Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 1, rok 2008, ročník LIV, řada strojní
článek č. 1582

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WELDING METHOD MAG MIXED GASES CONTAINING OXYGEN – NEW DEVELOPMENT AND USE AT WELDING THE STRUCTURAL STEELS

SVAŘOVÁNÍ METODOU MAG SMĚSNÝMI PLYNY OBSAHUJÍCÍMI KYSLÍK – NOVÝ VÝVOJ A POUŽITÍ PŘI SVAŘOVÁNÍ KONSTRUKČNÍCH OCELÍ

Abstract

The article deals with new trends in development of welding by using the MAG method for mixed gases on the basis of argon.

Abstrakt

Článek se zabývá novými trendy ve vývoji svařování metodou MAG pro směsné plyny na bázi argonu.

Welding

Nowadays the shielded arc welding is the most frequently used method of welding in the mechanical engineering and the repair business. In the initial crystallization the weld bath and a part of the weld bead by the protective atmosphere are effectively protected against the adverse effects of the ambient atmosphere. The protective atmosphere facilitates the arc ignition and its stabilization, it increases the liquidity of the weld bath, improves the wetting qualities of the weld surfaces. An optimal welding process results from a correct selection of the protective atmosphere.

For welding there are available over twenty basic gases and their mixtures - the protective atmospheres:

- protective gases at welding in protective atmospheres by using the MAG, MIG, WIG methods
- gases for welding by using the plasma beam gases for welding, cutting and thermal treatment by laser – CO_2, He, N_2, O_2

For MAG welding method there are determined KRYSAL®, ARGOMAG®, ARGOMIX® gases.

MIG and WIG methods use argon, helium and their mixtures, then MONOMIX ®gas, nitrogen and hydrogen.

Mixed gases for welding using the MAG method

Recently the mixed gases on the basis of argon have been displacing the welding in CO_2 protective atmosphere. It regards the mixtures with oxygen as the active component either as a single component or chemically bonded in form of carbon dioxide.

If we want to achieve a higher flashing output at higher welding currents it is necessary to use the protective gases on argon basis. These gases have splashing lower than when using the conventional CO_2. These gases are focused on two- and three- component mixtures with argon as the main component and oxygen plus carbon dioxide as admixtures in various percentages. These gases influence the processes in the welding arc and the metal transition, weld metal quality, the flashing output, shape of weld bead and penetration. CO_2 needs a voltage by 2V higher, but it is impossible to achieve a spray-type welding arc without splashing by combination of voltage and current.

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The most frequently used mixture for welding of unalloyed steels is the mixture 82/18 – Ar/CO_2.

The endeavour to achieve an economic and environmentally friendly production makes users of mixed gases use the mixtures that enable welding with minimal splashing, high speeds while saving the high quality of welds. The possibility to use the pulse welding is another requirement.

Therefore our company launched a trend of reducing the active component percentage and replacement of individual components.

The oxygen is the crucial active component when welding by using the MAG method. In the mixed gases on argon basis the oxygen is either present as an admixture or chemically bonded in form of CO_2. For the processes in the electric arc and reactions in the bath there is crucial the percentage of dissociated elemental oxygen. We can say that 1% oxygen in electric arc develops the same volume of elemental oxygen as 2% CO_2.

$$1\%\ O_2 \equiv 2\%\ CO_2$$

The argon mixtures used for welding structural steels:

18% CO_2, 82% Ar (DIN 32526 – M 21/ EN 439 – M 21)

8% O_2, 92% Ar (DIN 32526 – M 23/ EN 439 – M 22)

have the same „activation potential".

These mixed gases combine a small splashing with a good wetting of the joint when welding the thin sheets and a safe penetration at the multilayer welding.

Criteria of various mixed gases selection

Oxygen and CO_2 in the mixed gases have approximately the same effect therefore in principle they are replaceable. These properties were used as the base for the development of a wide palette of mixed gases including the three-component mixtures. When selecting the suitable mixtures on the basis of their composition there must be considered the criteria defined by user like:

- splashing
- shape of the weld
- wetting power
- suitability for the pulse technique
- welding in positions
- optimal penetration

A higher content of CO_2 improves the welding of thick sheets in positions, but the metal splashing is increased. By using the argon-oxygen mixture the splashing is significantly reduced. On the contrary at this mixed gas with a higher oxygen content it is reduced the suitability for welding in positions. In order to reduce the welding in positions there are more used the positioning equipments.

Welding in positions significantly reduces the flashing output. In PF position there is the maximum possible output 2,5 kg/h, whereas in position PA and PB it is 6-7 kg/h. New research enables more than 10 kg/h. Obviously also here there are the "exceptions proving the rule".

For the pulse welding technique the oxygen is more suitable than CO_2. In principle the content of CO_2 18% enables a smooth pulse arc whereas there is strongly limited the possibility to select the welding parameters for extremely splashing-less process. There is also an increase in the lower current values of the pulse technique.

Trend of reducing the active gas percentage

The pulse technique requires a reduction of CO_2 percentage in the mixed gas like from 18% to 8%. This improves the pulses efficiency.

Up to now at the argon-oxygen mixture there have been used two standard compositions: 12% O_2 and 8% O_2. A high percentage of oxygen - 12% - at the contaminated sheets enables the same size (robustness) of the weld as with the use of absolute CO_2, but with a minimum splashing and higher parameters of welding. Obviously there also are created the isles of slag, but they are not as marked as when using CO_2.

In the practice this fact used to result in using 8% O_2 for welding. Nowadays the modern welding plants manage the multilayer welding with 8% O_2 while saving the high quality. Obviously if it is necessary to achieve a good penetration at welding the thick sheets under an extremely high welding power there also is used the mixture with 12% O_2.

Nowadays to a larger extent there is monitored the slag formation in the covering weld bead. This is connected with the surface treatment of weldments – their painting.

In the sphere of painting for the environmental reasons there occurred changes in the used paints. The paints and lacquers on the basis of solvents are not used any longer. They were replaced by paints in water solutions and the lacquers are sensitive to slag. This is marked at the electrostatic coating.

The above changes resulted in requirements for other reduction in the oxygen percentage at welding the structural steel by means of MAG method.

The criteria are as follows:

- limited formation of slag
- extremely low splashing
- a good wetting power at welding the thin sheets
- suitability for welding the thick sheets

The percentage 4% $O_2$was set as an optimum.

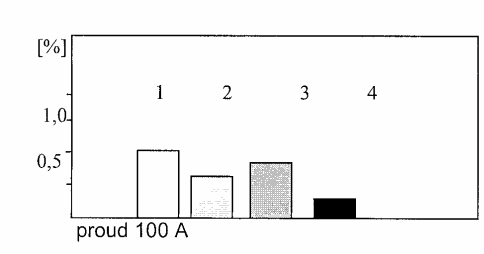
This mixture is a standard according to DIN 32526 - M23, EN 439 - M22

Welding with 4% share of oxygen

Thin sheets

The penetration is a bit wider on the weld surface in the upper part and narrower in the root. This also increases the safety against sinking the weld bath also at higher speeds of welding. Splashing in comparison with other mixtures in the short-circuit process – see Fig. 1

Splashing (%) at welding by means of MAG method with various mixed gases
admixture: SG2, ∅ 1,2 mm



1 82% Ar, 18% CO_2
2 82% Ar, 8% CO_2
3 92% Ar, 8% O_2
4 96% Ar, 4% O_2

Fig. 1

The diagram shows that a low splashing typical for mixed gases is more reduced. In the practice it means that in many cases the costly splashing removal before coating is eliminated.

Multilayer welding

For these cases there is ensured a perfect penetration and a good shape of the weld plus a minimized slag formation. There were achieved following mechanical values:

Three-layer fillet weld
mechanised welding
gas: 96% Ar, 4% O_2
material: St 52-3, tl. 10 mm
admixture: SG 2, ∅ 1,2 mm

		Weld metal	base material
Yield strength	MPa	528	345
Strength limit	MPa	604	490
Tensility /ductibility	%	28	22
Notch toughness	J	71	27

Practical use of mixture with 4% O_2

It was applied to welding of structural steel St 52-3, 8 -40mm thickness, single-layer and multilayer, approx. 280A and 26V values of current. It was found out that by using the mixture with 4% O_2 the slag formation was lower than in case of a conventional mixture. A reduced splashing and a low covering weld bead enabled to eliminate the grinding operation.

Characteristics of the use and the shape of the weld:

- a weld with a small amount of slag
- a wider weld covering
- a perfect wetting power
- a safe penetration
- an increased speed of welding

Welding with high currents

Welding by means of MAG method with high currents also called T.I.M.E. process has been promoted for approx. 10 years. At the beginning its application was not successful due to an insufficient instrumentation. This has changed recently. It was proved that by using of a four-component gas and a suitable equipment there can be achieved the flashing output 10 kg/h and more with a wire of 1,2 mm diameter.

The mixture of four gases - argon, helium, oxygen and carbon dioxide -was the primary gas used for this method. CO_2 with its 8% share is the substance of this mixture with regard to the technical application. This means a reduced percentage of the active component, which is crucial for a successful use of the high-current welding. Beside the used four-component mixtures there was carried out the research focused on preparation of a simpler mixture and further improvement for welding process. It was proved that by reducing the helium percentage we can eliminate oxygen. We will get the mixture of 8% CO_2, 20% He and 72% Ar. When using this mixture the arcing is quieter than in case of four-component gas. The mixture with 8% CO_2 is another alternative.

4% O_2 correspond to these 8% CO_2 on the basis of activation potential. Therefore unsurprisingly the extensive tests with 4% O_2 showed the possibility to use this mixture without any limitation also for welding with high currents it means for T.I.M.E. process.

Obviously also a rotating arc must be added to two conventional arcs (short-circuit and shower-type) in case of MAG high-current technique. The experience proved that for the rotating arc (smelting output 15 kg/h and more) the lower current zone was optimal.

The scope of rotating arc is connected with other problems like a variable thus unsteady profile of penetration.

Central supply

The advantage when using the argon-oxygen mixture as against argon-CO_2 mixture consists in the possibility to supply medium-size and big customers with the mixture prepared in advance in an overcooled liquid condition in so called mini-tanks or other cryogenic containers.

Mini-tank is a brand new conception of gas supply where Messer Technogas s.r.o. in its plant prepares for customers the liquid gas in the required composition, fills it into mobile cryogenic containers of 180 litres volume-so called mini-tanks-and the mini-tank is transported to the user. One mini-tank provides approx. 150 m^3 gas (the volume depends on the gas composition), it means the amount that corresponds to 15 – 20 pieces of pressure cylinders. Nevertheless the weight of a filled mini-tank is only 340 kg and by its 0,6 x 0,6 x 1,7 m dimensions it only occupies less than one half of the space that would be occupied by a corresponding battery of pressure cylinders.

The mini-tank thanks to the container arrangement is very easy to handle and the operation of two valves is simple. There is eliminated the perpetual connection and disconnection of individual pressure cylinders so the user saves time and can increase the labour productivity.

Conclusion

The operation tests and the use of new two component mixture - Ar/ O_2 with 4% O_2, both at welding the heavy weldments and at welding the thin sheets proved the suitability and the purpose of the launched trend – the reduction of active gas component percentage in protective atmospheres for welding.

The central supply by only one product-argon-oxygen mixture- stored in one container provides the possibility to reduce the input costs of weldments production because there is eliminated the necessity of the mixing equipment and reservoir for another component of the mixed gas.

Used sources:

[1] Svoboda, P.: Messer Technogas, Ostrava, 2004

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