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MODULE L
Shielded welding

Methods used for welding in protective atmosphere

Methods used for welding in protective atmosphere

- Currently, increasingly relies gas-shielded welding. These methods replace the manual welding with coated electrodes.
- They use especially when mechanization and robotics welding.
- Other great use when welding aluminum tubes and welding equipment for the energy and chemical industries.

The most widely used methods

- TIG - Tungsten inert Gas (German), TIG - Tungsten inert Gas.
- It welding the tungsten electrode in inert gas.
  - MIG - Metal inert Gas. Welding consumable electrode in an inert gas.
  - MAG - Metal inert Gas. Welding consumable electrode active gas.
- The basic principle when shielded welding
- In the methods of welding arc burns in a shielding gas.
- Protective gas prevents the access of atmospheric oxygen and nitrogen in the weld pool and the electrode and the additional material.
- Technology welding in protective gases are different according to

MIG / MAG

- Shielded welding consumable electrode (MIG / MAG) is a steel construction bearing material joining technology.
- Welding MAG is used mainly in welding of unalloyed and low-alloy steels, MIG welding high alloyed steels and non-ferrous metals.
- Source heat welding the electric arc which burns between the base material and the end of the consumable electrode (wire) under an inert gas (argon, helium or a mixture thereof) - MIG or active gas (carbon dioxide, argon-carbon dioxide, argon + nitrogen dioxide + oxygen) - MAG method.

MIG / MAG welding solid wires

- Currently we produced a wide range of equipment for MIG / MAG.
- Welding apparatus may be monofunctional for MIG / MAG welding, or multifunctional, and include methods of TIG and manual electrode welding. The basic equipment needed for MIG / MAG includes the following components:
  - Welding current source with a control unit,
  - Feeder wire electrode,
  - Welding torch,
  - Multifunctional torch cable with quick coupling,
  - Earthing cable with clamp,
  - Protective gas reservoir pressure reducer.

Kubicek, J. DANĚK L. Kandus B. Welding technologies and equipment. Textbooks courses for welding engineers and technologists. Plzeň: ŠKODA WELDING sro, 2011. p. 81.

MIG / MAG welding solid wires

- In depending on performance, complexity, performance and production requirements of today can be a powerful modern facility equipped with the following additional technical features:
  - A cooling unit for cooling the torch and welding cable,
  - Intermediate wire electrodes for welding at great distances,
  - Remote control of welding parameters,
  - A processor control unit for regulation and control of welding parameters in real time and archiving data in a memory unit and database programs welding cycles,
  - Trolley,
  - Arm for supporting a torch cable.

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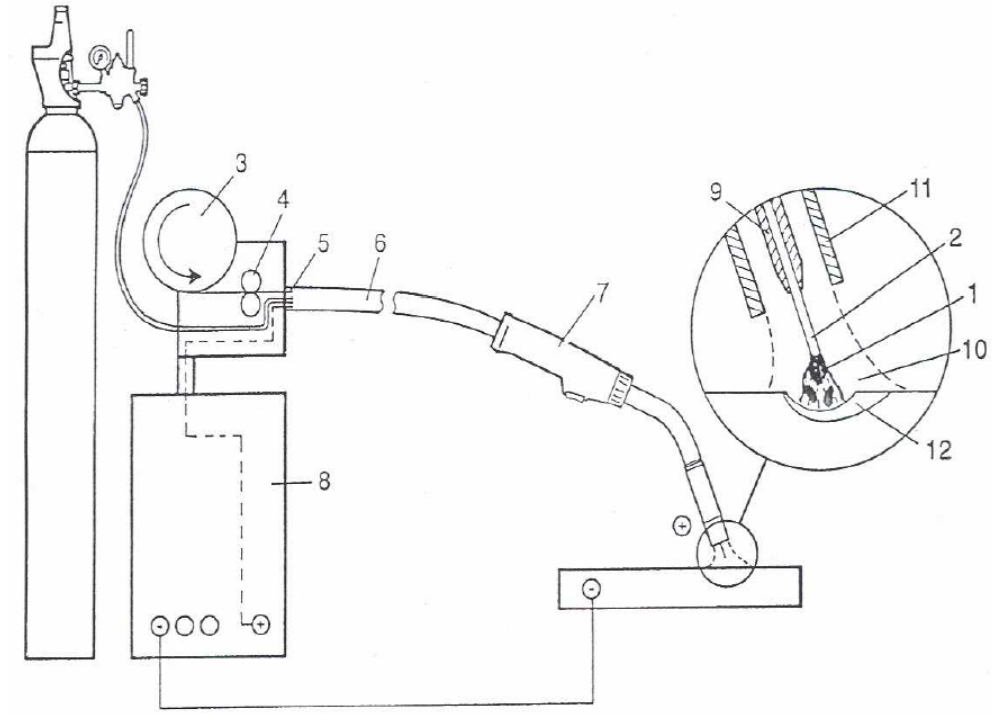
The basic scheme of MIG and MAG



1 electric arc p
2 wire electrode
3 wire magazine
4 feed rollers
5 quick coupler
6 burner panel
7 welding torch
8 source of welding current
9 contact welding die
10 shielding gas
11 gas nozzle
12 welding bath

AMBROŽ, O. A KOL. *Technologie svařování a zařízení: učební texty pro kurzy svářečských inženýrů a technologů*. Ostrava: ZEROSS, 2001. s. 147.

Source for MIG / MAG

- For standard MIG / MAG is used sources dc output current, where the positive pole is connected to the sources of wire electrode.
- New methods can be combined and alternating current character.
- They are cheap classical rectifiers and inverters currently largely different performance characteristics.
- Resources MIG / MAG have a flat static characteristic of the so-called. constant voltage is self-regulating capability of maintaining constant arc length.

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Source for MIG / MAG

- This control is based on a significant change in current with a relatively small change in arc length and thus the arc voltage.
- This the principle of regulation of the arc length is only possible at a constant wire feed speed.
- At change the length of the arc voltage is changed by a movement of the working point on the static characteristics of the current changes.
- At long arc current is reduced and the speed of melting of the electrode and at a constant wire feed speed starts to approach the wire to the weld pool and the arc is thereby reduced.
- Conversely with a short arc and a voltage drop is increased amperage and deposition rate is faster.
- Length arc and thereby increase real welding process oscillates around the set "equilibrium" values.

types of resources

- Compact source with integrated wire feeder mounted in a common housing with the source. This arrangement is common for sources with low to medium power (up to 250 A - 300 A) for cooling the burner flowing gas.
- Powerful sources with cooling unit in a common housing with the source and a separate feeder. Its performance is about 500 A.

types of resources

- Modular arrangement has the advantage that the individual components are easily accessible and can be quite easily.
- The assembly consists of a current source - now mostly inverter type, wire feeders and cooling units for efficient sources.
- At some types of equipment is still a separate control system or a filter unit with a mechanical filter.
- Cell assembly is usually carried by a movable carriage bracket for gas cylinders.

Wire feed

- In MIG / MAG welding filler material is a wire that is continuously fed to the burner via the feeder.
- Function wire feeder is in an even wire feed, for proper functioning of the administration can not be wire damaged and deformed as shape and surface.
- This function is ensured by a feeding mechanism with a drive wire double-bin, quadruple or extraordinary axes.
- feeding the pulley may have various types of grooves according to the characteristics of the supplied wire.

The power source for MAG welding

Welding torches

- Welding torch for MIG / MAG welding wire feed to provide a welding site, a power supply and a laminar flow of protective gas around the filler wire.
- For low input powers, the burners are cooled and the shielding gas passing through the high output of 150 A is used, forced cooling liquid flowing in a closed cooling circuit.
- In essentially burners distributed on the machine with a cylindrical clamping part and a hand grip fixed to the torch welder.
- All burners are equipped with a forming pipe, the end of which is disposed a die contact for supplying the wire current and the outlet pipe for the protective gas and the gas nozzle.

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Welding torches

- Contact current die is replaceable consumable part of the burner to the uniform supply wire electrode welding current.
- Fom due to the good electrical conductivity are made of copper alloy, wherein for increasing the wear resistance of the alloy is alloyed with chromium, or zirconium.

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Welding torches

- The hole for the lead wire with a new tip by 0.2 mm larger than the wire diameter.
- Too much wear big is the cause of irregularities in the power supply and deflection wire guide in the weld bevel which is unacceptable in mechanized and robotic welding systems.
- New the market divided sprung tip (Contec) With constant power conditions throughout substantially higher lifetime.
- Gas nozzle directs the flow of gas around the arc and the weld metal and to help prevent sticking of the drops is produced galvanically chrome-plated copper.

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welding torches

- Starting the welding current is controlled by a switch on the handle and a range of modern resources has also positioned handles continuous welding current intensity control using a potentiometer or button.

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Welding process controlled by a switch on the torch

- During welding control unit is incorporated in the source and is controlled by a switch on the welding torch.
- At welding using these control methods:
  - Two-stroke mode
  - Four-stroke mode

two-stroke mode

- After pressing the switch to turn on welding current, the action will shift the wire. The welding process is done all the time you turn on the switch.
- Two stroke mode is mainly used for the stitching parts, it is also possible to use it for short welds, it is also suitable for automatic welding on welding robots.

four-stroke mode

- It is suitable for long welds and program control flow in modern sources.
- At four-stroke mode, the first desert protective gas, then switch on the wire feed and welding current.
- This are two bars, the third tact switches off and the wire feed stream and a fourth clock is off shielding gas.
- Special four-stroke mode uses the current resource management and enables pressing and holding the switch to change the level of intensity of the current according to a set program.

Equipment welding power sources for MIG and MAG

- Today's modern power sources for MIG / MAG offer a range of advanced features for improved weld quality.
- Thanks development of power electronics can control, monitor and manage all welding parameters in real time.
- Between common sources include equipment. hot start to ensure early melting weld materials with high thermal conductivity, databases welding programs for the vast majority of welding consumables and synergic welding process.
- At Synergic control are one manually set parameters - thickness of the material stream or feed speed etc., controlled by any other welding parameters.

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Another feature with which we can meet with current sources

- Controlled ignition cycle in MIG / MAG allows a very quiet arc in a well defined location of the weld during mechanized and robotic welding.
- At ignition is in the first phase the wire is moved up into contact with the material.
- After fault is detected, the wire will start to stall at low ignition current, which ignites the pilot arc and the wire is stopped at the set arc length.
- followed Phase wire feed forward while current pulse which ignites the arc and melts the base material and wire electrode.
- For backward movement of the wire feed rollers are needed in the burner.
- Function to maintain a constant arc length is used for manual and mechanized welding.
- Microprocessor controlled sources on the order of microseconds compared real welding parameters are entered and set by the arc length is maintained irrespective of the distance of the torch from the welding material.

Ending the welding cycle current impulse

- Conventional end weld current reduction to the crater-fill is standard to most sources.
- On end of the wire remains the metal droplets exceeding the diameter of the wire, which worsens re-ignition especially in mechanized arc welding processes.
- Impulse at the very end of the welding cycle "trimmed" drop forming and end of the wire remains clean and flat.
- Reuse re-ignition arc parameters then takes place according to the wire diameter.

Metal transfer in the arc

- Short arc metal transfer is short circuit,
- Short arc is accelerated dip transfer,
- Transition long arc with irregular shorts,
- Long arc shower without short-circuit transmission,
- Pulse without short-circuit arc,
- Moderated without short-circuit transmission - accelerated short-circuit transmission
- Long rotating arc metal transfer.

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Inert gases suitable for MIG and MAG

- Mixed gas of Ar + 15% CO 25%$_2$ They are suitable for the welding of mild and low alloy steels MAG.
- From this group is the universal gas, a mixed gas of Ar + 18% CO_2.
- Distinguished very good welding properties, stable arc and deep fusion penetration.
- Allows welding, short circuit and spray transfer of metal and a small spray that does not adhere to the surface.
- Provides smooth surface with good weld transition into the base material and is applicable to any sheet thickness.

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Inert gases suitable for MIG and MAG

- A mixed gas of Ar + 8% CO_2 It is optimal for the impulse, shower and short circuit transfer of metal.
- Yippee Also recommended for highly efficient methods of welding at high currents.
- distinguished high speed welding, the flat weld, low spatter and minimal formation of dross.
- Yippee suitable for manual and mechanized welding of sheet thicknesses.

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Inert gases suitable for MIG and MAG

- Mixed gas of Ar + 5% to 13% CO_2 + 5% O_2.
- This compound provides quiet welding process arc soft, smooth and clean welds.
- High oxygen content ensures very good flow and excellent weld pool degassing.
- Shower metal arc transfer is possible even at low amperage.
- Preferably It is used in mechanized and robotic welding methods of small and medium thicknesses.

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Dissociation and ionization energy in gases

Gas	Dissociation energy eV / molecule	Ionization energy eV / atom (First ionization step)
Hydrogen	4.5	13.6
Oxygen	5.1	13.6
Carbon dioxide	4.3	14.4
Nitrogen	9.8	14.5
Helium		24.6
argon		15.8

AMBROŽ, O. A KOL. TECHNOLOGIE SVAŘOVÁNÍ A ZAŘÍZENÍ: UČEBNÍ TEXTY PRO KURZY SVÁŘEČSKÝCH INŽENÝRŮ A TECHNOLOGŮ. OSTRAVA: ZEROSS, 2001. S. 168.

Cylinder pressure reducer MAG welding

Arc stability

- When the welding process is GMAW necessary that the arcing is stable, whether this is any type of metal transfer.
- Net Argon ionisation has good capacity and is not suitable for welding common structural steel, since the arc burns restlessly, and the weld quality is low.
- For quality steel welding are necessary oxidation reactions, they guarantee a weld metal which has adequate quality.
- From for these reasons there is a small admixture of carbon dioxide or oxygen is needed even when welding stainless chrome-nickel steel.
- Argon is used for welding non-ferrous metals where even minimal oxidation not acceptable.
- In the MAG method uses carbon dioxide, the arc ignited even worse ionization voltage must be higher than that of argon.
- Benefits Both gases are used in mixtures where the arc is burning with high stability and regularity.

Influence of the gas on the heat transfer and bead shape

- Shielding gases greatly affect the heat introduced into the weld and thus also affect the shape of the weld.
- This It is affected by the different thermal conductivity gases.
- Somewhere must also increase thermal conductivity.
- E.g. in MIG as necessary to increase the thermal conductivity of argon and this is done by adding helium, particularly when welding thick-walled metal sheets of aluminum and copper alloys.
- Helium also increases the current density and thus the amount of heat transferred to the weld.
- Profile the caterpillar is the use of helium deep and welded without preheating.

Influence of the gas on the heat transfer and bead shape

- Pure argon for welding of high alloy steels is no longer recommended because in argon only reaches shallow fusion penetration deep fusion penetration in the axis of the arc.
- Rapid solidification of the melt at the bottom is the cause of the occurrence of inclusions and lack of penetration.
- Conversely, the heat transfer is very good in MAG welding using pure CO2 shielding gas.
- Penetration is deep and has a corresponding shape of the weld quality.
- Potentially, however, when high parameters of formation of the notches. They can also explore the cracks as a result of rapid cooling of the weld.

Additional materials for MIG / MAG

- MIG and MAG have a very wide application in practice.
- They use both for joining steels and for bonding non-ferrous metals.
- With successfully used in the repair or renovation especially during welding of hard facing deposits.
- Arc MIG / MAG welding filler materials are in the form of solid wire and optionally a filler wire (cored wire).
- Wires wire are wound on a plastic reel or the normal weight of 15 kg.
- Coils however, producing a wide range of sizes and weights of wires - 5 kg, 6 kg, 10 kg, 12 kg, 16 kg, 18 kg, 25 kg, 30 kg or for robotics supplied in roll packed in one cardboard package weighing up to 200 (450) kg.

Lead wire at MAG

- Data on reel:
  - Manufacturer's name,
  - Wire marking by the manufacturer and relevant standards,
  - Wire diameter,
  - Weight,
  - Heat number,
  - Classification and certification for other organs

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Additional materials

- Additional materials during transport and storage must be protected against access of air and dirt.
- Temperature should be above 10 ° C and relative humidity 50%.
- In currently, all the wires are protected polyethylene sealing foil.
- Standard wire diameters are 0.6 mm; 0.8 mm; 1.0 mm; 1.2 mm; 1.6 mm; 2.0 mm and 2.4 mm.
- Most often used diameters are 0.8 mm to 1.6 mm. Seamlessly drawn or against oxidation of the copper.
- Strange PM shape of the tape electrode for high-performance welding.
- Cored wires have different welding properties under load.

welding voltage

- The arc voltage is a potential difference between the wire electrode and the weld pool surface.
- Changing according to the length of the arc, and deposition Performance has little effect.
- Width the bead is influenced by the voltage.
- Settings voltage is about 2 V to 3 V higher for pure carbon than in the gas mixture.
- In general the following relationship applies: U = 15 + 0.035 Is (IN)
  - U = operating voltage
  - Is = Welding current

welding voltage

- The arc voltage has an important effect on the optimum conditions of self-regulation of the arc length and operating point stabilization.
- Influence of voltage on the transmission with respect to the gas used is as follows:
  - Voltage range of 14 V to 21 V corresponds to the short-circuit process in the carbon dioxide and the mixed gas,
  - At a voltage of 21 V to 25 V occurs partly bezzkratový process,
  - Voltage between 25 V to 30 V corresponds bezzkratovému metal transfer in the gas mixture and the partial short circuit transfer with large drops of metal with carbon dioxide,
  - Vt a voltage above 27 V takes place in the mixed gas spray arc

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Welding voltage

- Excessive stress increases the length of the arc and burn components, welds are susceptible to increased porosity and spatter.
- Weld bath is wide, shallow and there is a risk overtaking the weld pool in front of the arc.
- With difficulty handles weld pool positional.
- Low voltage is the cause of an unstable process, narrow caterpillars with high elevation especially at high speed welding.
- At Low Voltage no perfect melting weld edges in multilayer welding, and leads to the occurrence of cold connections.

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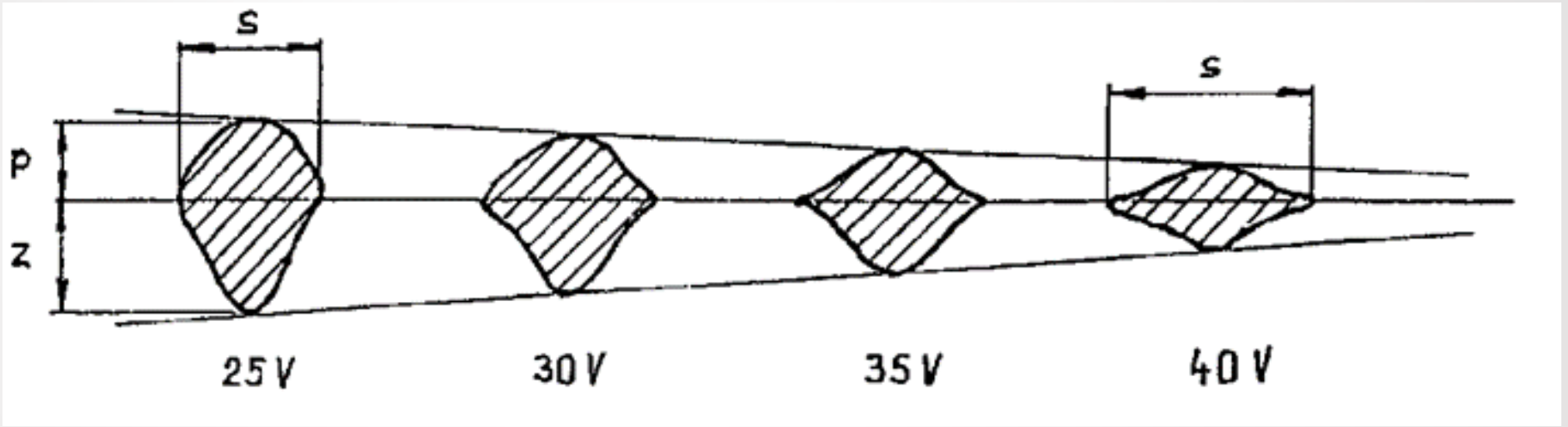
Dependence of weld bead voltage



S - width of the bead p - cant of - penetration depth

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Welding current

- The welding current has the character of metal transfer welding and cross-sectional shape of the weld bead greatest influence.
- WITH increase in current increases the current density, size and fluidity of the weld pool, and the factor fusion deposition performance.
- At a constant arc voltage occurs when increasing current penetration depths strong growth with a relatively small increase in the width of the bead and elevation.

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Welding current

- Welding current is significantly influenced by the nature of metal transfer in the arc:
  - Increase in current increases the frequency drops
  - Amperage according to the composition influences the forces acting on the metal droplets
  - Increase in current is the current types of metal transfer reduces the volume of drops.

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Welding current

- Preliminary current setting before beginning the welding is carried out based on experience or table.
- From the quality of the weld is preferable smaller wire diameter, because it allows a larger number of small droplets and the surface quality of the weld bead is very good.
- From directional stability standpoint trip wire and the economic cost is preferable larger diameter, because in order to reduce the number of wire turns is cheaper.
- That can be used for pulse welding, where the size of droplets is controlled by its own welding process.

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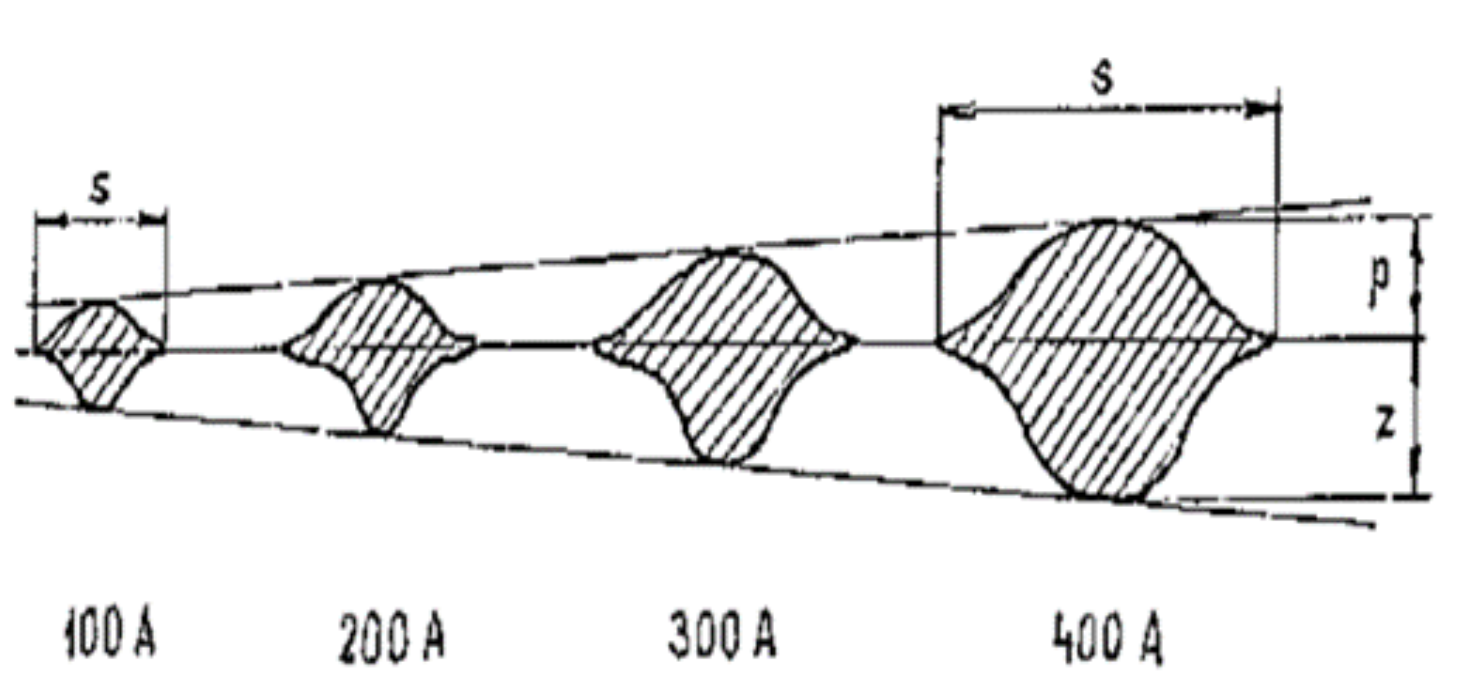
Current density

- The current density expresses the current load of the wire with respect to its cross section.
- Indicates In $A.mm^{-2}$ and increases with decreasing wire diameter.
- In conventional MIG / MAG welding wire at a diameter of 0.8 mm to 1.2 mm current density ranges from 80 $A.mm^{-2}$ 350 $A.mm^{-2}$But when welding methods highperforming reaches over 600 $A.mm^{-2}$.
- At cored wire is up to three times the current density of the solid wire of the same diameter.

The polarity of the welding current

- For the method for MIG / MAG welding is used direct current, therefore the polarity is indirect, ie., The electrode is connected to the positive pole of the power source.
- Advantage then deeper fusion penetration and wider weld.
- When the opposite electrode connection polarity is straight fusion penetration is smaller and excess weld is higher.
- This It is preferably used in renovation surfacing.
- On process stability is mainly due to the dynamic forces arc.
- Process CMT advanced the only uses AC current for MIG / MAG.

Dependence on bead shape amperage



S - width of the bead p - height, z - depth penetration

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Trip wire

- The free length of the wire is measured from the end of the contact arc current after the die and generally it is equal to ten times the wire diameter.
- On the actual length of the run of the wire affects multiple welding conditions - transmission type of metal used and the shielding gas.
- L = 5 + 5.d carbon dioxide
- L = 7 + 5.d for mixed gases, where d is the wire diameter in mm

Trip wire

- With the change in distance contact tips and welding material varies series of welding parameters.
- Significant is the change in current that decreases with increasing distance from the tip material and the consequence of this decrease is less penetration.
- Reduction current is caused by resistive heating wire is approximately 10 A to 20 A per 1 mm length variations of the wire enclosure.
- Overall changing the current intensity can be up to 80 A set value and the resulting penetration will be insufficient.
- Conversely when a small trip to arch higher intensity and becomes overheated weld pool.

Trip wire

Parameter values when welding steel MAG

type of weld	Thickness sheet	Diameter electrodes	Performance welding	Speed wire feed	Welding current	Speed welding
	mm	mm	kg.multidot.h^{-1}	m.min^{-1}	AND	cm.min^{-1}
I weld	1	0.6	1.0	7.0	60	83
	1.5	0.8	1.2	6.0	90	80
	2	0.8	1.5	6.8	110	83
	3	0.8	1.8	8.0	125	55
	3	1.0	2.1	6.0	150	63

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Parameter values when welding steel MAG

type of weld	Thickness sheet	Diameter electrodes	Performance welding	Speed wire feed	Welding current	Speed welding
	mm	mm	kg.multidot.h^{-1}	m.min^{-1}	AND	cm.min^{-1}
The weld	4	1.0	2.2	6.4	160	40
	5	1.0	2.2	6.4	160	28
	6	1.0 / 1.0	2.1 / 2.9	6.8 / 8.5	150/200	60/43
	8	1.0 / 1.2	2.1 / 3.9	6.0 / 7.6	150/260	43/28
	10	1.0 / 1.2	2.1 / 5.1	6.0 / 10.0	150/320	35/21

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Parameter values when welding steel MAG

type of weld	Thickness sheet	Diameter electrodes	Performance welding	Speed wire feed	welding current	Speed welding
	mm	mm	kg.multidot.h^{-1}	m.min^{-1}	AND	cm.min^{-1}
fillet contention	2	0.6	1.2	8.4	70	40
	2	0.8	1.6	6.8	110	53
	3	0.8	1.9	8.3	130	32
	3	1.0	2.4	7.0	170	40
	4	1.0	2.7	8.2	190	28
	5	1.2	3.9	7.8	260	26
	6	1.2	3.9	7.8	260	20
	6	1.2	4.8	9.5	300	22
	8	1.2	4.8	9.5	300	14

AMBROŽ, O. A KOL. *Technologie svařování a zařízení: učební texty pro kurzy svářečských inženýrů a technologů*. Ostrava: ZEROSS, 2001. s. 176.

Technology MIG / MAG

- Welding unalloyed and low-alloyed steels
- Weld mild and low alloy steels can be depending on the thickness of material i and the welding position to use all types of metal transfer arc.
- Like protective atmosphere is nowadays probably the most used mixed gas of Ar + 18 (8)% CO_2.
- In manual welding torch lead can be forwardly or rearwardly and mechanized welding torch is normally in a perpendicular position to the plane of the weld.

Technology MIG / MAG

- When the torch on robotized workstations with inclination angle of the torch controls the accessibility of the terminal element of the robot to the workpiece.
- Wired electrode must be fed at the beginning of the weld puddle in order to ensure deep penetration without the danger of cold joints and limits spatter.
- This requirement is important for welding fillet welds.
- Root weld beads are welded to the direct leadership of the torch and weld bead filler can be welded with transverse or longitudinal weaving torch.
- At weaving burner increases the size of the molten bath, improves the degassing of the weld, but it increases the amount of heat input into the weld, and thus the associated consequences.

The inclination of the burner and its leadership

- Welding forward has the following characteristics:
  - Clear view of the bevel
  - Good control of liquid bath in the weld root
  - Nozzle obscures views of the bead
  - Larger width caterpillars
  - Approximately 20% smaller penetration depth
  - Lower elevation
  - High speed sometimes causes solidification porosity
  - Danger overtaking weld pool by a cold joint

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. 96.

Fields of application:

- Welding thin sheets
- Welding of root welds
- Conventional welding work

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Welding back the following benefits:

- Stable arc
- Nozzle obscures views of the bevel
- Weld bead is narrower
- Greater penetration depth and cant
- Rougher surface caterpillars
- Weld pool is more liquid - lower porosity
- Cold joints and lack of penetration not found

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. 96.

Fields of application:

- Outer layer of butt welds
- Greater thickness of material
- Unsuitable for root weld - risk of forfeiture of the weld pool
- Fillet welds when there are a large excess and the notches

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