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LIST OF ABBREVIATIONS

AAS	Atomic absorption spectroscopy
AFT	Ash fuse temperature
Al	Alumina
Al ₂ O ₃	Alumina oxide
Al ₂ Si ₂ O ₇	Kaolinite
Al ₆ Si ₂ O ₁₃	Mullite
Ar	Argon
ASCII	American Standard Code for Information Interchange
ASTM	American Society for Testing and Materials
A	Preexponential factor
A _p	Surface area of the coal particle (m ²)
<i>act</i>	Actual
B/A	Base to acid ratio
Ba	Barium
BFP	Boiler feed pump
BWCP	Boiler water circulating pump
BUF	Booster fan
C	Carbon
Ca	Calcium
CaAl ₂ O ₄	Calcium aluminate
CaAl ₂ Si ₂ O ₈	Anorthite
CaFeAlSiO ₆	Esseneite
CaMgSi ₂ O ₆	Diopside
CaO	Calcium oxide, Lime
Ca(OH) ₂	Portlandite
CaCO ₃	Calcite

CaSiO ₃	Wollastonite
CaSO ₄	Anhydrite
Ca ₂ Al ₂ SiO ₇	Gehlenite
Ca ₂ SiO ₄	Calcium silicate
Ca ₃ Si ₂ O ₇	Rankinite
CCRR	Control Circulation Radiant Reheater
CCSEM-EDX	Electron Microscopy with Energy-Dispersed analysis of. X-rays
CEP	Condensate extraction pump
CFD	Computational fluid dynamic
CH ₄	Methane
cm	Centimeter
CO	Carbon monoxide
CO ₂	Carbon dioxide
CU	Copper
$C_{p,p}$	Specific heat of the coal particle (J/kg.K)
$C(T)$	Heat capacity of the coal particle (J/K)
°C	Degree of Celsius
DO	Discrete ordinates
DPM	Discrete Phase Model
DRW	Discrete random walk
DTG	Derivative Thermogravimetric Analysis
E	Activation energy (kJ/mol)
ECO	Economizer
EDS	Energy dispersive spectra analyzer
EGAT	Electricity Generating Authority of Thailand
EPMA	Electron probe x-ray microanalyzer
EPPO	Energy Policy and Planning Office
ESP	Electrostatic precipitator
Fe	Iron
FeCO ₃	Siderite
FeO	Iron oxide, Wustite
Fe ₂ O ₃	Ferric oxide

FeS	Iron sulfide, Pyrrhotite
FeS ₂	Pyrite
FDF	Forced draft fan
FGD	Flue gas desulfurization
FT	Fluid temperature (°C)
FW	Feed water
FWO	Flynn-Wall-Ozawa
F_D	Drag force (N)
F_x	Additional acceleration term
g	Gram
g_x	Gravitational force (N)
g°_i	Standard molar Gibbs energy (J/mol)
H	Hydrogen
H	Total enthalpy (J/kg)
h_{fg}	Latent heat of vaporization of water (J/kg)
HHV	Higher heating value (MJ/g)
HP	High pressure turbine
HPH	High pressure heater
HT	Hemispherical temperature (°C)
H ₂ O	Water
IC	Ion chromatography
ICP	Inductively coupled plasma
ICP-MS	Inductively Coupled Plasma - Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
IDF	Induced draft fan
IDT	Initial deformation temperature (°C)
IP	Intermediate pressure turbine
ISO	International Organization for Standardization
I_b	Black body coefficient
\bar{I}	Black body in scattering coefficient
j	Product
K	Potassium, Kelvin

KAS	Kissinger-Akahira-Sunose
K ₂ O	Potassium oxide
k	Kinetic
kV	Kilovolt
K _a	Absorption coefficient (cm ⁻¹)
K _o	Pre-exponential factor
k	Rate coefficient, Rate constant
k _c	Thermal conductivity of the coal (W/m.K)
k _t	Rate constant
kg	Kilogram
L	Length scales
LHV	Lower heating value (MJ/g)
LP	Low pressure turbine
LPH	Low pressure heater
LV	Low vacuum
MCWP	Main cooling water pump
Mg	Magnesium
MgO	Magnesium oxide
MJ	Megajoule
Mn	Manganese
Mn ₃ O ₄	Manganese oxide
MS	Mass spectroscopy
MT	Megaton
MW	Megawatt
Mtoe	Megaton of oil equivalent
m	Meter
mA	Milliampere
min	Minute
M _w	Molecular weight
m _{H₂}	Mass of H ₂ (g)
m _w	Mass of water vapor (g)
N	Nitrogen, Newton (kg.m/s ²)

Na	Sodium
NaAlSi ₃ O ₈	High-albite
Na ₂ O	Sodium oxide
NO _x	Nitrogen oxide
N/A	Not available
n	Number of data
n_i	Specie molar amount
O	Oxygen
OES	Optical emission spectroscopy
OFA	Over fire air
ox	Oxidation
P	Phosphorus
P ₂ O ₅	Phosphorus pentoxide
p	Static pressure
q	Flow of heat (J/s)
\dot{q}	Heat flux (W/m ²)
Q_c	Coal particle convection of heat transfer (W/m ² K)
Q_r	Coal particle radiation of heat transfer (W/m ² K)
Q_v	Coal particle vaporization of heat transfer (W/m ² K)
R	Universal gas constant
RNG	Renormalization group
RH	Reheater
Re	Reynolds number
R_f	Net rate of production of species
$R_{i,r}$	Net rate of species production
red	Reduction
r	Position function, Reaction
r_p	Radius of the coal particle (m)
S	Sulfur
SABS	South African Bureau of <i>Standards</i>
Si	Silica
SiO ₂	Quartz

SEM	Scanning electron microscopy
SEMPC	Scanning electron microscopy point count
SH	Ruperheater
SiO ₂	Silica oxide
SO ₂	Sulfur dioxide
SO ₃	Sulfur trioxide
SO ₄	Sulfate Sulfur
Sr	Strontium
SSC	Submerged scraper conveyor
ST	Softening temperature (°C)
s	Second, Direction function
<i>S.D.</i>	Standard deviation
<i>S_p</i>	Mass added to the continuous phase from the dispersed second phase
<i>S_u</i>	Any other force
<i>S_H</i>	Heat of chemical reaction and any other volumetric heat sources
<i>S_Y</i>	Rate of creation by addition from the dispersed phase plus any sources
TDR	Total deposition rate
TGA	Thermogravimetric analysis
TiO ₂	Titanium dioxide
TMA	Thermo-mechanical analyser
<i>T</i>	Absolute temperature (K)
<i>T_{FT}</i>	Fluid temperature (°C)
<i>T_{liq}</i>	Liquidus temperature (°C)
<i>T_p</i>	Temperature of the coal particle (K)
<i>T_s</i>	Steam phase wall temperature (K)
<i>T_{w,o}</i>	Outer wall temperature (K)
<i>T₁</i>	Temperature at the surface of the coal particle (K)
<i>T₂</i>	Temperature at the center of the coal particle (K)
<i>t</i>	Time (s)
<i>theo</i>	Theoretical
USA	United Stage of America
<i>u</i>	Fluid phase velocity (m/s)

u_o	Partial overall admittance factor (W/m ² K)
u_p	Particle velocity (m/s)
\vec{u}	Velocity vector (m/s)
WDD	wavelength dispersive detectors
WSGGM	Weighted sum of gray gases model
w_0	Initial weight (g)
w_f	Final weight (g)
w_t	Weight at time t (g)
XLT	Xiaolontan coal
XRD	X-ray Diffraction
XRF	X-ray fluorescence
x	Decomposed fraction of solid
(x)	Function of x depending on the reaction mechanism
\bar{x}	Average value
x_i	Data i
Y_i	Mass fraction of each species
Y_p	Mass fraction of any product species
Y_{RR}	Mass fraction of a particular reactant

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LIST OF SYMBOLS

α	Alpha, Temperature coefficient
β	Heating rate ($^{\circ}\text{C}/\text{min}$)
ε	Turbulence dissipation rate ($\text{J}/\text{kg}\cdot\text{s}$)
λ	Bulk viscosity coefficient
μ	Micro, Molecular viscosity coefficient, Viscosity ($\text{Pa}\cdot\text{s}$)
ν'	Stoichiometric coefficient
ν''	Stoichiometric for product
θ	Zeta
ρ	Density (kg/m^3)
σ_s	Scattering coefficient
∇	Operator



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STATEMENT OF ORIGINALITY

The largest thermal power plant in the north of Thailand, EGAT Mae Moh, will face increasing slag problems with remaining lignite reserve. In order to have better understanding of slag problem, investigation on factors that influence formation and deposition of slag is required. There have been many studies previously on Mae Moh lignites. However, this work is among the first studies to focus on chemical and mineral compositions related to possible occurrence of slag. Further contribution includes:

1. Effect of blended coal, with emphasis of different CaO contents in ash, was studied, based on AFT test, and the calculation of base to acid, silica/alumina, iron/calcium, and iron/dolomite ratios.
2. Thermo-equilibrium program was employed to predict formation of slag from equilib and quaternary phase diagram models.
3. Computational model of fluid flow was coupled with analytical model of coal combustion to predict the deposition of slag inside the boiler.

I hereby certify that, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights. Furthermore, this work has not been submitted for a degree at this or any other university.

ข้อความแห่งการริเริ่ม

โรงไฟฟ้าแม่เมาะเป็นโรงไฟฟ้าพลังความร้อนที่ใหญ่ที่สุดในภาคเหนือของประเทศไทยกำลังจะประสบปัญหาถ้ำหลอมที่รุนแรงขึ้นจากการใช้ถ่านหินลิกไนต์ที่เหลืออยู่ เพื่อความเข้าใจที่ดีขึ้นเกี่ยวกับปัญหาถ้ำหลอม จึงจำเป็นต้องศึกษาปัจจัยที่มีอิทธิพลในการเกิดและการสะสมตัวของถ้ำหลอม อย่างไรก็ตามแม้จะมีการศึกษาเกี่ยวกับถ่านหินลิกไนต์ของแม่เมาะมาก่อนหน้านี้จำนวนมาก แต่สำหรับงานนี้ถือเป็นการศึกษาครั้งแรกที่มุ่งเน้นไปที่องค์ประกอบทางเคมีและแร่ที่เกี่ยวข้องกับความเป็นไปได้ในการเกิดถ้ำหลอม รวมถึงการศึกษาเพิ่มเติมดังนี้

1. ผลจากการผสมถ่านหินโดยเน้นให้มีปริมาณแคลเซียมในถ้ำต่างกัน โดยศึกษาด้วยการทดสอบอุณหภูมิการหลอมตัวของถ้ำและการคำนวณอัตราส่วนเบสต่อกรด อัตราส่วนซิลิกาต่ออลูมินา อัตราส่วนเหล็กต่อแคลเซียม และอัตราส่วนเหล็กต่อโดโลไมต์
2. โปรแกรมสมดุลทางอุณหพลศาสตร์ ซึ่งใช้ในการทำนายการเกิดถ้ำหลอมจากแบบจำลองสมดุลและแบบจำลองแผนภาพเฟสสี่องค์ประกอบ
3. แบบจำลองเชิงคำนวณการไหลของของไหลควบคู่กับการวิเคราะห์การเผาไหม้ของถ่านหิน เพื่อทำนายการสะสมตัวของถ้ำหลอมภายในหม้อไอน้ำ

ข้าพเจ้าขอรับรองว่าวิทยานิพนธ์ของข้าพเจ้าไม่ละเมิดลิขสิทธิ์ของผู้อื่นหรือละเมิดกรรมสิทธิ์ใดๆ นอกจากนี้นางานนี้ยังไม่เคยถูกส่งเพื่อปริญาในมหาวิทยาลัยนี้หรือมหาวิทยาลัยอื่น