HEALTH APPRAISAL OF GAS SHIELDED METAL ARC WELDING

by

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KEY WORDS

ARC-GAP, AEROSOL, OZONE, PULMONARY OEDEMA, TOXIC FUMES.

INTRODUCTION

Gas shielded metal Arc welding had established its persence in fabricating Industries over many other processes due to its advantages of higher productivities, less cost of welding and ultimately zero defect welding with less dependent on the welders skill. An increasing trend is being observed through out the world in switching over to GMA welding wherever possible from conventional welding. Added to this, the free availabilities of different kinds of Gas mixtures, mainly Argon based mixed Gases and various types of Flux cored wire had increased the process capabilities to suit almost every application that we can think off. Indian Welding Industry has also started adopting GMAW process more and more in order to take the advantages of availabilities related to Inverter based power packages, various Gas mixtures and solid/Flux cored wires of various composition etc.

With the increased trend on the health consiousness, OSHA (Occupational Safety and Health Association, USA) and Kiev Institute of Labour Hygiene and occupational Diesease, had established various standards related to the fumes and ultraviolet radiation generated during various processes of welding. Safety devices are gaining more and more popularity in American and Europian markets to protect the welders health.

In this paper I shall deal with the Fumes and ultraviolet radiation generated during GMAW process and the safety devices which are available to protect the welders health from possible damages. The principal factors that have ill-effects on the human organism when Gas shielded open arc welds are made, are the fumes and ultraviolet rays and the intensive radiation from the arc. Let us now concentrate on each of them.

WELDING FUMES

Process variables affecting the formation of particulate welding Fumes :

During GMA welding, particulate Fume is produced because the minerals decompose and literally boil as they are transferred across the intensively hot arc gap. These vapours condense or recombine chemically on encountering the colder environments surrounding the arc. Both the condense vapours and the recombined minerals characterise welding Fume. Commonly they are spherical and crystallographically amorphus or glass like. These particles are so small by the nature that they are lifted in the thermal currents created by the arc and remain suspended in relatively still air. These are also commonly known as AEROSOLS. Although composed of the same elements found in the parent electrode, their concentrations in the fume normally differ. The more refractory elements and compounds will collect in the slag cover and the more volatile will concentrate in the Fume compound such as fluorides which decompose easily will segreagate in the weld fume.

Incidently, oxygen in the welding environment accelerates the development of fume. Whether intentionally added as oxygen or carbon dioxide to stabilise the arc of MIG welding or aspirated into the system as air produced by the decomposition of fluxes in the

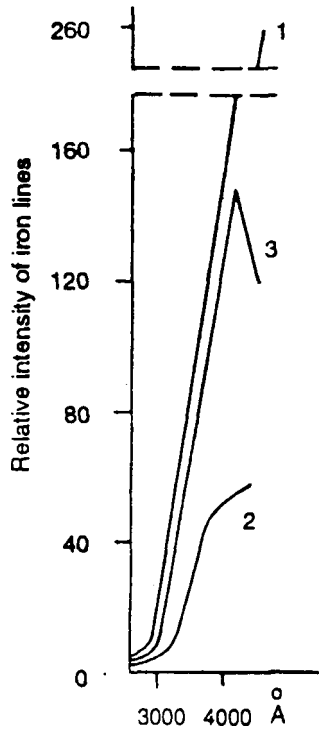


Fig. 1 : Relative intensity of the iron lines in the spectre of arcs Burning in different shilding gases

1. Argon & Oxygen
2. Carbon Dioxide
3. Argon, Carbon Dioxide & Oxygen

electrode, or present as air itself in the self-shielded electrodes, the amount of fume generated is greater than that which would have formed in the absence of oxygen.

Fig. 1 shows the effect of oxygen/ carbon dioxide present in Argon rich sheilding Gases and the fume generated during welding at a particular current. The total amount of dust generated during welding were determined and the Toxic gases were measured by using Gas chromatography. The results shows that when welding were made with CO_2 process or with the gas mixtures such as 95% Ar & 5% O_2, 80% Ar, 15% CO_2 & 5% O_2 and 70% CO_2 & 30% O_2, in mild steel using 70-S-6 grade of solid wire, the chemical composition of dusts formed was almost the same in every case. It constains 53-63% Fe and 7-13% Mn with altogether 4.2 to 3.8% of SiO_2. **Table I** shows the amount of aerosol components formed during welding in mg/min with various composition of shielding Gases. Combining **Fig. 1** and **Table I**, we can easily say that the welding fumes produced is proportional to the square of welding current and level of oxygen present in the shielding Gas i.e.

$$F = C.I^2$$

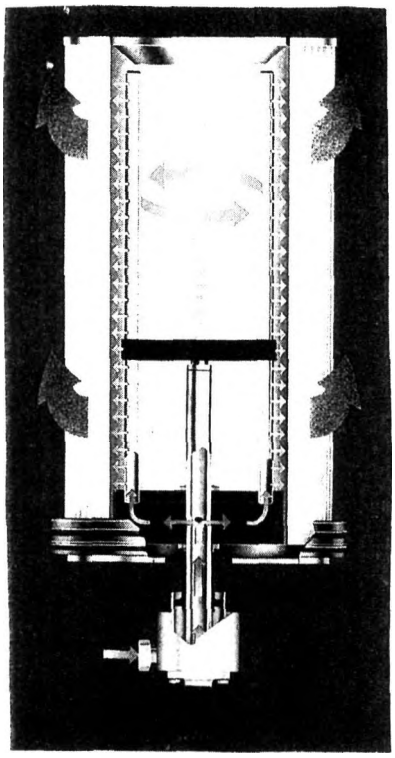
where C is the constant which characterises the electrode and physical system associated with the welding process.

However Arc length also need to be defined. Since the residence time of drops traversing the arc plasma is proportional to the arc length, the amount of fume produced also will be proportional to arc length. Given more time, more fume will be generated.

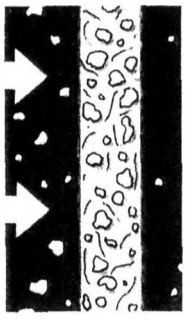
With regard to the extent of their possible ill effect on human organism, referring **Table I** we can see that welding with a gas mixture of 95% Ar & 5% O_2 has the minimum biological activity, follow through the gas mixture of 80% Ar. 15% CO_2 & 5% O_2 and then 100% CO_2 and CO_2+O_2 mixtures.

Table I : Amount of Aerosol Components fromed during Welding. mg/min.

Sheilding gas	d_{el} mm	Dust	Carbon monoxide	Oxides of nitrogen.	Ozone
CO_2	1.2-2	0.25-1.62	0.17-0.23	0.009-0.015	0.001-0.0014
70% CO_2 & 30% O_2	2	2.10	0.26	0.019	—
80% Ar, 15% CO_2 &5% O_2	1.2-2	0.14-1.0	0.12-0.14	0.011-0.017	0.001-0.002
95% Ar & 5% O_2	2	0.68	0	0.026	0.002



In the case of surface filtration the harmful substances are seperated at the surface of the filter medium. The filter can easily be cleaned.



In the case of depth filtration the harmful substances penetrate into the filter medium so that it gets choked. Cleaning of the filter becomes more difficult.

Fig. 2 : Working principal of Cartridge type Air Purifier

Experimental research with animals had established that the aerosol formed during GMA welding has an extremely toxic effect on the organism. Sign of chronic toxic effects such as palmonay oedoma etc. had also been reported in one or two cases. Although the commonest cause of Plamonary oedema is acute left ventricular failure following Acut Myoeardial Infraction, Hypertensive heat desease. Aortic valve desease, cardiomyopathies etc, there are many non-cardiac causes. These include severe Anaemia, over transfusion, shock lung in Septicaemia, Aspiration of Gastric acid, paraquat poisioning and Inhalation of certain Toxic Fumes.

The common feature is accumulation of Oedema fluid in Pulmonary alveolar spaces leading to severe breathing difficulty. The lungs become stiff, increasing the work of breathing. Gas exchange is impaired and if unrelieved, progressive hypoxaemia (O_2 lack) and hypercapnia (CO_2 excess in the blood) follow as the patient tires which can eventually lead to permanent sickness.

To avoid the fumes generated during GMA welding, in the early eighties, the use of fume extraction/ventilation systems were introduced in advanced countries. The fume extraction system consists of a blower motor for extraction and the extention arms which can be taken to the welding points. These systems although relatively cost effective but does not really purify the fumes or eliminate the harmful gases are being sucked from the welding points and disbursed in the area where other persons can get effected. A study conducted by an independent authority in Europe shows that fume extraction/ventilation system used for removal of welding fume had affected the other workmen of the shopfloor and most common effect was observed as Hypercapnia (CO_2 excess in blood).

However, fume extraction system became out of wood due to its inefficiency and higher cost of maintenance and repeatative service requirement. In the middle of eighties, introduction of Mechanical & Electrostatic type fume exhaust sustems had given relief to the health conscious welders where the fume is totally filtered and then the filter air is released in the room. These fume exhaust systems were found to be insufficient to cater the entire range of requirement.

With the introduction of cartridge type of fume exhaust system, this limitation of filtration efficiency

Table II : Purification Efficiency of Various Types of Filters

Type of Filters	Mechanical Filter	Electro-Static Filter	Cartridge Filter
Efficiency	89%	98%	99.99%

was taken care of. **Table II** shows the filteration efficiency of Mechanical, Electrostatic and cartridge type fume exhaust system and **Fig. 2** shows, the working principal of cartridge type filter which works on surface filtration and cleaning method is pneumatic by rating nozzle requires electric supply and the compressed air line for carrying out the filteration. With the advent of solid state Engineering, these filters are now available with two types of models i.e. transportable type and wall mounted type. By connecting multiple arms with these units, the entire range of industrial requirement can now be met which had certainly benefited the welding Industry **Fig. 3**.

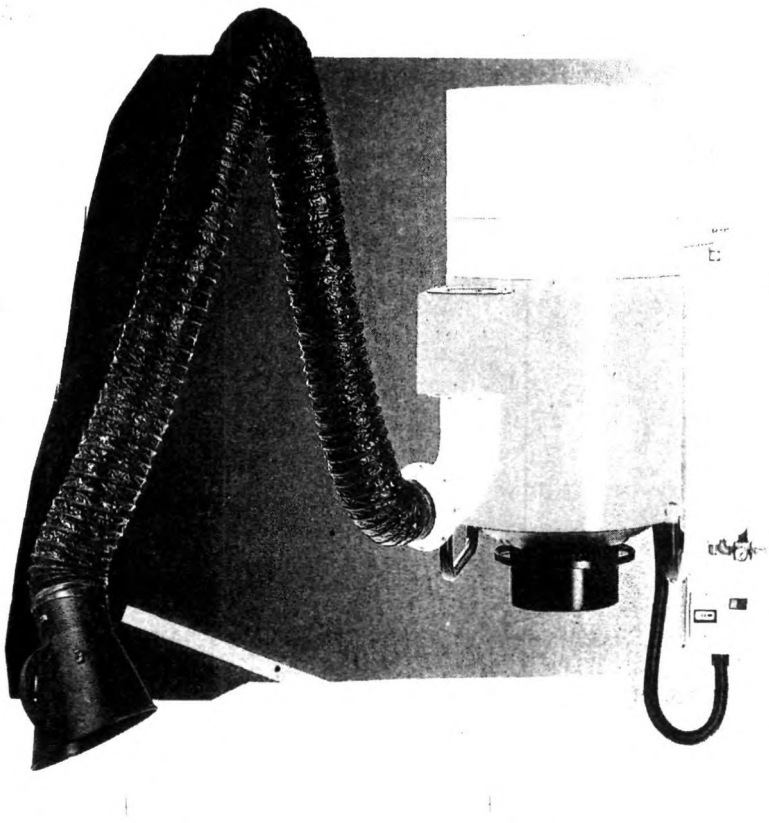


Fig. 3 : Wall mounted type cartridge fume exhaust system

ULTRAVIOLET RADIATION

GMA welding carried out with Argon-oxygen mixture (95% Ar, 5% O_2) Carbon dioxide (100% CO_2) and Argon, Carbondioxide and Oxygen mixture (80% Ar, 15% CO_2 & 5% O_2) as shielding gases had confirmed that in every case the maximum radiation lies in the long wave region of the ultraviolet spectrum (3594-4024Å).The relative intensify of ultraviolet radiation was studies with an ISP-28 spectrograph. This is important from the health aspect, because we know that ultraviolet rays with a mean wave length between 2537 to 2600 and 2800-3200Å are biologically most active and this might have some carcinogenic effect.

The data obtained indicate that the composition of the atmosphere in which the arc burns has a substantial effect on the intensity of ultraviolet radiation. Referring **Fig. 4** we can see that the intensify of radiation caused by the ionisation of gas in the arc gap is at a maximum where welds are made in a mixture of 95% Argon and 5% O_2 but the results are less and almost same when CO_2 or Argon/CO_2 gas mixtures are used as shielding gases. At the maximum radiation region, it is atmost about 83% less than in case of an arc burning in a mixture of Argon and Oxygen.

Table III : Visiblity and Safety Characteristics of Commercially available transparent Welding Curtains

Type of Curtain	Relative Visibility through curtain %	Type of Welding Process being used			
		Ferrous Metal Pure Gas Ar Or He AMPS	Aluminium Metal Pure Gas Ar. Or He. Including CO_2, O_2, H_2 AMPS	Ferrous Metal Mixed Gas Vapour AMPS	SMAW Or FCAW Flux AMPS
Spectra orange	69	1300	750	550	450
Gray	56	225	125	100	75
Green	63	150	90	70	50
Yellow	100	80	50	35	30
Blue	44	40	25	20	15

★ Data based on maximum permissible arc current that is allowable for various types of welding process for personnel more than two meters from the arc for an eight hour exposure.

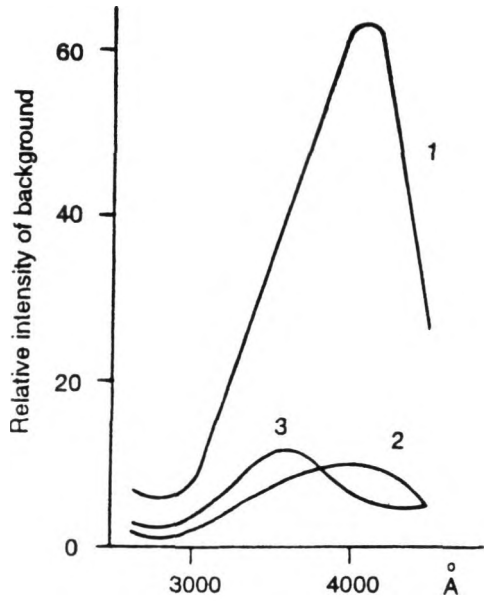


Fig. 4 : Relative intensity of the background in the radiation spectra for arcs burning in different shielding gases :
1. Argon & Oxygen 2. Carbon Dioxide
3. Argon, Carbon Dioxide & Oxygen

The relative intensity of the iron lines is also at its maximum when welds are made with the mixture of 95% Argon and 5% O_2 compared to other two gases **Fig. 5**. It should be emphasised that in spite of higher intensity of ultraviolet radiation when welds are made in mixtures of Argon and Oxygen, the amount of Ozone formed is not much greater.

In order to protect the welders from the harmful ultraviolet radiation it is essential that most careful measures are being taken. Use of good quality welding helmets with provision for ultraviolet and I/R protection and good quality Apron with hand gloves can protect the welder from the possible damage. With the availability of high response, solar powered welding helmets with U/V and I/R protection facilities, the welders can now get a better relief during Welding. However, it is not only the welder alone who should be protected from the harmful radiation, the workmen around the welding point can also get affected due to the intensity of the light generated by the arc. Use of welding curtains have also become more popular in fabrication industry in abroad. The commonly available curtains are Grey, Green, Yellow and Blue and the selection is done depending upon

welding processes and the welding current being used for personnel more than two meters away from the arc for an eight hour exposure period. **Table III** shows the comparative data on the various curtains commercially available as specified by U.S. Army Environmental Hygene Agency.

CONCLUSION

In summary, welding fume generation rates are proportional to the square of welding current and Arc length and level of oxygen present in the shielding Gas in GMA welding. The generation of fume can be reduced by increasing the stickout or by reducing the wire diameter. Use of cartridge type air purifying system will eliminate the harmful effect of fumes. Use of good quality welding helmets and curtains to protect the harmful ultraviolet and radiographic rays will eleminate the commonly known terms such as Arc-Eye and Burnt Skin etc.

Time has come for us to look after the well being of the welders by providing cleaner environment in order to get continuous good quality welding output.

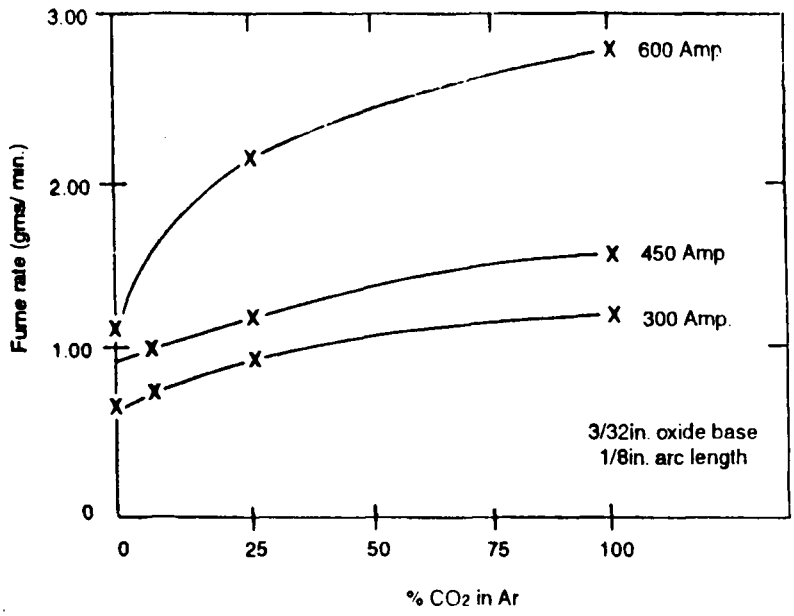


Fig. 5 : Rate of fume generated with % variation of CO_2 in Argon-rich gas mixture at given current.

ACKNOWLEDGMENT

I wish to thank the management of Advani-Oerlikon Limited and Dr. A. Lesnewich, Late N. C. Sarkar, Dr. A. Chatterjee, Calcutta, Mr. G. Manatos, Germany for their kind co-operation.

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