ASME STANDARDS TECHNOLOGY, LLC

STP-PT-085

EFFECT OF HOT WIRE FILLER METAL ADDITION ON GTAW HEAT INPUT FOR CORROSION RESISTANT OVERLAYS

STP-PT-085

Effect of Hot Wire Filler Metal Addition on GTAW Heat Input for Corrosion Resistant Overlays and its Resulting Effect on Heat-affected Zone Hardness and Toughness and Corrosion Resistant Overlay Chemical Composition

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TABLE OF CONTENTS

Foreword iii
1 Background and Introduction 1
  1.1 Project Objective 1
  1.2 Materials 1
2 Weld Trial Matrix – CRO Welds 2
3 Testing Program 5
  3.1 Hardness Testing 5
  3.2 Chemical Analysis 6
  3.3 Deposit Area Measurement 6
  3.4 CRO Test Results 7
4 Summary of CRO Test Results 20
5 Groove Weld testing 22
  5.1 Testing Program 23
  5.2 Groove Weld Test Results 24
6 Summary and Conclusions 32
Appendix A: Hardness Mapping of the P-22 As-Welded Samples 35

LIST OF FIGURES

Figure 2-1: ARC-HVT set for horizontal welding position 3
Figure 2-2: ARC-HVT set for flat welding position 3
Figure 3-1: Microhardness test locations for CRO welds 5
Figure 3-2: CRO chemical analysis locations for API vs ASME qualification 6
Figure 3-3: Image of P22 sample A/B used for weld bead area determination using Jackson Method. 7
Figure 3-4: Macro sections of P22 CRO welds 8
Figure 3-5: Macro sections of 4130 CRO welds 9
Figure 3-6: Relationships among HAZ Hardness, Heat Input Rate, and Percent Fe – P22 / As-welded 10
Figure 3-7: Relationships among HAZ Hardness, Heat Input Rate, and Percent Fe – P22 / PWHTd. 11
Figure 3-8: Comparison of as-welded and PWHT HAZ hardnesses for P22 CROs 12
Figure 3-9: Relationships among HAZ Hardness, Heat Input Rate, and Percent Fe – 4130 / As-welded 13
Figure 3-10: Relationships among HAZ Hardness, Heat Input Rate, and Percent Fe – 4130 / PWHTd 14
Figure 3-11: Comparison of as-welded and PWHT HAZ hardnesses for 4130 CROs 15
Figure 3-12 HAZ hardnesses versus wire feed speeds and WFS:TS ratios for P22 CROs 16
Figure 3-13: HAZ hardnesses versus wire feed speeds and WFS:TS ratios for 4130 CROs 17
Figure 3-14: Comparison of heat input rates with wire feed speeds and WFS:TS ratios for P22 and 4130 CRO 18
Figure 3-15: Percent Fe versus weld bead area, wire feed speed, and wire feed speed-travel speed ratio – P22 19
Figure 3-16: Percent Fe versus weld bead area, wire feed, speed and wire feed speed-travel speed ratio – 4130 19
Figure 5-1: Groove joint design 22
Figure 5-2: Microhardness test locations for groove welds 23
Figure 5-3: Macrosections of P22 groove welds – As-welded 24
Figure 5-4: Close-ups of P22 groove welds – As-welded 24
Figure 5-5: Macrosections of P22 groove welds – PWHTd 24

Figure 5-6: Close-ups of P22 groove welds – PWHTd....................25
Figure 5-7: Macrosections of 4130 groove welds – As-welded....................25
Figure 5-8: Close-ups of 4130 groove welds – As-welded....................25
Figure 5-9: Macrosections of 4130 groove welds – PWHTd....................26
Figure 5-10: Close-ups of 4130 groove welds – PWHTd....................26
Figure 5-11: P22 as-welded and PWHTd average breaking energies versus notch location....................27
Figure 5-12: P22 as-welded and PWHTd average breaking energies versus HIR....................28
Figure 5-13: 4130 as-welded and PWHTd average breaking energies versus notch location....................28
Figure 5-14: 4130 as-welded and PWHTd average breaking energies versus HIR....................29
Figure 5-15: P22 groove weld microhardness traverses....................30
Figure 5-16: 4130 groove weld microhardness traverses....................30

LIST OF TABLES

Table 2-1: Welding parameters and resulting heat input rates for P22 and 4130 CRO welds....................4
Table 3-1: As-welded P22....................10
Table 3-2: PWHTd P22....................11
Table 3-3: As-welded 4130....................13
Table 3-4: PWHTd 4130....................14
Table 5-1: Groove weld parameters....................23
Table 5-2: Impact test results....................27
Table 5-3: Vickers microhardness test results....................29

FOREWORD

The purpose of this project is to explore the effects of hot wire filler metal addition with respect to the resulting weld metal and heat-affected zone (HAZ) properties.

Welding procedures for corrosion-resistant overlays (CROs) are heat input limited for the first layer. In applications where NACE International standard NACE MR0175 requirements additionally limit the range of qualified procedures, hot wire filler metal addition is commonly employed to enhance the relatively low deposition rate of the gas tungsten arc welding (GTAW) process. For these applications, typical conditions/requirements include: use of hardenable base metals, maximum iron content at minimum qualified overlay thickness of 5% with Inconel 625 filler metal, and maximum HAZ hardness of 250 HV10. While understood that increasing the heat input will result in a softer HAZ, that increase will also result in greater dilution, negatively affecting the chemical composition of the CRO.

For these applications, the industry requires that the energy supplied to preheat the filler metal ("hot wire") is included to contribute to the heat input for the process, even though not required by the ASME Boiler and Pressure Vessel Code (BPVC) Section IX. This secondary power is not even listed as an essential variable.

The primary industry impacted by this is the upstream petroleum equipment manufacturers and their suppliers. The economic impact relates to the effect on productivity. If the secondary power being applied to the filler metal does affect the resulting weld properties, then the committee should consider adding qualification restrictions. At this point, it is not clear whether this secondary power has either positive or negative effects.

The authors extend their thanks to various members of the ASME BPVC Section IX Committee for their support of this project. It is hoped that the results generated in this report will benefit all of this code. Thanks are also given to reviewers Ms. Teresa Melfi, Mr. Michael Rice, Mr. Marcello Consonni, Mr. Eugene Woelfel, Mr. Jonathan Lee, Mr. Phillip Van Fossen, Mr. Michael Pischke, and Mr. Arjan Roza for their thoughtful comments and to Mr. Steven Rossi of ASME ST-LLC and Mr. Gerardo Moino of ASME for coordinating various phases of this project.

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1 BACKGROUND AND INTRODUCTION

Steel piping, valves, blow-out preventers (BOPs), and other processing components require protection from contact with hydrogen sulfide-laden oil or gas. These "sour" products are the current norm for deep wells in the Gulf of Mexico and other areas. Corrosion-resistant alloy overlays are also used in the pressure vessel industry for various applications. Without a protective layer of a corrosion-resistant alloy, catastrophic failures, due to stress-corrosion cracking, will occur. The prominent method for application of this protective layer is to apply a CRO using some welding process. The process most favored is the gas tungsten arc welding process using an energized filler metal feed, commonly referred to as "hot wire" (GTAW-HW). By preheating the filler wire, greater deposition rates can be achieved.

ASME BPVC Section IX does not address the use of hot wire filler metal addition in terms of parameter limits or whether the power is included in the determination of heat input rate (HIR)[1]. In upstream (pre-refinery) oil and gas applications, the tendency has been to add this secondary (hot wire) power to the primary (arc) power to calculate HIR; however, there have been questions raised in terms of whether the secondary power actually contributes to the amount of energy being supplied to the base metal or is consumed in the process of preheating the filler metal. This study will attempt to quantify that contribution, if any, is provided by the secondary power to affect the resulting HAZ properties and chemical composition of the CRO.

1.1 Project Objective

The primary objective of this study was to determine if any technical justification exists for consideration of the addition or modification of essential variables to include the secondary power from hot wire additions.

1.2 Materials

While this topic may be of interest in other industries and applications, it is known to be of concern in these upstream oil and gas applications. ARC Specialties is the leading producer of automated welding systems used for applying CROs to a variety components, with 300+ systems in operation around the world. While several different welding processes are employed in these systems, the vast majority utilize GTAW-HW.

Consequently, the materials chosen for this study will be those most commonly employed for these upstream oil and gas applications. The two base metals most commonly employed are quenched and tempered versions of AISI 4130 and 2¼ Cr – 1 Mo (P-5A, Grade 22). In most cases, the forged versions of these base metals are used; however, this adds significantly to the cost. In the original proposal, Grade 22 was the only material to be included in this study, but there is far more 4130 material used than Grade 22. Consequently, to provide more data, pipe grades of the two materials were used because compositionally the pipe and forging materials are virtually identical. Below are the two base metals to be used for this study, and material certs are attached:

- SA335 Grade P22 – Ht #986957 – CE_{IIW} = 0.825; 8.625 inches OD x 0.812 inches wall
- A519 Grade 4130 – Ht #J4038 – CE_{IIW} = 0.663; 8.625 inches OD x 1.5 inches wall

The overlay material was Inconel® 625 (SFA5.9, ERNiCrMo-3). The size used was 0.045 inches (1.2 millimeter (mm)) diameter. Lincoln offered to supply the filler metal for this work. The type and classification are shown below and the material cert is attached.

- 0.045 inches [1.2 mm] TECHALLOY 625 33SSP – Ht #QT594

[1] This publication uses the technically-correct term *heat input rate (HIR)* to describe the amount of energy input per unit length of weld. This varies from the terminology, *heat input (HI)*, used in ASME BPVC Section IX; however, for the purposes of this publication, the two terms shall be considered synonymous.