**American Journal of Engineering Research (AJER)**
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-5, pp-134-138
www.ajer.org

Research Paper Open Access

# Ferrite Count Evaluation of an In-Service CRU Reactor Center Pipes and Scallops

Okpala, Alexander Nwachukwu
*Department of Mechanical Engineering, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria*

***Abstract:*** *Insitu-Metallographic analysis and ferrite count evaluation were carried out on the CRU reactors center pipes and scallops of a refinery. The investigation carried out on the ASTM A312 TP 321 materials was aimed at determining the ferrite count and hence their susceptibility to cracking. The produced micrographs were then analyzed in consonance with the requirements of ASTM E562-05 using microstructure characterizer software, MiC 2.0. The results obtained showed that the ferrite count for the scallops and center pipe of reactor 1 are within the predicted range in the Shaeffler diagram. The center pipe of reactor 3 has a ferrite content of 16.7% which is far beyond the predicted limit by Shaeffler diagram. It was concluded that reactor 1 was not susceptible to cracking while reactors 2 and 3 were susceptible.*

## I. Introduction

This article dwells on the in-situ Metallographic analysis and Ferrite count evaluation of CRU reactors center pipes and scallops. Though, according to Koteki (1986), metallographic determination of weld metal ferrite content in largely austenitic welds are largely uncertain, this article set out to use metallographic technique and ferrite meter to determine the ferrite content of the of the in-service ASTM A312 TP 321 center pipe and scallop materials. According to Karthikeyans, S.(2010), the ferrite level is only important to assure minimum exposure to solidification cracking when depositing austenitic stainless steel weld metal. The lower ferrite number is better for corrosion resistance, while balancing higher ferrite content to avoid solidification cracking in the weld deposit. The investigation carried out on the ASTM A312 TP 321 materials was therefore aimed at determining the ferrite count and hence their susceptibility to cracking.

## II. Procedure

The scallops and pipes used for this study consist of ASTM A312 TP 321 materials. A total of nine Replicas were taken, one from each center pipe and two from the scallops of each of the three reactors. The scallops and center pipes were ground, polished and etched elecrolytically with 10% oxalic acid. Microstructure replicas were then taken and examined with metallurgical microscope. The produced micrographs were then analyzed in consonance with the requirements of ASTM E562-05 using microstructure characterizer software, MiC 2.0. The micrographs together with their respective solarized images are presented in Figures 1,3,5,7,9,and 11 while the ferrite count results are presented in Figures 2,4,6,8,10 and 12. Sequel to the available of off-cuts from scallops of reactors 1 and 3; they were also subjected to confirmatory ferrite count evaluation using Ferrite scope. The results are found in Table 1. Similar to the use of shaeffler DeLong diagram by Lundin(1980) et al to determine the relationship between hot cracking tendency and the ferrite potential, Shaeffler diagram was used to predict ferrite content and result compared with that obtained by metallography.

## III. Results

Magnification [800X]

Solarized Image

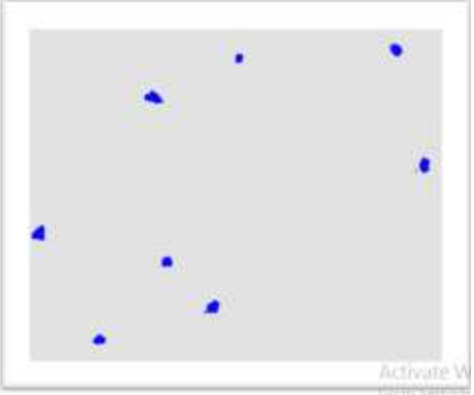
**Fig 1**: Micrograph And Solarized Image Of Scallops Of Reactor 1

| Sr.No. | % Ferrite |
|---|---|
| 1 | 0.32 |
| 2 | 0.57 |
| 3 | 0.66 |
| 4 | 0.79 |
| 5 | 0.75 |
| **Average** | 0.62 |

Average % Ferrite = 0.62

**Fig 2**: Ferrite Profile For Scallops Of Reactor 1

Magnification [800X]



Solarized Image

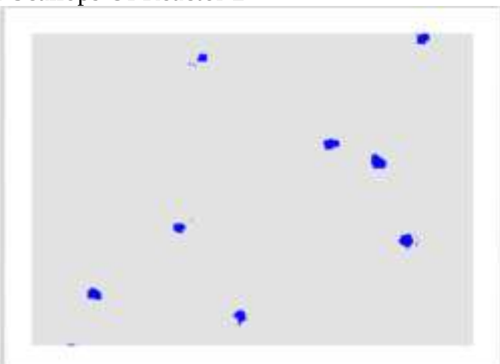
**Fig 3:** Micrograph And Solarized Image Of Scallops Of Reactor 2

| Sr.No. | % Ferrite |
|---|---|
| 1 | 1.25 |
| 2 | 0.99 |
| 3 | 0.87 |
| 4 | 0.82 |
| 5 | 0.89 |
| **Average** | 0.96 |

Average % Ferrite = 0.96

**Fig 4:** Ferrite Profile for Scallops Of Reactor 2

Magnification [800X]



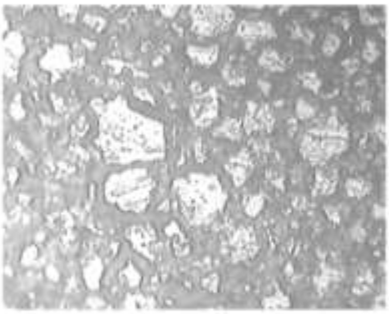
Solarized Image

**Fig 5**: Micrograph And Solarized Image Of Scallops Of Reactor 3

| Sr.No. | % Ferrite |
|---|---|
| 1 | 0.87 |
| 2 | 1.21 |
| 3 | 1.24 |
| 4 | 1.12 |
| 5 | 1.06 |
| **Average** | 1.1 |

Average % Ferrite = 1.1

**Fig 6**: Ferrite Profile For Scallops Of Reactor 3



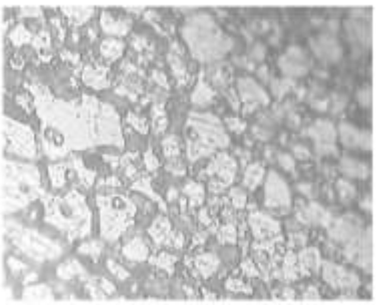
Magnification [800X] Solarized Image

**Fig 7:** Micrograph And Solarized Image Of Centre Pipe Of Reactor 1

| Sr.No. | % Ferrite |
|---|---|
| 1 | 6.7 |
| 2 | 10.9 |
| 3 | 7.2 |
| 4 | 5.1 |
| 5 | 10.6 |
| **Average** | 8.1 |

Average % Ferrite = 8.1

**Fig 8**: Ferrite Profile For Centre Pipe Of Reactor 1



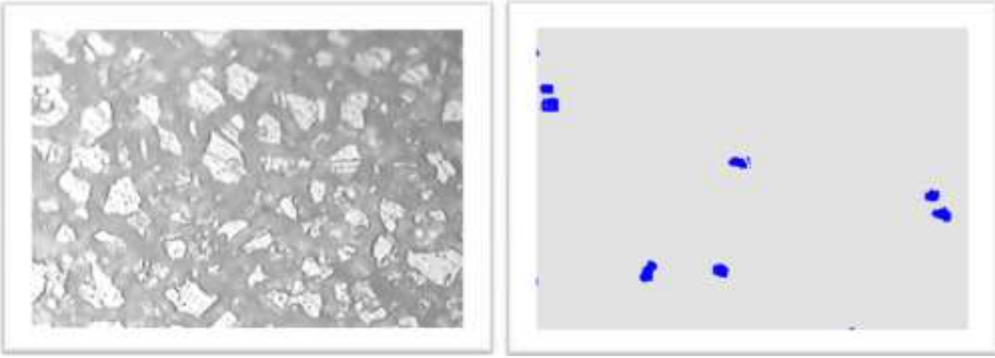
Magnification [800X] Solarized Image

**Fig 9**: Micrograph And Solarized Image Of Centre Pipe Of Reactor 2

| Sr.No. | % Ferrite |
|---|---|
| 1 | 12.5 |
| 2 | 9.6 |
| 3 | 12.8 |
| 4 | 10.3 |
| 5 | 7.8 |
| Average | 10.6 |

Average % Ferrite = 10.6

**Fig 10**: Ferrite Profile For Centre Pipe Of Reactor 2



Magnification [800X] Solarized Image

**Fig 11**: Micrograph And Solarized Image Of Centre Pipe Of Reactor 3

| Sr.No. | % Ferrite |
|---|---|
| 1 | 17.6 |
| 2 | 10.3 |
| 3 | 19.7 |
| 4 | 18.4 |
| 5 | 17.4 |
| Average | 16.7 |

Average % Ferrite = 16.7

**Fig 12**: Ferrite Profile For Centre Pipe Of Reactor 3

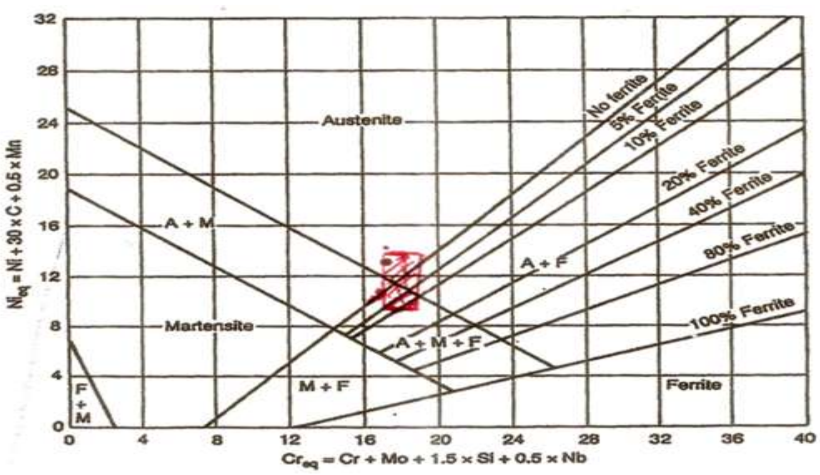



**Fig 13:** Shaeffler Diagram [ Source: Davies, A.C.(1996)]

**Table 1**: Ferrite content of scallops of R01 & R03 via Ferrite scope

| Ferrite % | Scallop of 12R01 | Scallop of 12R03 |
|---|---|---|
| | 0.4 | 0.35 |
| | 0.5 | 0.54 |
| | 0.62 | 0.89 |

## IV. Discussion Of Result

The results obtained showed that the ferrite count for the scallops and center pipe of reactor 1 are within the predicted range in the Shaeffler diagram presented in Fig 13. The predicted range using Figure 13 and interpolating for a typical SS321 with a Nickel and chromium equivalent within the SS321 composition limits is 0-10%. However the center pipe of reactors 2 is just on the boundary between 5% and 10% which makes it susceptible to exhibit hot cracking. The center pipe of reactor 3 has a ferrite content of 16.7% which is far beyond the predicted limit by Shaeffler diagram.

The austenite must contain no ferrite to reach maximum strength. Ferrite at elevated temperature is much weaker than austenite and reduces the creep-rupture strength of the alloy. For optimum strength properties, therefore, the composition of each alloy grade should be controlled at the most favorable balance of the available chromium-to-nickel ratio.

## V. Conclusion

It could be concluded that reactor 1 was not susceptible to cracking while reactors 2 and 3 were susceptible. Plans should therefore be made to change reactors 2 and 3 center pipes and scallops.

## References

[1]. ASTM E562-05, Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count, ASTM International, West Conshohocken, PA, 2005, www.astm.org.

[2]. C. D. Lundin, C.-P. D. Chou, & C. J. Sullivan (1980),Hot Cracking Resistance of Austenitic Stainless Steel Weld Metals, Welding research Supplement, WRC Bulletin 256, pp 226-232, USA.

[3]. Davies, A.C.(1996)Welding,10th Edition,Cambridge Press, UK

[4]. Karthikeyans, S.(2010), Influence of ferrite count on weld overlay, http://materials-welding.blogspot.com.ng/2010/12/re-mw8966-influence-of-ferrite-content.html

[5]. Koteki, D.J.(1986), Ferrite control in duplex Stainless Steel weld, welding research Supplement, WRC Bulletin 314, pp 273-278, USA.