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MODULE P

Resistive welding

Resistive welding



The principle of resistance welding

- Resistance welding is an electromechanical process that produces a weld joint by applying a pressure while the passage of welding current, wherein the heat source is a resistive heat generated by the Joule's law.
- Advantage resistance welding, in particular that the property does not require filler metal, but the welded joint is produced by melting the material itself welded parts.
- Between other highlights include besides joint quality, speed and efficiency of design and the possibility of mechanization and automation.



Characteristic resistance welding

- Resistance welding technology belongs to a pressure welding in which the weld joint forms at the point of heating to welding temperature by electrical resistance heat still under pressure.
- At this process, a portion of the material enters the melting state and in the vicinity of this zone to a plastic state (or into a plastic state at a pressure of contact of welding).
- Its electrical resistance welding is the concentration of the electric heat to the place where is to be welded.
- During creating weld resistance and work flow changes.
- Overall heat generated between the electrodes at time t , according to Joule's law:
- $Q = U * I * t$



The total electrical (ohmic) resistance system of

- ▶ Resistance electrode
- ▶ Transition resistances in the contact electrode - welded material
- ▶ Own resistance welding materials
- ▶ Transition resistor contact surfaces of the welded materials.

- ▶ Each of these resistors is a function of the temperature and the transition resistance depends considerably on the quality of the surface of the materials being welded and the electrodes and the pressure between the electrodes.
- ▶ Moreover is the total resistance of the welded joint between the electrodes is time dependent.

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Characterization of resistance welding technology and application range

▶ Welding positions	All
▶ Type welding material copper, nickel and their alloys	unalloyed steel, alloy steel, aluminum,
▶ Welded thicknesses range	0.4 mm to 10 mm (sometimes more)
▶ Welding current	103 A to 105 A
▶ Work stress	0.5 30 V
▶ Type of welding current	alternate (Exceptionally DC)
▶ Welding time	0.04 s to 2.0 s
▶ Welding pressure	15 MPa 200 MPa
▶ The rate of temperature rise	when 100 000 ° C / s

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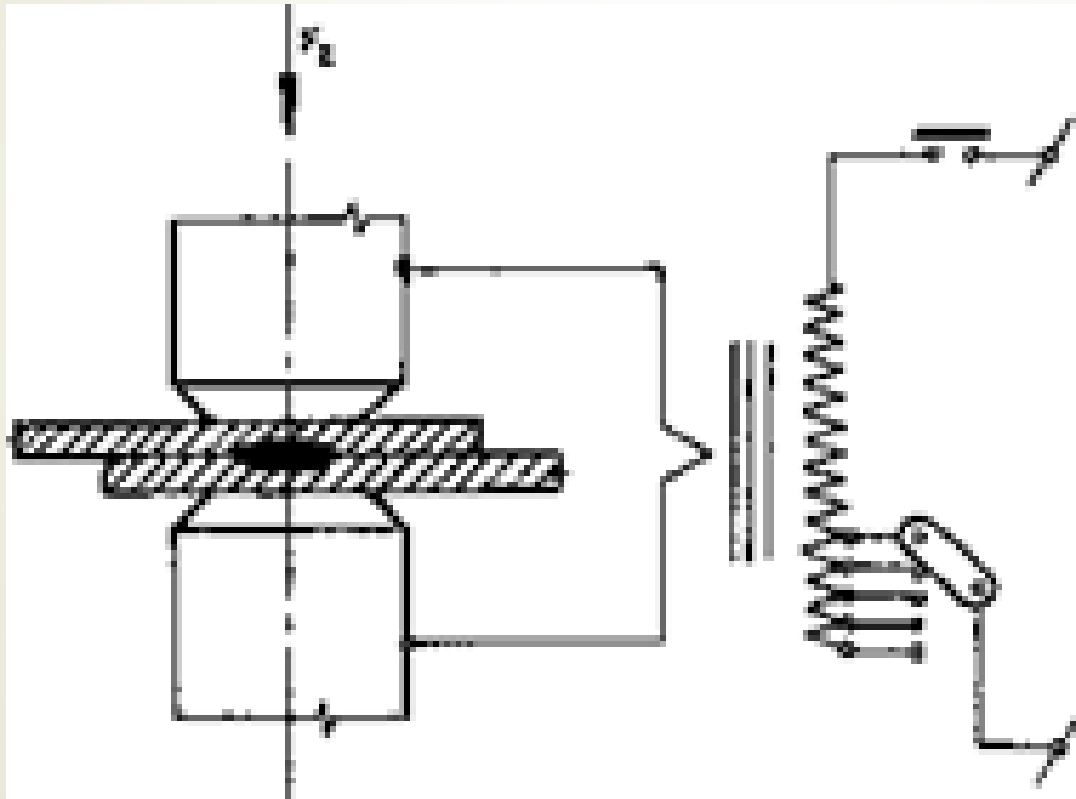


Distribution kinds of resistance welding

- Spot welding
- Seam welding
- Projection welding
- Pressure butt welding
- Contact deposition welding



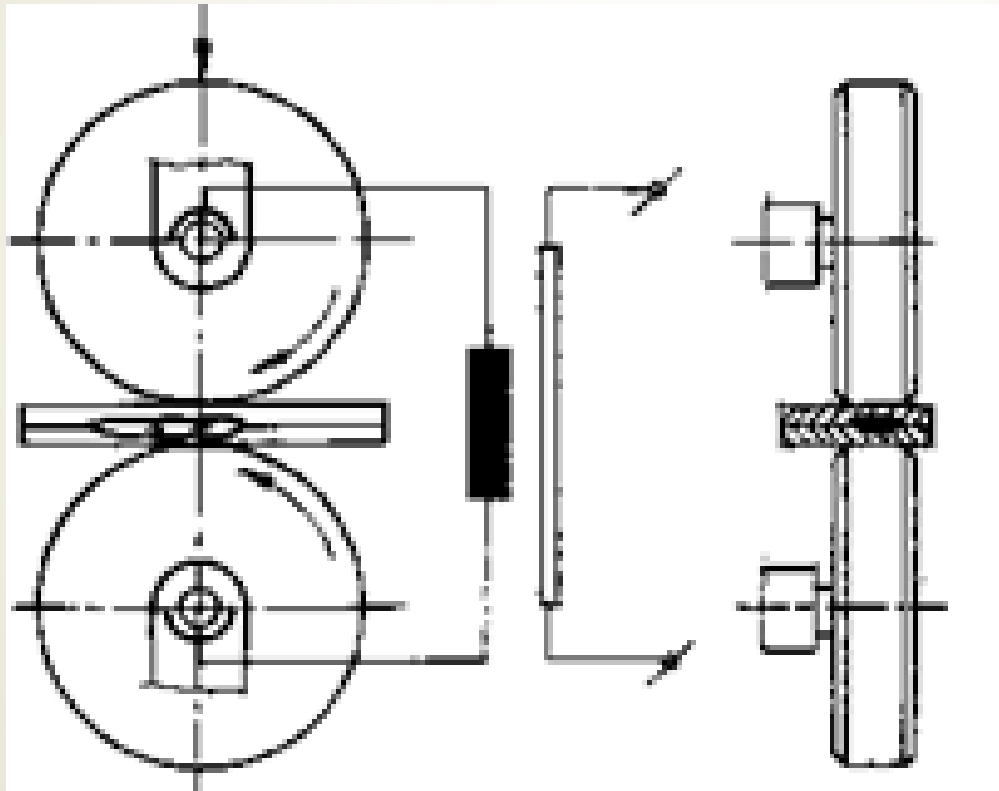
Spot welding



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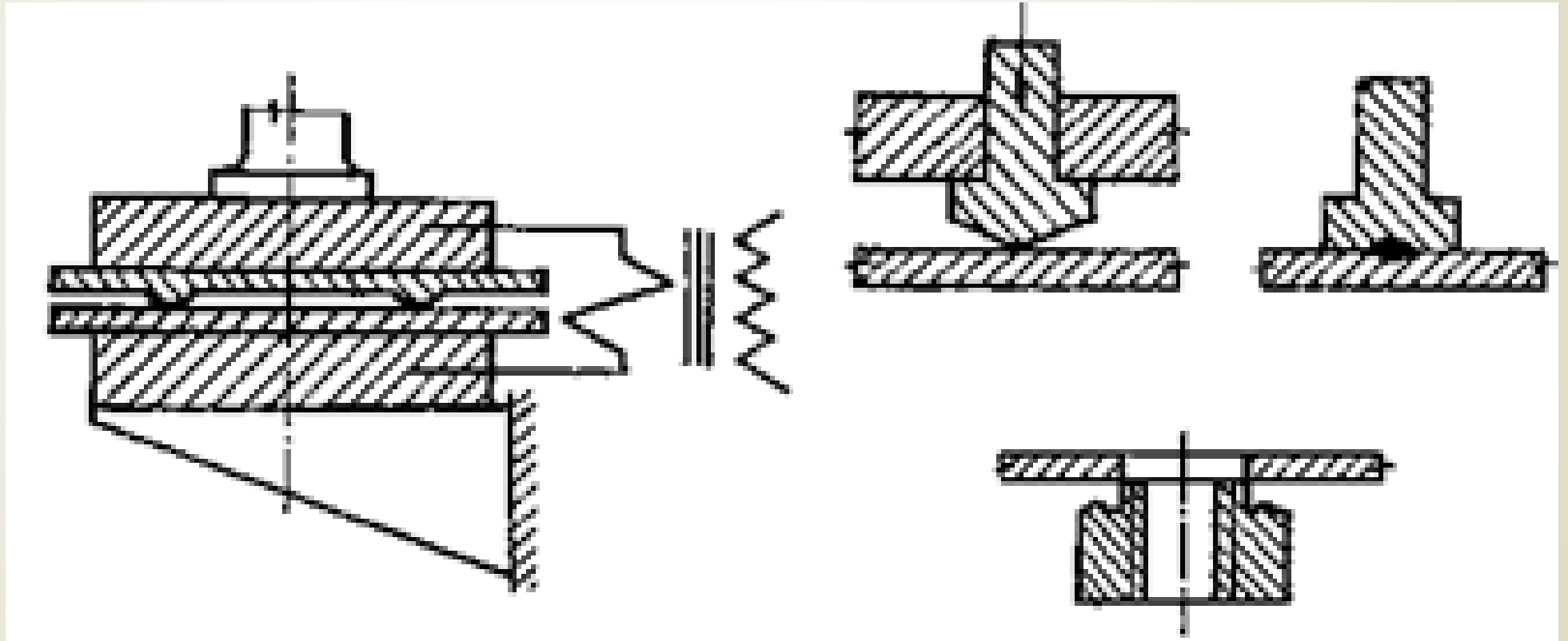
Seam welding



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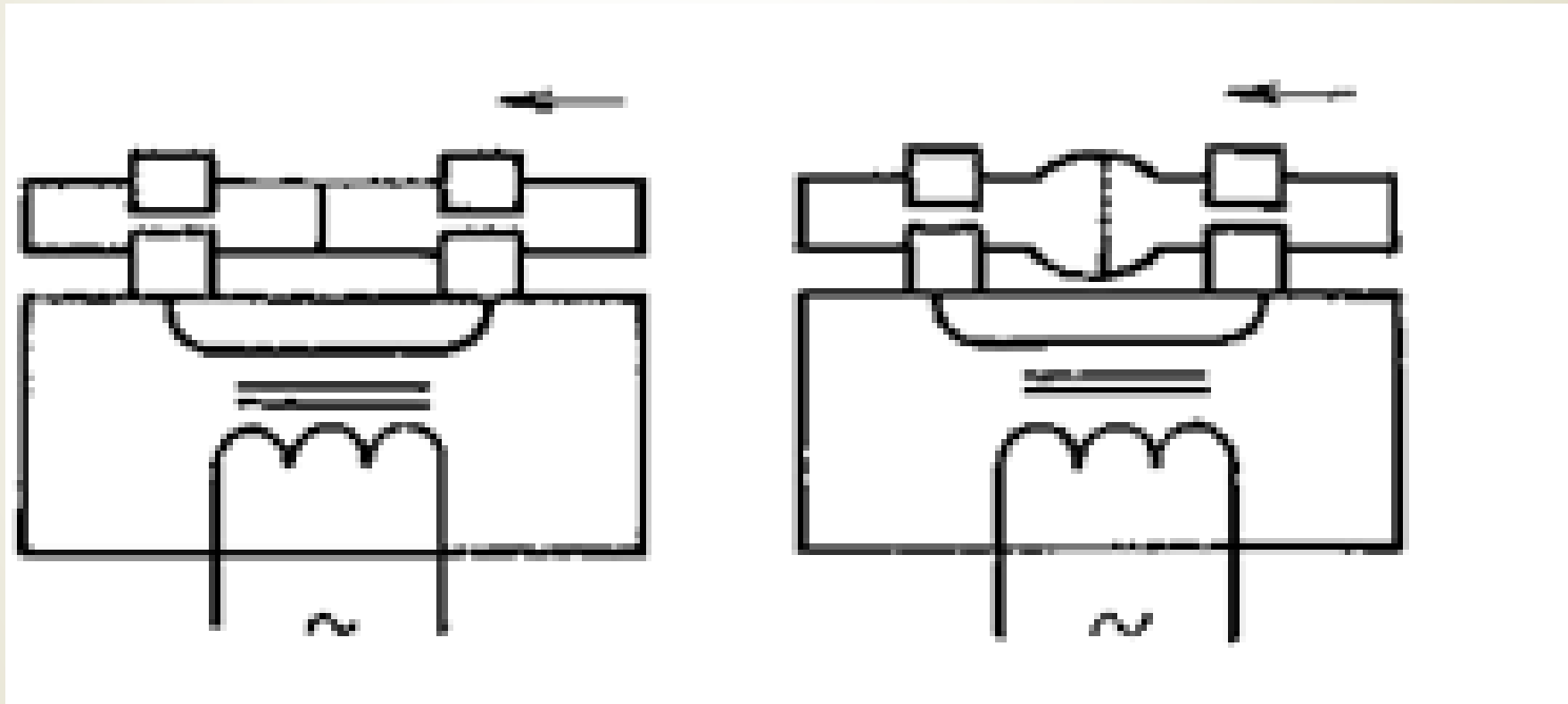
Projection welding



KUBICEK, J. DANEK, L. KANDUS B. *Welding technology and equipment. Textbooks courses for welding engineers and technologists.* Plzeň: ŠKODA WELDING sro, 2011. p. 121.



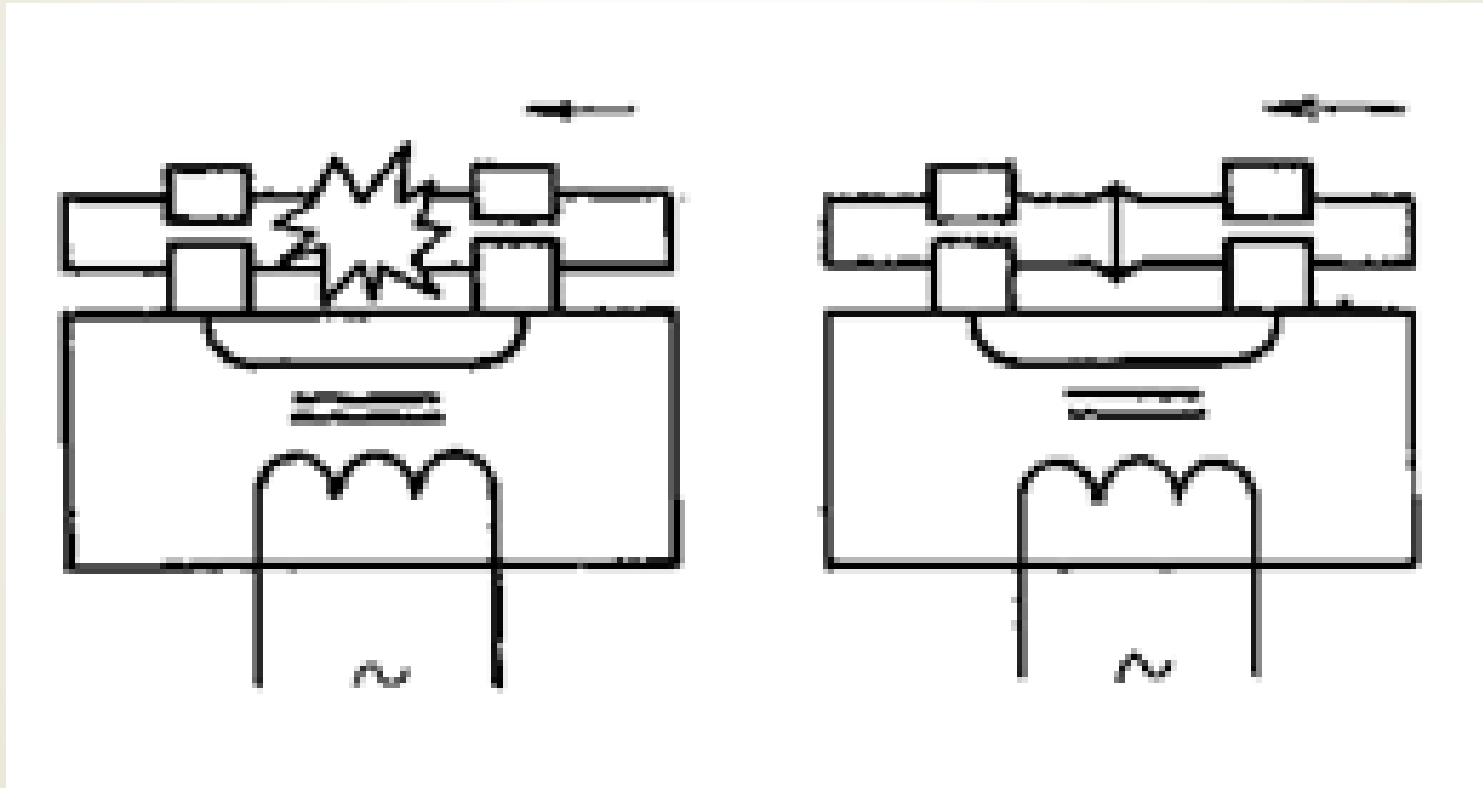
Pressure butt welding



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Contact deposition welding



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Basic parameters of resistance welding

- Welding current,
- Welding time and pressure, which affects the contact resistance in the contact electrodes and contacting both materials.



Modes of resistance welding

- Soft welding mode
- Hard welding mode



Soft welding mode

- The smaller welding current, welding time longer, smaller pressing force.
- Distinguished is higher by heat treatment of the material, welding the lens has a small diameter has a large height and a coarse-grained structure, which degrades the mechanical properties of the weld joint.
- Electrodes they are thermally highly stressed and therefore have a short life and also leave the material welded footprint is deep.
- Higher it is the power consumption (low efficiency, increased heat loss).
- This mode is intentionally used in the case of welding of materials susceptible to hazing.



Hard welding mode

- Higher welding current, welding time is shorter, more downforce.
- Hard mode features include higher productivity, smaller heat losses, a smaller footprint is larger electrode lifetime and less distortion.
- Welded lens having a larger diameter (like electrode), their height is about 30% of the total thickness of both sheets, the mechanical properties of welded joint are improved.
- Welding however, the machine must have more inputs and stronger construction for added downforce.



welding cycle

- ▶ It affects the dynamics of the process, ie. weld formation lenses, metallurgical changes and final properties of the weld joint.
- ▶ Most often It is used in the welding cycle with a constant force and constant current.



thermal equilibrium

- The emergence of resistance weld perfect assumes relative to the contact plane of symmetry of the welded parts wrought in the weld joint.
- This assumption is valid only for the cooking phase, but also for the cooling phase.
- When the thermal equilibrium is disturbed (different properties of welded materials dissimilar thicknesses, etc.), welded material will be heated unevenly and asymmetrically.
- The consequence the uneven melting of the welded materials and due to the interface weld material forming an asymmetrical lens.



Spot welding



Principle spot welding

- ▶ Spot welding is resistance welding, in which the welded materials přeplátují each other and pressed between two copper electrodes.
- ▶ Temporal switch turns on the electric current that passes through the material has a large current intensity on the contact surfaces is rapidly braked, thereby forming the heat required to form a weld.
- ▶ Contention a lens shape and forms without filler material.
- ▶ Source welding current, the welding transformer.
- ▶ Current from the secondary winding of the transformer is supplied to the fixed electrodes and the flexible leads of the welding machine.
- ▶ Passage electric current is controlled mostly electronically.



Spot welding





Spot welding





Spot welding





Welding parameters for spot welding

- ▶ In technical practice in choosing welding parameters using tables prepared on the basis of tests.
- ▶ Except the size of the basic parameters (welding current I , the pressing force F , and the welding time t) for each class and the thickness of materials is given as other data:
 - ▶ Registered diameter bearing surfaces of the electrodes,
 - ▶ Minimal size of the overlap,
 - ▶ Minimal spacing of adjacent welds,
 - ▶ Minimal distance from the axis of the weld edges of the sheet and other parameters.
- ▶ Welding current and welding time It may be given in the form of two operating modes (Soft welding mode and hard mode welding).



The emergence of spot weld

- Insertion welded parts between electrodes
- Grip electrode
- Turning current
- Disconnection current
- Zoom out electrode



Resistors welding circuit

- ▶ The total effective resistance R is formed by the sum of the contact resistance material resistances.
- ▶ These resistors are not during the duration of the welding cycle is constant.
- ▶ Transition resistance varies depending on the size of the pressing forces at the temperature value and the condition of the surfaces of contact materials.
- ▶ Material resistances are a function of the resistivity of the material, material thickness and the cross-section of an imaginary electrical flow material.
- ▶ Changing also with a temperature that is a function of time. The cross section of the flow of electric current is the cross section of the electrodes.
- ▶ The diameter of the electrodes is given by:
 - ▶ $D = 5j \sim s$ [mm]; s - thickness [mm]



Seam welding



The principle of seam welding

- Seam welding in principle resembles spot welding.
- Unlike spot welding, a weld joint is formed between two rotating discs - electrodes (one in special cases).
- Weld seam is created from the individual, if the spot welds.
- If the welds sufficiently overlap, joint is tight.
- Distance between the individual welds depends on the peripheral speed of rotation of the electrodes, the natural modulation (50 Hz) of the welding current or target interruption current.
- Current in each period has two maxima - positive and negative, then the core is formed welds.
- When the current passes through zero, there is no heat.
- For one second, thus creating 100 welds.
- Resistances in the welding area are similar resistances in spot welding.

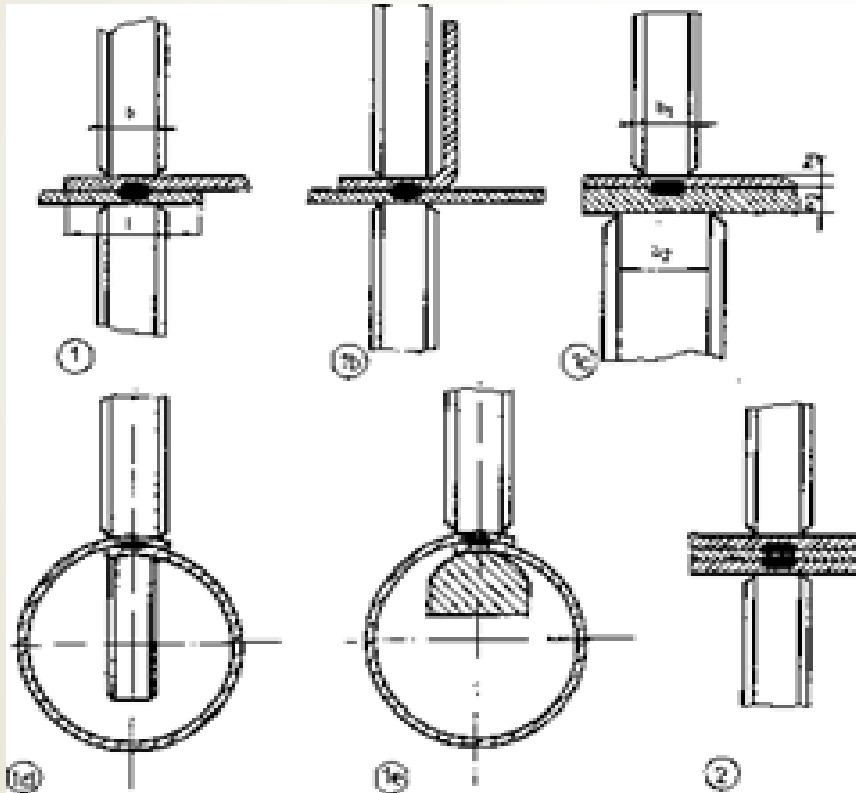


Welding parameters and types and shapes of joints

- ▶ When seam welding uses the following welding parameters:
 - ▶ Welding force F (constant during welding)
 - ▶ Welding current I (constant during welding)
 - ▶ Welding speed (circumferential speed of the discs - constant during welding)
 - ▶ Modulation of the welding current (power interruption, if necessary)



Types of seam welds



- 1a - basic type;
- 1b - weld made unilaterally beveled blade;
- 1c - weld with unequal thicknesses;
- 1d - Plastic container joints;
- 1e - Plastic container connection made to the darkness;
- 2 - weld with three thicknesses of sheet metal

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Projection welding



The principle of the projection welding

- Projection welding is one method of resistance welding, wherein welds are formed on preformed projections.
- Projections they are made mostly on one of the welded parts.
- Lobed welding can create multiple spot welds at once.
- The role projections is to concentrate current and power into the weld joint.
- On welding is used for welding press, wherein the welds are made either between the flat electrodes or in preparations or in the jaws.
- Solution thermal equilibrium is as spot welding.

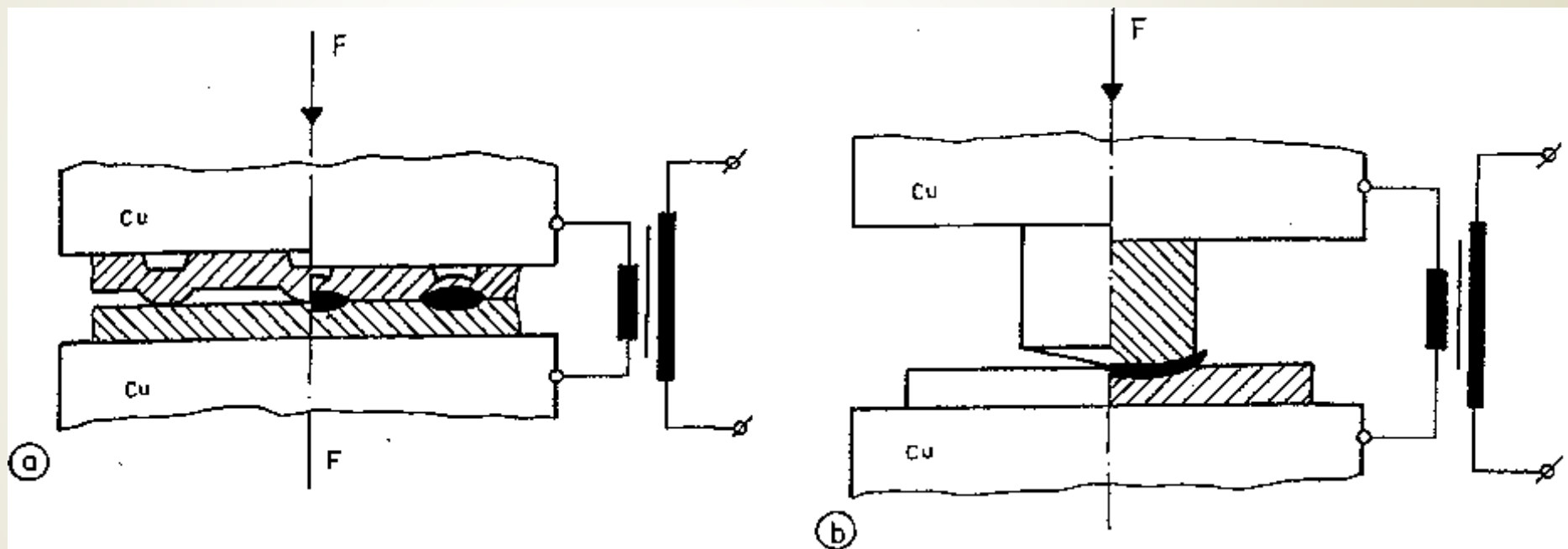


Ways the projection welding

- ▶ projection prolisovaných using welding lugs (welding metal sheets)
- ▶ projection welding with solid protrusions (or using interfaces).



Projection welding



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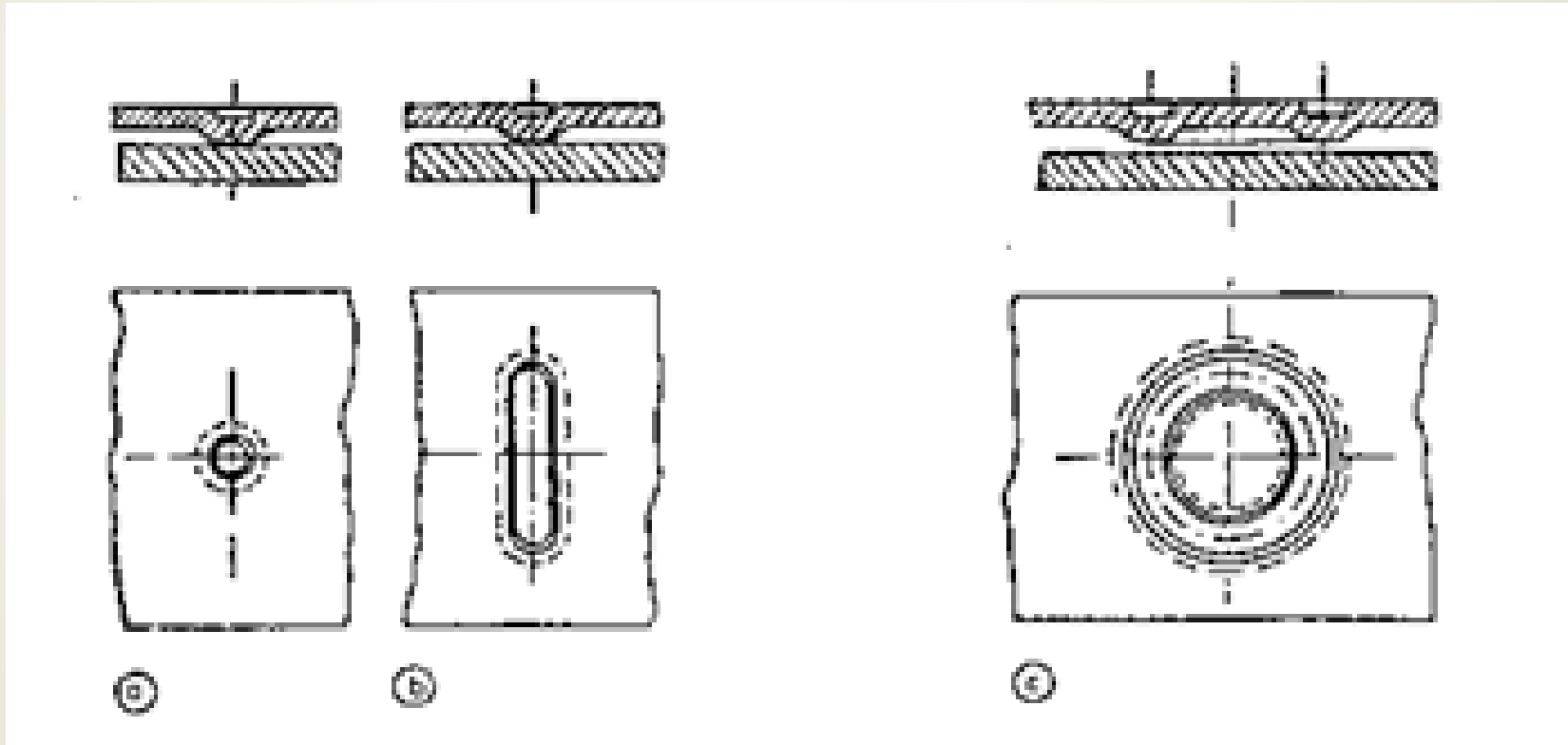


Welding parameters

- ▶ In the projection welding are the same welding parameters as spot welding: contact force F , the welding current I and the welding time t .
- ▶ We can also use a hard or soft welding mode.
- ▶ Process program parameters (welding cycle) is similar to that in spot welding.



Types of welded joints made by lug





Pressure butt welding



The principle of the contact pressure welding

- ▶ The contact pressure welding process is a resistance welding process in which welding of parts (usually wires or bars) are pressed together the end faces.
- ▶ At passing electrical current preferentially heats the contact area of both end surfaces, since this point is the greatest electrical resistance.
- ▶ Because to frequent the great length are welded components oriented horizontally.
- ▶ Current is supplied to the panel by means of jaws which not only have the function of electrodes, but also mechanically clamped components and to prevent their slippage draw welding (pressing) forces.
- ▶ When pressing the welded materials and the passage of the welding current reaches a temperature near the melting point.
- ▶ Highly the heated plastic material is extruded from the weld part and produce flash.
- ▶ It follows that the panels during welding contracts.
- ▶ After off welding power, cooling and solidification of the material creates a diffusion weld joint.
- ▶ Only it may be canceled welding power.



Welding parameters for butt welding

- ▶ Welding parameters are the same as spot welding and the projection:
 - ▶ Thrust force F ,
 - ▶ Welding current I
 - ▶ Welding time t .
- ▶ We can also use a hard or soft welding mode.
- ▶ At welding two different materials is an important quality material balance resistors R_m .
- ▶ Enlargement more conductive resistance of the material is performed a plurality of jaws sliding material compared to the material of inferior conductivity.
- ▶ That to ensure thermal equilibrium.



Contact deposition welding



Principle butt extinguishing welding

- Contact deposition welding a similar principle as a pressure butt welding.
- Welded panel before pressing connected to the welding transformer is energized.
- Used low voltage (3 V to 5 V) in order to avoid arcing.
- Elements then they begin to approach each other at very low speeds (on the order of 1 mm.s^{-1}) touch at one or more locations.
- Touching incurred by current bridges.
- Because compressive force is minimal (approaching zero), the contact resistance between the components is extremely large, and the current flow will be small.
- Material the ground contact portion sharply melted and the molten metal splashes.



Principle butt extinguishing welding

- Splashes of liquid metal, and metal vapour expanding the coextruded weld the heated air and protect the weld area from oxidation.
- In the former site of a bridge crater filled with metal melt and disrupting current bridge a gap between the panels.
- Elements they are getting closer, so that then creates new contacts, new jet bridges and the whole process is repeated until the molten metal craters not cover the whole area on the faces of the parts to be welded by a continuous layer of the metal melt.
- Then followed by a second phase - compression.
- Elements each other under the force increased strongly compressed and then current is switched off.
- Molten metal two end faces for interaction forces create a weld.
- Together the high portion of the hot material displaces and creates a weld flash.



Welding parameters butt welding odtavujícího

- ▶ In the butt extinguishing welding uses the following welding parameters:
 - ▶ Welding current I (during deposition rate drops to below $25 \text{ A}\cdot\text{mm}^{-2}$)
 - ▶ The compression force F (in phase deposition rate is minimized to increase the compression phase)
 - ▶ Deposition speed (about $0.25 \text{ mm}\cdot\text{s}^{-1}$ for large to $6 \text{ mm}\cdot\text{s}^{-1}$ Small sections)
 - ▶ Length l_0 deposition rate (in the range 0.2 to 0.5 of the diameter D or 2-5 x developed thickness).

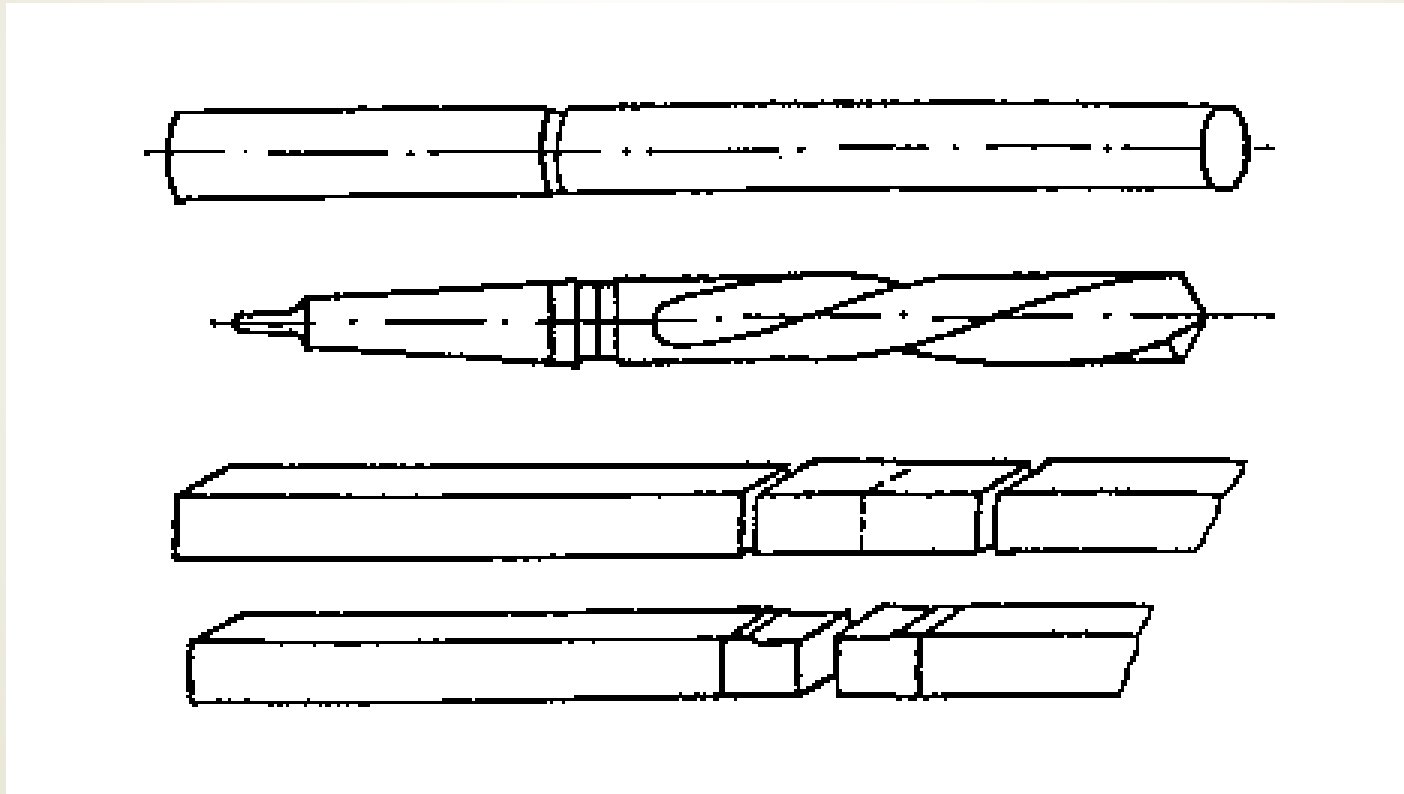


Welding parameters butt welding odtavujícího

- In some cases, using the contact deposition welding preheating.
- Preheating is effected by intermittent faults.
- Elements repeatedly pressed against each other and recede (ie. Reversing preheating).
- At each contact is heated, but also partially melts.
- Preheating assists during deposition phase (reduced power) and prevent possible quenching.



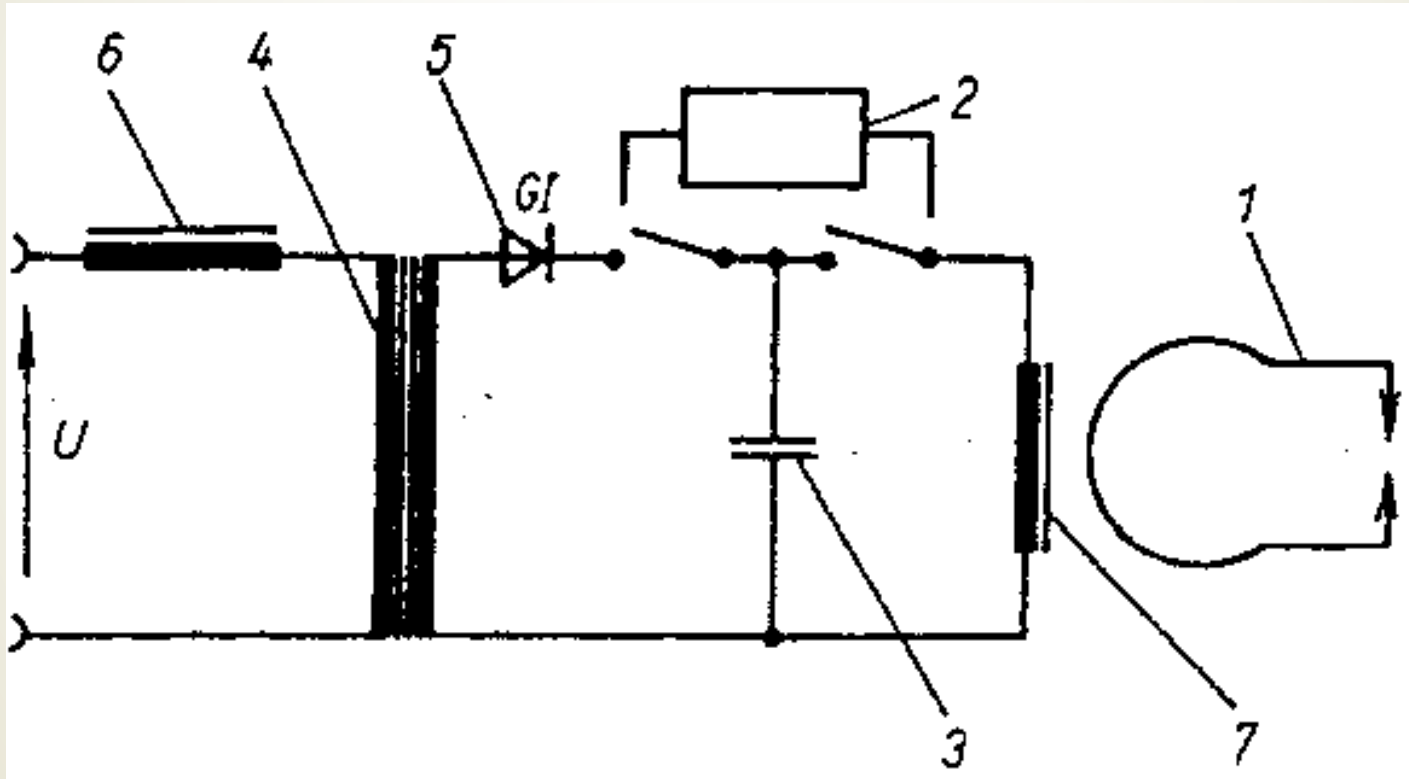
Types and shapes of joints



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Resistance welding Capacitor



Wiring diagram
Capacitor welding
1 - welding circuit;
2 - cycle
management;
3 - capacitor bank;
4 - high voltage
transformer;
5 - rectifier;
6 - choke;
7 - pulse transformer

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Resistance welding capacitor

- ▶ This technology capacitor bank ultra pulse welding charges stabilized voltage to provide power to a constant size.
- ▶ Performance supplied to the weld is large, it is a welding current surges with the current size of 10 kA 250 kA after a very short time of 1 m / s to 10 m / s, with precise control of heat generation in connection with precisely controlled pressing force.
- ▶ This during the welding process, with a large concentration of energy, short welding time work to create a very narrow heat-affected zone and minimal distortion and leads to a connection part with minimal melting, which is the reason that there is no mixing of materials and metallurgical changes.



Resistance welding capacitor

- ▶ Using this method is useful for bonding small, molding parts produced in precision mechanics, in serial and mass production.
- ▶ After the material can be used for this method of joining non-ferrous metals and combinations thereof and in combination with steel.
- ▶ Welding is performed either on the principle of spot welding, or the projection welding press.



Questions to ponder

1. What are the advantages of resistance welding?
2. What is the principle of resistance welding?
3. What are the main ways of resistance welding?
4. What is it soft and hard mode for resistance welding?
5. What are the welding parameters for resistance welding?
6. Describe the work spot welding.
7. Which uses a seam welding?
8. What is the principle of work by butt welding with melting off?
9. Which uses the pressure resistance butt welding?



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.
- ▶ BERNASOVÁ, E. A KOL. *Svařování*. Praha: SNTL, 1987. ISBN 04-221-88.
- ▶ 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.