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Fluid Flow Behaviour under Different Gases and Flow Rate during Gas Metal Arc Welding

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ABSTRACT
Gas metal arc welding (GMAW) is a highly efficient and fast process for fabricating high quality weld. High quality welds are fabricated by proper selection of consumable includes gas and filler metals. The optimum flow rate of gas will ensure the proper quality of weld. In this project, a fluid flow behavior of different flow rate is modeled and the change quality will be studied.
Keywords- *Hydraulic diameter, Gas flow rate, Pipeflow, Reynolds number*

I. I.INTRODUCTION

Gas metal arc welding (GMAW) is a highly efficient and fast process for fabricating high quality welds. High quality welds are fabricated by proper selection of consumable includes gas and filler metals. The optimum flow rate of gas will ensure the proper quality of weld. In this project, a fluid flow behavior of different flow rate is modeled and the change quality will be studied. The arc is established between the workpiece and a continuously fed wire anode.

It is a welding process where an electrode wire is continuously fed from an automatic wire feeder through a conduit and welding gun to the base metal, where a weld pool is created. GMA welding is used as a semi-automatic or automatic arc welding process in many applications. In this process the arc is burning between a continuously fed and consumable wire electrode and the workpiece. The shielding gas undertakes a lot of tasks, for example the cooling of the torch, the definition of the arc properties or the protection of the melt from oxidation.

If a welder is controlling the direction of travel and travel speed the process is considered semi-automatic [1]. The process is fully automated when a machine controls direction of travel and travel speed; such is in the case of robotics. The plasma flow and the arc attachment at the wire have an important influence on the droplet formation and the heat transfer. Conversely, the droplet geometry, surface temperatures and vaporization affect the fluid flow and the heat transfer inside the arc. A comprehensive understanding of the welding process and the physical effects involved are necessary to reduce the number of experimental parameter studies required and to advance the development of welding techniques and equipment.

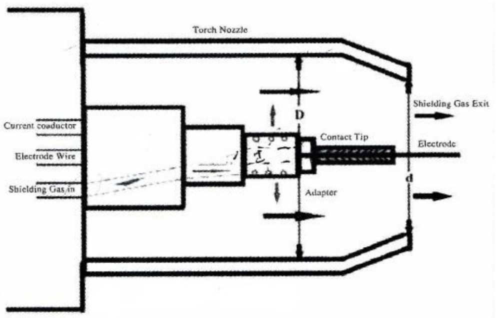
1.1. SHIELDING GASES

At high temperature, all metals commonly used for fabrication will oxidize in the presence of the atmosphere. Every welding process provides shielding from the atmosphere by some method. When welding steels we want to exclude oxygen, nitrogen, and moisture from the area above the molten puddle. In the Oxy-fuel process, the weld pool is shielded from the atmosphere by the combustion by-products of carbon monoxide (CO) and carbon dioxide (CO2) [1].

If air is aspirated into the shielding gas line through a leak, nitrogen and moisture will also contaminate the shielding gas. Nitrogen, while very soluble in the puddle at high temperatures, will cause porosity as it escapes during cooling of the weld bead. Metallic and argon ions transfer the positive charge across the arc. If air is aspirated into the shielding gas line through a leak, nitrogen and moisture will also contaminate the shielding gas [2]. Oxygen is obtained from direct additions of oxygen or from CO_2.

II. EXPERIMENTAL SETUP

An analytical model for estimation of fluid flow behaviour in various sizes of gas metal arc welding torch nozzle under different shielding gas and inlet Gas Flow Rate (GFR) has been worked out. The variation in fluid flow behavior with a change in gas flow rate and shielding gas has been satisfactorily analyzed. To verify the model, surface appearance of weld deposit has been studied under different GFR at a given shielding gas during weld bead on plate deposition on plain low carbon steel [4]. The theoretical model may provide wider opportunity to design the different GMAW torch nozzle for welding of various plate thicknesses and groove design.



(1).Inlet velocity

Fig 2.1. Various components of torch nozzle

2.1. CO_2 AS SHIELDING GAS-30 lpm

Carbon dioxide is composed of 72% oxygen and 29% carbon. It is the least expensive shielding gas to purchase for welding plain carbon steel [5].

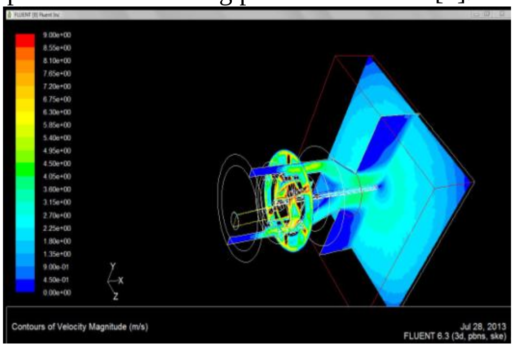


Fig 2.1.1 Contour showing 5.5 m/s velocity

$$V_i = \frac{GFR}{A_1} = \frac{0.001166}{0.00002826} = 41.25 \text{ m/s}$$

GFR at 50 lpm =30/60000 = 0.000833m/s

and A_1 is 28.26mm^2 = 0.00002826m^2

For a given GFR and torch nozzle outlet area of 10 lpm and 254mm^2 respectively, typical estimation of fluid flow in the GMAW torch nozzle is as given below. Where, the torch nozzle inlet area and shielding gas considered as 24.61mm^2 and 100% CO_2 respectively

(2). Outlet torch nozzle velocity

$$V_o = \frac{A_1 * V_1}{A_2} = \frac{0.00002826*41.25}{0.000254} = 4.59 \text{ m/s}$$

(3). The perimeter (P)

P = 3.14*[D + d] = 3.14*[38+18] = 0.175m

(4). Hydraulic diameter

$$D_H = \frac{4*A_2}{P} = \frac{4*0.000254}{0.17} = 0.0058 \text{ m}$$

(5). Reynolds number of given torch nozzle is

$$Re = \frac{\rho * V_o * D_H}{\mu} = \frac{1.8*3.28*0.0058}{0.000007} = 3500$$

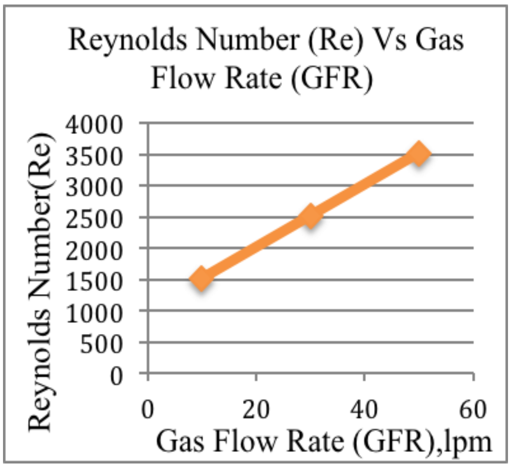


Fig 2.1.2 Effect of GFR on Re for CO_2

It is observed that irrespective of shielding gas and outlet area, the increase of gas flow rate enhances the R_e .it is also observed that in case of 100% CO_2 shielding gas the GFR exceeds beyond 35lpm.

2.2. ARGON AS SHIELDING GAS-50 lpm

Colorless, odorless, tasteless and non-toxic, argon (Ar) is a noble gas that comprises 0.93% of the earth's atmosphere. Argon can provide an inert and clean environment free from nitrogen and oxygen for annealing and rolling metals and alloys. In the casting industry, argon is used to flush porosity from molten metals to eliminate defects in castings[6].

(1). Inlet shielding gas flow velocity

$$V_i = \frac{0.000833}{0.00002826} = 29.47 \text{ m/s}$$

(2). Outlet torch nozzle velocity

$$V_o = \frac{0.00002826*29.47}{0.000254} = 3.28 \text{ m/s}$$

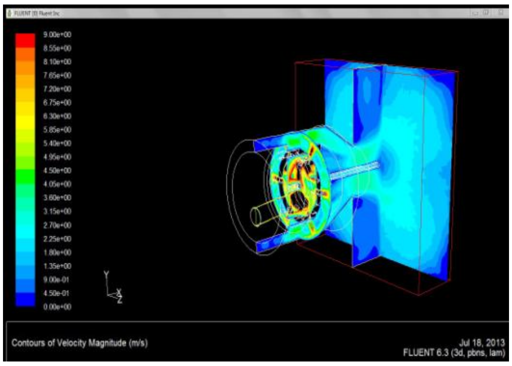


Fig2.2.1. Contour showing 9 m/s velocity

Perimeter and Hydraulic diameter are similar to the case of CO_2

(3). Reynolds number of given torch nozzle is

$$Re \quad \frac{1.6*3.28*0.0058}{0.000021} = 1449.01 \text{ m/s}$$

It is also observed that in case of 100% ARGON shielding gas the GFR exceeds beyond 70 lpm (irrespective of A_2); the fluid flow behavior is turbulence flow. Thus, it is concluded that or effective gas shielding in GMAW process better to keep the GFR less than 70 lpm.

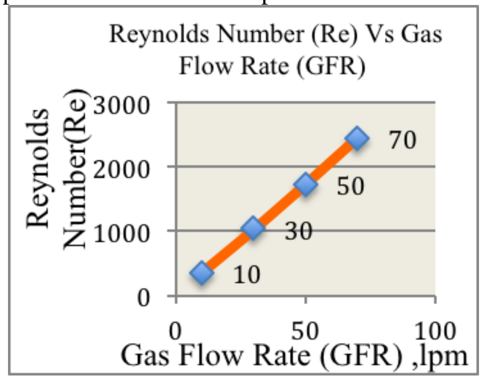


Fig2.2.1 Effect of GFR on Re for Argon

2.3. 80 % ARGON AND 20 % CO_2 AS SHIELDING GAS-50 lpm

When two shielding gases are mixed, they may also be called dual blends or binary blends. There are many advantages for using a mixture of argon and carbon dioxide. By optimizing the amount of CO2 in the argon mixture, the fluidity of the weld puddle can be controlled to give good bead shape in a variety of welding positions.

It allows for good control and speed when in flat, horizontal, or vertical welding positions (up or down). Because Argon/CO2 mixtures provide an arc that remains more stable when welding over light mill scale or residual oil, there is a significant reduction of the possibility of weld porosity occurring. Also, by increasing the percentage of CO2 in a mixture, there is a greater tendency to remove some material contamination in advance of the arc, which can improve overall weld quality, particularly when coated steels are used.

(1). Inlet shielding gas flow velocity

$$V_i = \frac{0.000833}{0.00002826} = 29.47 \text{ m/s}$$

(2). Outlet torch nozzle velocity

$$V_o = \frac{0.00002826*29.47}{0.000254} = 3.28 \text{ m/s}$$

(5). Reynolds number of given torch nozzle is

$$Re = \frac{1.64*3.28*0.0058}{.000018} = 1733.3 \text{ m/s}$$

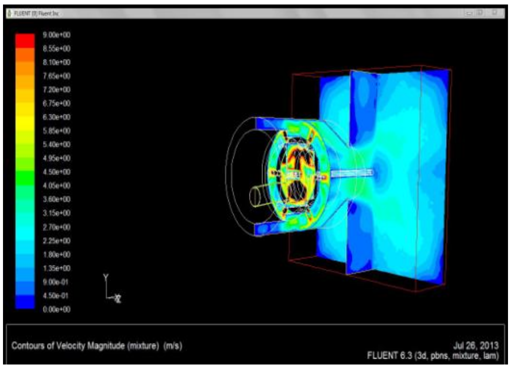


Fig2.3.1. Contour showing 9 m/s velocity

Perimeter and Hydraulic diameter are similar to the case of CO_2

It is observed that in case of 80 % ARGON and 20 % CO_2 shielding gas the GFR exceeds beyond 70 lpm (irrespective of A_2); the fluid flow behavior is turbulence flow. Thus, it is concluded that or effective gas shielding in GMAW process better to keep the GFR less than 70 lpm.

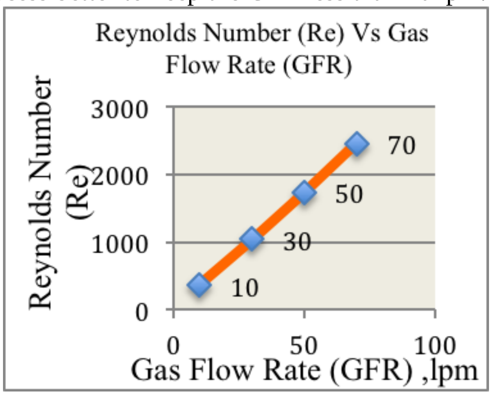


Fig2.3.1. Effect of GFR on Re for 80 %Argon and 20 % CO_2

III. CONCLUSION

In case of 100% CO_2 shielding gas the GFR exceeds beyond 35 lpm (irrespective of A_2); the fluid flow behavior is turbulence flow. Thus, it is concluded that or effective gas shielding in GMAW process better to keep the GFR less than 30 lpm. Whereas, in case of 100% Ar and 80% Ar + 20% CO_2 shielding gas the turbulence flow may occur when the GFR exceeds beyond 90 lpm. In the plasma region, the kind of flow is open channel flow. For open channel, the laminar and turbulence flow exits when the Re is less than 500 and more than 2000 respectively. This is much lower than pipe flow[7].

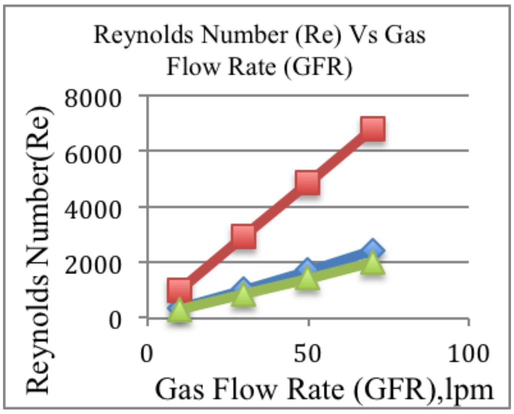


Fig2.2.1. Effect of GFR on Re for CO_2, ARGON and 80 %Argon and 20 % CO_2

The modeling and analysis carried out in this work has been found effective in quantitative understanding of the nature of the fluid flow and its behavior during GMA welding of low carbon steel. It is clearly identified that the variation in GFR and shielding gas significantly affects the nature of fluid flow.

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