



EFFECT OF NITROGEN CONTENT IN ARGON SHIELDING AND BACKING GASES ON PROPERTIES OF HYPER DUPLEX UNS S32906

By

Mohamed Mahmoud Ali Ali Hassan

**A Thesis Submitted to the
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in Partial Fulfillment of the
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in
METALLURGICAL ENGINEERING**

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Title of Thesis: Effect of nitrogen content in argon shielding and backing gases on properties of hyper duplex UNS S32906.

Key Words

Hyper duplex; nitrogen; shielding gas; backing gas; root weld; corrosion

Summary: This research was aimed at investigating the effect of shielding and backing gases composition by supplementing nitrogen compared to usage of pure argon on: **(i)** microstructure of hyper duplex stainless steel root weld and phase balance within the weld regions; **(ii)** mechanical properties of the root weld zone in terms of amount of impact toughness and Vicker's hardness; **(iii)** ferrite Content measurement); **(iv)** susceptibility to pitting corrosion in terms of mass losses It was found that adding 2% nitrogen to argon in the composition of the shielding/backing gases in welding the root passes by gas tungsten arc welding process significantly improves the weld mechanical characteristics, phase balancing and noticeably enhances the corrosion resistance of the weldment. This is related to nitrogen which is a strong austenite stabilizer which leads to increase the austenite content in the weld zone during welding. And it was found that inferior mechanical properties, imbalanced microstructure which leads to poor corrosion resistance in the root weld zone were obtained in case of using pure argon gas as a shielding/backing gas.



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List of Symbols and Abbreviations

•	AISI	American Iron and Steel Institute
•	AMS	Aerospace Material Specifications
•	ASME	American Society of Mechanical Engineers
•	ASTM	American Society for Testing and Materials
•	ASS	Austenitic Stainless steel
•	SASS	Super Austenitic Stainless steel
•	AWS	American Welding Society
•	SAE	Society of Automotive Engineers
•	API	American Petroleum Institute
•	BCC	Body Centered Cubic
•	BHN	Brinell Hardness number
•	C	Carbon atom
•	CCT	Continuous Cooling Transformation
•	Cm	Centimeter
•	CVN	Charpy V-Notch (Impact Test or Specimen)
•	Cr	Chromium
•	Cr₂N	Chromium Nitrides
•	CR	Corrosion Resistant
•	CSCC	Chloride Stress Corrosion Cracking
•	DBTT	Ductile-To-Brittle Transition Temperature
•	EDS	Energy-Dispersive Spectroscopy
•	etc.	et cetera (and so forth)
•	FCC	Face Centered Cubic
•	FCAW	Flux-Cored Arc Welding
•	Fe	Iron
•	FeCl₃	Ferric Chloride
•	FIG.	Figure
•	FN	Ferrite Number
•	GMAW	Gas Metal Arc Welding
•	GTAW	Gas Tungsten Arc Welding
•	HAZ	Heat Affected Zone
•	H₂S	Hydrogen Sulfide
•	HDSS	Hyper Duplex Stainless Steels
•	HD	Hyper Duplex Stainless Steels
•	HIC	Hydrogen Induced Cracking
•	HV	Vickers hardness

•	IIW	International Institute of welding
•	IGA	Intergranular Attack
•	IGSCC	Intergranular Stress Corrosion Cracking
•	ISO	International Organization for Standardization
•	J	Joule
•	Kev	Kilo Electron Volt
•	KSI	(1000 lb.) per Square Inch
•	M	Meter
•	Mo	Molybdenum
•	MC	Metal Carbides
•	MIC	Microbiologically Influenced Corrosion
•	MPa	Mega Pascal
•	NACE	National Association of Corrosion Engineers
•	N	Nitrogen atom
•	NA	not available
•	NAOH	Sodium Hydroxide
•	NACL	Sodium Chloride
•	Ni	Nickel
•	OFW	Oxy fuel gas welding
•	OP	Optical microscope
•	PAW	Plasma arc welding
•	Para.	Paragraph
•	PMI	Positive Material Indicator
•	Ppm	Parts per Million
•	PPt.	Precipitates
•	Psi	Pound per Square Inch
•	PQR	Procedure Qualification Record
•	PRE	Pitting Resistance Equivalent
•	PREN	Pitting Resistance Equivalent Number
•	PWHT	Post Weld Heat Treatment
•	REF	Reference
•	SAW	Submerged Arc Welding
•	SiC	Silicon Carbides
•	SCC	Stress Corrosion Cracking
•	SEM	Scanning Electron Microscope
•	SMAW	Shielded Metal Arc Welding
•	TGSCC	Trans -granular Stress corrosion Cracking