World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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Controlling the high weld rejection rate of mechanized gas metal arc welding process (GMAW)

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World Journal of Advanced Research and Reviews, 2024, 21(03), 1003–1008

Publication history: Received on 22 January 2024; revised on 02 March 2024; accepted on 04 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.3.0749

Abstract

Welding is a crucial part of any fabrication and construction activities for Oil and Gas industries. Achieving the welding with the highest quality possible is the main objective of all companies in this field. Therefore, great attention was given for selection of the proper welding process and optimize the variables to achieve welding quality that meets or exceeds customer requirements. In this paper we will focus on the selection of Gas Metal Arc Welding (GMAW) process and its characteristics. We will also explain in details one of the lessons learned in how to control the high weld rejection rate to the minimum possible by utilizing the proper investigation tools and implementing the immediate corrective actions

Keywords: Gas Metal Arc Welding; Weld Rejection Rates; Magnetized Pipes; Welding Procedures

1. Introduction

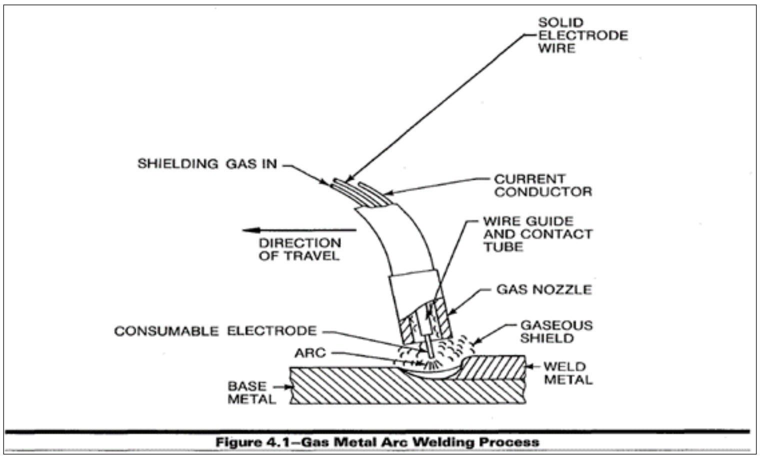

Figure 1 GMAW Process

The GAS METAL ARC Welding (GMAW) is an arc welding process that uses an arc between a continuous filler metal electrode and the weld pool. The process is used with shielding from an externally supplied gas and without the application of pressure. It may be operated in semiautomatic, machine, or automatic modes.

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THE GMAW PROCESS incorporates the automatic feeding of a continuous, consumable electrode that is shielded by an externally supplied gas. The process is illustrated in Figure 1 [1]. After initial settings by the operator, the equipment provides for automatic self-regulation of the electrical characteristics of the arc. Therefore, the only manual controls required by the welder for semiautomatic operation are the travel speed and direction, and gun positioning. Given proper equipment and settings, the arc length and the current (wire feed speed) are automatically maintained.

1.1. Metal transfer mechanisms

The characteristics of the GMAW process are best described in terms of the three-basic means by which metal is transferred from the electrode to the work:

1. Short circuiting transfer
2. Globular transfer
3. Spray transfer

Only Globular and Spray transfers will be briefed as they are our main focus in the Procedure qualification.

1.1.1. Globular transfer

WITH A POSITIVE electrode (DCEP), globular transfer takes place when the current is relatively low, regardless of the type of shielding gas. However, with carbon dioxide and helium, this type of transfer takes place at all usable welding currents. Globular transfer is characterized by a drop size with a diameter greater than that of the electrode. The large drop is easily acted on by gravity, generally limiting successful transfer to the flat position.

Carbon dioxide shielding results in randomly directed globular transfer when the welding current and voltage are significantly above the range for short circuiting transfer. The departure from axial transfer motion is governed by electromagnetic forces, generated by the welding current acting upon the molten tip, as shown in Figure 2 [1].

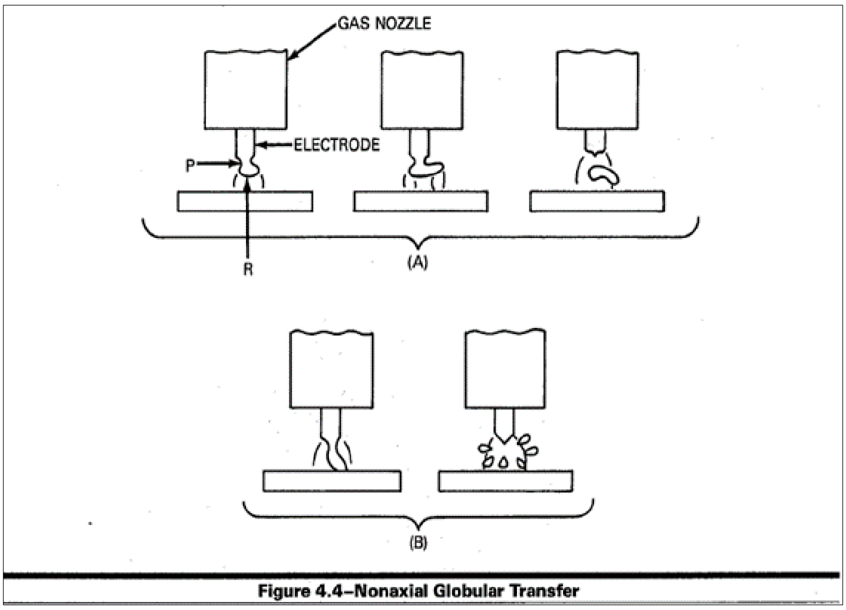

Figure 2 Nonaxial Globular Transfer

1.2. Spray Transfer

WITH ARGON-RICH SHIELDING it is possible to produce a very stable, spatter-free "axial spray" transfer mode as illustrated in Figure 3[1]. This requires the use of direct current and a positive electrode (DCEP), and a current level above a critical value called the transition current. Below this current, transfer occurs in the globular mode described previously, at the rate of a few drops per second. Above the transition current, the transfer occurs in the form of very small drops that are formed and detached at the rate of hundreds per second. They are accelerated axially across the arc gap.

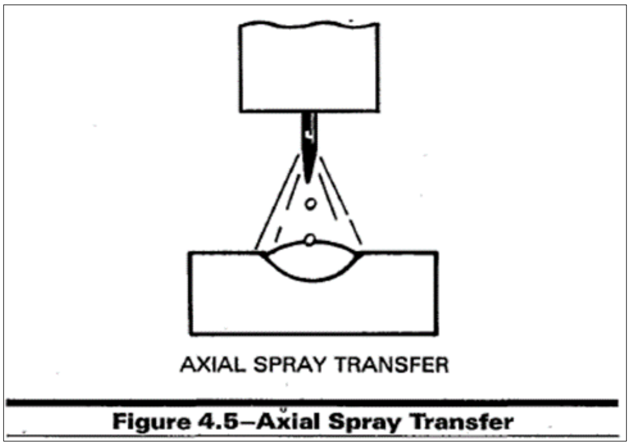

Figure 3 Axial Spray Transfer

2. Background

The mechanized GMAW process was selected as the main welding process of the project because of its known advantage of high production with significant weld quality.

100% of the welding joints were examined by Automated Ultrasonic Testing (AUT). Unfortunately, the overall project weld rejection rate was 11%, which was highly exceeding the 5% established project quality objective.

2.1. Welding equipment

The following are the welding equipment that utilized for welding the 40 & 42" OD pipelines;
Root pass: CRC EVANS / IWM+ Lincoln DC-400 (Figure 4)
Fill & Cap: PAW2000+ Lincoln DC-400

Figure 4 CRC EVANS / IWM

2.2. Qualified Welding Procedure Main Variables

The main qualified welding variables are;

1. Qualified Base Material: API-5L Garde X65 and lower
2. Qualified OD range: 30 inches to 60 inches
3. Qualified thickness range: 9 to 15 mm
4. Joint Design (figure 5)
5. Filler Metal (figure6)
6. Shielding Gas: 80%Ar+20%CO_2（Root）+100%CO_2（Fill）+80%Ar+20%CO_2（Cap）

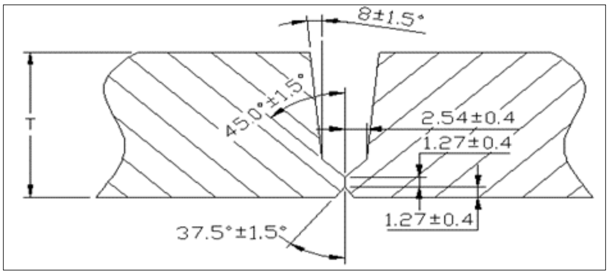

Figure 5 Joint Design

Filler Metal						
		Root			Fill & Cap	
AWS Spec. & Classification		AWS A5.18 ER70S-G			AWS A5.18 ER70S-G	
Trade Name		CRC TS-6			BOEHLER SG3-P	
Size		0.9mm			0.9mm	
Chemical Composition in % of the product ER70S-G						
	C	Si	Mn	P	S	Ti
CRC TS-6	0.08	0.77	1.57	0.008	0.007	0.05
BOEHLER SG3-P	0.07	0.79	1.57	0.007	0.006	0.06

Figure 6 Filler Metal

2.3. Joints weld defects

A total of 300 weld joints were examined by AUT in which 33 joints were found rejected resulting in 11% weld rejection rate. The main reason of rejection was the root lack of fusion, which contributed by 90% of rejections as per following analysis (figure 7).

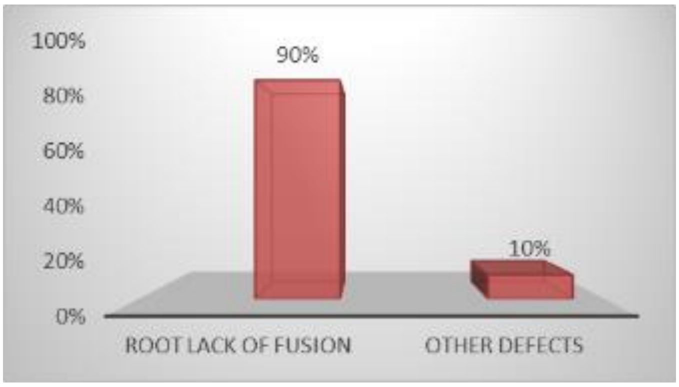

Figure 7 Weld Rejection Root Cause Analysis

Investigation was conducted for the root cause of this high rejection rate and is discussed in the following section.

3. Root cause analysis and corrective action

As the main reason of this high weld rejection rate was the root lack of fusion, a deep investigation was carried out to identify the root causes of this defect and implement the corrective actions to repair all the defects and prevent it from recurrence.

3.1. Root Cause Analysis

1-The AUT reports were thoroughly reviewed to identify if there is any pattern observed for the root lack of fusions defect (figure 8), and it was found that in about 20 joints the defect was repeated in the same location of the weld joint, which gave an indication that one of the IWM nozzles was not functioning properly

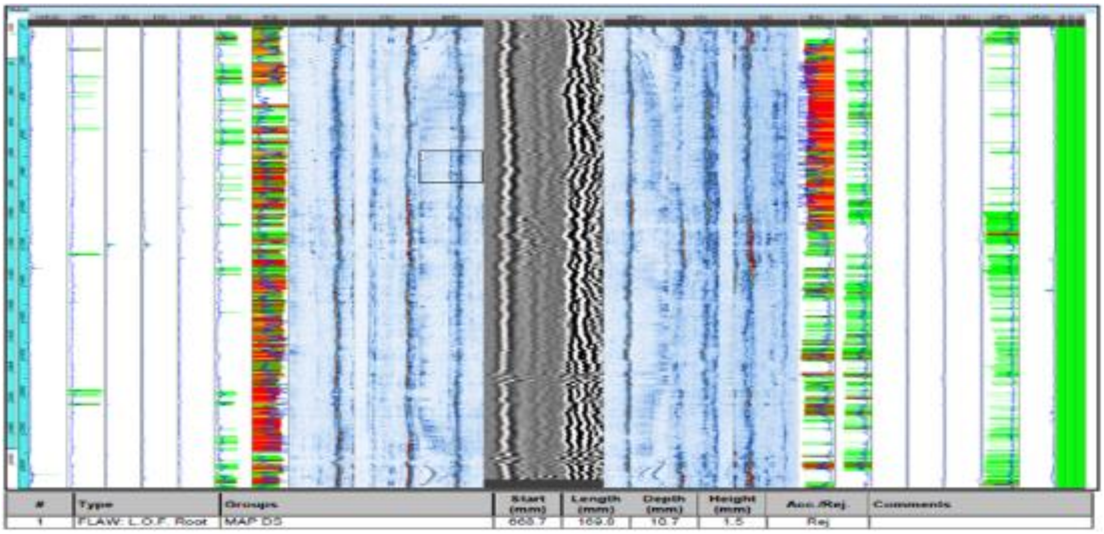

Figure 8 AUT Scan

2-The remaining rejected joints due to root lack of fusion (10 joints) didn't have the same pattern, and despite trying the corrective actions for possible root causes such as,

- Cleaning all groove faces and weld zone surfaces of any mill scale impurities prior to welding.
- Increase the wire feed speed and the arc voltage and reduce electrode extension.
- Minimize excessive weaving to produce a more controllable weld puddle.
- Reduce travel speed,

still the defect was found in the weld joint.

More investigation was done and it was noticed that this defect occurs only in specific batch of pipes and by examining those pipes, it was found that the pipes has a magnetism strength of 30 Oersted (Oe), which was the reason of this defect.

3.2. Corrective Action

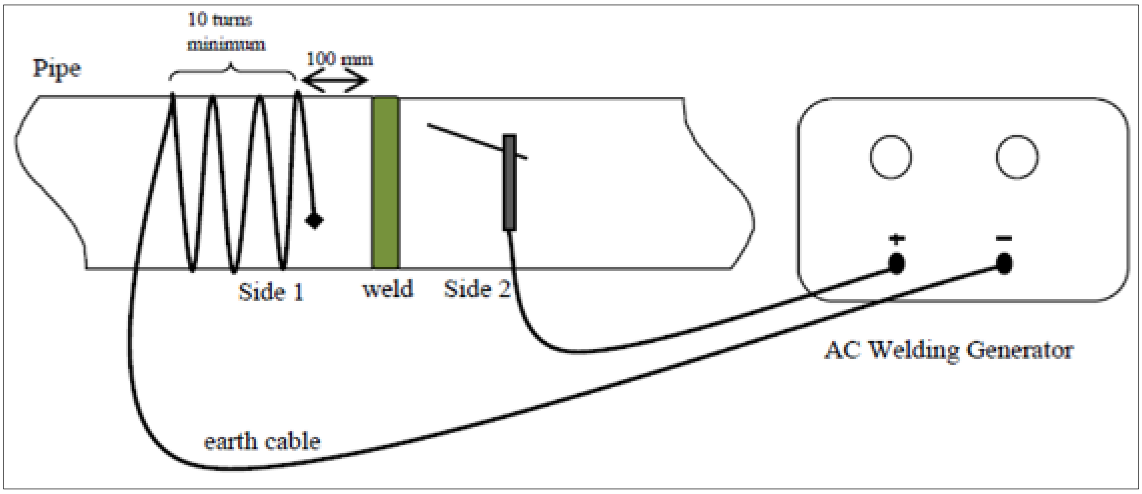

Figure 9 Demagnetization

The following corrective actions were taken to repair the defects and prevent their recurrence in future;

1. Repair all the defected joints with Qualified Manual SMAW Welding procedure as per API 1104, section 10 [2].
2. The IWM was repaired and the malfunctioning nozzle was properly fixed.

3. The welding machine was checked weekly during the weekends to ensure that there is no errors or malfunction on the nozzles or any other components.
4. All the pipes with residual magnetism were demagnetized (see figure 9) to achieve a magnetism strength of less than 20 Oe.

After implementing the above set of actions, the project weld rejection rate was controlled to less than 5% rejection during the entire project life cycle.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] AWS, Welding Handbook Eighth Edition Volume 2 WELDING PROCESSES .

[2] Welding of Pipelines and Related Facilities, API STANDARD 1104 TWENTY-SECOND EDITION.