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ANALYSE FOR TYPES AND METHODS OF WELDING IN INERT GAS ENVIRONMENT

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Abstract: Argon, helium, hydrogen, nitrogen, oxygen, and carbon dioxide are the shielding gases employed in we ding. Some othem differ greatly in their specific weight, chemical behavior, energy content, and espec ally thermal conductivity, energies of dissociation and ronization, and other properlres. By optimally combining a variety of characteristics, gas mrxtures of particular benefit will be obtained, above all ensuring sound welds and the desired profitability, Examples of a number of materials welded with various pro cesses will be presented and discussed.

Keywords: welding in inert gas, Constant Flow Gas Mixers

I. lNTRODUCTION

Argon, helium, hydrogen, nitrogen, oxygen, carbon dioxde, and a wide range of mixtures of these are used in gas-shie ded arc weldrng processes. These gases exhibit a wide range of physical and chemical propedies. The gas manufacturer's objective is to use these differences in gas proped es to arrve at the most suitable gas or gas mixture for a given welding problem, so that the user can accomplish a production task involving welding wlth the highest possible quality, reliability and profitabil ty. The statements made in this paper relate exclusive y to the gases relevant to gas-shielded arc welding [1-7]

Table 1. Physical and chemical properties of shielding gases used in welding

Gas	Content in the air, Vol. %	Boiling point at 1,013 bar, °C	Atomic or average molecular weight	Density at 15 °C and 1 bar, kg/m³	Density relative to air = 1 and 1 bar	Dissociation and ionization energies, eV	Chemical activity
Hydrogen H_2	$0,5.10^{-6}$	- 252,9	2,016	0,085	0,06	4,48 13,59 ------	reducing
Argon Ar	0,934	- 185,9	39,948	1,669	1,38	------ 15,76 27,50	inert
Helium He	$5,2.10^{-6}$	- 268,9	4,002	0,167	0,14	----- 24,56 54,10	inert
Nitrogen N_2	78,084	- 195,8	28,013	1,170	0,91	9,76 14,55 29,60	fairly inert
Carbon Dioxide CO_2	0,033	- 78,5	44,011	1,849	1,44		oxidizing

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Oxygen O_2	20,946	- 183,0	31,998	1,337	1,04	5,08 13,62 35,20	oxidizing

II. EXPOSITION

2.1. Requests for methods of welding in inert gas environment

Argon

Argon is one of the so-called atmospheric gases. Although it constitutes only 0.934 % of the atmosphere by volume, this gas is obta ned by the air I quefactron and d sti lation process devised by Dr, Carl von Linde in 1895, Argon has a relatively high aiomic weight and accordingly a high density, 1.38 times that of air, which permits its use to create a stable gas shield for we ding.

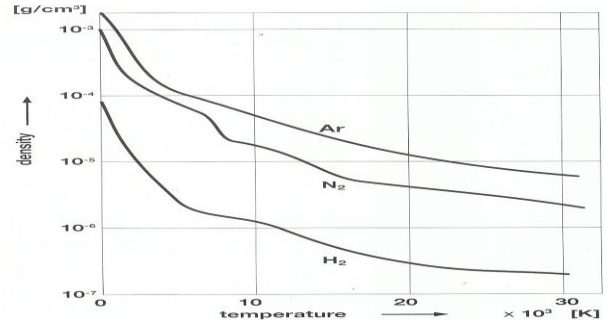

Fig. 1 Densities of argon, nitrogen and hydrogen plasma versus temperature (p = 1 bar)

Argon, a colorless, odorless rare gas, is nonflammable, nontoxic and inert; that is, it does not react with other materials even at high temperatures. "Welding-grade" argon, with a purity of 4.6 or higher, is employed when metallurgical reactions between the weld metal and the gas are undesirable, as in TIG welding of high-alloy CrNi steels, Al materials, nickel and nickel-alloy materials, copper-based materials, titanium, zirconium and other fusion-weldable materials, or in MIG welding of Al and Ni materials. Argon is also the most common basis for MAG welding of high-alloy CrNi steels and especially of hightonnageunalloyed and low-alloy structural steels. Even low levels of active gases in the argondrastically shorten the electrode life. Helium and hydrogen are increasingly added to the gas for the methods mentioned, in order to take advantage of cerlain physical peculiarities of these gases. For example, helium differs from argon in moreways than just its higher price.

Helium

The helium employed in welding usually has a purity of 4,6. Only in rare cases is pure helium used: in TIG welding of Al materials, for example, and in TIG welding of nickel-based materials - a new development. Mixtures of 50-75 % helium, Research projects in this area are under way. This application of helium also makes use of the fact that helium has a higher thermal conductivity than argon. The high ionization energy of helium causes weiding problems besides that of hard arc starting. The recombination process iargely involves the regaining of ionization energy, mainly through the transformation of kinetic energy of the (negaiively charged) electrons to heat the positive pole, so that the recombination energy is directly linked with the ionization energy.The result is deeper penetration (or higher welding speed) or a greater metal-deposition rate.

Hydrogen

Hydrogen is a co or less, odorless, nontoxic gas, lt is flammable (ignition temperature 560grad C) and much lighter than air. Despite the high enthalpy and very high thermal conductivity of hydrogen, low density makes the pure gas unsuitable for use in plasma-arc cutting, since the stream has too little momentum to expel the molten material, A mixture of argon and hydrogen combines a I the needed properties and is thus suitable for plasma spraying and especially for plasma-arc cutting. This mixture finds use in the cutting of high al or CrNi steels, where the reducing action of the hydrogen makes it possible to obtain oxide-free cut edges. The same reducing effect is utilized in ox fuel gas welding with acetylene (CrHr). ln the inner cone of the flame, acetylene decomposes to carbon and hydrogen; given correct positioning of the flame and the work, an essentially oxide-free weld pool results. Another use of hydrogen is in the brazing of noble and nonferrous metals. Tungsten hydrogen welding, in which the arc burns under hydrogen between two tungsten electrodes, has not met with much acceptance. The hydrogen employed in welding is usually of purity grade 5.6. lt is always mixed with another gas, most often argon.

Nitrogen

Nitrogen, which accounts for about 7B % of air, is colorless, odorless, nontoxic and nonflammable. Chemically it is fairly inert, so there is no need to fear that a nitride-forming reaction will take place

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between nitrogen in the forming gas and the material near the comparatively small, cool weld pool at the root. ln comparison with the gases already discussed, nitrogen is of limited importance for gas-shielded arc welding. lt's principal disadvantage is that it can cause pore formation if the welding zone is inadequately shielded from the ambient atmosphere. The sole use of nitrogen in gas-shielded arc welding, as described above, is as a forming gas, and for this purpose it is generally mixed with hydrogen.

Carbon Dioxide

Carbon dioxide, which is obtained from natural sources, is colorless and odorless, lt is nontoxic and nonflammable. The gas employed in welding has a purity from 99.5/99.7 %. lt is not used in processes with tungsten electrodes.

Among the MAG welding processes that employ CO2 is electro gas welding, which is used for pearls over 30mm thick positioned as nearly vertical as possible. This method is relatively little used at present, No problems arise with CO, in short-arc MAG welding (l = 80-150 A depending on electrode diameter), for example in root passes, since the metal transfer in this situation takes place in a short circuit (the arc is so short that the droplet formed makes contact with the liquid melt pool and is drawn into the pool by surface tension). This type of welding is also possible with mixed gases.

Shielding gas	R_m N/mm²	R_e N/mm²	A_5 * %	Weld metal analysis % C	Mn	Si	Impact energy J (mean of 4 specimens) + 20 °C	± 0 °C	− 20 °C	− 30 °C	− 40 °C	− 50 °C	O_2 content of weld metal % by weight
CORGON® 1 91 % Ar, 5 % CO_2 4 % O_2	610	472	28.1	0.08	1.32	0.67	138	124	87	83	58	48	0.031
CORGON® 10 90 % Ar, 10 % CO_2	640	544	25.7	0.09	1.43	0.72	130	88	64	55	60	41	0.029
CORGON® 18 82 % Ar, 18 % CO_2	620	522	26.8	0.09	1.37	0.70	144	120	86	62	50	40	0.0305
CORGON® 25 75 % Ar, 25 % CO_2	601	505	29.3	0.09	1.30	0.65	124	97	76	61	51	41	0.034
CORGON® S 12 88 % Ar, 12 % O_2	591	510	27.5	0.06	1.20	0.60	138	126	87	67	46	40	0.0355
100 % CO_2	594	437	27.8	0.10	1.21	0.62	84	54	48	35	28	22	0.062
Wire electrode to EN 440 – G3Si1				0.115	1.53	0.98							

47-J-limit

Fig. 2. Shielding Gases for MAG Welding of Structural Steels
Effect of Shielding Gas on Mechanical and Engineering Properties

Constant Flow Gas Mixers

Mixers of this type of mixing different gases dosed with various gas flows, and thus provides the required gas mixture. Unlike mixers with storage tank where the gas mixture is passed some time in court mixers provide a constant flow constant pressure drop in a very wide range of consumption. One of them is the requirement for the minimum flow rate to ensure adequate accuracy.

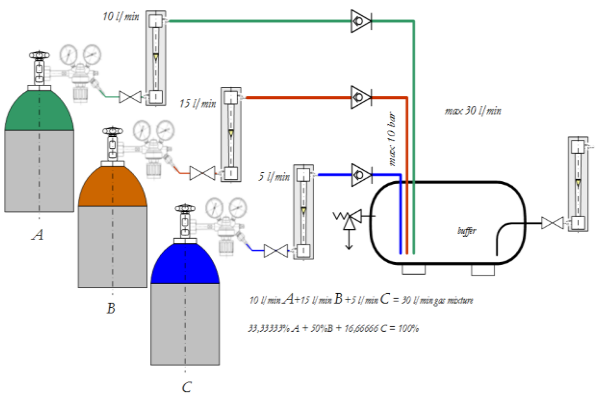
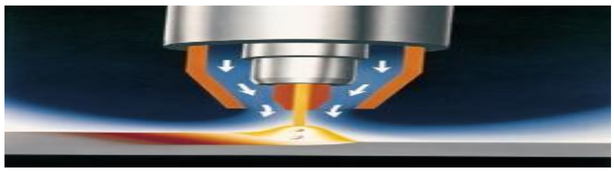


Fig. 3. Constant Flow Gas Mixers

2.2. Types of welding

MIG/MAG Welding

Arc welding with inert gas melting electrode. The arc burns between the melting electrode wire to the device. Electrode, the arc and weld pool are isolated from the harmful effects of the atmosphere by shielding gas. The electrode is in the form of phone used diameters were 0.5, 0.6, 0.8, 1.2 and 1.6 mm (in a fully mechanized welding wire is used with a larger diameter). As a rule, use thick wire. For unalloyed, low-alloy and chrome-nickel steel, and also for welding were developed and cored wires. When welding in a protective inert gas method is LAG. When the protective gas reacts with metal main method is MAG. MIG / MAG pulsed arc welding has significant advantages over conventional technologies.



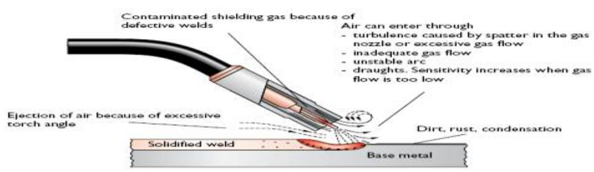


Fig. 4. How the shielding gas atmosphere and weld pool can be contaminated during gas metal arc welding

WIG Welding

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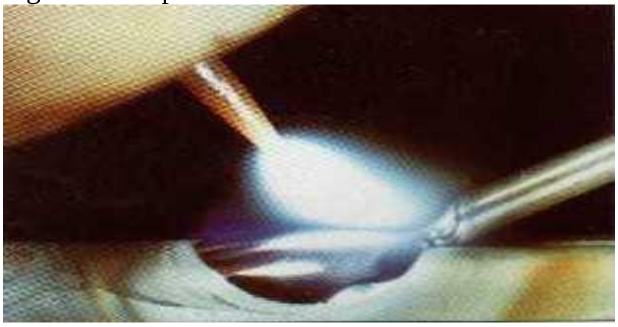
BB (TE - inert gas). Arc welding inert gas netopyasht electrode. The arc burns between netopyasht tungsten electrode product. The protective gas is an inert (argon, helium or a mixture of argon and helium). The electrodes are of diameters 0.5, 1.0, 1.2, 1.6, 2.0, 2.4, 3.2, 4.0, 4.8 mm (in mechanized welding to 12 mm). They consist of a tungsten (with a high melting point, with the possibility of intensive utilization of electrical current) and have a complex doped with a small amount of thorium, zirconium, cerium or other rare earth elements, which facilitate the emission of electrons. The additional metal is in the form of rods for manual welding, and in the form of wire in mechanized welding. The biggest advantage of the method is the high stability of provara. Pulse TIG welding allows for exceptionally high quality stitch formation regardless of position.



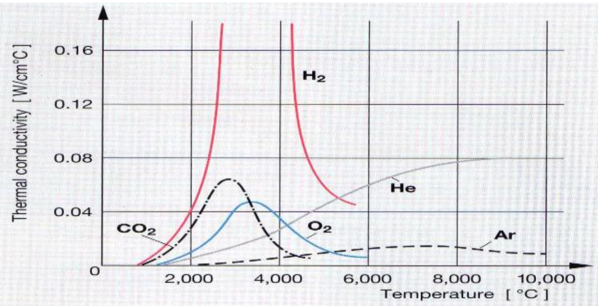


Fig. 5. Thermal conductivity of gases

2.3. Effect of protective gas at welding inert gas

Gases should comply with the following EN 439 groups:

– Group R (Ar/H2 mixtures)

– Group I (Ar + Ar/He mixtures) and

– Group F (N2 + N2/H2 mixtures)

In order to positively prevent oxidation tints, the forming gas feed must continue until the part has cooled to approx. 220 °C. Preventing oxidation in the welding of pipe requires pre-purging for a time that depends on the purge gas flow rate and the geometry of the part. To prevent oxidation when welding pipes, air must be eliminated by purging before starting to weld. A guideline for the required volume of shielding gas is 2.5 – 3.0 times the geometric volume of the pipe from the injection point to the weld. The flow rate should be approx. 5 to 12 l/min, depending on the diameter of the pipe. In titanium-stabilised CrNi steels, forming gases containing N2 cause a yellow coloration of the weld root. For base materials containing N2, e.g. super duplex steels, forming gases containing high N2-percentages (up to 100 %), e.g. to improve corrosion resistance arc of benefit.

Fig. 6. Effect of protective gas at welding inert gas

III. CONCLUSIONS

The following new and optimized applications of shielding gases are fundamental among recent achievements aimed a1 enhancing the reliability and improving the economics of welding.

Addition of H, to argon, in order to increase the penetration or the welding speed in TIG welding of CrNi steels:

- Use of argon with added hydrogen as root shielding gas for TIG welding of titanium-stabilized steels, in order to prevent yellow coatings of titanium nitride as produced with forming gases containing nitrogen (Nr-H, mixture),

- Use of pure helium for TiG welding of nickel materials, in order to improve the penetration or the welding speed.

- Use of Ar-He mixtures (50-75 % He) for manual TIG welding and pure he um for mechanized TIG welding (dcsp) of aluminum and aluminum alloys, in order to increase the penetration or the welding speed and reduce the porosity of the weld metal.

MIG welding of aluminum, copper and nickel materials with Ar-He mixtures (25 75 % He), in order to improve the appearance of the weld, reduce the porosity of the weld metal to a substantial degree, and increase the penetrate on or the welding speed,

- Use of Ar-CO, mixtures for MAG welding of CrNi steels, in order to improve weld appearance, reduce spatter and diminish the amount of oxides on the weld, and also to save on

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the costs of weld finishing (e.g pickling) and insure the corrosion resistance of the weld.

- Use of Ar-COr-He mixtures (50 % He) especially for multipacks MAG welding of nickel-base materials, in order to achieve good wettability and good weld-pool flow, avoid the need for grinding of the individual runs, and tonsure the corrosion resistance of the weld.

Advances in the area of shielding gases will continue to be needed because of the development and improvement of base and filler metals; the development of variant welding methods, new power sources, and mechanized and automated equipment; and the imposition of more stringent requirements on product quality and manufacturing cost, Gas manufacturers will have to have properly qualified staff and test facilities in order to keep up with these demands. Welding methods are used by Linde Gas end Messer Group.

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