ASSESSMENT OF EFFICIENCY OF A FUME EXTRACTION SYSTEM DURING GAS METAL ARC WELDING

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Abstract

An work environmental study of welding fume and the air movement around the weld zone during GMA welding was conducted by attaching a fume extraction system under study, at different positions on the weld gun and also detaching the system. The paper highlights the industrial hygiene sampling procedure for the welding fume, air movement and also the fume extraction system. The study reveals that minimum fume exposure levels were achieved with increased fume extraction efficiency and the required weld quality, when the extractor system is attached at 25 mm distance from the tip of the gun. The weld quality is affected below 25mm attachment and the fume extraction is not efficient at and above 100mm position.

INTRODUCTION

At the outset, it must be said that the fumes generated by the welding processes are not as dangerous to a worker as compared to other hazards like intense light and heat generated during welding. Because of this, not much work has been done to assess and suggest remedies for the dangers of welding fumes. Welding being an intermittent process, the generation of fumes is not continuous and in most workshops with good cross ventilation, the fumes do not constitute a threat. However, in many shops where production welding is adopted there is a large number of welding sets and over a period of time, the whole shop is often full of fumes.

Gas Metal Arc welding is a process in which an electric arc is formed and maintained between a consumable metal wire electrode and the work piece. In the arc heat, the electrode wire tip is melted and the molten metal is transferred across the arc into the molten weld pool The arc and the weld pool are protected from the atmospheric contamination by a shield gas. The shield gas can be Argon. CO_2 or Argon and CO_2 gas mixture based on the type of parent metal being welded.

Under properly controlled conditions the welder should be safe from exposure to toxic fumes and other hazards arising from welding, but problems can arise if safety procedures are not implemented and complied with. The best protection is afforded by using ventilation systems either general (in a work shop) or local (at source) to the job being welded. In order to check that installed ventilation systems are operating effectively the levels of gases and particulates in the welder's breathing zone will need to be measured.

Objective

The object of the study was to assess the weld fume levels with (at different hose positions on the gun) and without the fume extraction system under study.

Methods

Gas Metal Arc welding

The study was conducted during Gas Metal Arc welding. In the gas metal arc welding process, coalescence was achieved by the heat of an electric arc maintained between the end of an electrode and the work surface. Shielding of the arc was provided by Carbon dioxide with a gas flow of 10 litres per minute. The electrode used was the Fluxofil 11 wire. The arc current was maintained at 300 amperes and the voltage at 30V. The welding was done on Carbon steel plates.

Fumex fume extraction system

The extraction system, the 'Fumes Model A 210' made by Essenjay Marketing Pvt. Ltd, Madras, is a portable single point fume collection unit. The system extracts the polluted air and filters the fume particulates thereby providing a clean and fresh air to welders. It improves operator visibility by cleaning the fume atmosphere and reduces the rejection of working piece of poor quality due to inadequate gas shielding. It has got a bleeder unit to control the suction thereby facilitating the flow of shielding gas during the welding.

It displaces 190m^3 of air per hour. It consists of primary fabric prefilter

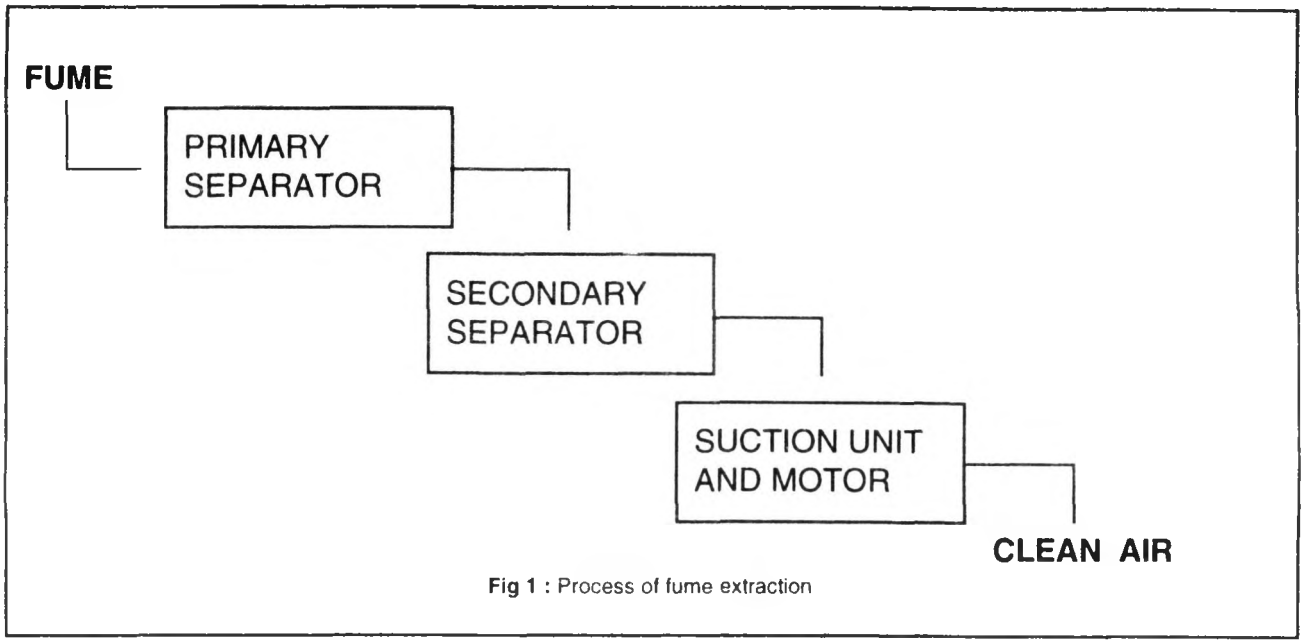

Fig 1 : Process of fume extraction

and secondary HEPA filter with a cable length of 10 metres. The process of fume extraction is shown in **Fig. 1**.

Industrial hygiene monitoring

Particulate welding fumes emanate mainly from the metals being used in the welding process. Fume particles are usually in submicron size and so remain airborne, making it necessary to sample in the welder's breathing zone with and without the Fumex fume extraction system attached to the weld gun. The particulate sampling instrument is a portable, handy Casella air sampling system consisting of a sampling head, a filtering medium to trap the particulates and a battery operated sampling pump to draw the air sample through the filter at about 1.8-2.2 1/min. The sampling head (37 mm) was positioned at about 25 mm from the left or right cheek of the welder with the plane of intake opposite to the cheek. In normal use, the filter head consists of a PVC Millipore membrance filters of pore size 0.8 um fitted on the head shield or the upper portion of the collar of the shirt and the head being connected to the pump using a suitable length of flexible tubing. The flow was calibrated before and after the sampling. When the sampling period of 1 hour was complete the pump was switched off and the sampling time, flow rate and mass of the fume on the filter were calculated. the filter paper was kept inside an oven at 40 - 80°C before and after sampling to eliminate the moisture effect on the collected particulates.

Then Total particulate fume concentration (C) = (1000*m) / (R*t)

where m is the mass of fume on the filter (mg)

R is the sampling rate (l/min.)

t is the sampling time (min.)

The Time Weighted average concentration of the particulate fume is calculated using the formula :

$$TWA = \frac{C_1t_1 + C_2t_2 + ... + C_nt_n}{t_1 + t_2 + ... + t_n}$$

The fume sampling was done when the fume extraction hood was attached at different distances from the tip of weld gun (or) torch, the fume concentration in terms of TWA are listed in **Table I**.

Table I : Fume Concentration Levels - TWA
(n = 10)

01	Without Fume extractor	1.67 mg / m^3
02	With Fume extractor at 100mm above the tip	1.25 mg / m^3
03	With Fume extractor at 25mm above the tip	0.94 mg / m^3
TLV.TWA for Total welding particulates : 5.0 mg/m^3		

Air movement measurements

Air movement at the zone of welding was done by Air velocity meter, in which the heated head is a hot wire, thermocouple or thermister bead through which an electric current is passing to maintian it at a constant temperature. As air blows over it cooling takes place depending upon the air velocity. The current which is required to keep the temperature constant is registered on a meter which has been previously calibrated in m / sec. The probe of the air velocity meter was kept near the welding zone initially to measure the background air velocity at the zone. Then air velocity was measured at different conditions on the extractor systems and also at different positions on the weld gun when it was attached. The values were measured in m/sec and was given in **Table II**. The pictorial presentation of the variations and the relative efficiencies were given in **Fig. 2 & 3.**

Table II : AIR MOVEMENT LEVELS in m / sec
(n = 10)

01	Background air movement at the zone of welding	0.13 ± 0.035
02	After detaching the hose near the mouth of the extractor	7.96 ± 0.084
03	Near the mouth of the hose before attaching to the weld gun	27.1 ± 0.516
04	Near the mouth of the hose when attached with the weld gun	7.35 ± 0883
05	Near the tip of the weld gun when attached 25 mm above the tip	0.97 ± 0.083
06	Near the tip of the weld gun when attached 50mm above the tip	0.18 ± 0.035
07	Near the tip of the weld gun when attached 100mm above the tip	0.13 ± 0.063

Table III : Fume Reduction Levels at Different Positions

	Situation	Construction (Mg / m3)		% Fume reduction factor
		Without Extractor	With Extractor	
01	Normal position	20	-	-
02	House attached 100 mm above the tip	-	15	25
03	House attached 25 mm above the tip	-	11.25	44

Results and Conclusions

The collected welding fume samples were gravimetrically analysed for total particulates and the measured values were compared with the recommended Threshold Limit Values by ACGIH which is 5.0 mg/m^3 as the Time Weighted Average Concentration.

The fume concentration levels at different positions with and without fume extraction system were statistically analysed for the percentage fume reduction and the fume reduction factors are given in **Table III** the relative variations of fume concentrations and air movement with reference to different positions.

The analysis of the data revealed the following facts :

1) The measured fume concentration levels near the breathing zone were well within the recommended TLV both with and without fume extraction system. The system added further comfort to the welder, when it was attached.

2) Fume extraction efficiency was found to be 44% when the extractor hose was placed at 25 mm above the tip of the weld gun. That was a 19% increase in efficiency over the 100 mm position.

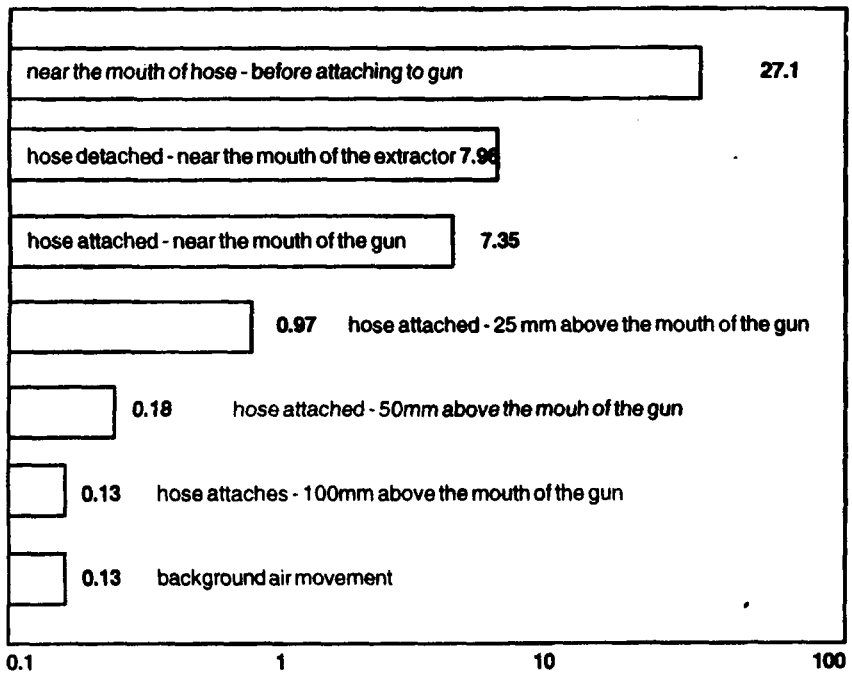

Fig 2 : Air Movement Variations

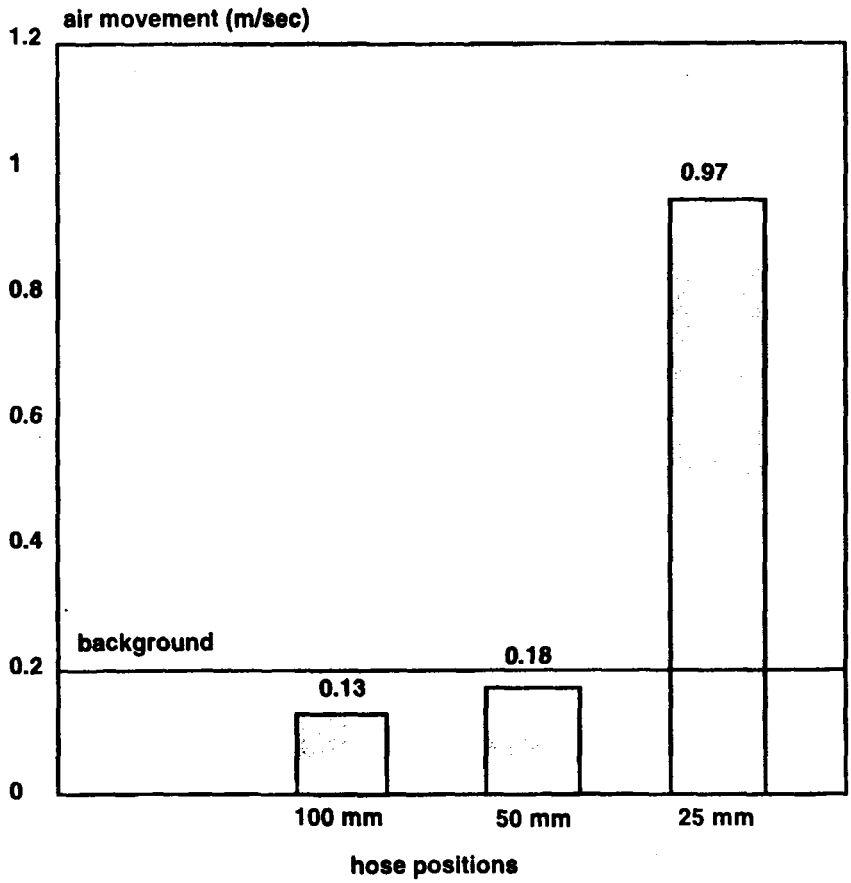

Fig 3 : Relative Efficiencies at different positions

3) The air movement was optimum at 25 mm above the tip position. Below the level (less than 25 mm) it interfered with the shielding gas and as a result the quality of the weld was affected. At 100 mm position, it maintained the background air movement level.

And hence, the system was found effective when it was placed at 25 mm position, with lesser fume concentration and an optimum air movement facilitating the weld quality.

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