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MODULE T
Soldering and brazing

Soldering soft annealing and soldering hard - characteristics

Soldering soft annealing and soldering hard - characteristics

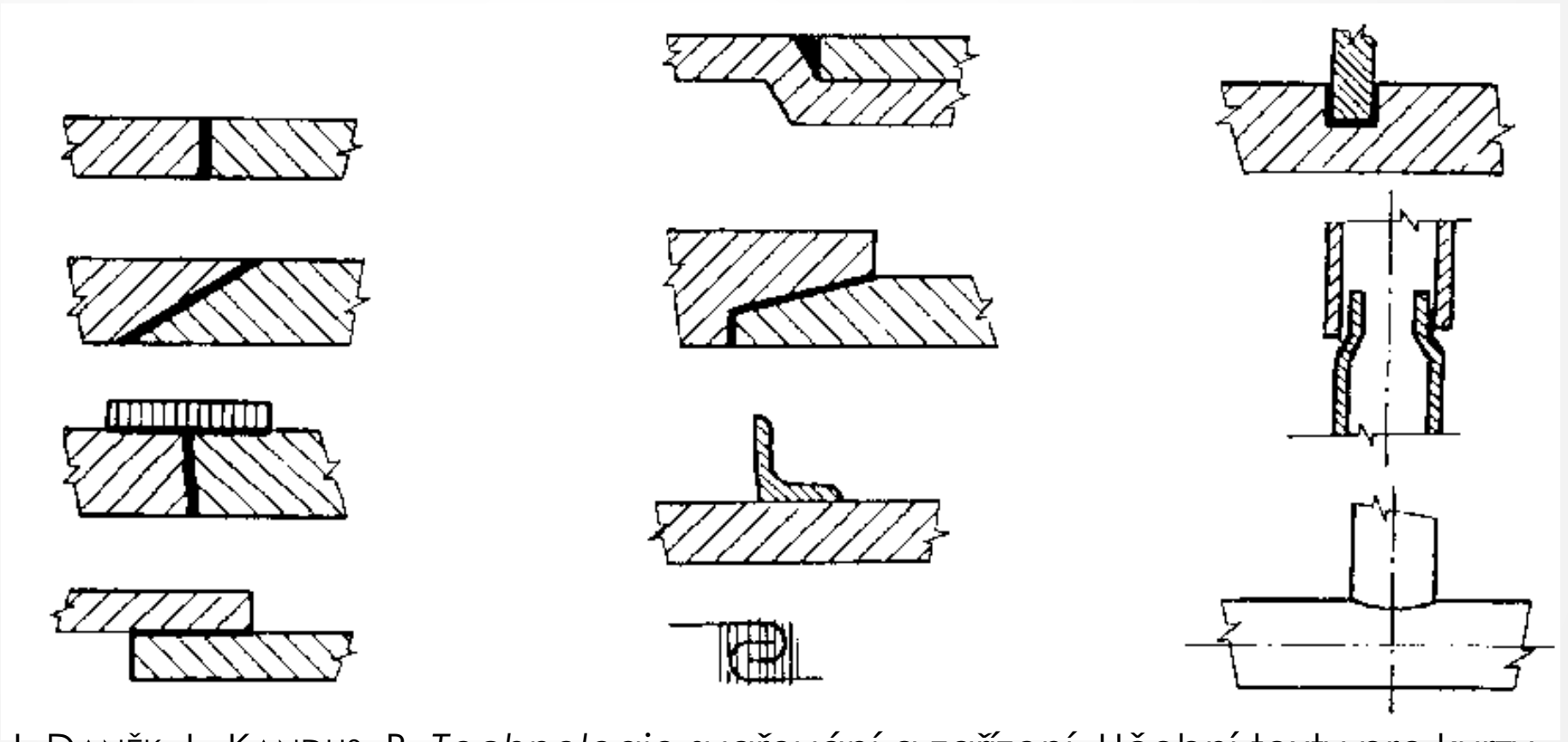
- Solder is possible to create a permanent joints. Thus in addition to welding, riveting and bonding another method that can make this connection.
- On unlike fusion welding works with smaller operating temperatures. This means that the basic material always remains in the solid state.
- Like filler material is used solder having a lower melting point than the materials joined.

Establishment soldered communications

- Solder joint created by using three materials, and basic materials (soldered), additional (solder) and auxiliary (flux).
- Heated solder seep due to capillary forces or gravity into the soldering gap, which wets the metallic clean, heated to a brazing temperature of soldered area.
- Between atoms soldered and the solder material are created conditions for the formation of adhesive and cohesive forces.
- At working brazing temperatures will be dissolved and mutual diffusion of solder materials and solder.
- After cooling the solder formed undetachably. Its type depends on the relative solubilitysoldered and solder material in the solid state.
- The strength of the soldered joint is generally higher than the strength of the solder depends on the type and size of the joint.
- Soldering generally requires the use of special types of joints generally designed so that the solder joint stress as much as possible the shear.

Soldering soft annealing - connection conveyor to the kettle downpipe

Types of soldered joints



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Benefits soldering

- High productivity
- High reproducibility of products
- High dimensional accuracy, the possibility to combine the brazing heat treatment
- Lower heat load of solder materials, less thermal stresses and structural changes
- Better working environment, good looks connections
- Possibility of automation, the possibility of soldering even in inaccessible places.

Distribution by soldering operating temperature

- According to the solder melting temperature solder is divided into two groups:
  - Soldering soft (melting point of the solder is 450° C)
  - Soldering solid (melting point above 450° C)
  - Strange subgroup the brazing solder is a high temperature solder having a liquidus above 950° C.

Soldering

- Soldering can be divided according to other criteria, e.g. according to the method of heating solder joint shape, degree of mechanization and automation, environment, etc. a method of connection.
- According to the method of transport of solder into the soldering gap divided soldering capillary and filler (gravity).
- When soldering must melting temperature of the materials used satisfy the condition that the brazing temperature is 30° C to 100° C above the liquidus temperature of the solder.

Solders

- What narrowest interval melting temperature (ideal is a eutectic composition), good wettability, flow and capillarity
- Elements not contained in solder with solder material to form brittle intermetallic phases
- What lowest electrochemical potential between the solder and the solder material.

Properties of solders

- Wettability solders
  - Wettability it is defined as the ability of solder to adhere liquid to clean the surface of the joint material at the operating temperature.
  - Yippee it is one of the most important features significantly affecting the quality of solder joints.
  - Wettability significantly influences the surface tension of the molten solder.
  - At wetting solder drop takes a shape in which the surface energy of the system (base material - solder - flux).

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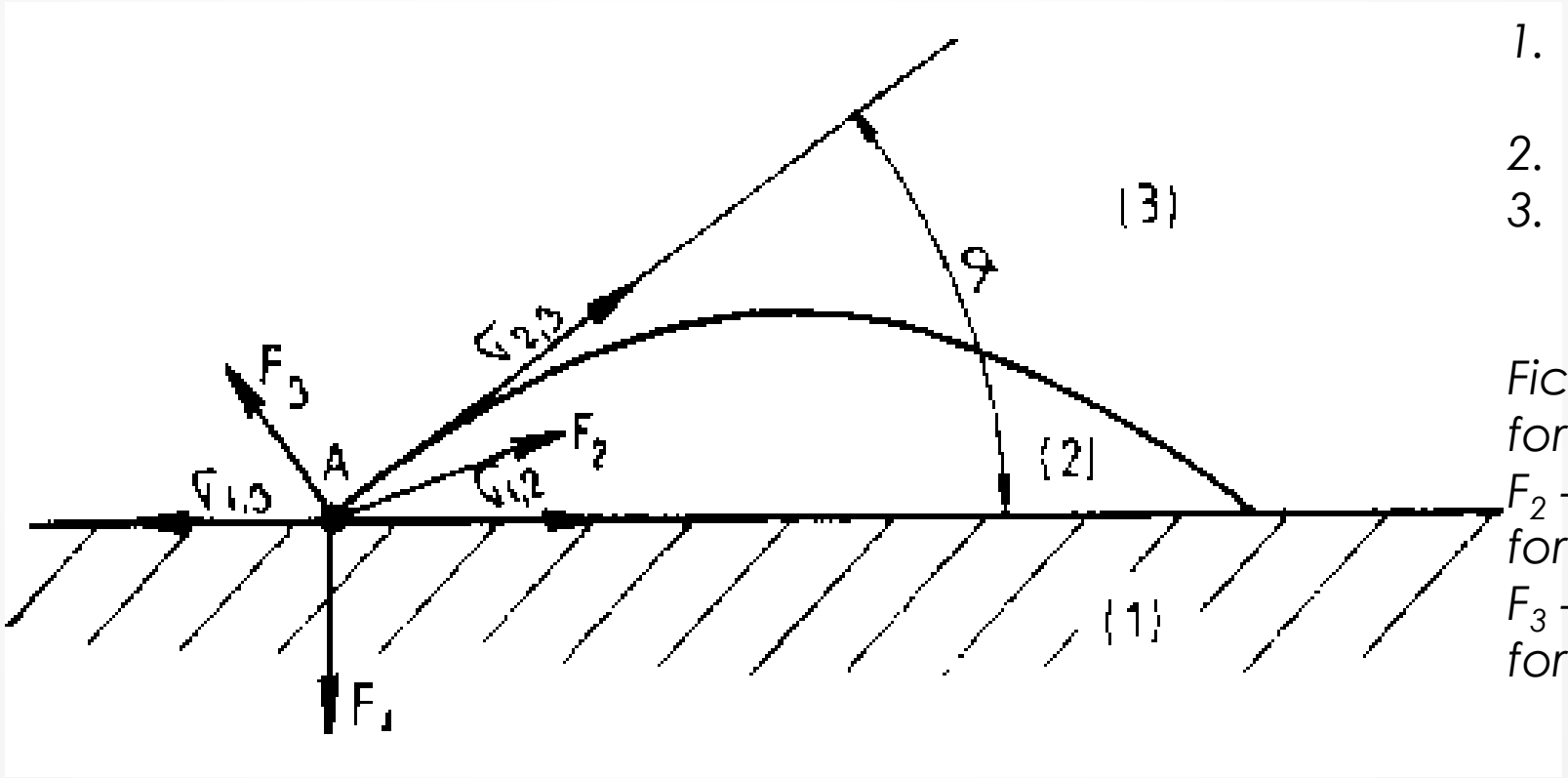
Tension and forces in the system of basic material - solder - Environment



1. *soldered material,*
2. *solder.*
3. *surrounding Atmosphere - Environment*

Fiction - adhesion forces;
F_2 - cohesive forces;
F_3 - attractive forces

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Tension and forces in the system of basic material - solder - Environment

- a = 0 ° up to 15 ° - wettability perfect (suitable for capillary soldering)
- a = 15 ° 75 ° - wettability good (suitable for deposition soldering)
- a = 75 ° 90 ° - solder wettable (Still sufficient for solder deposition)
- a > 90 ° - solder nonwettable (Inappropriate for any brazing method)
- Wettability closely related to the fluidity and the solder spreadability.

solder spreadability

- It is the ability of solder to cover as much area of the solder material.
- Sizes wetted area is also flowability evaluated.

solder wicking

- Capillarity is defined as the ability to fill in liquid solder at the working temperature of a narrow gap joint by capillary forces.
- Size capillary force is determined by the laws of hydrodynamics.
- Capillary wicking is dependent on the type of solder at its surface tension, density and size of the gap joint.

Metallurgical reactions during soldering

- During brazing, the molten solder, and a solid base material a certain time (several seconds to minutes depending on the type of heating) in mutual contact.
- That the most important condition is fulfilled metallurgical reactions in joints.
- According to kind of solder and the base material may limit their contact experience any of these reactions:
  - Adhesive connection,
  - Mutual diffusion of elements of the solder and the base material,
  - Dissolution solder base material,
  - Reaction components of solder having a surface oxide base material.

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Metallurgical reactions during soldering

- Adhesive bonding jointing call such case in which no mutual dissolution of the solder and the base material (e.g. by combining Pb - Fe. Cu. ZnNi, Mo, Al, or Ag - Fe. Cr etc.).
- Adhesive connection is used when there must be a change in the chemical composition of the materials, eg. in electronics.
- Adhesive joint has a good electrical conductivity but has lesser strength.

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Metallurgical reactions during soldering

- In most cases, when brazing creates a transition region thickness, which are (due to diffusion or dissolution), other chemical, physical and mechanical properties than the bonded materials.
- In generally, however, the solder joint may not occur all the mentioned areas.

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Soft solder

- Solder for soldering are characterized by low working temperature and also low strength (5 MPa).
- Therefore they are used for connections which are not robustly thermally stressed.
- They are heavy metal alloy (Sn, Pb, Cd, Sb, Bi) and forms two groups: solder, special solder.

Tin solder

- They are alloys of tin and lead with a working temperature of 190 ° C - 350 ° C.
- Tin is in these solders active ingredient and provides good wettability.
- Content Sn substantially affects the quality of soldering.
- In contrast, the lead is poor wettability and metallurgically to the base material does not react.
- Simply, however, a small addition of tin (min. 3%), respectively. other surface-active element (e.g. Sb) In order to substantially improve the soldering properties of the solder.
- For tin solders tin content ranges from 4% to 90%.
- Modern solders have a minimum lead content in order to reduce the negative impact on the environment.

Soft tin oxide solder

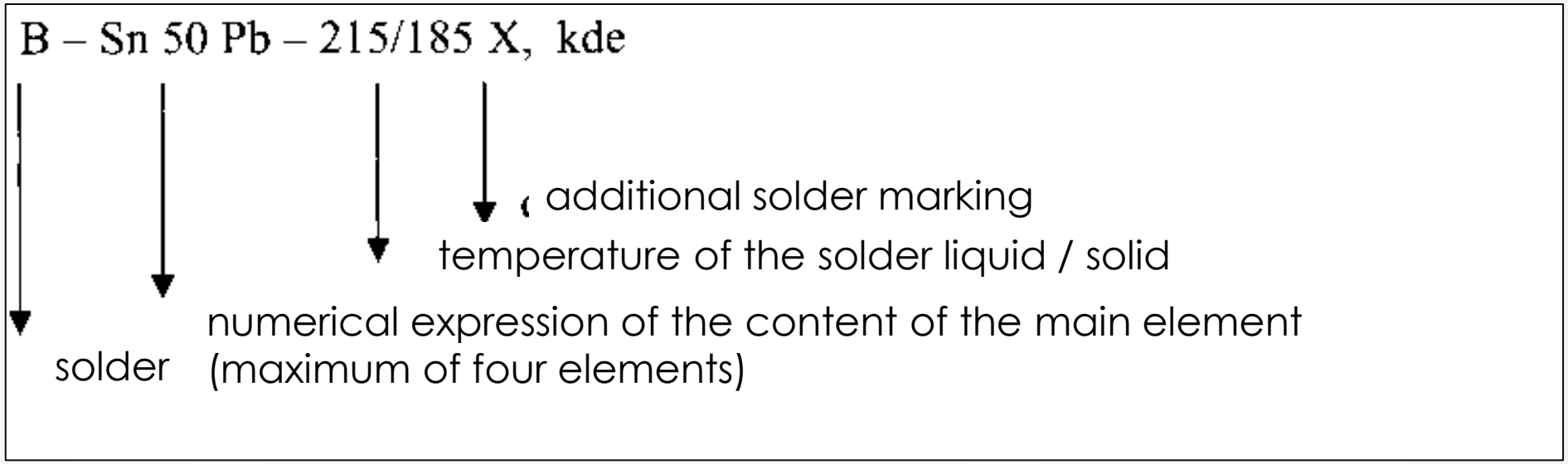
Special soft solder

- Satisfy the specific requirements (e.g. reliability and tightness at cryogenic temperatures, the corrosion resistance in a specific environment, etc.).
- It is a dual or multi-component alloy consisting apart sn and Pb and also from Cd and Zn and their composition is close to eutectic.
- Alloying other elements (Ag, Cu, Sb, Bi, In) forming the solder satisfying specific requirements.

Dividing special solders

- Solder for food and refrigeration industry
- Solder for electrical engineering and electronics
- Solder for soldering glass
- Solder for low temperature soldering and heat fuses
- Modeling the solder filling inequalities (eg. body).

Marking soft solders



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Brazing

- Braze having a melting temperature higher than 450 ° C.
- This includes in particular solder aluminum, copper, brass and silver.
- Aluminum solders are typically eutectic alloy of Al and Si (silumin) and serves for the brazing of aluminum and its alloys.
- Copper solders are either pure copper or copper with the addition of 8% or 1% P Ag They are used for the brazing of steel and provide a vacuum tight seal.
- Brass solder they are commonly used for soldering copper, steel or cast iron and malleable iron.
- Due to the higher content Zn it is difficult for them to achieve vacuum-tight joints.
- Silver solder they are used for brazing copper and stainless steel.

Brazing

- For other types of hard solder should be mentioned primarily based solder Ni (solder heat resistant and stainless steels), based solder palladium (nuclear energy, electronic, gas turbines) and solder based on precious metals used in dental technology and manufacturing jewelry.
- Solders are available to the consumer in the form of drawn wires, strips, films or granules.
- It can also be wrapped sticks flux, or flux cored tube.
- Labeling hard solders is similar to the labeling of soft solders, eg .:
- B - Cu 60 Zn - 900/880 (brazing material containing 80% Cuthe rest Zn)

Flux

- The task is to prepare a flux soldered area - to remove surface oxides and other impurities, and optionally in contact with the solder reduce its surface tension and thereby improve wettability and flow.

Requirements flux

- Good wetting and solder base material
- The reaction temperature of the flux needs to be about 50 ° C to 150 ° C lower than the melting point of the solder
- Minimum viscosity in the working temperature of the solder
- Constant surface tension
- Lower density than the density of the solder
- Chemical stability at room and operating temperature,
- After soldering easy removal
- Medical harmlesness.

Soldering cream

Soft soldering fluxes

- Organic fluxes - used mainly in electronics e.g. rosin, pastes and greases are used
- Inorganic fluxes - mostly case of ammonium chloride and zinc chloride solution.
  - Disadvantage - corrosive, so it is necessary to properly remove flux residues.

Salmiak to clean soldering iron tip

Fluxes for brazing

- As a result of higher soldering temperatures the soldered surfaces of the solder and faster cover oxides which must be removed.
- On other hand, the higher temperature accelerates the reaction between the soldering flux and oxides and in some cases may be brazed without the use of fluxes, because the high temperature enables the reduction of oxides with hydrogen or carbon monoxide (brazing in furnaces with atmosphere).

Fluxes for brazing

- The basic component of most flux brazing solders based Cu and Ag borax ($Na_2B_40_7$) And boric acid, further additives are used, decreasing the effective temperature (silicates, phosphates, carbonates, chlorides and fluorides).
- For brazing aluminum alloys are used in the flux substantially identical fluxes for aluminum welding, i.e. a mixture of chlorides and fluorides of alkali metals.
- Fux in the form of powders or pastes. They are also the flux, which is evaporated at elevated temperature.
- At in mass production soldering flux is used, if possible, as little as possible and replaced by a reducing atmosphere.

Methods soldering

Distribution by the heat source used for melting the solder material

- Soldering soldering iron
- Soldering flame
- Hot gas soldering
- Resistance soldering
- Induction brazing
- Laser soldering
- Soldering electron beam
- Dipping into molten solder or flux
- Furnace brazing
- Wave soldering
- Other.

Distribution by soldering environment

- Soldering in air, commonly using a flux
- Brazing in a reducing gas which high affinity for oxygen will reduce the amount of oxides on the surface of the soldered.
  - The flux is not used.
- Soldering the internal gas.
  - It is usually without flux. Internal gas reduces the formation of oxides during soldering.
- Vacuum brazingWithout flux.

Soldering

- Before soldering is generally necessary in a suitable manner to prepare a base material.
- Preparation It consists of: degreasing, mechanical processing, grinding or blasting, respectively. chemical preparation of pickling.
- After pickling must be followed by neutralization and rinsing with lukewarm water, to establish the correct position for optimum solder gap and the required dimensional accuracy of the soldered components.
- After adjusting the soldering soldered joints and removes flux residues followed by rinsing with hot water.
  - After high temperature soldering, there is added the heat treatment.

Defects in solder joints and solderability materials

- The solder may occur following defects:
  - Cold joint, not wetted solder points
  - Overheated joint (solder degeneration - coarsening of grains, burning elements, high residual voltage)
  - Gas void (air, hydrogen, CO_2)
  - Solder drops (excess solder, a large gap at the solder joint)
  - Flux residues
  - Insufficient solder transition
  - Crack - rapid cooling joints.
- Not all metals are capable of forming a solder joint properties required.

Materials for soldering

- Steel
- Cast iron
- Other metals

Steel

- Soldering can be all kinds of steel when properly chosen technology and method.
- Unalloyed structural steel: solderability depends on the carbon content.
- If the content of C may occur at the solder joint pores.
- They are based solder Cu and Ag.
- Alloy structural steel: solderability again depends on the content of additives.
- Detrimental effect of Co, Ni and W.
- If the content Cr, Al, Ti, Si, and MnThat make up the surface oxides, it is necessary to observe the special conditions soldering technology.
- Using Ni solder can be soldered to high-grade stainless steel.

cast iron

- Brazing can be soldered all kinds of cast iron.
- wettability graphite cast iron deteriorates, and therefore is to be removed from the surface by brushing or sandblasting.
- Favorably acts Mn. Crneither. Solder joints made of brass solder achieve the basic material strength alloysCu.
- Hard can be soldered Cu The content$_2$ to 0.1%.
- At higher oxygen content results in a hydrogen atmosphere so. Hydrogen disease (pores at the grain boundary) and therefore it is not possible to solder these materials in a reducing atmosphere.
- At soldering flame is necessary to use a neutral flame.
- brass can be soldered Ag solders.
- bronzes They tend to Liquation and therefore need to be soldered Ag solders with a working temperature below 800 ° C.

Other metals

- Other metal can be soldered Al, Ti, Ni, BeAu, Ag. Mo, Zr, W and alloys thereof.
- We can be soldered and ceramics and glass.

Electric soldering iron

Gas soldering iron

Questions to ponder

1. What is the principle soldering?
2. According to what divides soldering soft annealing and hard?
3. What is at soldering flux?
4. What qualities have solder?
5. What are the advantages of soldering?
6. What are the working temperature during the soldering?
7. What defects joints can occur during soldering?
8. Which materials can be soldered?
9. What is preparation of materials prior to soldering?

Recommended literature and information sources

- AMBROŽ, O. A KOL. *Technologie svařování a zařízení: učební texty pro kurzy svářečských inženýrů a technologů*. Ostrava: ZEROSS, 2001, 395 s. Svařování. ISBN 80-85771-81-0.
- KUBÍČEK, J. DANĚK, L. KANDUS, B. *Technologie svařování a zařízení. Učební texty pro kurzy svařovacích inženýrů a technologů*. Plzeň: ŠKODA WELDING, s. r. o., 2011, 242 s.