Mathematical Modeling for Electric Arc Furnace Refining Stage of Low Carbon Flat Steel Grades

By

Mohamed Mahmoud Abd-Alla Elkoumy

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

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Summary:
The current study aims at modeling of the very effective Electric Arc Furnace (EAF) refining stage to understand the dynamics of the process which affects the consumptions of the EAF. The study uses 3D computational fluid dynamic models to analyze the melt flow and heat profiles inside the electric arc furnace. The model investigates the effect of changes in metallurgical thermo-physical parameters and operating conditions on steel velocity during waiting and arcing time. The investigated parameters include slag thickness, and thermo-physical properties of molten steel at different chemical compositions and temperature ranges.

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Dedication

This PHD Thesis is dedicated to the soul of my father who died on Friday 14th of August 1998

& for long life to My Mother and Sisters

Cairo, 1st of March 2018

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Nomenclature

Symbol	Meaning
AC	Alternative Current
ASTM	American Society of Testing of Materials
CFD	Computational Fluid Dynamic
Cp	Heat Capacity at Constant Pressure
DC	Direct Current
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EAFD	Electric Arc Furnace Dust
EBT	Eccentric Bottom Tapping
FeMn	Ferro-manganese
FeSi	Ferro-silicon
FeSiMn	Ferro-silicon-manganese
g	Gravity Acceleration
G	Heat Generation Source Term
HBI	Hot Briquetted Iron
kwh	kilo watt hour "Energy Measuring Unit"
LES	Large Eddy Simulation
LRF	Ladle Refining Furnace
MW	Mega Watt "Power Measuring Unit as Active Power"
MWH	Mega Watt Hour "Energy Measuring Unit"
MVA	Mega Volt Ampere "Power Measuring Unit as Apparent Power"
SVC	Static VAR Compensator
TTT	Tap to Tap Time
U	velocity component in X direction
UHP	Ultra High Power

V	velocity component in Y direction
VAR	Volt Ampere Reactive
W	W velocity component in Z direction
P	Pressure
ρ	Density
K	Thermal conductivity
k	Turbulence kinetic energy
ε	Turbulence dissipation rate
μ	Molecular Viscosity
μ_t	Molecular Viscosity
μ_e	Effective Viscosity " $\mu + \mu_t$"
σ_k	Model constant
σ_ε	Model constant

بِسمِ اللّٰهِ الرَحمٰنِ الرَحِيم

In the name of Allah, the Compassionate, the Merciful