Declaration

I hereby declare that the work presented in this Thesis titled **"Investigations on dissimilar metal welding for marine applications"** submitted to the Indian Institute of Technology Jodhpur in partial fulfillment of the requirements for the award of the degree of Doctorate of Philosophy, is a bonafide record of the research work carried out under the supervision of Prof. Rahul Chhibber and Dr. Chandan Pandey. The contents of this thesis in full or in parts, have not been submitted to, and will not be submitted by me to, any other Institute or University in India or abroad for the award of any degree or diploma.

Anup Kumar Maurya
(P19ME007)

Certificate

This is to certify that the thesis titled "**Investigations on dissimilar metal welding for marine applications**" submitted by Anup Kumar Maurya (P19ME007) to the Indian Institute of Technology, Jodhpur, for the award of the degree of Doctorate of Philosophy, is a bonafide record of the research work done by him under my supervision. To the best of my knowledge, the content of this report, in full or in parts, has not been submitted to any other Institute or University in India or abroad for the award of any degree or diploma.

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Dedicated to

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List of Symbols

Symbol	*Description*
γ	Austenite
α	Alpha Ferrite
α'	Alpha Phase
β_a	Anodic Tafel Slopes (mV/dec)
F_N	Applied Normal Load (N)
β_c	Cathodic Tafel Slopes (mV/dec)
χ	Chi Phase
Cr_{eq}	Chromium Equivalent
I_{corr}	Corrosion Current (mA)
E_{corr}	Corrosion Potential (V)
CR	Corrosion Rate (mpy)
T	Corrosion's Time Scale (sec)
V	Cumulative Volume Loss (g)
δ	Delta Ferrite
k	Equilibrium Distribution Coefficient
η	Eta Phase
γ''	Gamma Double Prime Phase
γ'	Gamma Prime Phase
R	Growth Rate ($minutes^{-1}$)
H	Hardness ($HV_{0.5}$)
C_l	Liquid Compositions At The Solid-Liquid Interface
ε_x	Longitudinal Strains
M	Martensite
M_s	Martensite Starting Temperature
ρ_s	Mass Density of Sand Particles (g/cm^3)
ρ	Material Density (g/cm^3)
$M_{23}C_6$	Metal Carbides
Ni_{eq}	Nickel Equivalent
Cr_2N	Nitrides
P	P Phase
V_{sp}	Peripheral Velocity (m/s)
π	Pi Phase
$PREN$	Pitting Resistance Equivalence Number
υ	Poison's Ratio
R_p	Polarization Resistance ($ohm\text{-}m^2$)
R	R Phase
γ_2	Secondary Austenite
σ	Sigma Phase
S	Sliding Distance (mm)
E_w	Slurry Erosion Wear Rate (g/g of solids)
C_s	Solid Compositions At The Solid-Liquid Interface
C_v	Solid Concentration By Volume
C_w	Solid Concentration By Weight
K_s	Specific Wear Coefficient (m^3/Nm)
G	Temperature Gradient (K/m)
K	Thermal Conductivity (W/(m·K)
T	Time of Exposure (sec)
ε_y	Transverse Strains
V	Voltage (V)
K	Wear Coefficient
Q	Wear Rate
W	Weight Loss (g)
I	Welding Current (A)

S	Welding Speed (mm/min)
E	Young's Modulus (MPa)
μ	M Phase

List of Abbreviations

Abbreviation	*Full Form*
API	American Petroleum Industry
ASTM	American Society For Testing And Materials
ASME	American Society Of Mechanical Engineers
CE	Carbon Equivalent
DHD	Deep Hole Drilling
DCEN	Direct Current Electrode Negative
DCEP	Direct Current Electrode Positive
DMW	*Dissimilar Metal Welding*
DWJ	Dissimilar Weld Joint
DSS2205	Duplex Stainless Steel
EEC	Electrical Equivalent Circuit
EIS	Electrochemical Impedance Spectroscopy
EBW	Electron Beam Welding
EPMA	Electron Probe Microanalyzer
EDS	Energy-Dispersive Spectroscopy
FCC	Face-Centered Cubic
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
GCP	Geometrically Close-Packed
GBA	Grain Boundary Austenite
HAZ	Heat Affected Zone
HTHAZ	High-Temperature Heat Affected Zone
HHI	Higher Heat Input
HSLA	High-Strength Low Alloy
IGA	Inter-Granular Austenite
ISO	International Organization For Standardization
LBW	Laser Beam Welding
LTHAZ	Low-Temperature Heat Affected Zone
LHI	Lower Heat Input
OES	Optical Emission Spectroscopy
PTA	Partially Transformed Austenite
PAW	Plasma Arc Welding
PAGB	Prior Austenite Grain Boundaries
SEM	Scanning Electron Microscopy
SMAW	Shielded Metal Arc Welding
SGB	Solidification Grain Boundaries
SSGB	Solidification Subgrain Boundaries
SAW	Submerged Arc Welding
Sdss 2507	Super Duplex Stainless Steel
TMCP	Thermo-Mechanical Controlled Processing
TTT	Time-Temperature-Transformation
TCP	Topologically Close-Packed
UTM	Universal Testing Machine
UMZ	Unmixed Zone
WA	Widmanstätten Austenite
WCEDM	Wire-Cut Electrical Discharge Machining
XRD	X-Ray Diffraction