CAUSES OF SHIELDING GAS POLLUTION IN USE

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Abstract

The quality requirements for welding structures are constantly increasing. More and more steel grades have to be welded. The use of Aluminum, non-ferrous metals and high tensile steel is growing on the marked.

The purity of shielding gas is responsible for the quality of our welding production. Typical effects of impurities are pores when welding Aluminum or pores and hydrogen cracks when welding mild steel. Especially high tensile steel is sensitive to humidity. Also the wear of tungsten electrodes rises as a result of impurities.

Typical impurities are some components of the air, oxygen, nitrogen and humidity.

The required quality for shielding gases and gas mixtures is fixed in the ISO 14175. The quality, delivered by the gas supplier, most of the time, is higher as required in the ISO.

Responsible for the welding results is not the quality inside the cylinder. The quality of the shielding gas at the point of use is what we should pay attention to.

On the way to the point of use the shielding gas should be contaminated as little as possible. But on its way to the melt pool the shielding gas crosses a lot of sources of pollution.

There are hoses, pressure regulators, the welding machine, the torch and some more components which may course the gas being contaminated with components of the air and the surrounding area.

1. Introduction

Very often the faulty quality of the shielding gas seems to be responsible for various welding problems. The problems reach from pores to annealing colours to cracks to black seams and bad penetration. Not to forget the wear of electrodes when TIG welding. The kind of problem is depending on the kind of pollution and the material being welded.

But if we talk about the quality of the shielding gas we have to talk about its quality at the point of use, which means at the weld pool!

The quality of the gas inside the cylinder mainly is better than required. On the way from the cylinder or bundle to the melt pool there are a lot of sources for a pollution of the shielding gas.

The main pollution is coursed by the air and its humidity.

2. Components of the air

The air mainly consists of Nitrogen, Oxygen, Argon and humidity. As liquid or hot stainless steel is sensitive to oxygen, other metals such as titanium, zirconium, molybdenum or magnesium are sensitive to other components of the air. Aluminum for example is sensitive to oxygen and humidity, mild steel to humidity and nitrogen. So we have to prevent metals against the contact to air while welding.

Air:

- Nitrogen 78%
- Oxygen 21%
- Argon ca.1%
- Humidity

3. Chemical Reactions with hot or liquid metals

To understand some of the problems mentioned above it's necessary to take a look to the different chemical reactions some metals do in contact with the air under elevated temperatures.

3.1 Oxygen

Many Metals and their alloying elements are sensitive to Oxygen. At high temperatures and in contact with Oxygen they form oxides. They can be visible as a layer (annealing colors), as slag or they can be integrated into the micro structure of the material. These elements are e.g. Iron, Chromium, Nickel, Niobium, Titanium, Copper, Aluminum, Silicon and some more. They follow chemical reactions like:

$$xO_2 + yMe \leftrightarrow MeO, MeO_2, Me_2O_3, Me_3O_4 \ldots$$

0 10 18 28 49 73 97 150

Fig. 1 Stainless steel, annealing colours depending on residual oxygen (ppm)

The oxidation and the oxides have different effects to the material. They can lead to a lower corrosion resistance, to less tensile strength, to less toughness or to a lower cross-section area.
Such oxidized seams and heat affected zones must be cleaned. This means brushing, grinding, sand blasting or etching. These procedures are expensive and need a lot of time. Another solution is back shielding or forming. It helps to save money and time.
But not all oxides take place on the surface. Aluminum oxides e.g. are heavier than the liquid aluminum and sink into the melt pool.

3.2 Nitrogen

Nitrogen in contact with liquid metals forms nitrides at high temperatures or can be diluted in the micro structure of metals. The atoms are able to move and course problems. Nitrides are very small and get embedded into the micro structure of the material. They can have different geometric design depending on their binding partner. The effects may be positive or negative. Not only Titanium is very sensitive to nitrogen. The nitrides are very hard and lead to embrittlement directly or after a very short live time.

$$2Ti + N2 \leftrightarrow 2TiN$$

Especially mild steel is very sensitive to nitrogen. Above 590°C iron can solve up to 0.1% nitrogen. At room temperature the solubility decreases down to nearly zero. Nitrogen courses embrittlement. The hardness raises and the ductility decreases enormously. So aluminum gets added to liquid steel. Aluminium forms nitrides witch are harmless to the material and nitrogen gets dissolved from the microstructure.

3.3 Humidity

Humidity gets dissociated in the electric arc and at high temperatures. If we take a look at our chemistry book we can find a fundamental reaction:

$$2H2O \leftrightarrow 2H2 + O2$$

This reaction will happen at temperatures above 2000°C. In presence of metals the dissociation of hydrogen is reduced to possibly 650°C.

$$H2O + Me \leftrightarrow H2 + MeO$$

Now we have molecular hydrogen witch gets spread in the arc to ions and then can be solved in the liquid or hot metal and in its microstructure.

3.4 Hydrogen

Hydrogen gets solved in form of ions in liquid metals. In the case of iron the ions form molecules again when iron gets cold without leaving the material. As the dimensions of the molecules are very big compared with the ions an enormous stress grows inside the material. This leads to the so called hydrogen induced cracks especially when there is further stress to the material. In The case of stainless steel it is no problem.
In liquid aluminum also hydrogen gets solved as ions but builds molecules and later bubbles when the liquid material gets colder. Here hydrogen courses a lot of pores. Also other metals have different problems with hydrogen like titanium and copper.

4 Potential sources for pollutions

Bevor we start welding the complete system between cylinder and weld pool is filled with air. So at first the gas supply system has to be purged. This takes a few seconds, if the system is tight.
A short-time purging is necessary after each short welding brake because of the air flowing back into the open torch. The pressure surge when pushing the button of the torch helps to clean the system. Gas savers are counterproductive and an additional purge cycle has to be made.
If there are leakages for example, not only the shielding gas will disappear out of the system also air will continuously enter into it.

Materials are a very sensitive issue. Materials like rubber, plastic, etc. are able to solve contents of the air like a sponge.

4.1 Cylinder valve

If the valve or the connection between valve and pressure regulator isn't tight there will come out gas and air will go in. Most people think that when gas is coming out no air can go in. This is quite wrong because air is no liquid.
The magic words are "partial pressure" and "gaseous". Between the molecules or atoms of a gas and also the air is much room. So the molecules are able to move anywhere. And they move until everywhere is the same concentration of types of molecules or atoms.

4.2 Pressure regulator

Here we have the same problem. Leakages lead to a pollution of the shielding gas.
Very often the seal to the valve is damaged or old, brittle and cracky. Seals should be replaced during a frequently check. Cylinder valves should be opened carefully and when the regulator is relaxed to prevent the regulator against damages.
Additionally inside the regulator is a membrane. This membrane can be made of any plastic or stainless steel. In the case of stainless steel there is less risk of any pollution. In the case of rubber or plastic pollution with components of the air especially humidity is possible. Rubber or plastic might be like a semipermeable membrane.

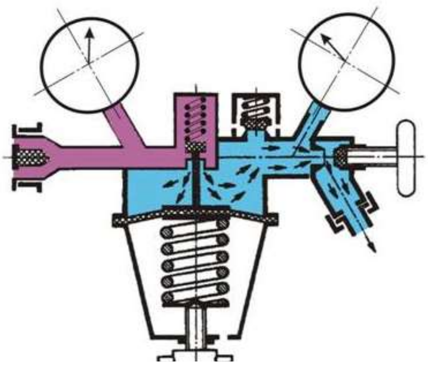

Fig. 2 Pressure Regulator with membrane

4.3 Connectors

There are two kinds of connectors, correct ones according to EN 560 or EN 561 and improvisations. A correct connector is mechanically tight. This kind of seal is the best choice because there is no diffusion and no leakage when the connector has no damages.
Most of the time people don't have a correct connector so they have to improvise. This kind of connector should only be used as an exception for only a short time and should be replaced at the next opportunity.

Fig. 3 Connector EN 560

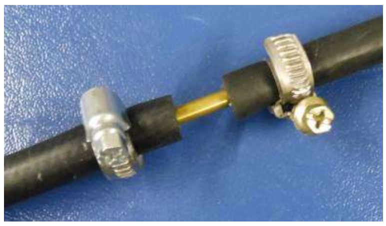

Fig. 4 Improvisation

4.4 Hoses

Hoses offer a flexible use and are mobile. There are a lot of hoses on the market. The price ranges from a few cents to several euros per meter. The range of Materials and Qualities is enormous and confusing.

Old hoses might be damaged, brittle or cracky. They should be checked frequently.
The material of a shielding gas hose should be suitable to shielding gas. They should be in accordance with ISO 3821 or EN 1327. Rubber and plastics are able to solve the components of the air like nitrogen, oxygen or humidity. The components diffuse through the hose and get transported to the shielding gas.

Fig. 5 Hose in accordance with ISO 3821

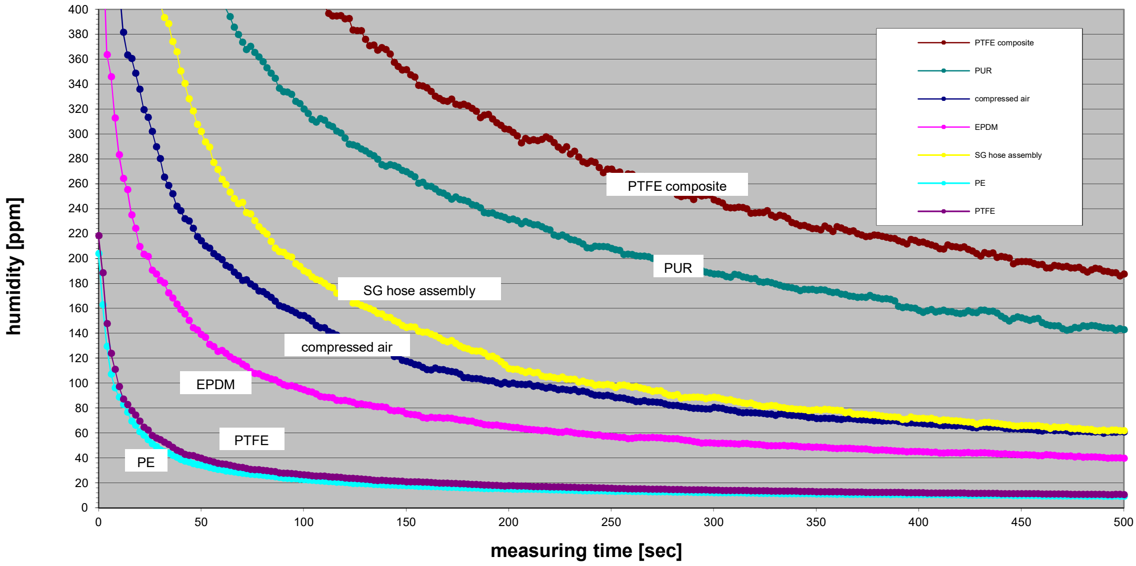

Fig. 6 Humidity in shielding gas by different hoses

The amount of nitrogen, oxygen or humidity which gets transported into the shielding gas depends on the material and on the type of production. So the time for purging and the success depends on the material.

4.5 Welding machine

A welding machine consists of many different components. These include magnetic valves, hoses, hose couplings, connectors and many more.
Here we find all the problems like leakages and diffusion through different materials.
Examples are the inlet nozzles. They have to fit to the wire diameter. Very often the diameter is too big so it is possible to use it for 1.0mm and 1.2mm diameter. But when using 1.0mm wire the nozzle isn't tight. Air gets transported through the wire guide to the weld pool.
So also a welding machine should be checked frequently.

Fig. 7 Inlet nozzles

4.6 Conveyer hose

Hose packs are connected to the welding current source or wire box via a coupling. A gasket is required at the connection for the gas supply. It is often observed that this is defective or even missing. A remedy is provided by a regular inspection of the seal and, if necessary, its replacement.
In some hose packs unsuitable or outdated hose materials are installed. Very often these are PVC hoses. Depending on the welding task, high-quality hoses should be used.
The hoses used in the hose pack are, as a definition, part of the welding torch and are therefore subject to EN 60974-7. Please contact your torch manufacturer if the hoses needs to be changed.
Air can also reach the welding point via the wire guide if it's too large. For good quality welds, suitable wire, wire guide and wire nozzles must be used.

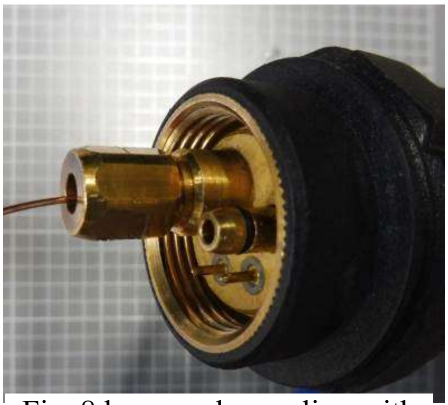

Fig. 8 hose pack coupling with gasket

4.7 Welding torch

Even with the most modern welding processes, spatters cannot be completely avoided. Both spatters and welding fumes can soiling the shielding gas nozzle so that a sufficient shielding gas shield is no longer achieved. The shielding gas nozzle must be regularly cleaned of spatters and welding fumes. If a gas diffuser is used, it must also be regularly cleaned and, if necessary, replaced.
A worn seat of the protective gas nozzle at the welding torch can cause the nozzle to no longer be centered and being leaky. This causes a deficient shielding gas cover and can cause pore formation. The tightness of the shielding gas nozzle must therefore be checked regularly.
The additional wire is connected to the current through the contact nozzle. The correct size of the current contact nozzle must be taken into account. A too large contact tube leads to ignition problems and an excessive wire guidance. In addition, an injector effect can occur when air is attracted through the contact tube. A suitable current contact tube must be used, which should be replaced regularly.

Fig. 9 Gas nozzle with and without spatters

4.8 Torch position

The torch position is no component of the welding equipment but it has a significant influence to the content of air in the shielding gas at the weld pool.
If the angle of the torch is too small it courses an injector effect and air get's mixed with the shielding gas and get's in contact with the melt pool.
If the speed of the gas flow is too high it courses turbulences. The speed depends on the amount of gas and the diameter of the gas nozzle. So the adjusted amount of gas has to fit to the diameter of the torch.
If there are spatters inside the nozzle the diameter get's less and the speed of the gas flow rises. Turbulences lead to a mixing of shielding gas and air.

Fig. 10 Torch and its causes of pollution