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Performance of activated TIG process in mild steel welds

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Abstract : *Gas tungsten arc welding is fundamental in those industries where it is important to control the weld bead shape and its metallurgical characteristics. However, compared to the other arc welding process, the shallow penetration of the TIG welding restricts its ability to weld thick structures in a single pass thus its productivity is relativity low. This is why there have been several trials to improve the productivity of the TIG welding. Different kind of oxide Cr_2O_3 ,$MgCo_3$, 1:1 mixture of both these powder, MgO, CaO, Al_2O_3 oxide powder were used on mild steel. The experimental results showed that activating flux aided TIG welding has increased the weld penetration, tending to reduce the width of the weld bead .Also on increasing penetration by applying the flux on mild steel its hardness get reduced and there subsequently increased in depth to width ratio. The Cr_2O_3 flux produced most noticeable effect*

Keywords- *Cr_2O_3 ,$MgCo_3$, MgO, CaO, Al_2O_3 flux used, active flux used on mild steel plate.*

I. Introduction

Activated tungsten inert gas (A-TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. In A-TIG welding, a thin layer of activated flux is brushed on to the surface of the joint to be welded.

In TIG welding, a high frequency generator provides an electric spark; this spark is a conductive path for the welding current through the shielding gas and allows the arc to be initiated while the electrode and the workpiece are separated, typically about 1.5–3 mm (0.06–0.12 in) apart. The electric arc produced can reach temperatures of at least 5000° C.

Fig 1.1 conventional tig welding

Activated flux is used in the A-TIG welding, which is the only difference from the conventional TIG welding. Activated flux can be prepared by using different kind of component oxides packed in the powdered form with about 30-60 µm particle size. These powders mixed with acetone,methanol, ethanol etc to produce a paint-like consistency. Before welding, a thin layer of the flux, brushed on to the surface of the joint to be welded. The coating density of the flux should be about 5-6 mg/cm². Activated TIG welding can increase the joint penetration and weld depth-to-width ratio, thereby reducing the angular distortion of the weldment.

II. Literature Review

Magudeeswaran et al; (2014) studied the major influencing ATIG welding parameters, such as electrode gap, travel speed, current and voltage, that aid in controlling the aspect ratio of DSS joints, must be optimized to obtain desirable aspect ratio for DSS joints. The above parameters of ATIG welding for aspect ratio of DSS welds are optimized. The optimum process parameters were found to be 1 mm electrode gap, 130 mm/min travel speed, 140 A current and 12 V voltage by using taguchi technique

Patel et al; (2014) studied the effect of TIG welding parameters on the weld's joint strength and then, the optimal parameters were determined using the Taguchi method. SiO_2 and TiO_2 oxide powders were used to investigate the effect of activating flux on the TIG weld mechanical properties of 321austenitic stainless steel. The experimental results showed that activating flux aided TIG welding has increased the weld penetration, tending to reduce the width of the weld bead. The SiO_2 flux produced the most noticeable effect. Furthermore, the welded joint presented better tensile strength and hardness.

Badheka et al; (2013) studies the effect of current, welding speed, joint gap and electrode diameter on weld bead dimensions on 6 mm thick dissimilar weld between carbon steel to stainless steel, was studied under Activated Flux-Tungsten Inert Gas Welding process. During this investigation three different types of oxide powders were used-TiO_2, ZnO and MnO_2. After welding samples were subject to mechanical testing, in addition to characterization via micro hardness and microstructures of Normal Tungsten Inert Gas Welds and Activated Flux-Tungsten Inert Gas Welds. Highest depth/width (D/W) ratio reported under TiO_2 and ZnO fluxes compare to Normal-Tungsten Inert Gas Welds. Lowest angular distortion was observed under TiO_2 flux compare to Normal-Tungsten Inert Gas Welds. Mechanical properties, Joint Efficiency of Activated Flux-Tungsten Inert Gas Welds are higher than normal-Normal Tungsten Inert Gas Welds.

Zou et al; (2013) adopted the method of double-shielded advanced A-TIG (AA-TIG) welding in this study for the welding of the duplex stainless steel with the shielding gases of different oxygen content levels. The oxygen content in the shielding gas was controlled by altering the oxygen content in the outer layer gas, while the inner layer remained pure argon to suppress oxidation on the tungsten electrode. As a result, a deep weld penetration was obtained due to the dissolution of oxygen into the weld metals

Tseng et al; (2012) investigates the influences of specific flux powders, including FeF_2, FeO, and FeS on the surface appearance, geometric shape, angular distortion, hot crack susceptibility, and metallurgical properties of 5-mmthick 17Cr–10Ni–2Mo alloys welded using the tungsten inert gas (TIG) process. Results indicated that TIG welding with FeF_2 powder produces a weld of satisfactory appearance. TIG welding with FeO and FeS powders results in a substantial increase in both the joint penetration and weld aspect ratio, thereby reducing angular distortion of the weldment.

Hung et al; (2012) investigated the influence of oxide-based flux powder and carrier solvent composition on the surface appearance, geometric shape, angular distortion, and ferrite content of austenitic 316L stainless steel tungsten inert gas (TIG) welds. The flux powders comprising oxide, fluoride, and sulfide mixed with methanol or ethanol achieved good spread ability. For the investigated currents of 125 to 225 A, the maximum penetration of stainless steel activated TIG weld was obtained when the coating density was between 0.92 and 1.86 mg/cm^2. The arc pressure also raised the penetration capability of activated TIG welds at high currents. The results show that higher current levels have lower ferrite content of austenitic 316L stainless steel weld metal than lower current levels.

Randhawa et al (2012); was carried out Tig welding process and experimental investigation towards the Effect of A-Tig Welding Process Parameters on Penetration in Mild Steel Plates are conducted. TIG welding is mostly used to weld thin sections for high surface finish. A major drawback in the processes having very small penetration as compare to other arc welding process. The problem can be avoided by using active flux in conventional TIG welding. In the present study investigate the optimization of A-TIG welding process on mild steel for an optimal parameter by using Taguchi technique. The effect of various process parameters (welding current (I), welding speed (V), active flux) .IN the present study efforts were made to increase the weld penetration by Appling the active flux and to optimize the process parameters.

Tseng et al (2010); investigated the effect of activated tungsten inert gas (activated TIG) process on weld morphology, angular distortion, and hardness of type 316stainless steels. An autogenous TIG welding was applied to 6mm thick stainless steel plates through a thin layer of flux to produce a bead-on-plate welded joint. The oxide fluxes used were packed in powdered form. Their experimental results indicated that the SiO_2 flux is more preferrable over Al2O3. To obtain high quality welds and stable weld arc, the activated TIG process requires large diameter electrodes to support a given level of the weld current.

Sakthivel et al; (2011) joined 316L(N) stainless steel plates using activated-tungsten inert gas (A-TIG) welding and conventional TIG welding process. Creep rupture behavior of 316L(N) base metal, and weld joints made by A-TIG and conventional TIG welding process were investigated at 923 K over a stress range of 160–280 MPa. Creep test results showed that the enhancement in creep rupture strength of weld joint fabricated by A-TIG welding process over conventional TIG welding process.

Qiu et al; (2011) studied the micro-structural characteristics. Mechanical properties were studied with micro-hardness and tensile test. Results show that no obvious difference from the microstructures of the joints prepared with and without SiO_2 flux, the joint HAZ (heat affected zone) with SiO_2 flux was observed to be slightly wider than the one without the flux. The weld joint penetration with SiO_2 flux was about 26% deeper than what without SiO_2 flux.

Niagaj et al; (2010) investigated the impact of activating flux on A-tig welding of grade 2 titanium. They also studied the dimensions and macrostructure of welds and also studied the mechanical properties such as strength impact energy and hardness of weld zones.

Huang et al; (2008) investigated the effects of shielding gas composition and activating flux on weld morphology, angular distortion, retained delta-ferrite content, mechanical properties and hot cracking susceptibility. Activating flux materials consisted of a manganese oxide powder and zinc oxide powder mixture. The results showed that the penetration and cross-sectional area of the weld increased with the increase of nitrogen added to the argon-base shielding gas. An increase in shielding gas nitrogen content had markedly reduced the angular distortion of the weldment. Increasing the nitrogen increased the tensile strength and hardness.

Xu et al; (2007) investigated the flux effect on TIG. The experimental result showed that increase of active flux on the weld bead tends to increase the penetration of the weld pool at first and then decreases steeply. This does not coincide with the simulated results. It is probably because part of the oxide in the flux is not totally decomposed when the flux reaches a critical value. The solid oxide particles in the weld pool act as the obstacles of the fluid flow and reduce the velocity of the flow.

Modenesi et al; (1998) explained that A-TIG welding uses a thin layer of an active flux that results in a great increase in weld penetration. The effect of the flux on the weld microstructure was studied. The results indicate that even the very simple flux that was used can greatly increase the penetration of the weld bead.

Problem formulation

It is observed that although enormous work has been done in the field of conventional TIG welding of the mild steel related to increasing the depth of penetration and the reduction in the width of the weld bead, but lesser work has been done on activated flux TIG welding. Activated TIG welding can enormously increase the penetration and weld depth-to-width ratio. The productivity of the mild steels can be increased by using activated flux in TIG welding.

The result by using A-TIG welding will be compared with the conventional TIG welding process and the effect of flux on the properties of the weld will be studied.

Objective of the study

The objective of the study is to study the following factores:

1. depth of penetration
2. depth-to-width ratio
3. Hardness

of the mild steel by using activated TIG welding process and their comparison with the conventional TIG process.

Basically mil steel is the most common form of the steel as its price is relatively low while it provides material properties that are acceptable for many applications. Mlid steel contains 0.16%-0.29% carbon, therefore it is neither brittle nor ductile. It is often used when large amounts of the steel is needed for example as structural steel, it is used for almost all non-specialist steel products-cars, domestic goods, wires, rings etc.

Experiment procedure

Table 5.1:Composition of base metal (mild steel)

Job	C%	Mn%	P%	S%	Si%	Cu%	Ni%	Cr%	Al%	Mo%
M.S. Plate	0.1870	1.037	0.02464	0.00647	0.1393	0.0108	0.0049	0.0017	0.052	-----

In Present study, in order to increase the penetration oxide powder Cr_2O_3, $MgCO_3$ and 1:1 mixture of both these powder, Al_2O_3, MgO, and CaO also were used. These are compared with conventional tig welding. 8mm thick plate of mild steel were used. These oxide powders were mixed with acetone to obtained paste of these powders. After then paste is uniform applied on plates.

PARAMETER	VALUE
Current	136 Amp
Voltage	14V
Inert gas flow rate	13-14 litre per min

TIG Welding with these parameters of given value is apllied on mild steel welds. To check the penetration central zoom microscope is used in the enviroment condition of temperature 24 degree Celsius and for hardness vicker harndess test is used.

III. Results

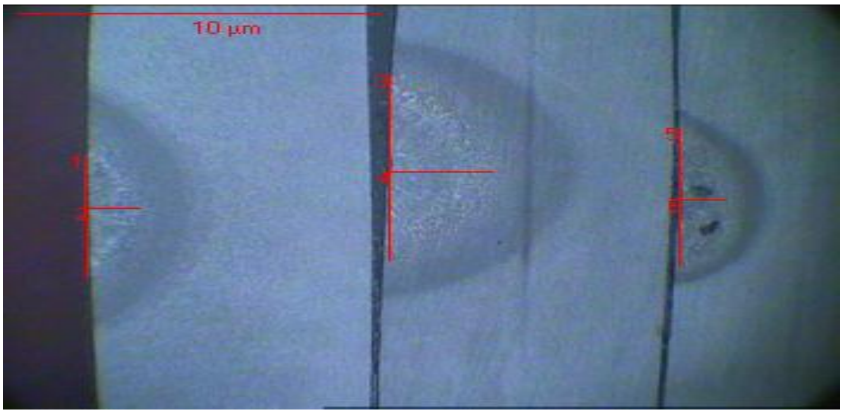

Fig 6.1 represents depth to width ratio of Conventional tig welding, Cr_2O_3, $MgCo_3$)

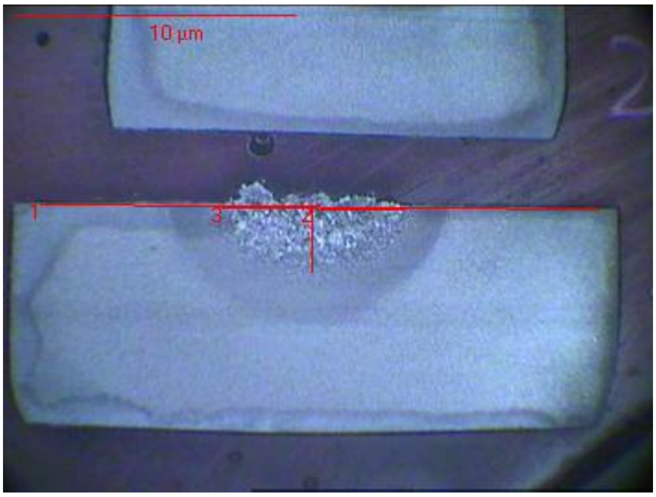

Fig 6.2 Represents Depth To Width Ratio Of

6.1 Penetration Results:

SAMPLE	PENETRATION
SIMPLE Tig welding	1.43mm
Cr_2O_3	2.81mm
Flux mixture (1:1)	2.72mm
$MgCo_3$	1.24mm
Al_2O_3	2.63mm
Mg0	2.53mm
CaO	2.55mm

6.2 Depth to width ratio result:

SAMPLE	DEPTH	WIDTH	DEPTH TO WIDTH RATIO
Conventional tig welding	1.43mm	5.75mm	0.25mm
Cr_2O_3	2.88mm	8.30mm	0.35mm
$MgCo_3$	1.34mm	6.47mm	0.19mm
Flux mixture (1:!)	2.72mm	7.95mm	0.34mm
Al_2O_3	2.63mm	7.83mm	0.34mm
Mg0	2.53mm	7.60mm	0.33mm
CaO	2.55mm	6.54mm	0.39mm

6.3 Hardness Results:

SAMPLE	Load 10Kgf	Load 20kgf
Simple tig welding	313 Hv10	438 Hv20
Cr_2O_3	231.9 Hv10	253.9 Hv20
Flux mixture(1:1)	242.4 Hv10	195.2 Hv20
$MgCo_3$	267.9 Hv 10	261.3 HV20
CaO	237.5 Hv 10	199.5 Hv 10
MgO	234.0 Hv 10	229.7 HV20
Al_2O_3	275.4 Hv 10	332.2 HV20

IV. Conclusion

1. The Cr_2O_3 flux produced most noticeable effect ,it increased the penetration double time as compared with conventional tig welding.
2. The $MgCo_3$ flux gives very poor result,it has lowest penetration result as compared with other sample.
3. The flux mixture also increased penetration,but due to poor result of $MgCo_3$ its penetration decreased slightly.
4. On aplying the flux the quality of weld increased ,as vicker hardness test shows activated samples hardness decreased as compared with conventional tig welding.
5. Depth to width ratio result shows that CaO, Cr_2O_3 and flux mixture gives higher value, therefore suscepatibilty to get crack also get reduced.

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