

DESIGN AND DEVELOPMENT OF SMAW ELECTRODE COATINGS FOR DISSIMILAR METAL WELDS IN USC POWER PLANTS

A Thesis Submitted by
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In partial fulfilment of the requirements for the award of the degree of
Doctor of Philosophy

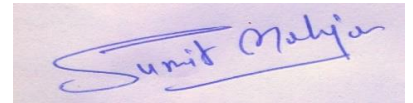


॥ त्वं ज्ञानमयो विद्वानमयोऽसि ॥

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Mechanical Engineering
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Declaration

I hereby declare that the work presented in this thesis titled "*Design and development of SMAW electrode coatings for dissimilar metal welds in USC power plants*" submitted to the Indian Institute of Technology Jodhpur in partial fulfilment 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 *Dr Rahul Chhibber (Associate Professor, Dept. of Mechanical Engineering, IIT Jodhpur)*. 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.



Sumit Mahajan
(P15ME004)

Certificate

This is to certify that the thesis titled “**Design and development of SMAW electrode coatings for dissimilar metal welds in USC power plants**” submitted by Sumit Mahajan (P15ME004) 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, have not been submitted to any other Institute or University in India or abroad for the award of any degree or diploma.



Dr. Rahul Chhibber
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PhD Student

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List of Symbols

Symbol	Description	Units
γ_{SL}	Interfacial tensions at the solid-liquid interface	(N/m)
γ_{SG}	Interfacial tensions at the solid-gas interfaces	(N/m)
γ_{LG}	Molten slag surface tension	(N/m)
W_a	Adhesion energy (specific surface energy)	(J/m ²)
θ	Contact angle	Degree (°)
n	No of experiments	-
k	No of regression variables	-
D	Composite desirability function	-
d_i	Desirability of specific response	-
T_C	Thermal conductivity	W/mK
T_D	Thermal diffusivity	mm ² /s
ΔH	Change in enthalpy	J/g
SH	Specific heat	MJ/m ³ K
D	Density	g/cm ³
$\Delta W \%$	Percentage weight loss	%
Hv	Microhardness	-
C_E	Carbon equivalent	-
K_p	Parabolic rate constant	mg ² /cm ⁴ s
t	Oxidation time	s
T	Temperature	°C
$\Delta W/A$	Weight gain/unit area	mg/cm ²
η_{Cr}	Mass transfer coefficient (Chromium)	-
η_{Mn}	Mass transfer coefficient (Manganese)	-
η_{Nb}	Mass transfer coefficient (Niobium)	-
η_{Si}	Mass transfer coefficient (Silicon)	-

List of Abbreviations

<i>Abbreviation</i>	<i>Full form</i>
PCC	Pulverized coal combustion
SC	Super critical
USC	Ultra super critical
AUSC	Advanced ultra super critical
IGCC	Integrated gasification combined cycle
SMAW	Shielded metal arc welding
GTAW	Gas tungsten arc welding
GMAW	Gas metal arc welding
SAW	Submerged arc welding
MMA	Manual metal arc
TIG	Tungsten inert gas
A-TIG	Activated Tungsten inert gas
DMW	Dissimilar metal weld
AC	Alternative current
DC	Direct current
DCEP	Direct current electrode positive
CaO	Calcium oxide source
CaF ₂	Calcium fluoride
SiO ₂	Silica
Al ₂ O ₃	Aluminium oxide
TiO ₂	Rutile
P	Phosphorous
Mg	Magnesium
Fe	Iron
S	Sulphur
Nb	Niobium
Al	Aluminium
Ni	Nickel
Mo	Molybdenum
Ti	Titanium
C	Carbon
BI	Basicity Index
IIW	International Institute of welding
ASTM	American Society for Testing and Materials
BM	Base metal
FM	Filler metal
WM	Weld metal
HAZ	Heat affected zone
CGHAZ	Coarse grain heat affected zone
FGHAZ	Fine grain heat affected zone
XRF	X-ray fluorescence
TGA	Thermogravimetric analysis
FTIR	Fourier Transform Infrared Spectroscopy
XRD	X-ray diffraction
SEM	Scanning electron microscopy
EDS	Energy dispersive spectrometry
ANOVA	Analysis of variance

SS	Sum of square
DOF	Degree of freedom
MS	Mean sum of square
CE	Commercial electrode
UTM	Universal testing machine
Y_s	Yield strength (N/mm ²)
UTS	Ultimate tensile strength (N/mm ²)
%E	Percentage elongation
SM1	Salt Mixture 1 (Na ₂ SO ₄ + 60% V ₂ O ₅)
SM2	Salt Mixture 2 (Na ₂ SO ₄ + 50% NaCl)