

# Experimental Analysis of the Influence of CO<sub>2</sub> in Argon as a Shielding gas in GMAW of Martensitic Stainless Steel

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**ABSTRACT:** In Gas Metal Arc welding (GMAW) process for protecting the arc and molten weld-pool from atmospheric contamination a shielding gas of argon or CO<sub>2</sub> is supplied continuously during welding. Argon is generally used for welding of non-ferrous metals. CO<sub>2</sub> gas is used for welding of mild steel. For alloy steels and even for mild steel applications requiring higher quality, a blend of argon/CO<sub>2</sub> gas mixture is normally used. The arc characteristics, metal transfer and weld pool behavior are greatly influenced by the type of shielding gas. The improved arcing characteristics and metal transfer in GMA welding with argon/CO<sub>2</sub> mixed gas is due this influence. In this experimental work, martensitic stainless steel (SS 410) is bonded by GMAW (MIG welding) process under different gas mixtures such as 100%Ar, 98.5%Ar + 1.5%CO<sub>2</sub>, 95%Ar+5%CO<sub>2</sub>. The improved weld quality is attributed to the varying arc and weld-pool dynamics caused by the differing thermo-physical properties of the shielding gases that are supplied varying the mixture proportion. The macro, microstructure of the welded samples has been investigated. Welding have been carried out under different shielding gas mixture. The suitable shielding gas mixture of 95%Ar+5%CO<sub>2</sub> achieved better results. the tensile and impact test have been carried out the above welded plates. The samples that was welded under 95%Ar+5%CO<sub>2</sub> shielding media was found to be the best in terms of tensile strength and impact strength. The Martensitic Stainless steel (SS 410) are having good corrosive resistance at low cost. Typical applications include highly stressed parts needing the combination of strength and corrosion resistance like plates and heavy structures.

## I. INTRODUCTION

The martensitic stainless steel (SS410) has been widely used in many application owing to their superior mechanical properties, corrosion resistance, process ability and lower economic cost, which are particularly attractive to the water, oil industry and food processing industries. The scope of this study is to experimental analysis of the influence of CO<sub>2</sub> in argon as a shielding gas in martensitic stainless steel under different mixture. In Gas Metal Arc welding (GMAW) process for protecting the arc and molten weld-pool from atmospheric contamination a shielding gas of argon or CO<sub>2</sub> is supplied continuously during welding. Argon is generally used for welding of non-ferrous metals. CO<sub>2</sub> gas is used for welding of mild steel. For alloy steels and even for mild steel applications requiring higher quality, a blend of argon/CO<sub>2</sub> gas mixture is normally used. The arc characteristics, metal transfer and weld pool behavior are greatly influenced by the type of shielding gas mixture. The improved arcing characteristics and metal transfer in GMA welding with argon/CO<sub>2</sub> mixed gas is due this influence.

## II. OBJECTIVES

To study the influence of CO<sub>2</sub> in argon as a shielding gas like 100% Ar, 98.5% Ar+1.5% CO<sub>2</sub>, 95% Ar+5% CO<sub>2</sub> in GMAW of martensitic stainless steel (SS410). To find which proportion of CO<sub>2</sub> with Ar leads to the most appropriate geometric parameters, appearance of weld bead. To study the macro, micro structure and mechanical characteristic of weld under different shielding gas mixture as above. To increase the penetration and the fusion area of the weld beads and improves bead convexity in addition of CO<sub>2</sub> in Ar. To find suitable shielding media for martensitic stainless steel (SS410) from the macro and microscopic investigation and best in terms of tensile strength and impact strength of the welded samples.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

### III. PROBLEM IDENTIFICATIONS

The shielding gas used for this process has to protect the weld pool and molten droplet transferred across the arc. Uses of argon alone is unsuitable for welding as it cannot obtain the desired arc stability and desired weld bead characteristics for some of the stainless steel. Traditionally, CO<sub>2</sub> is used as a shielding gas due to its cheapness, but its use has been limited because of the problem of spatter, oxidation losses and poor all-position performance. In addition of CO<sub>2</sub> in argon should promote a stable arc, the desired mode of metal transfer, weld bead characteristic and mechanical properties of the weld. Therefore, CO<sub>2</sub> mixed with argon is being preferred as a shielding gas for arc stability, mode of metal transfer, weld bead characteristics and improve the mechanical properties.

### IV. EXPERIMENTAL WORK

In this study, SS410 martensitic stainless steel specimens with a thickness of 10mm were welded to each other by the semi-automated Gas metal arc welding method using a welding wire 1.2mm in diameter. The chemical composition of SS410 is given in Table I. The chemical composition of the welding wire is tabulated in Table II.

TABLE I  
CHEMICAL COMPOSITION OF BASE METAL WEIGHT (%)

C	Mn	Si	S	P	Ni	Cr
0.14	0.89	0.93	0.03	0.039	0.70	12.3

TABLE II  
CHEMICAL COMPOSITION OF FILLER WIRE WEIGHT (%)

C	Mn	Si	S	P	Ni	Cr
0.11	0.55	0.49	0.03	0.029	0.60	12.5

Stainless steel plate was cut in dimensions of 200 X 400mm with a hydraulic saw machine using a cooling liquid then the sample's edges to be bonded were chamfered at 30°. Bonding was carried out under different shielding gases mixtures. Which are supplied by gas feeding arrangement. Three different shielding gases were used for each sample. Shielding gases and welding parameters are shown in Table III. Three samples were welded using the same welding parameters. Except the gas mixtures.

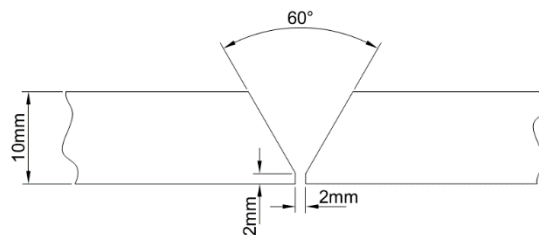


Figure 1. Welding Configuration

Surfaces of samples were cleaned and then placed adjacent to each other with a 2mm distance between them on a plate in a flat position. A CHOWEL OK 350 II-type semi-automatic welding machine was employed with a welding speed of 150mm/min and a gas flow ingrate of 10 L/min. A constant wire-feeding rate was maintained for all the welds by CHOWEL WIRE FEEDER machine. The welding process was completed in two steps. Samples were cooled in air after each step. Three samples were welded using the same welding parameters.

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Table III: Welding parameters

Raw material grade	SS410
Plate Size	200X400X10mm
Welding technique	GMAW
Filler metal	ER410 (make – Ador)
Wire diameter	1.2mm dia
Shielding gases	100% Ar, 98.5% Ar+1.5%CO <sub>2</sub> and 95% Ar+5%CO <sub>2</sub>
Root Gap	2mm
Groove Type	Single “V”
“V” Angle	60°
Joint Type	Butt joint
Welding current	240A
Welding voltage	20V
Welding speed	150mm/min
Gas flow rate	10 l/min
Standoff Distance(SOD)	2mm

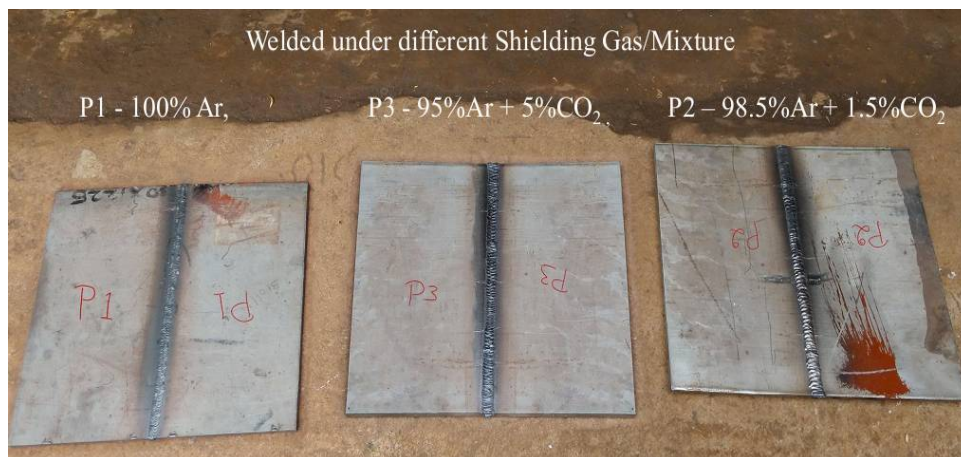


Figure 2. The welded plates

The primary objective of macro, microscopic examination is to reveal constituents and the structure of metals and their alloys. The method adopted for metallographic examination can be divided into two groups are Macro examination- either with the naked eye or under a very low magnification (x5-10) and Micro examination- at high magnification (x20-2000). Metallographically polished samples were etched in picric acid–95ml distilled water. After preparing the specimen by polishing and etching, it is examined either by the naked eye or by low power magnification up to X5Macro. After preparing the specimen by polishing and etching, it is examined under a microscope at magnifications from X40 to X150. These microstructural examinations were carried out using a METSCOPE-1A microscope. Penetration depth profiles were also examined and shown in figure 3.

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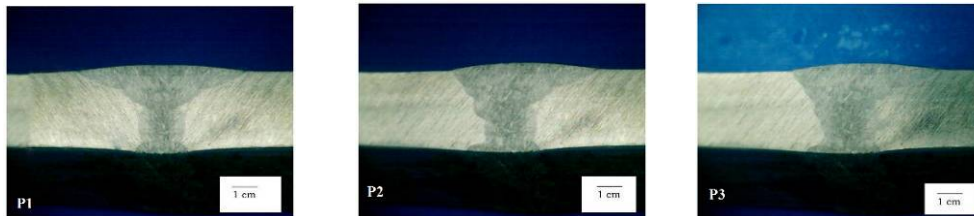


Figure 3. Macrostructure of penetration profiles bonding welded under different shielding: (P1) 100% Ar, (P2) 98.5% Ar and 1.5% CO<sub>2</sub>, (P3) 95% Ar and 5% CO<sub>2</sub>.



Figure 4. Microstructure of penetration profiles welded under shielding of 100% Ar (P1).

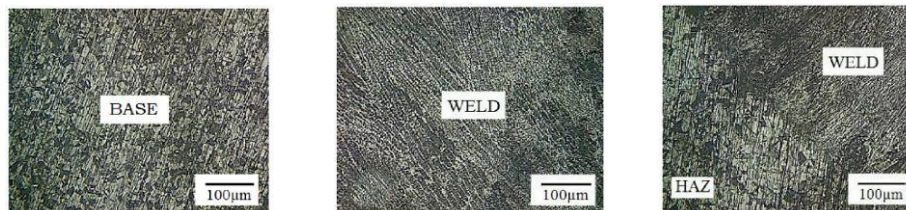


Figure 5. Microstructure of penetration profiles welded under shielding of 98.5% Ar and 1.5% CO<sub>2</sub> (P2).

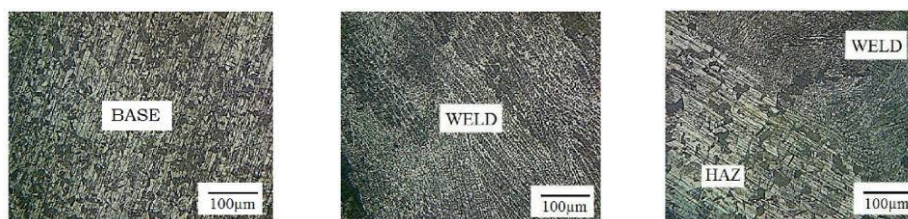


Figure 6. Microstructure of penetration profiles welded under shielding of 95% Ar and 5% CO<sub>2</sub> (P3).

Tensile strength measurement of the samples was done in accordance with AWS D1.1. Tensile test was carried out with the computer aided FIE make Universal Testing Machine. Impact tests of the samples were also carried out to check toughness of the samples. Tensile samples were prepared as shown in figure 7 and impact samples were prepared as shown in figure 8 and were subjected to the standard V notch charpy test by using impact test machine. V notches were opened on the weld metal region.

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Figure 7. Samples for Tensile test

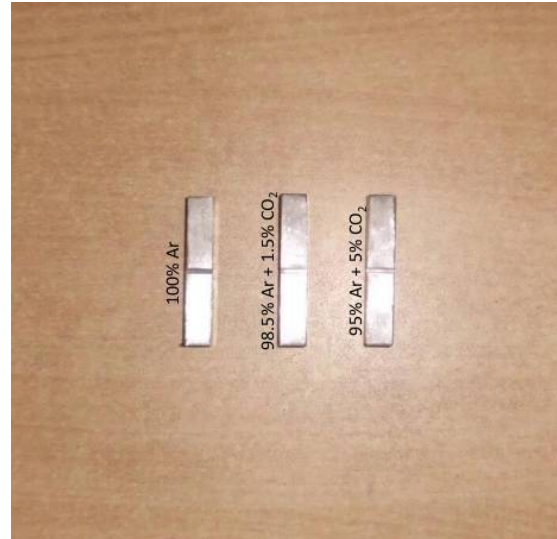


Figure 8. Samples for Charpy Impact Test

Table IV: Tensile strength and impact test results

SHIELDING GAS	MAX TENSILE STRENGTH (Mpa)	% ELONGATION	CHARPY IMPACT TOUGHNESS (Joule)
100% Ar	486	21	108
98.5% Ar and 1.5% CO <sub>2</sub>	501	23	122
95% Ar and 5% CO <sub>2</sub>	525	27	125

## V. RESULTS AND DISCUSSION

The results showed that fracture for all the tensile test occurred in the welded region and base metal. Mechanical test results are given in table IV. The highest tensile strength was obtained from the sample welded under a shielding gas of 95% Ar + 5% CO<sub>2</sub> while the lowest tensile strength was obtained from the sample welded under pure Ar. CO<sub>2</sub> addition to the shielding media increased the mechanical properties of welding. However, 5% CO<sub>2</sub> addition gave better mechanical performance and microstructural profile than 1.5% CO<sub>2</sub> and 100% Ar addition. CO<sub>2</sub> addition effect on welding properties are given in table IV.

Figure 3 shows the three macro sections of the fusion zone obtained in MIG welding under different shielding media. It can be clearly seen figure 4 that the melting efficiency of MIG welding increases with increasing CO<sub>2</sub> content in argon. The results showed that Macro and micro profile of the welded region. Test results revealed that the influence of CO<sub>2</sub> in argon as a shielding gas like 100% Ar, 98.5% Ar+1.5% CO<sub>2</sub>, 95% Ar+5% CO<sub>2</sub> in GMAW of martensitic stainless steel as shown in above figures. The microstructure is found to consist of large acicular ferrite and pearlite structure. Number of large size inclusions are observed.

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

## VI. CONCLUSION

- Thus the proportion of 95% Ar+5% CO<sub>2</sub> gas mixture leads to the most appropriate, better appearance of weld profile comparatively other proportions from the results.
- The highest tensile strength was obtained from the welding that was carried out under 95%Ar + 5% CO<sub>2</sub> shielding.
- The best toughness value was obtained from the samples that were welded under 95%Ar + 5% CO<sub>2</sub> shielding.
- Increasing of CO<sub>2</sub> content in argon as a shielding medium increased the penetration profile depth and width and above mechanical properties.

## ACKNOWLEDGMENT

I would like to thank our Director Dr.M.G.VENUGOPALAN, Principal Dr.R.ELANGO VAN, HOD Prof.V.SAMSON JAYAKUMAR, Project Coordinator Mr.S.JERY ANDREWS FABIAN and our Project Guide Mr.M.MARIAPPAN for their profound guidance, valuable suggestions and making this project grand success.

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