



Co-funded by the  
Erasmus+ Programme  
of the European Union



Erasmus+

# MODULE I

## The power source for electric arc welding

Energy sources for arc welding



## Introduction to welding power sources for arc welding

- ▶ Electric arc welding is among the fusion welding technology, which use the heat of the arc.
- ▶ Large heat is concentrated in a small area, it is possible to quickly melt the weld surfaces and filler material to melt.
- ▶ Power sources supply the energy that is needed to ignite and arcing.



# Requirements for welding power sources

- ▶ On power sources for arc welding are subject to the following requirements:
  - ▶ Good arc ignition, stable arc,
  - ▶ Smooth and fine regulation of the welding current, voltage and possibly by a welding stable performance and high efficiency.
  - ▶ Open circuit voltage must correspond to the type of current and the welding process and should not be higher than the permissible values,
  - ▶ Static characteristics must match the welding process.
  - ▶ Must be resistant to momentary short circuit at the short circuit metal transfer from the electrode,
  - ▶ Dynamic characteristics must ensure a rapid increase after a short circuit welding voltage,
  - ▶ High operational reliability, ease of fault detection and rapid elimination.
  - ▶ Reasonable cost and low operating costs.
  - ▶ Structure must ensure the safety of operations in compliance with applicable standards and regulations.
  - ▶ Simple and easy operation.

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. s. 42.



## Requirements for welding power sources

- ▶ Arc welding power sources must meet the requirements of welding technology and safety regulations.
- ▶ Welding resources are built nominal supply voltage phase (230 V 50 Hz) or the line voltage (400 V 50 Hz) optionally voltage three-phase (3 x 400 V 50 Hz) mains.



## Welding resources

- ▶ Open circuit voltage of arc welding power sources must environments without increasing the risk of electric shock comply with the following requirements:
  - ▶ At DC welding power sources may be the peak value of the open circuit voltage up to 113 V,
  - ▶ At sources of alternating welding current can be the peak value of the maximum load voltage 113 V and the effective value of voltage of maximum 80 V

KUBICEK, J. DANEK, L. KANDUSB. *Welding technology and equipment. Textbooks courses for welding engineers and technologists.* Plzeň: ŠKODA WELDING sro, 2011. p. 42.



# Distribution of welding power sources

- ▶ Power sources for arc welding are divided according to:
  1. method of energy conversion:
    - ▶ rotational power (welding dynamo)
    - ▶ sources of static, non-rotating (welding transformers, rectifiers, converters)
  2. kind of supply current at:
    - ▶ DC power source (welding dynamo)
    - ▶ rectified current source (welding rectifiers, inverters)
    - ▶ AC power source (welding transformers)

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. s. 42.



# Distribution of welding power sources

- ▶ Power sources static (non-rotating) is divided into:
  1. Supply a power transformer
    - ▶ AC source: welding transformers
    - ▶ Rectified current source
      - ▶ Welding rectifier uncontrolled
      - ▶ Welding controlled rectifier
  2. Supply without mains transformer
    - ▶ Welding converters (inverters)

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. s. 42.



# Basic technical parameters of welding power sources

- ▶ Static characteristics
  - ▶ Static characteristic welding power source is the curve of the operating voltage source welding current at steady state and a certain degree setting regulatory resources.

KUBICEK, J. DANEK, L. KANDUSB. *Welding technology and equipment. Textbooks courses for welding engineers and technologists.* Plzeň: ŠKODA WELDING sro, 2011. s. 43rd





## static characteristics

- ▶ The values of the characteristics are obtained by measuring voltage and current in the electric circuit of the welding current, which is connected to the control device.
- ▶ State and idle state briefly - these are the two extreme points of static characteristics.
- ▶ At Idle state welding circuit no current flows and the voltage source is usually highest - open circuit voltage.
- ▶ with increasing current load voltage on the power decreases.
- ▶ Electrode is in contact with the materials to be welded - briefly state, i.e., the highest current flows through the circuit so. short circuit.
- ▶ According to the course of the static characteristics in the vicinity of working point, i.e., by the steepness of the characteristics are determined by the characteristics of welding power sources:

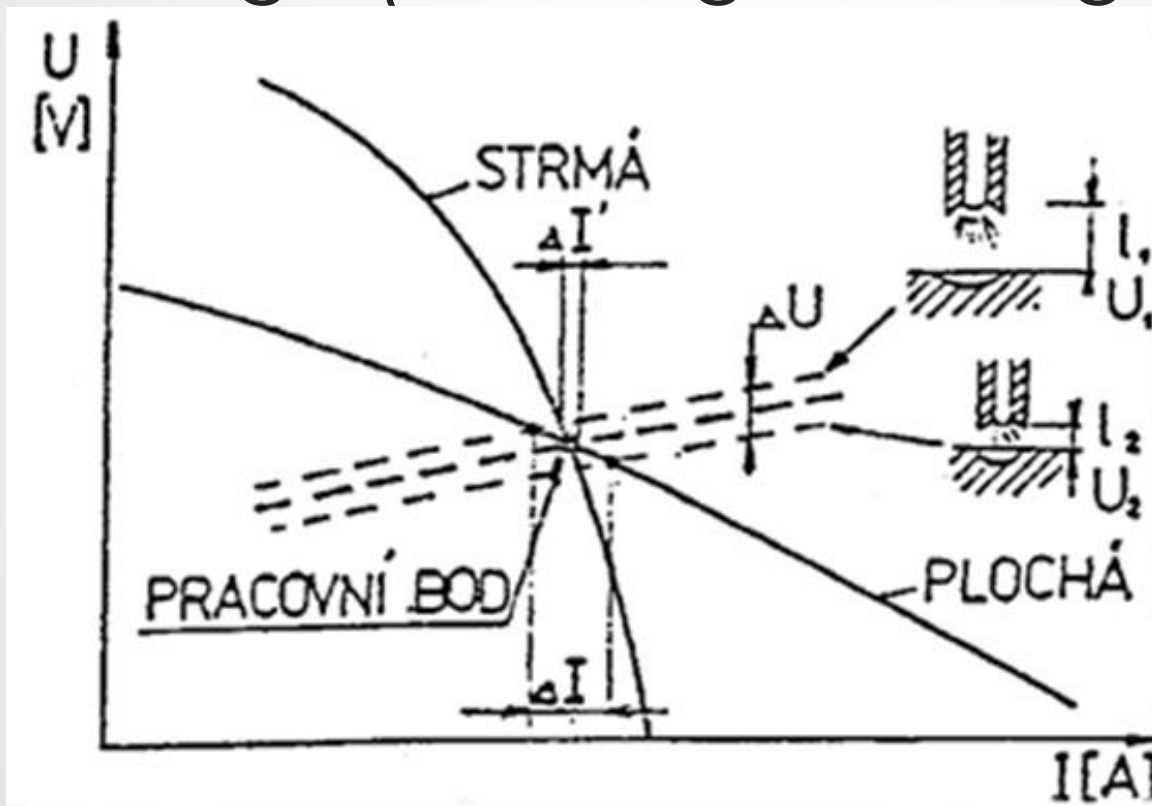


# Properties welding power sources

- Sources with constant voltage (ie. solid sources) - Small changes in voltage, flat characteristics,
- Source of constant current (ie. soft power) - Small changes in current steep characteristic,
- Constant power sources have increasing welding current when the voltage drop at the source such that their product  $U \cdot I$  times (power) can be regarded as constant, the derating curve slightly downward (polostrmou).



Influence of flat and steep characteristics to power fluctuations caused change arc voltage (arc length change)



AMBROŽ, O. A KOL. *Technologie svařování a zařízení: učební texty pro kurzy svářečských inženýrů a technologů*. Ostrava: ZEROSS, 2001. s. 91.



## Power sources

- Some power sources have the ability to switch the tendency of static load characteristics.
- Characteristics can be switched stepwise or continuously and welding power sources usually have a whole set of static load characteristics.
- Normalized the arc voltage is the adjusted position of the operating point of the load characteristics determined as the intersection of this line with the characteristics of standard working voltage ( $U_p = f(L_2)$ ).
- Position the operating point is given by the intersection of the selected static load characteristics of the source of current-voltage characteristic curve.



## Power sources

- ▶ For manual arc welding power source is suitable for the steep static characteristic where steepness large load characteristics of sources around the operating point provides a relatively large voltage fluctuations on the arc (when changing the length of the arc), slight changes in the welding current.
- ▶ In should the slope reached  $90^\circ$  (static characteristic around the operating point is perpendicular to the current), then the variation in the arc length when the welding current value is not changed.
- ▶ Length arc, which directly affects the arc voltage can be varied e.g. as a result of turbulent line electrodes or due to surface unevenness of the material.

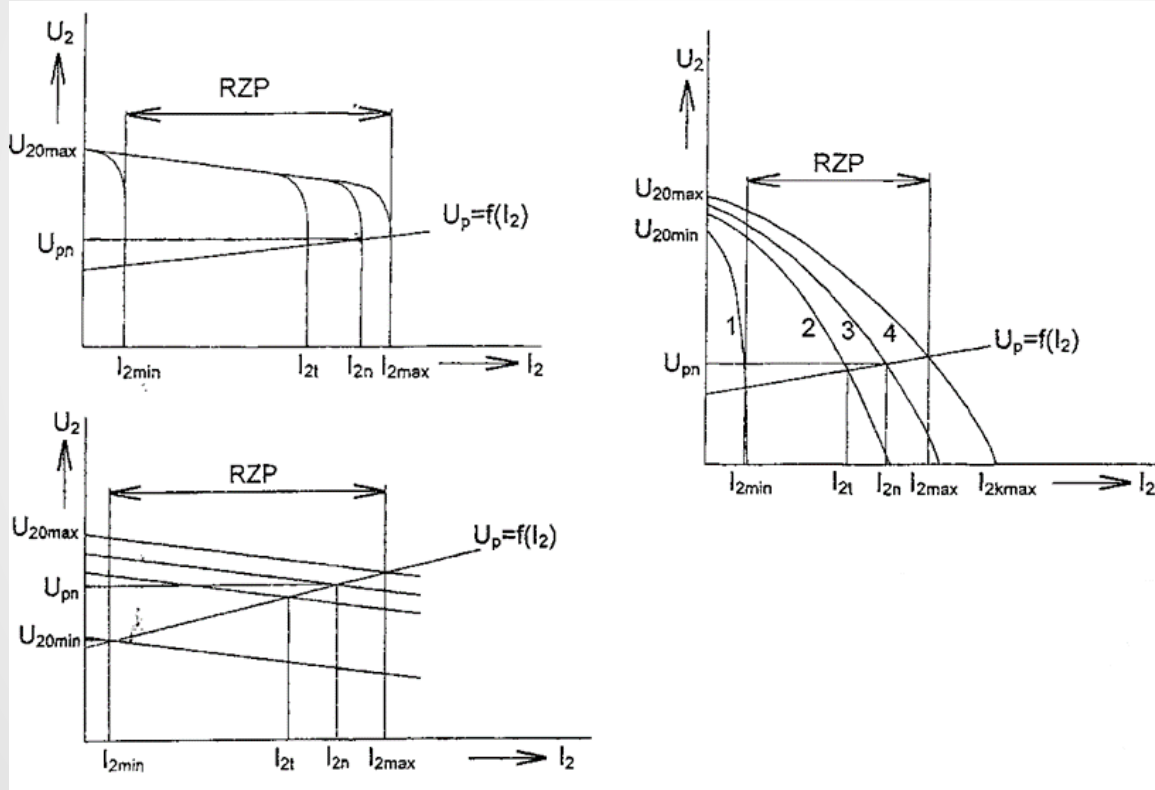


## Power sources

- ▶ A flat characteristic is used for the automatic submerged arc welding.
- ▶ Set arc length remains unchanged when the feed speed of the electrode (wire) is the same as the rate of deposition rate.
- ▶ Speed melting of the electrode depends on the size of the welding current.
- ▶ Shift the wire to the torch (the electrode feed rate) is constant.
- ▶ In if for some reason there is e.g. to shorten the arc length and consequently to reduce the arc voltage, then the flat load characteristic of the source will increase the welding current, thereby increasing deposition the speed of the electrode.
- ▶ Length Arc is gradually increased to the originally set value.
- ▶ This called. Flat self-regulating function of the load characteristics it is effective even in the opposite case, when there is a increase in the length of the arc.



# Characteristics of welding power sources



Characteristics resources  
 steep, polostrmé and flat  
 $AT_{pn}$  - standard operating  
 voltage  
 $AND_{2n}$  - Normalized  
 operating current  
 $AND_{2t}$  - permanent  
 operating current  
 PLA - Load current range



## Working point

- The position of the operating point is determined by the intersection of the selected static load characteristics of the source of current-voltage characteristics of the appliance (arc).
- Good quality welded joint is subject to arc stability.
- Stability arcing during welding depends on the welding technology as well as the characteristics of power sources.
- On comparing the slope load characteristics of sources and volt-ampere characteristics of arc welding arc stability expressed as the difference between the slope of the load characteristics of the source and the steepness of the current-voltage characteristic curve at the intersection of these two characteristics were still in the operating point.





# Dynamic characteristics

- ▶ Dynamic characteristics of the welding power source indicates the transient voltage and current values during fast changes during welding (e.g. arc ignition, short circuit, short-circuit interruption and the like.).
- ▶ For power sources are important dynamic characteristics that depict the time dependence of current and voltage at a cycle of "load - short - no-load" or "load - short - Load", and having regard to the steepness of the initial current and expressed in  $\text{kA.s}^{-1}$ .
- ▶ For optimum process must be dynamic slope in a very specific range, the particular short-circuit process is very sensitive to the slope of dynamic compliance.
- ▶ At short circuit (drip) transferring the material to load the welding source is changing very rapidly due to the arc-borne droplets from the electrode to weld metal bath.
- ▶ Every drop causes a short circuit when the voltage drops almost to zero and the current value increases through the transition to a steady value of short circuit current (short circuit current).
- ▶ After circuit voltage rises over the transition value to a steady value, which is proportional to the arc length and the current drops to a value of welding current.



## Input and output parameters

- Each welding power source is characterized by the following basic information:
  - Input data (conditions for connection to mains power)
  - Output information (welding properties resources)



# Input data

- ▶ Rated Input (supply) voltage - 230 V phase voltage or line voltage of 400 V or single grid voltage 3 x 400 V three-phase distribution network
- ▶ Nominal frequency - 50 Hz
- ▶ Rated input power - power source at nominal input voltage and rated output current welding
- ▶ Maximum input power - power source at nominal input voltage and maximum output current welding
- ▶ Network protection - value and type of network policies
- ▶  $\cos \varphi$  - the phase shift between voltage and current

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. s. 45.



# Output data

- ▶ Open circuit voltage - the voltage at the terminals of the power source when unlit arc. For security reasons restricts the size of the open circuit voltage.
- ▶ Working voltage - the voltage between the electrode and the work piece. The size of the operating voltage depends on the characteristics of the power source (welding current value), the second electrode, the arc length and other factors.
- ▶ Welding current - output current from the power source.
- ▶ Load factor DZ (relative load time) - the ratio of load welding power sources ( $T_{with}$ ) Intermittent load to the total length of the working cycle (loading time  $T_{with}$  + Pause time  $t_o$ ).  $DZ = T_{with} / (T_{with} + t_o) \times 100$  [%]
- ▶ Rated welding current - current that can be drawn from the power source at rated load factor on which the resource is designed. Unless otherwise specified, assumed to be the nominal load factors  $DZ = 60\%$ .
- ▶ Permanent welding current - the highest current that can power source giving at constant load ( $DZ = 100\%$ ), ie. uninterrupted flow on which the resource is designed.



# Welding currents

- ▶ Most manufacturers of welding power sources indicates a range of welding currents and a range of operating voltages for a load factor DZ.
  - ▶ Rated welding performance - the performance of the power source at nominal welding current and rated operational voltage
  - ▶ The lamp efficacy = nominal welding current / rated lamp wattage x100 [%]
- ▶ Normalized cycle manual welding is used for welding with load intermittent duty cycle = 60%, and the total length of the working cycle of 5 minutes (or 10 minutes).
- ▶ When the length of the working cycle time is 5 minutes welding  $T_{\text{with}} = 3$  minutes and the pause time  $t_o = 2$  minutes; when the length of the working cycle time is 10 minutes welding  $T_{\text{with}} = 6$  min and pause time  $t_o = 4$  minutes.



# The characteristics of the various types of welding power sources

- Rotary welding resources
- Welding transformers



## Rotating power sources

- ▶ Rotating power sources generate DC current.
- ▶ Usually they are formed by welding dynamo which is driven either by an electric motor often three-phase asynchronous motor or a combustion petrol or diesel, where available electricity network.



# Rotating power sources

- ▶ Welding dynamo and motor together form a single component on a common chassis - welding unit.
- ▶ Welding dynamo has a static characteristic steep, gives a soft arc suitable for manual welding with coated electrodes and for TIG possibly MIG / MAG.
- ▶ Regulation welding current within the control range is smooth and provides the change of the magnetic field excitation of the stator of the dynamo.
- ▶ Regulator for adjusting the welding current can be located either directly on the welding unit, or outside in the remote power source.
- ▶ Electric stream is produced at the welding dynamo induction in the conductors of the armature (rotor) rotating electromagnetic field in the stator windings.

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. s. 47.





## Rotating power sources

- ▶ Rotating power sources do not meet the current criteria of economic efficiency and the required quality of the weld joint.
- ▶ They are very hard, the noise level exceeds permitted limits, have high power consumption, another drawback is that their huge fan whirls the dust around the power source.
- ▶ At they previously made and used rotary power sources under the trademark TRIODYN.



# Welding transformers

- ▶ Welding transformer for arc welding is usually a one-time source of AC power.
- ▶ Each transformer comprises a ferrous core (in the shape of a frame, rings, etc.) consisting of thin steel sheet (in the chem. composition is 8% to 10% Si), primary and secondary coils, wherein the windings of the two coils are isolated from Cu or Al wires (wires of circular, square or rectangular).
- ▶ At welding transformer primary winding is connected to the network, but directly into the secondary circuit of the welding. AC mains flowing through the windings of the primary coil induces an alternating electromagnetic field extending predominantly iron core (magnetic circuit) of the transformer.



# Welding transformers

- Consequently, there is on the principle of electromagnetic induction in the coil winding of the secondary alternating voltage after arc welding produces a closed circuit formation of secondary (welding) current.
- Regulation welding current can be stepped or continuous.



# Welding transformers

- Static load characteristic is slightly decreasing (polostrmá).
- Welding transformers are generally suitable for manual welding with coated electrodes, possibly also for the TIG method with which in particular to improve the arc stability is used as a source of high frequency ionizer high voltage pulse connected either in parallel or in series with the secondary winding of the transformer.
- In compared with rotary welding power source has a welding transformers low power during idle, improved efficacy (85% to 97%), but the power factor is relatively small (0.5 to 0.7).
- Power three-phase electric grid welding transformer burden unevenly because, when welding burden one or two phases, depending on whether the input supply voltage phase (230 V 50 Hz) or combined (400 V 50 Hz).

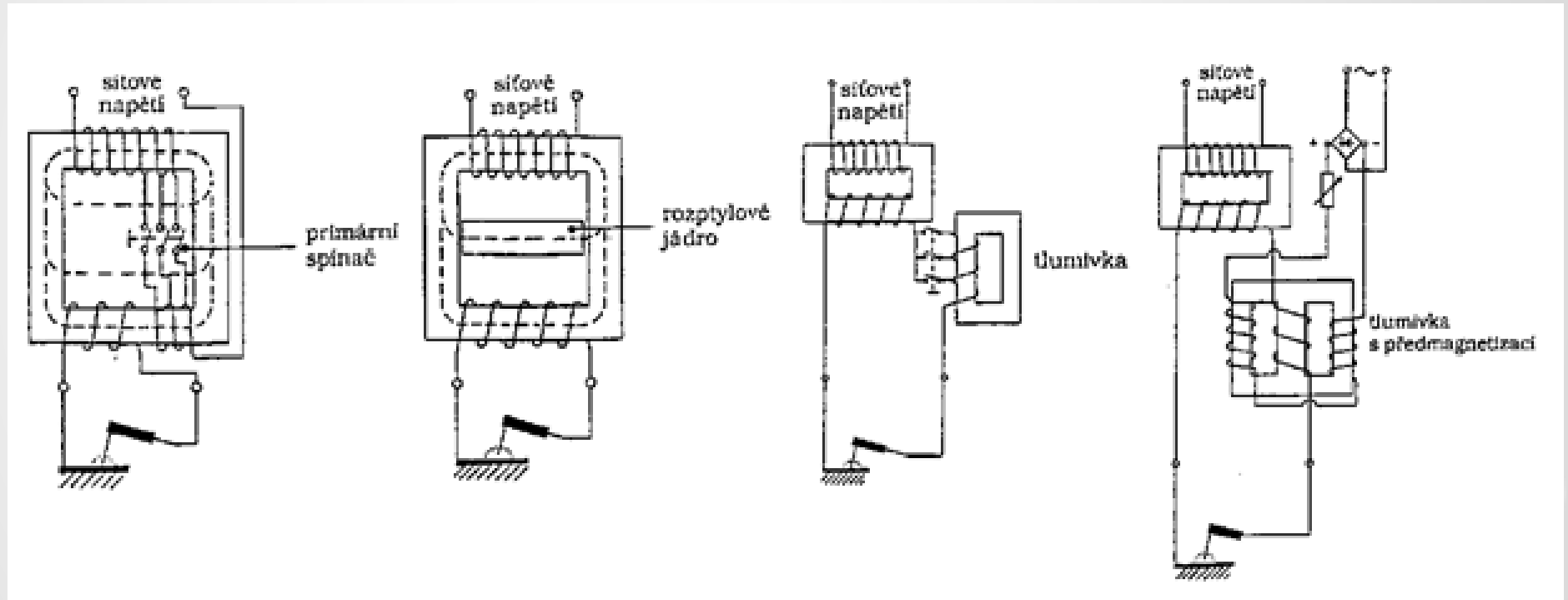


# Welding current regulation

- ▶ Control of the welding current is dependent on the construction of the transformer is carried out eg .:
  - a) By varying the number of turns in the primary winding
    - ▶ The welding current varies stepwise (and inversely proportional voltage) based on the switching implemented by changing the number of turns on the primary winding and thus the gear changing transformer.
  - b) Slide or swiveling diffusing core
    - ▶ The welding current varies continuously according to the changes in core position (located between the primary and secondary windings), which determines the proportion of the magnetic flux blocking flow passing through the core to the secondary coil windings.
  - c) Choke with control switch
    - ▶ Welding current (and also the steepness of static characteristics) varies stepwise according to the number of involved switch of windings of inductors connected in series with the secondary winding of the transformer. If the choke small number of windings, the static characteristic is steep. At increasing the number of turns becomes a characteristic step.
  - d) Regulatory choke with bias (Transducer)
    - ▶ Welding current (a static characteristic) varies continuously changing reactance choke in response to changes in DC premagnetising core chokes. small premagnetising choke means high inductance and reactance chokes and thus low welding current at large bias choke inductance and its reactance is low and the welding current is high.
  - e) Relative motion of the primary and secondary windings facing each other
    - ▶ The size and slope of the welding current static characteristics are influenced by the degree of tightness of binding on the basis of mutual inductance winding two coils.



# Welding transformers



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. s. 48.



# Welding rectifiers

- Welding rectifier is DC source (rectified) current.
- Consisting from the mains transformer and associated rectifier elements connected in the secondary circuit of the transformer.
- Transformer It is either a single phase or three phase.
- Rectifier elements consist of semiconductor silicon diodes and thyristors used in disposable welding power sources in the two way bridge rectifier (i.e. Graetz wiring) or three-phase welding power sources in the engagement six-way bridge rectifier.
- Output voltage rectified by the rectifier lump is relatively large, the ripple frequency is twice the mains frequency.



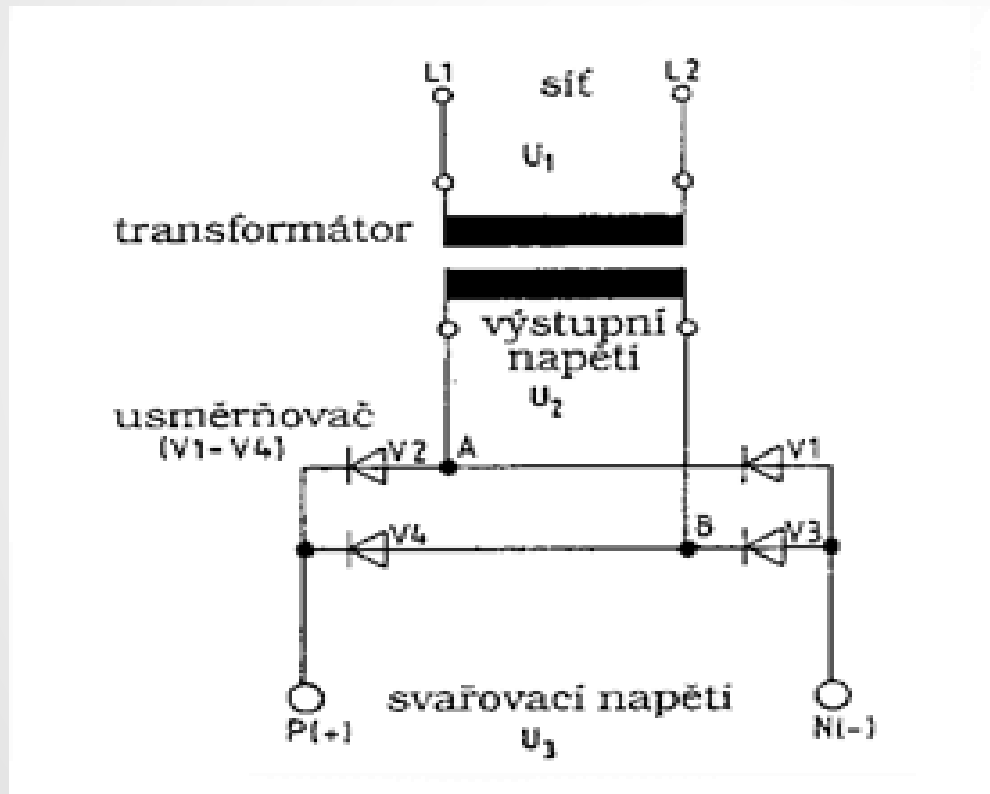
# Welding rectifiers

- At three-phase rectifier ripple rectified voltage is lower.
- Three-phase welding rectifier is suitable for high current loads, has good welding properties and compared to a single welding rectifier utility power supply network loads symmetrically.
- Transformer allows welding to use both direct and alternating current.
- Welding rectifier compared with rotary welding power sources exhibit lower losses during idling, i. lower energy consumption, reduced noise, higher efficiency (average 80%), the relatively low weight and good welding properties. Welding rectifiers have very good dynamic characteristics, it is particularly apparent in the rapid changes of voltage and current.





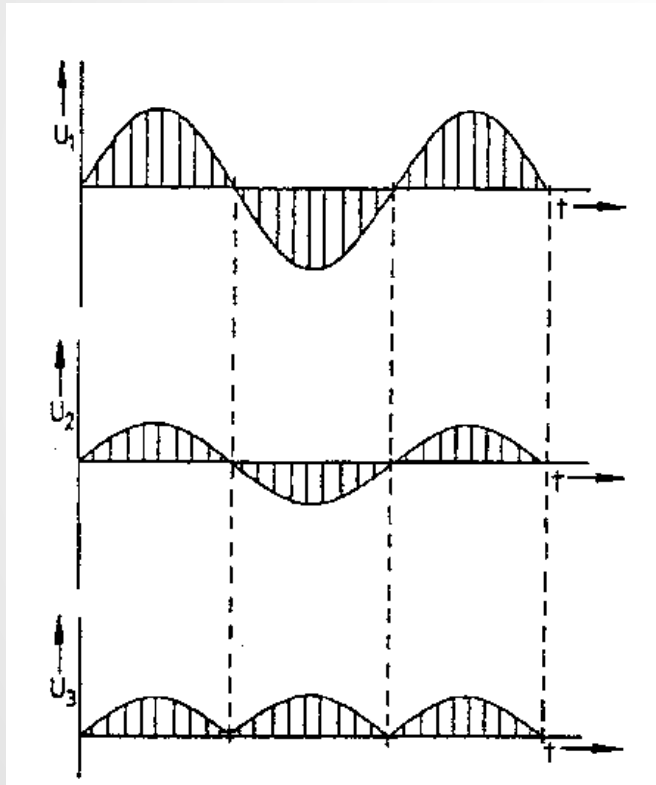
# Phase rectifier



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. s. 49.



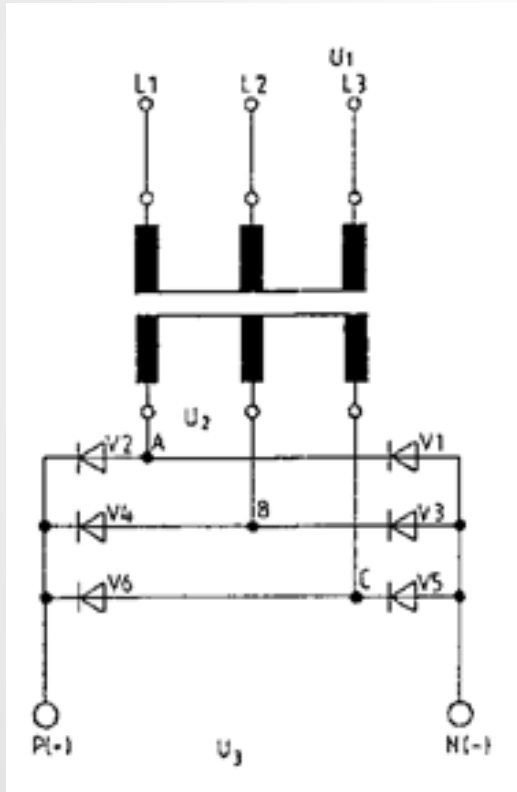
# Phase rectifier



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. s. 49.



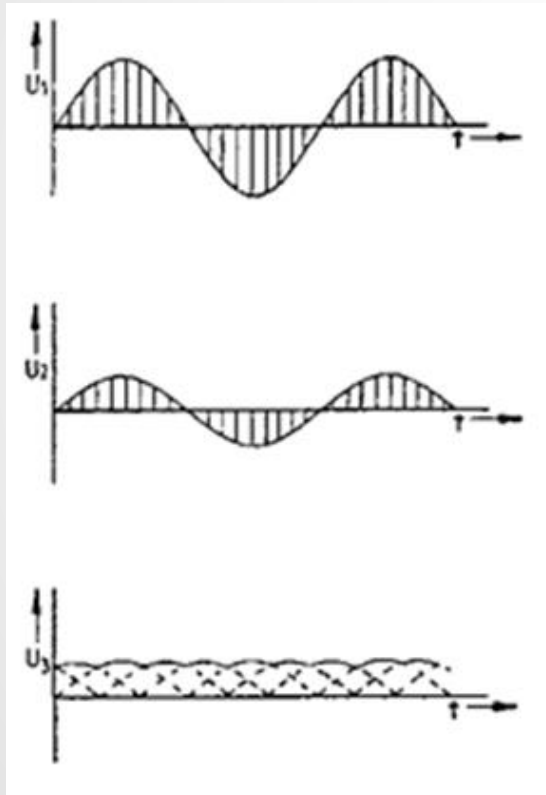
# The three-phase rectifier



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. s. 49.



# The three-phase rectifier



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. s. 49.



## Phase rectifier

- ▶ Control of the welding current and setting appropriate load characteristics at welding rectifier performs e.g. via regulating inductors (transducer) thyristor control, analog control transistor or control the clocked transistor.



# Welding rectifier with choke control

- ▶ Control of welding current settings and load static characteristics on the same principle as the power source, where the change in reactance inductors (transducer) DC bias ferromagnetic core.
- ▶ For transducer directs the flow of uncontrolled rectifying valves - diodes. This control is used for both single and three-phase welding rectifier.
- ▶ Can achieve the desired static characteristics of the power source needed for various welding methods by steep load characteristics of sources for manual electrode welding and TIG welding to a flat load characteristics of sources eg. for automatic welding technology MIG, MAG.
- ▶ Advantage This power source is of relatively simple construction and hence low failure rate and good efficiency (80%).
- ▶ disadvantage the relatively large size and weight, poor dynamic properties and unfavorable power factor.

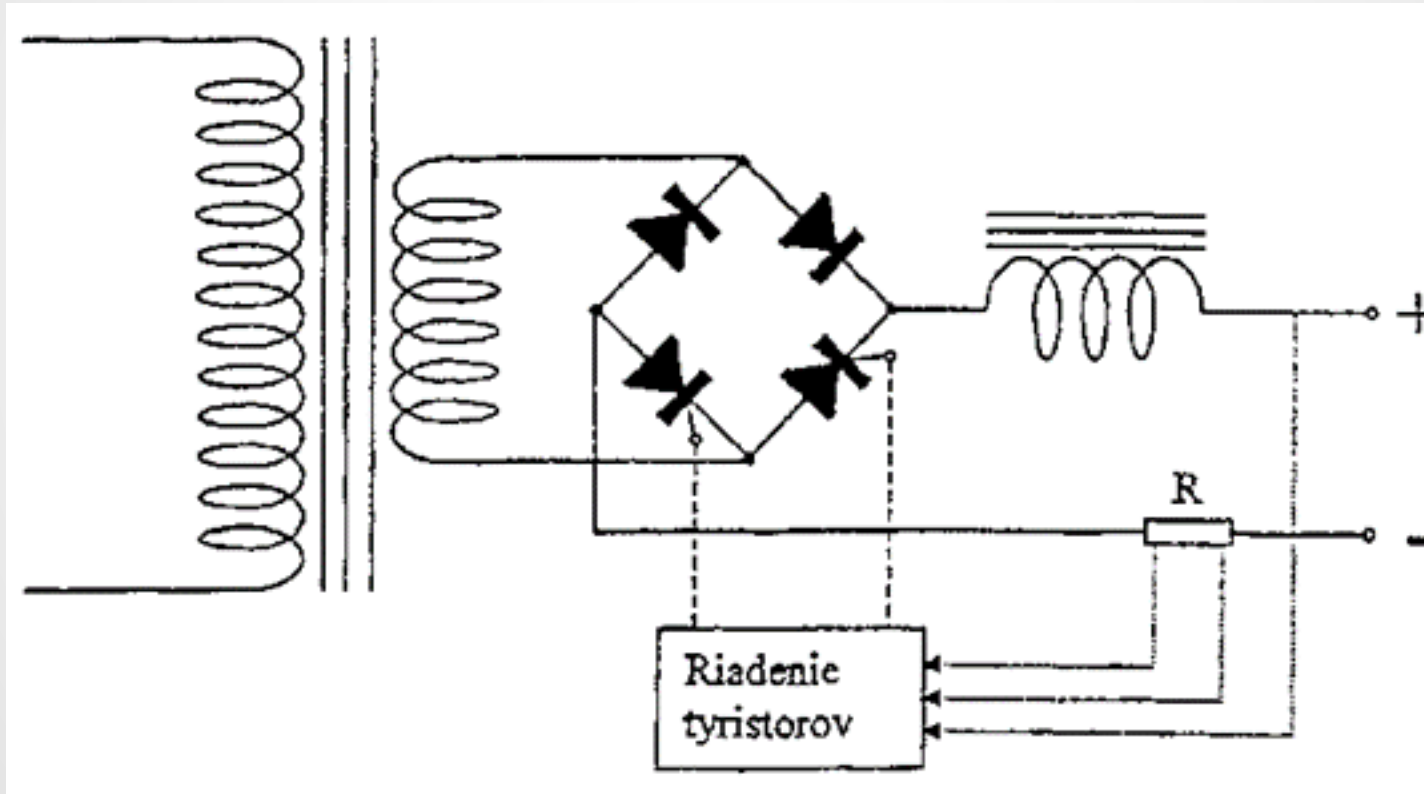


# Welding rectifier with thyristor management

- ▶ Adjust the intensity of the welding current is performed by using phase control thyristors, the welding current is modulated mains frequency.
- ▶ Thyristor usually in a bridge circuit, connected to the secondary side of power transformer having functions controlled rectifier valves.
- ▶ Moment supplying control pulses to the thyristors affects the amount of current or power transmitted by the thyristor.
- ▶ That is regulated only a certain part of the stream, which is further smoothed choke.
- ▶ Welding source with thyristor control process allow to realize pulse with a frequency corresponding to the grid frequency.
- ▶ Directional An electronic control unit thyristor is completed feedback allows programming of welding parameters and their maintenance.
- ▶ Efficiency these welding sources is very good (80% to 90%).
- ▶ Dynamic properties are somewhat inferior due to the use of relatively large smoothing reactor, which manifests itself particularly when short-circuit arc.



# Shift pattern thyristors



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. s. 50.





# Welding rectifier with analogue control

- ▶ The assembly of the power source forms a mains transformer with a rectifier semiconductor diodes in a bridge circuit and a smoothing capacitor stage analog control transistor in the function of a variable electrical resistance in the welding current circuit.
- ▶ Feedback Welding current regulator controls the smooth opening and closing of the transistor grade based on continuous comparison of set and actual values of voltage and current during welding.
- ▶ This control method is very effective due to the fact that the semiconductor elements on the secondary side of the transformer means. a transistor stage, react very rapidly to control signals and hence possible to change the output power according to the needs of the welding process.
- ▶ Because the high stability of arc welding and virtually spatter-free welding power sources are suitable for use in robotic welding.
- ▶ Some disadvantage remains relatively high weight and large dimensions of the mains using a transformer.



## Welding rectifier with digital control to secondary

- The construction of the power source is also formed from an input power transformer, bridge rectifier uncontrolled type and an adjoining digitally controlled transistor stage in the performance of the semiconductor switch in the welding current circuit.
- Transistor level is periodically switched on and off in the rhythm of the clock frequency (e.g. 20 kHz).
- This periodic switching on and off is known as "stepping."
- Great preferably, the switching transistors is their high switching speed up to a frequency of about 200 kHz.

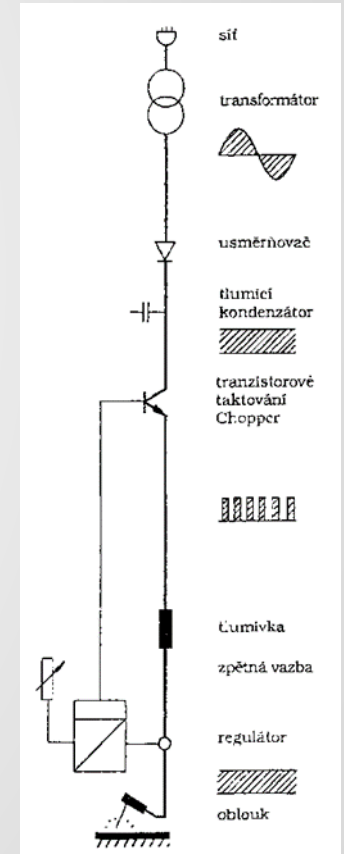
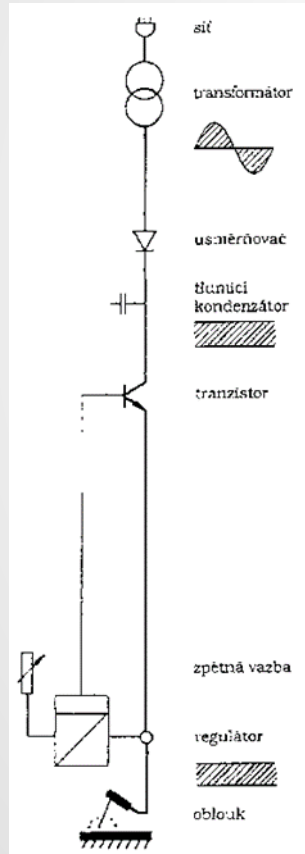


## Welding rectifier with digital control to secondary

- ▶ They character amps quite a small electric power of several watts control the welding power source of e.g. 20 kW (500 amps).
- ▶ Reactor transistor stage for providing energy storage and smoothing the welding current pulse.
- ▶ Feedback regulator supplies the generated clock pulses to the transistor level based on the comparison of set and actual values of the voltage and current.
- ▶ Benefits and disadvantages same as for analog control.
- ▶ For a source with digital control is a characteristic pulse welding process.



# Diagram welding rectifier with analogue and digital control



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. s. 51.



# Welding inverter power source

- ▶ Inverter welding power sources are primarily controlled with the power transistors operate on the principle of medium frequency converters (inverters) with a frequency of 20 kHz to 100 kHz and is currently the most progressive concepts of modern power sources.



# Welding inverter power source

- ▶ The basic feature of inverter transformer source is located in the energy chain beyond the switching transistor.
- ▶ The reason this arrangement is the dependence of the weight and volume of the transformer at the operating frequency.
- ▶ The higher the frequency, the smaller volume and weight. Therefore, these sources of light weight and small size, without a decrease in their performance.
- ▶ Current practically weight not exceeding 0.05 kg / A.
- ▶ Other advantage is the high value of electrical efficiency (90%).
- ▶ That to benefit from high clock frequency, it is necessary first AC line voltage to direct. DC voltage that is available for the primary rectifier, through the transistor switch is converted to high frequency.
- ▶ Output voltage transformer is then subsequently been rectified.



# Welding inverter power source

- ▶ The heart of the device is an electronic control unit that regulates the interactions of functional blocks of the power source with wire feed units and supply of protective gas, controls the correct operation of the device communicates with the operator via the display for setup and control parameters also it acts as a library programs.
- ▶ At larger device, the control system power source also equipped with an output for peripherals issuing a permanent record continuously monitored selected operating parameters (printer, recorder, etc.), or to communicate with an external computer through which you can program special courses of various parameters based on real time.



# Construction of inverter welding power sources gives requirements for:

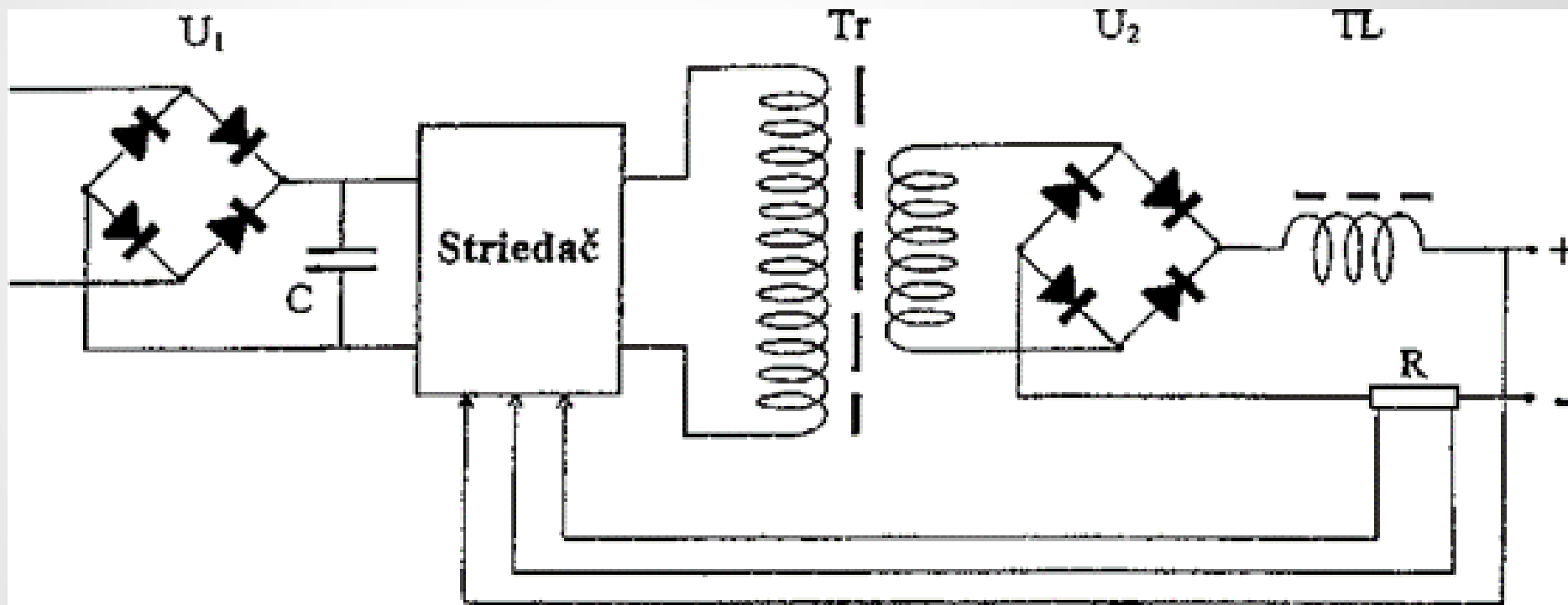
- High and stable welding performance.
- Optimum variously adjustable static characteristic modes MIG, MAG, TIG and MMA,
- Simple and effortless operation,
- Versatility,
- Output option for data processing in the management and quality control,
- The ability to easily communicate with automated and robotized workplace
- High operational reliability, respectively. easy detection of defects and their quick removal.

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. s. 52.





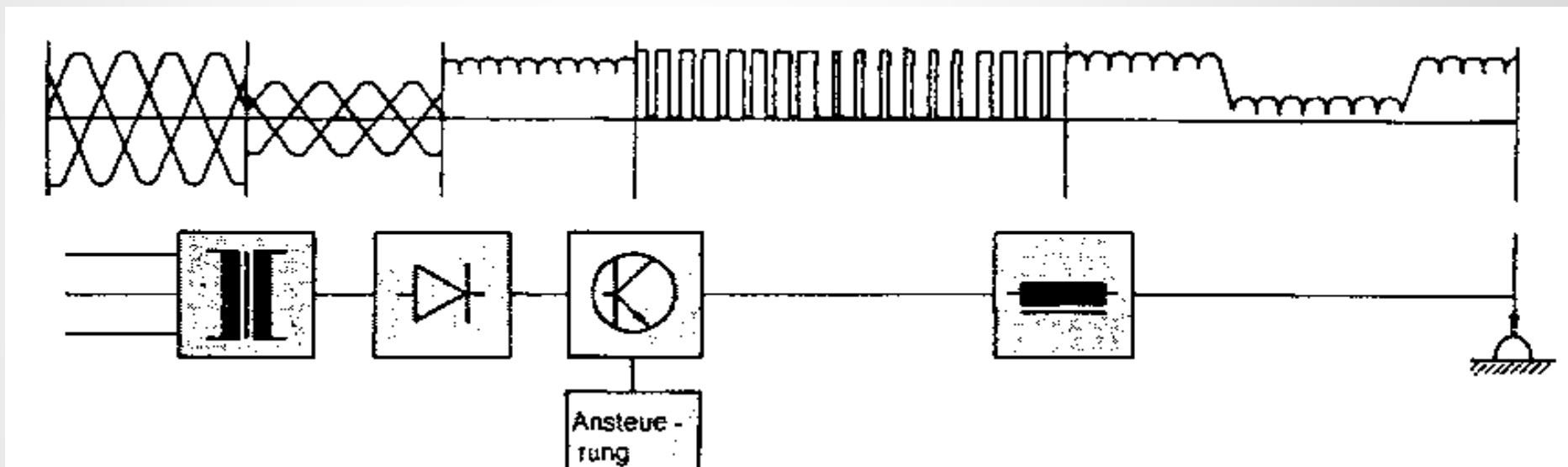
# Wiring diagram of an inverter power



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. s. 52.



# Block diagram and current waveforms inverter power



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. s. 52.



# Digital power source

- An electronic control unit of resources is the result of revolutionary progress in the development of power sources.
- Delivers full digitalization of their systems.
- Use digital signal processors ensures high operating speed, which is necessary for fast data processing.
- That opens new possibilities to influence the welding process via software.
- Outside this increases the accuracy and reproducibility of results obtained welding, because it eliminates the analog semiconductor components, weighted by the temperature drift.



## Digital power source

- Communication between the power source and the peripherals (wire feeder, remote controller, etc.) is effected via a central data bus of the microcomputer.
- All Information transmitted bidirectionally allow subtract or change operating parameters or data not only on its own resources, but also on the wire feeder or directly on the burner.
- Directional microcomputer processes the data with the highest precision and carefully control the critical welding parameters.
- When welding will be 10 000 management and regulatory steps per second, which compares the actual welding parameters are entered and if deviations are immediately corrected by the entered values.
- Together is controlled AC voltage, current gas feed welding wire and other essential functions of the device.



# Welding surge current

- Welding pulse current is based upon a suitable modulation of the output current power source when the current amplitude within the period varies from the level of the basic current (lower level) at the level of pulse current (higher value), the clock pulse frequency is either derived from the mains frequency (multiple of 50 Hz), or is generated independently of the mains frequency.
- Ratio impulse current to the base current can be varied continuously and stepwise optionally also can be altered ratio of pulse width to the gap width of the current period.
- Change current from the base and back to the pulse can be realized jump (rectangular waveform pulse current), or with a certain slope of the leading edge eventually falling edge current (trapezoidal waveform pulsed current).



## Welding surge current

- To allow for controlled sources arbitrarily adjust welding performance in large extent, It is necessary to change the ratio of the ON time (pulse width) for the time off (the gap width).
- This method is known as pulse width modulation.
- Necessary the shape and course of the pulse is also influenced by the ratio of amplitude and pulse base current.
- At the pulse frequency in the range of e.g. 1 Hz to 1000 Hz exists for each material corresponding pulse shape.



## Welding surge current

- ▶ Pulse arc ensures optimum combination of settings (automatic or manual) without short-circuit material transfer with minimal spatter levels.
- ▶ To molten bath of a mercury wire electrode to each pulse, one drop of additional material.
- ▶ Impulse technology allows you to set the whole power range constant droplet size and the rate of melting away.
- ▶ That you can precisely define the speed of the process and the quality of the welds and of course the introduced thermal energy into the material.



# Controlling one parameter - synergic welding mode

- The ideal course of the entire welding process from the approach phase before ignition of the arc after the arc is extinguished and the phase current deposition rate last drop wire is reachable only by a plurality of infinitely variable parameters.
- Adjustment such a large number of parameters by operating the power source very complicated.
- With by so-called. "synergic mode" (one control parameter, e.g. the speed of the auxiliary material), where the preprogrammed parameters for any wire / gas combination, the user can control the entire apparatus totally simple manner.
- Task optimization parameters for a wide range of basic and auxiliary materials and gases assumes the manufacturer of welding equipment.





# Controlling one parameter - synergic welding mode

- These knowledge is stored in a database (called. Library programs) in an electronic memory unit.
- User set directly on the welding power source only wire diameter, shielding gas type and the type of material and embedded microprocessor will take care of smooth power adjustment in its entirety.
- That It is provided to achieve high quality of the welds, productivity and speed the process while significantly simplifying operation and control.
- Incorrect Operation is virtually impossible.
- Moreover, thanks to computer processing of the results of the welding process, given the possibility of monitoring and control of welding parameters.



## Controlling one parameter - synergic welding mode

- ▶ The control system power source also allows the user to create and configure their optimal parameters for welding any case, store them in memory, and if necessary, thus created its own program in a simple way (pressing) again cause.
- ▶ In addition, in some cases, a welder during the welding process according to immediate needs by drivers on the torch handle infinitely adjustable current (edited arc) and thereby change the welding performance eg. In the range of up to  $\pm 50\%$  from the value current welding program.



# Remote control

- Modern electronic systems, welding power sources allow you to control the source of welding process remotely (eg. The automated and robotic applications), check and record the real parameters of individual welds (with the option of archiving and prints waveforms of each parameter) and programming special variations of the various parameters based on real-time .
- Classic remote controls for manual or foot control in a separate covering are interconnected with its own welding supply cables of any length.
- In some cases to increase the comfort of work welder remote control is built into the handle of the torch with the possibility to produce all relevant parameters are set and continuously monitor the display driver.



# Accessories welding power sources

- ▶ Starting equipment
- ▶ Connecting to the electricity source sewing
- ▶ Welding cables
- ▶ Mounts electrode
- ▶ Welding clamps



# Starter equipment

- ▶ In some cases it is appropriate to implement arc ignition without touching the electrode base material.
- ▶ E.g. arc ignition with touch technology can cause WIGalloying weld metal material of the tungsten electrode.
- ▶ Also AC welding, it is desirable to support the re-emergence of the arc when changing polarity.
- ▶ This can be arranged such that the time required for the voltage to between the electrode and the work piece to such a high value that the gas located between the electrode and the work piece occurred avalanche ionization.
- ▶ Such startup process ensures ionizer, which under normal conditions should provide voltage pulses with an amplitude of several thousand volts exceeding the dielectric strength of the medium between the electrodes.
- ▶ Starting ionizer must be after the arc electronically disconnected.
- ▶ Ionizer supporting AC welding is plugged permanently.



# Connection to mains power

- ▶ Every power source is from the perspective of general electrical electrical machine.
- ▶ Therefore has all parts of its construction comply with the relevant electrical standards and regulations, partly technical, but especially security.
- ▶ For our mains single-voltage (230 V 50 Hz) or three-phase voltage (3 x 230/400 V 50 Hz) power sources connected usually flexible cord terminated with the appropriate plug for insertion into the hard power distribution.



## Connection to mains power

- ▶ In some rare cases, large welding power sources, which are permanently and immovably placed at one location within the welding work, they can be a distribution of electric power supply connected fixed.
- ▶ As movable and fixed supply must be correctly sized (both the electrical and mechanical) according to the maximum power source.
- ▶ Solid power distribution in comparison with the movable resp. fixed supply must have the same or larger cross-section of wires and the circuit breaker must be protected by the appropriate size with a slow breaking characteristic.



# Connection to mains power

- The power source is usually judged by electrical standards, such as electrical devices of class I, and must therefore have protective terminal for connection of the protective conductor, which is movable or fixed inlet fitted.
- Protection operation against accidental contact with live parts sources (current leaders parts) is secured by shielding, insulation and additional insulation (using protective equipment) in accordance with the relevant standards.
- Degree coverage for the power source is usually IP 21 to IP 23rd
- Protection operator upon contact with inanimate portions skeletons protection and covers and supporting hardware.
- Apply up working at fault isolation and is usually provided as a protection reset voltage protection or possibly RCD.
- Previously frequently used protective earth is now used very rarely.





# Welding cables

- ▶ Welding cables are single core composite core and the rubber insulation, supplying the welding current from the power source to the electrode holder or the welding torch (gun) and the clamp attached to the welding material welded for closing the circuit (circuit) source.
- ▶ Cross-section core is dimensioned according to the maximum welding current.
- ▶ The maximum length of a welding wire is determined so that the voltage drop at rated load would not exceed 2 V.
- ▶ When longer necessary to use a welding wire than said limit length, its cross section is selected with a higher degree.



# Welding cables





# Connection of welding cables





# Electrode holders

- ▶ Electrode holder for clamping electrodes during welding.
- ▶ Basic these requirements are especially low weight, safety, good handling for the exchange of electrodes and welding positions.
- ▶ Mounts electrodes for manual arc welding are standardized in CSN 05 2250 or DIN EN 60 974-11.
- ▶ Size welding brackets depends on the size of the jaws and the current load.



# Welding electrodes without holder





# Attaching electrodes to the welding holder





## Welding clamps

- ▶ Used together with cable for applying the second polarity of the power source to the weld material.
- ▶ Clamps must be firmly clamped to the least possible resistance.
- ▶ Clamp we place as close as possible to the welding point.
- ▶ Clamps they vary in size depending on the size of the welding current.



# Welding clamps







# Questions to ponder

1. What are the requirements for power sources?
2. What is the distribution of welding power sources by way of energy conversion?
3. What is the distribution of welding power sources by type of supply current?
4. How can ignite the arc?
5. What gives the dynamic characteristics of the power source?
6. Describe static characteristics.
7. What are the input and output parameters of welding power sources?
8. Characterize rotary power sources.
9. The nature of the welding transformer.
10. What this is synergic welding mode?
11. Characterize welding cables and accessories.



## 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.