Cairo University

EFFECT OF TEMPERATURE ON MICROSTRUCTURE AND PROPERTIES OF 2205-DUPLEX STAINLESS STEEL WELDMENTS

By

Mohammed Ahmed El-Saady Ali AWAD

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY

In

Metallurgical Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis: Effect of Temperature on Microstructure and properties of 2205-Duplex stainless steel weldments
Key Words
Duplex stainless steel; Sigma phase; Chi phase; Pitting corrosion; Welding method

Summary: This study aims at evaluating both pitting corrosion and microstructure of duplex stainless steel (2205) welded by (2209) as filler after exposure to increased service temperatures. In this work selected welded samples were aged at different temperatures (650°C, 850°C, 950°C and 1050°C), in order to simulate heat exposure during processing or sevice stages. The results showed that the pitting corrosion rate increased in chloride environments with increasing aging temperature till 850°C, afterwards pitting corrosion rate started to decrease and the joints restored their original pitting resistance at 1050°C, by the increasing the aging to above 1050°C, pitting resistance was found to decrease again. Also, The results showed that the formation of brittle phases increased as the temperature and holding time are increased in the temperature range (475-850°C), and it dissolved to form ferrite phase again on increasing the temperature to above 850°C. When the temperature reached 1050°C all brittle phases completely disappeared and the ferrite to austenite ratio was restored. As the temperature increased to 1150 the ratio γ/δ was decreased due to increase of the ferrite phase. A correlation between different welding processes and aging times were also conducted.

ACKNOWLEDGMENTS

A special thanks and gratitude should be given to Prof. Iman S. Elmahallawi, Head of Department of Mining, petroleum, and Metallurgy, Faculty of Engineering, Cairo University for her continuous help, support, and advice.

Also I'd like to thank my research advisor Dr. Waleed Khalifa for his help, and motivation.

Special thanks to my mother, who pushed me to finish this study and motivated me to get Ph.D degree. Also I'd like to thank my brothers and sister,who supported me to the end.

I am completely indebted to my father-in-law and my wife for their support, and understanding throughout my research period.

Finally, I would like to gratefully thanks my company PetoJet, which support me to execute the researches and approved the use of company tools, materials, and equipment for the experimental work.

DEDICATION

To Soul of my Father

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Nomenclatures and Abbreviation

Abbreviation	***Description***
AISI	American iron standard institute
ASME	American society for mechanical engineers
ASS	Austenitic stainless steel
BCC	Body center cubic
CPT	Critical pitting temperature
CS	Carbon steel
Cr eq	Chromium equivalent
DSS	Duplex stainless steel
EDX	Energy – dispersive X-ray spectroscopy
FCC	Face center cubic
FACW	Flux cored arc welding
GMAW	Gas metal arc welding
GTAW	Gas tungsten arc welding
HAZ	Heat affected zone
HDSS	Hyper duplex stainless steel
LDSS	Lean duplex stainless steel
Ni eq	Nickel equivalent
PREN	Pitting resistance number
PWHT	Post weld heat treatment
SAW	Submerged arc welding
SCC	Stress corrosion cracking
SDSS	Super duplex stainless steel
SEM	Scanning electron microscopy
SMAW	Shielded metal arc welding
SS	Stainless steel
UNS	Unified number system
UTS	Ultimate tensile strength
σ	Sigma phase
χ	Chi phase
δ	Delta ferrite phase
γ	Austenite phase
γ_2	Secondary austenite