate or combine simple or progressive tools by performing several operations of various kinds (Figure 6 13c, such as bending and punching)

Pressing tools



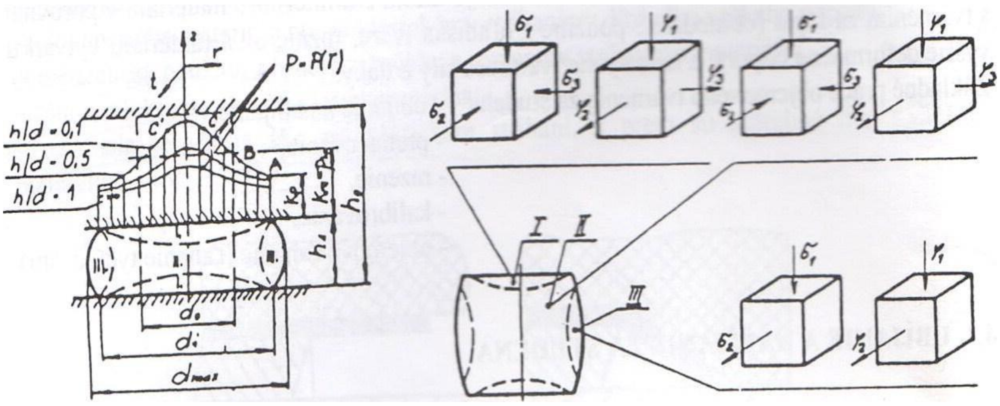
A-simple, b-progressive, c-associated

- Cold forming is the process of forming the blank, which is prepared by cutting or cutting from the rod material.
- The process is carried out under the temperature of recrystallization of the molded
- material.
- Deformation reinforcement of the material is a concomitant feature of cold volume
- molding.
- It is the result of increasing the hardness and strength of the material.

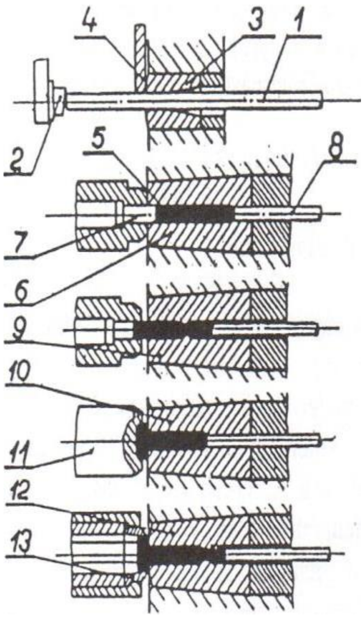
4.2. Catching and charging with cold

- **Collapsing** - The material is compacted by shifting so that the cross section of the workpiece increases to the length or height.
- **Charging** is basically the process of sinking. It creates a process of cross-section enlargement either at the end or at another cross-sectional point.
- **Friction** on the contact surfaces is also the cause of the uneven distribution of molding pressure on these surfaces and the formation of so-called barrel-like shape in free-flowing

Scheme of stress and strain during pressure drop and distribution on contact surfaces



Schematic of the operating cycle of the four operating procedures



1-wire,
2-stop,
3,4-trimming table,
5-semi-finished product,
6, 9, 10, 12 dies,
7-punch,
11-head hunter,
13-trimmer

4.3. Rolling

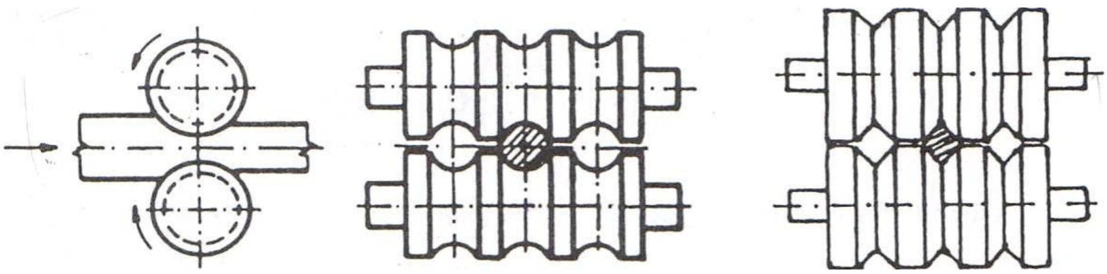
Rolling is understood as a continuous process in which the molded material deforms between rotating work rollers under conditions of predominant versatile pressure. The rolled material deforms between the cylinders. Rolling is done mainly hot but also cold. The result of the process is rolling.

We divide the operation of rolling:

- Longitudinal rolling - the cylindrical axes are parallel, the blank is drawn between the rolls -

the rolls are rotated "against each other"

- Longitudinal rolling:
- (Fig.6.19) - the shape of the caliper is determined by the cross section of the rolling mill,
- Intermittent molding takes place in a caliber formed on the part of the circumference of the cylinder,
- The periodic - caliber shape is the repeating shape of the product
- Diagram of longitudinal continuous rolling



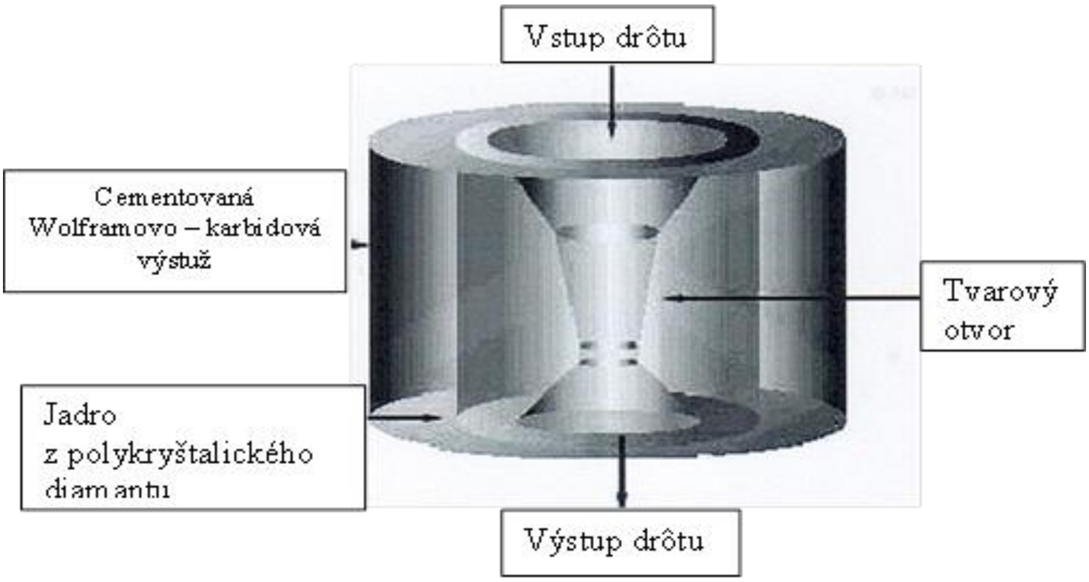
A- rolling a rod of a circular cross-section, b- rolling a rod of a square cross-section

- Transverse rolling - the cylinders and semi-product axes are parallel. The direction of rotation of the rollers is the same. The blank rotates between the cylinders around its axis. The diameter of the rolled semifinished product changes.
- Rolling cylinders - the cylindrical axes are not parallel, they make up the angle of about 5°. The plunger rotates around the axis while advancing forward. The tensile stresses inside the product form a cavity. Divided into:
    - Darting by rolling - The cavity is formed using a mandrel
    - Long duty rolling - the shape of the roll is given by the screw caliber on the circumference of the rollers.
- Roll-out - the scarf ring-shaped blank is rolled up by the pressure roller to the desired shape
- Knitting - is based on the formation of grooves on the surface of the rotary blank
- Thread rolling - threaded cylinders form a thread on the blank. Thread rolling is in serial and mass production.

4.4. Wire and profile pulls

The pull is dragging the blank through the opening of the die, which reduces the cross-section and increases the length. At the same time, mechanical properties change (increasing slip limits and strength limits). Improves surface quality and achieves precise shapes and dimensions.

Draw diagram



Legend: vstup drotu - wire input, výstup drotu - wire output, tvarový otvor - shaping hole, cementovaná wolframovo-karbidová výstuž - cemented tungsten carbide reinforcement, jadro z polykryštalického diamantu - core made of polycrystalline diamond

Pulling of pipes and profiles

Dragging seamless tubes and profiles, the intermittent process is used.

Basic methods of pipe drawing:

- Pulling pulls
- Pulling on a retained mandrel,
- Pulling on free thorn,
- Pulling on a pole,
- Profiles of irregular shapes

4.5. Overpressure

Overpressure is a molding process. In this process, the material is pressed over a narrowed cross-section (extrusion tool). This process generally produces smaller, practically finished, finished products of non-ferrous metals, soft steels, and also of high strength steel and tool steel.

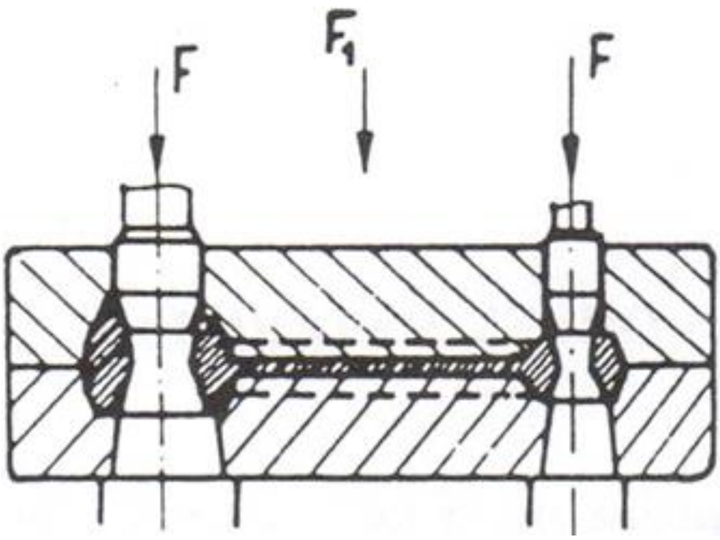
4.6. Routing

In the technological process of cutting, the thickness of the workpiece is changed. The molded material fills the space between the punch and the shape punch. Shape and dimensional accuracy is dependent on the size of the product and the type of material to be consumed. Moves within ± 0, 05 - 0, 1 mm.

4.7. Calibration

Surface calibration is used to refine the dimensions of the opposing and parallel surfaces of the workpiece when forming eg ballasts, connecting rods, levers, etc. Cold calibration is used to refine the geometric shape and dimensions of all parts of the parts. Along with this technology, calibration of holes with calibration spikes can also be performed.

Calibration of connecting rod with simultaneous calibration of holes



Calibration can be divided into the following operations:

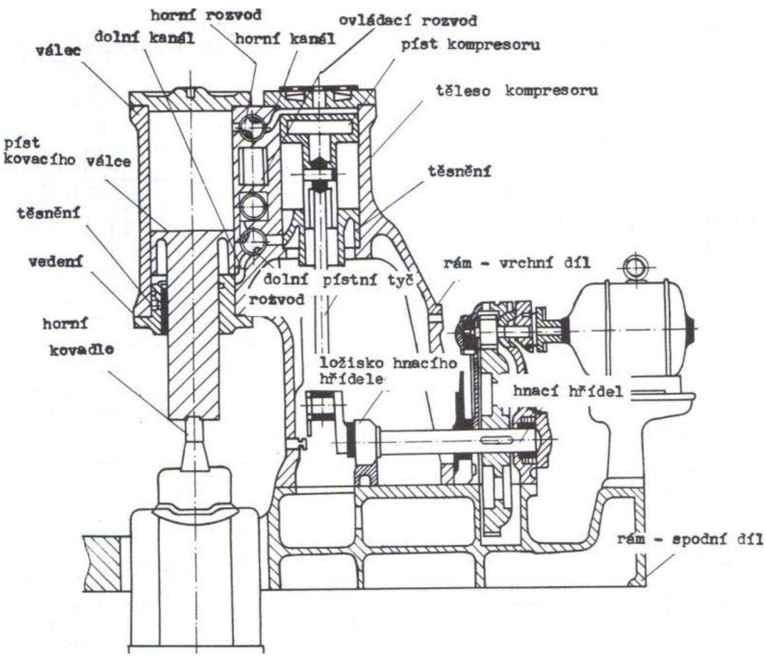
- Calibration by sight (push)
- Planar calibration
- Calibration after pulling - flat, bulk
- Calibration after bending
- Calibration of holes
- Shape calibration

4.8. Free forge

Free forging can be done manually or mechanically. Hand forging is a matter of artistic forging. For free machine fitting, a preform or ingot is used as a semi-finished product.

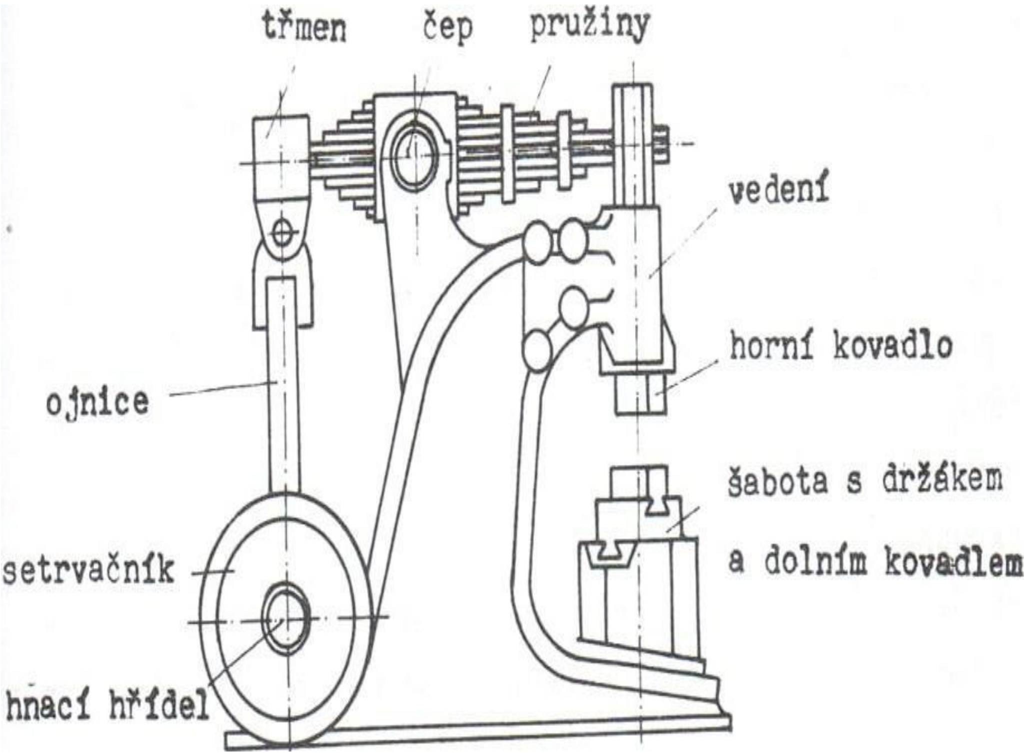
Basic slitting operations include mowing, overburdening, stamping, stamping, offsetting, bending and punching.

Compressor hammer



Legend: válec - cylinder, píst kovacího válce - forging cylinder piston, těsnění - sealing, vedení - guiding part, horní kovadlo - upper swage, rám-spodní díl - bottom frame, hnací hřídel - drive shaft, ložisko hnacího hřídele - drive shaft bearing, rozvod - supply, dolní pístní tyč - lower piston rod, rám-vrchní díl - upper frame, těleso kompresoru - compressor, píst kompresoru compressor piston, ovládací rozvod - guiding, horní kanál - upper channel, horní rozvod - upper supply, dolní kanál - lower channel

Spring forging hammer



Legend: třmen - clevis, čep - pin, pružiny - springs, vedení - guiding, horní kovadlo - upper swage, šabota s držákem a dolním kovadlem - shabbard with bracket and lower swage, hnací hřídel - drive shaft, setrvačník - flywheel , ojnice - connecting rod

4.9. Die forging

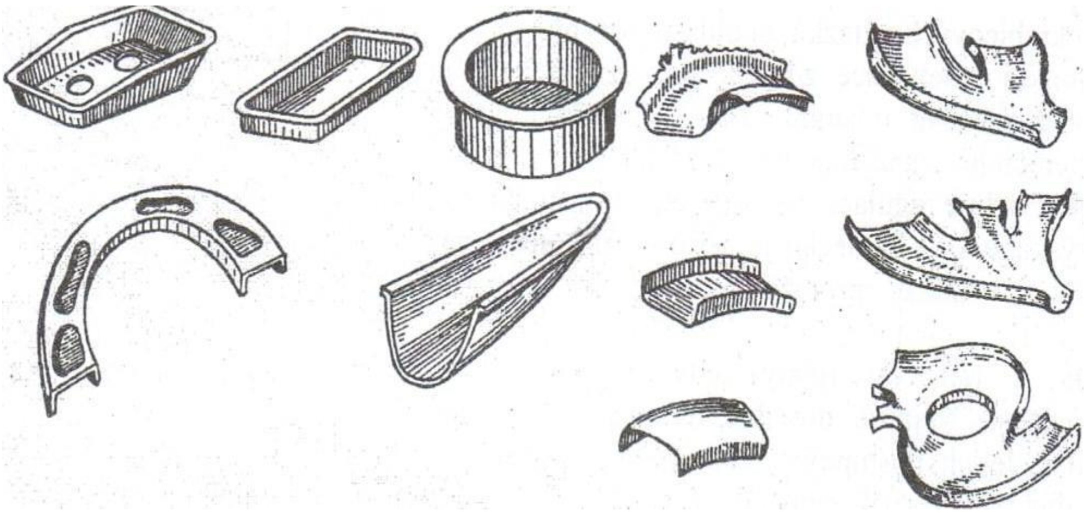
We can divide dies for:

- forging in open dents (in fact, it is forging with a bump),
- forging in closed dies (it is forged without basting).

Depending on the type of forging machine used, we can divide the die forging into (Bača, J., Bílik, J., 2000):

- Hammering,
- Bending on presses
  - forging on vertical forging machines,
  - forging on horizontal forging machines,
- forging on forging rollers.

Shapes and parts made in buckets



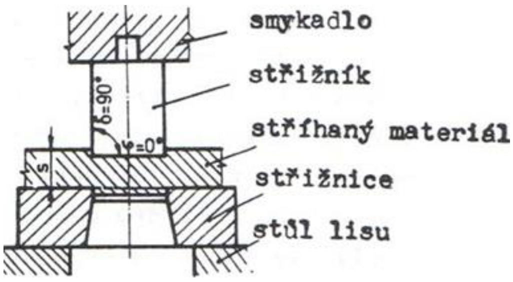
4.10. Surface molding

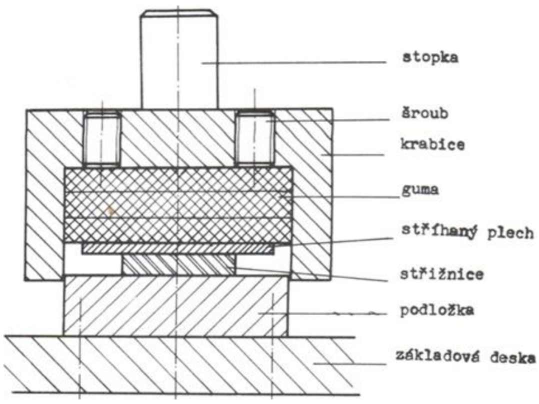
Surface molding is a process in which a shape change occurs. The sheet metal blank converts to the desired part. We divide the tool into a single-operation, step-by-step and multi-step process for the surface-forming operation of the tool.

4.11. Cutting

Cutting is the most used molding operation. Cutting is used in forges and mills for:

- Cutting parts,
- dividing the basic plotters.
- finishing operations,
- Auxiliary operations.





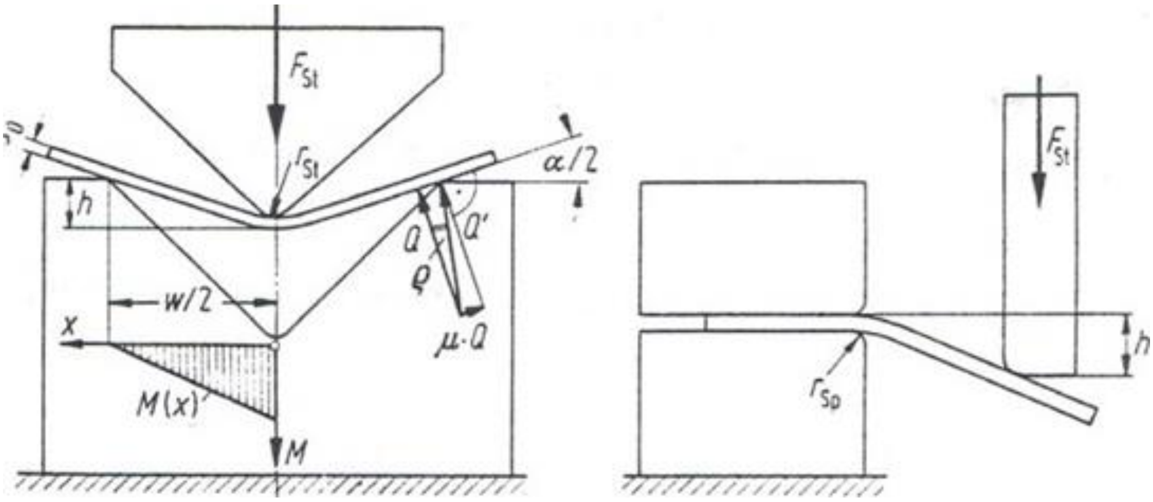
Scheme of shearing with shear cutting *Cutting in a non-rigid tool*

Legend: smykadlo - sliding shoe, střižník - punch, stříhaný materiál - sheared material, střižnice - die, stůl lisu - table plate, stopka - nose, šroub - screw, krabice - box, guma - rubber, stříhaný plech - sheared sheet, podložka - mat, základová deska - plate

4.12. Bending

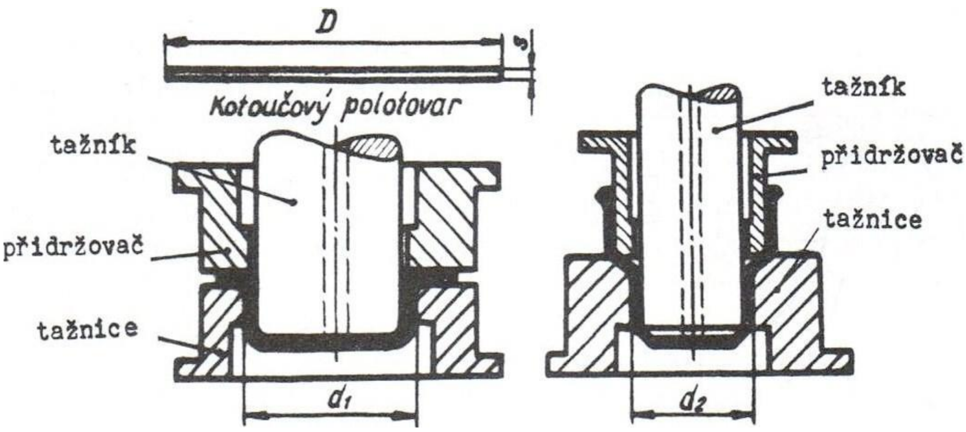
Bending is an elastic-plastic deformation. This distortion is caused by moments of external forces. It's creating sharp or rounded edges. This operation makes it possible to straighten inappropriately formed sheet metal.

Free bending



4.13. Drawing

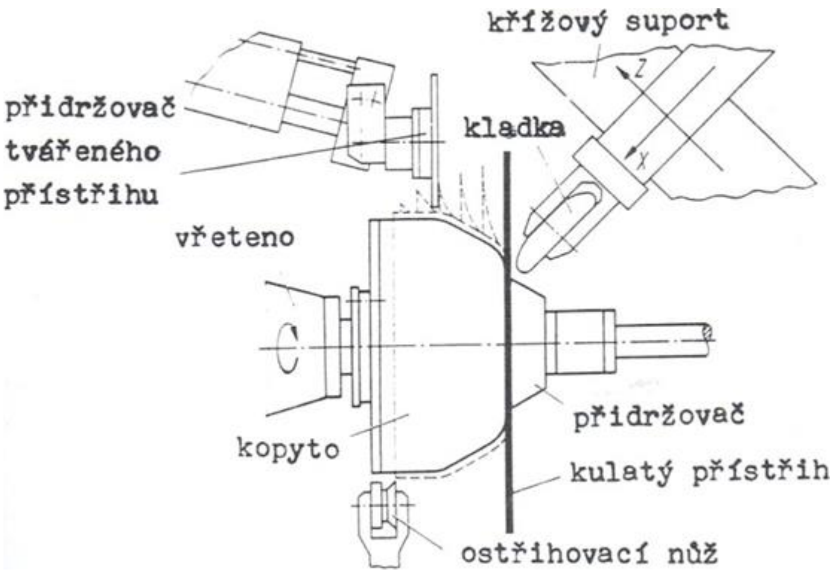
Draws with the retainer in the first and second drawing operations



Legend: tažník - drawing punch, tažnice - drawing die, přidržovač - retainer, kotoučový polotovar - disc blank

4.14. Pressing

Pressure of hollow bodies



Legend: přidržovač tvářeného přístřihu - blank holder, vřeteno - spindle, kladka - pulley, křížový suport - cross slide, kulatý přístřih - round blank, ostřihovací nůž - trimming knife