Effect of Various Fluxes on Weld Characteristics in Activated Metal Inert Gas Welding Process

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***Abstract*— In the past years so many developments and innovation are made to increase the performance of the welding machine by reducing the power consumptions, cost, labour skills and many more. In a row, A-MIG welding process is one of the welding processes which increase the welding properties of material at the same consumption of the power and resources. A-MIG welding is wildly used to optimize the parameter of MIG welding. A constant-current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapours known as plasma. Metal inert gas (MIG) welding is most commonly used to weld thick sections of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys. Three kinds of oxides, Fe_2O_3, SiO_2, and $MgCO_3$, were used to investigate the effect of activating flux aided gas metal arc welding (GMAW) on weld bead geometry, angular distortion and mechanical properties.**

The most significant effect on the internal form factor was experienced in case of MnO active flux, which decreased the internal form factor by 20 %. In case of the external form factor the applied SiO_2 active flux caused the biggest increase which is 37 %. In the hardness distribution and the microstructure of the joints, including the weld metal and the heath affected zone, no significant differences were experienced compared to the sample welded without any flux material.

***Keywords*— Gas metal arc welding, Active flux welding, Weld geometry, Structural steel, Microstructure.**

I. INTRODUCTION

Metal inert gas welding is also known as gas metal arc welding which uses a consumable electrode to generate arc between workpiece and electrode. The inert gas argon, in rare cases helium (more expensive) gases are use to protect the weld bead for atmosphere contaminates, these gases are also called shielding gas and filler materials are normally used. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. MIG welding is use to joint ferrous and non-ferrous materials such as steel, copper, aluminium, magnesium, nickel, and their alloys.

MIG welding process has fails to weld thick section of material in single pass and it has low productivity. To improve the performance of MIG welding activated flux are use to increase the depth of penetration in single pass. Activated flux is mixed with the acetone and blinder and applied thin past on the workpiece by brush or spray. A-MIG welding technique makes it possible to intensify the conventional MIG welding practices for joining the more than 10 mm thick plate by single pass with no edge preparation. The mechanical properties improved compared to the welds made without any flux material. In our research we investigated the effects of eight different active fluxes and mixtures in detail during GMAW using active shielding gas. In case of arc welding the driving force of the occurred flows in the weld pool can be originated from four different phenomena, the buoyancy, the surface-tension (which resulted in the so called Marangoni effect [9]), the high velocity movement of the arc plasma, and the Lorentz force [10, 11]

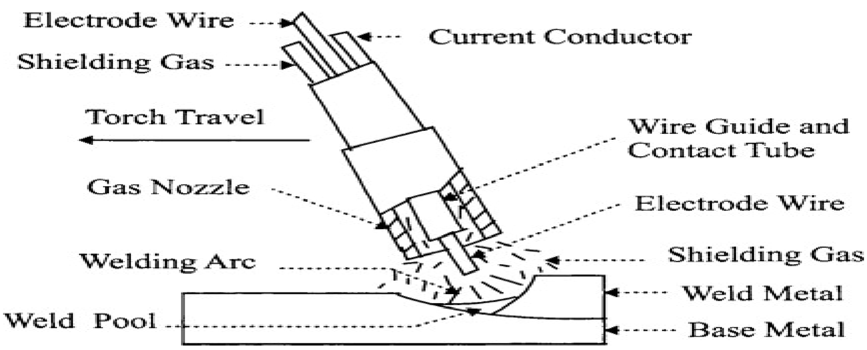


Fig. 1 Schematic diagram of MIG welding

M. Zuber et al. (2014) have investigated on Effect of flux coated gas tungsten arc welding on 304L. In this investigation the researcher used SiO_2 flux and the result shows that the penetration increased up to 200%, ferrite number increased up to 14 % and the hardness value of the material also increased.[1] G. venkatesan et al. (2014) has studied on Effect of ternary fluxes on depth of penetration in A-TIG welding of AISI 409 ferritic stainless steel. In this study the flux increased depth of penetration up to 100%. [2] Xiong Xie et al. (2015) have researched on Effects of nano-particles strengthening activating flux on the microstructures and mechanical properties of TIG welded AZ31 magnesium alloy joints. The researcher used mixed TiO_2 and nano-SiC particles as activated flux and showed that microstructure, microhardness in fusion zone, ultimate tensile strength was improved [3].

Based on previous researches, the present investigation is deals with three types of activated fluxes which are applied on the workpiece prior to welding. The bead geometry is then compared after welding with and without using activated fluxes. The effect of the different fluxes is also studied.

II. MATERIAL AND EXPERIMENTAL PROCEDURE

A. Base metal and its composition

The material used in this study is austenitic stainless steel 301. The composition of the base metal is given in table 1. The work pieces were cut in the dimension of 100 mm X 50mm X 10mm plates. Before welding the work pieces were grinded with 220 grit emery papers and it cleaned with acetone.

Table 1 Composition of material

Component	Percentage (%) Weight
C	0.054
Si	0.284
Mn	1.11
P	0.021
S	0.008
Cr	14.25
Mo	0.093
Ni	6.15
Co	0.067
Ti	0.009
V	0.054
Fe	Rest

B. Preparation of flux

The weld bead geometry of welding should be studied after applying the flux paste on the surface of workpiece.

The pasted were made with the mixing of acetone and very small amount of sodium silicate as binder and apply with the help of brush or spray shown in Figure 2. Acetone has tendency to vaporize and leave the flux on the surface of workpiece and sodium silicate has tendency to sticking and bind the flux particle together.

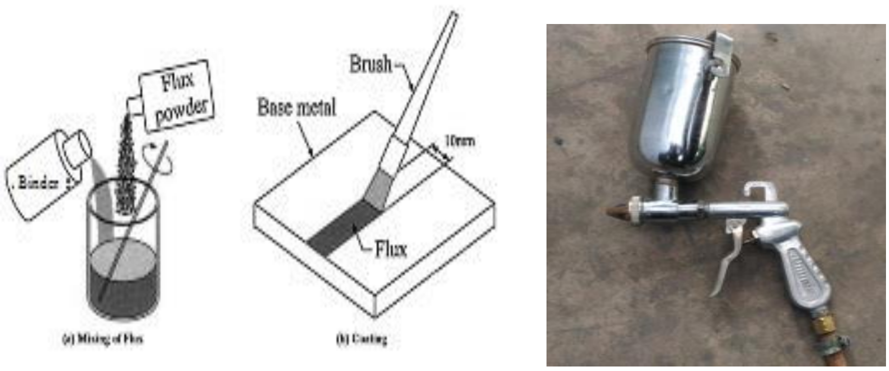


Fig. 2 Flux preparation

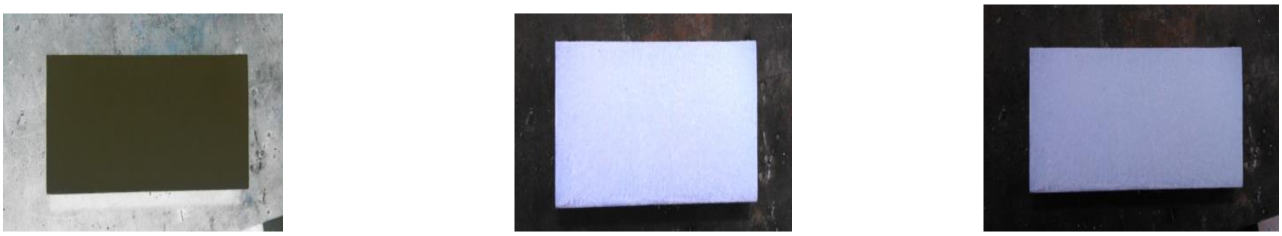
C. Experimental procedure

In the first step, the welding parameters are decided on the basis of several trial experiments and are listed in table 2.

Table 2 Process parameter for welding

Parameters	value	units
Welding current	180	A
Total arc voltage evolution	12-18	V
Travel speed	120	mm/min
Arc gap	2.5	mm
Diameter of electrode	2.6	mm
Gas flow rate	14	L/min

Prior to welding the metal power is mixed with acetone and sodium silicate (as binder) to make paint like solution and applied a very thin layer approximately 0.2mm on the workpiece surface with the help of brush or spray. Uniformity in applied flux is most important to get good quality of weld and more depth of penetration.



(a) (b) (c)

Fig. 3 Photograph of applied fluxes (a) MnO_2 flux, (b) TiO_2 flux and (c) SiO_2 flux.

TIG welding is done on the work pieces which are coated with the fluxes and without flux. The pattern of the TIG welding on workpiece shown below,

(a) (b) (c) (d)

Fig. 4 Photograph of weld bead on workpiece (a) without flux (b) MnO_2 flux (c) TiO_2 flux (d) SiO_2 flux

D. Stereo zoom microscope analysis

The weld bead measurement was done as per UNS SS30100 Standard on stainless steel specimen on the stereo zoom microscope analyser available at SLIET Longowal (Punjab). For stereozoom microscope analysis, the specimens have been prepared using standard procedure like grinding, polishing using successively fine grades of emery up to 3000 grit size and Al_2O_3 power. It was help to remove scratches on the surface that are to be metallographic-ally analysed. Before analysis, etchant is use to reveal bead geometry. Stereo zoom analyser is used to measure the bead geometry like bead width, depth of penetration and heat affected zone (HAZ) of the specimens.

III. RESULTS

Stereo zoom analysis of the weld bead with and without flux is represented as follows:

A. Effect of weld bead with and without flux of weld bead

In conventional TIG welding, the direction of convection in weld is towards the edge from the centre of the weld. This convection shows low depth of penetration and wide weld width. But in activated TIG welding the convection is reverse from edge to centre to the weld. The images show the differences between conventional TIG welding and activated TIG welding. [4]

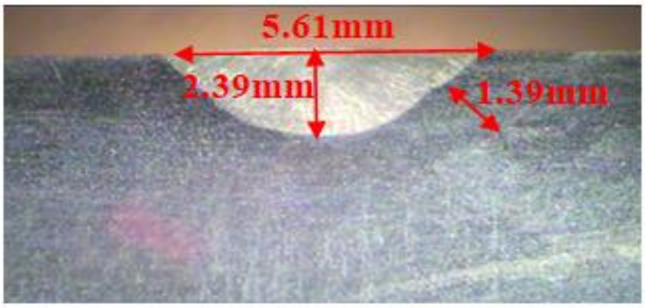


Fig. 5 Stereo zoom analyser images for without flux

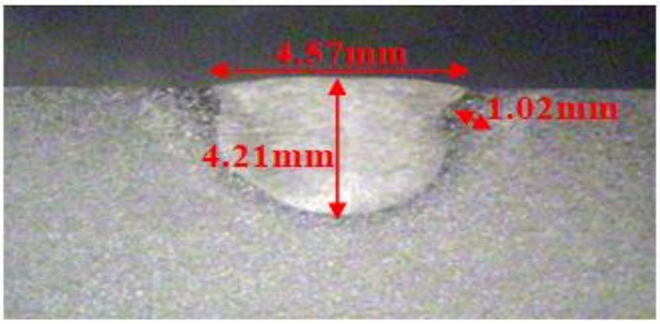


Fig. 6 Stereo zoom analyser images for MnO_2 flux

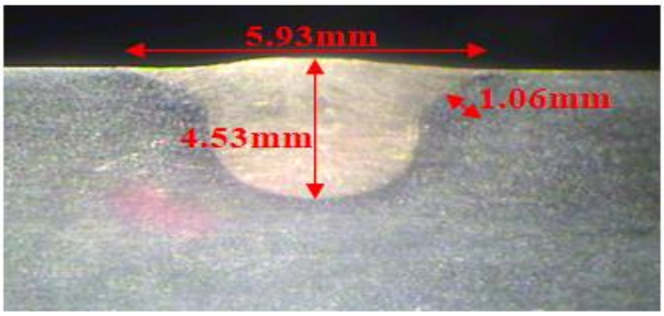


Fig. 7 Stereo zoom analyser images for TiO_2 flux

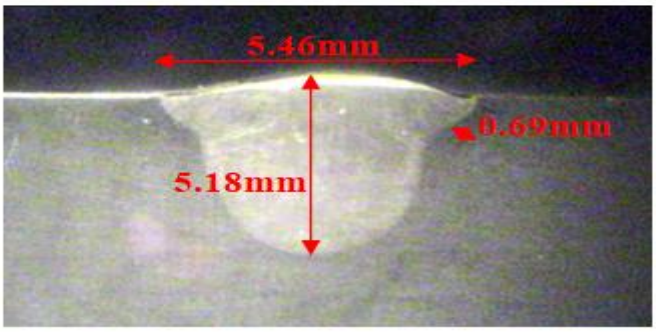


Fig. 8 stereozoom analyser images for SiO_2 flux

The results show that application of fluxes increase the depth of penetration. MnO_2 activated flux has lowest penetration among the other fluxes up to 4.21mm and SiO_2 activated flux has highest depth of penetration up to 5.18mm.

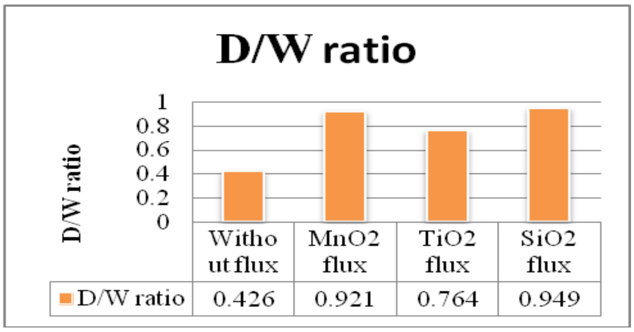
B. Effect of aspect ratio with and without fluxes

In conventional welding, the surface tension at centre of weld is less than edge of the weld that shows molten metal take place form centre to edge, this phenomena is called Marangoni effect. Due to phenomena of surface tension in conventional TIG welding depth of penetration is less than width of weld bead.[4] Therefore the aspect ratio in conventional welding is 0.426. Application of flux constrict the arc to the centre of the weld bead this leads the surface tension towards the centre of the weld bead and the penetration achieved more than the conventional TIG welding process. It is observed that use of SiO_2 activated flux provide better aspect ratio as compare to other used flux in study.

Table 3 Aspect ratio for various fluxes

TIG Welding process	Depth of penetration (mm)	Weld width (mm)	Aspect ratio
Without flux	2.39	5.61	0.426
Using MnO_2 flux	4.21	4.57	0.921
Using TiO_2 flux	4.53	5.93	0.764
Using SiO_2 flux	5.18	5.46	0.949

Graph of aspect ratio



IV. CONCLUSIONS

From the Study following conclusion are drawn.

1. The use of flux is more beneficial as compare to conventional TIG welding.
2. It is observed that aspect ratio with flux is increase 80-122% for different coated flux.
3. Maximum aspect ratio observed is 0.949 for SiO_2 flux. So it is more beneficial to use SiO_2 flux.
4. It is observed that using SiO_2 flux results in minimum heat affected zone (HAZ), results in unaffected strength of weld and base metal.

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