Dedicated to

My Family, Friends

and

Well Wishers

Who Supported and Endured Me

Tezpur University

CERTIFICATE

This is to certify that the thesis entitled "***Exergetic performance analysis of MHD (Magnetohydrodynamics) and MHD integrated gas turbine power plant***" submitted to the School of Engineering, Tezpur University in part fulfillment for the award of the degree of Doctor of Philosophy in Mechanical Engineering is a record of research work carried out by Mr. Prabin Haloi under my supervision and guidance.

All help received by him from various sources have been duly acknowledged. No part of this thesis has been submitted elsewhere for award of any other degree.

Date: Supervisor

Place: (Prof. Tapan Kr. Gogoi)

Declaration

I do hereby declare that the matter embodied in this thesis is the result of study and investigations carried out by me in the Department of Mechanical Engineering, Tezpur University, Tezpur, India under the guidance of Professor Tapan Kr. Gogoi, Professor, Department of Mechanical Engineering, Tezpur University.

In keeping with the general practice of reporting scientific observations, due acknowledgements have been made wherever the work described is based on the findings of other investigators.

Date: Prabin Haloi

Place:

ACKNOWLEDGMENT

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(Prabin Haloi)

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Nomenclature

A_e	Nozzle exit area (m^2)
A^*	Nozzle throat area (m^2)
$\bar{c}_p$	Molar specific heat (kJ $kmol^{-1}K^{-1}$)
$\dot{E}$	Rate of energy transfer (MW)
$\Delta\bar{g}^0$	Standard Gibbs free energy change (kJ $kmol^{-1}$)
$\Delta_f\bar{g}^0$	Standard Gibbs energy of formation (kJ $kmol^{-1}$)
h	Plank's constant (J-sec)
$\bar{h}$	Molar specific enthalpy (kJ $kmol^{-1}$)
$\bar{h}_f^0$	Molar specific enthalpy of formation (kJ $kmol^{-1}$)
H_p	Enthalpy of products (kJ)
H_r	Enthalpy of products (kJ)
M^*	Mach number at throat
$\dot{m}_a$	Mass flow rate of air ($kg\ s^{-1}$)
M_a	Molecular mass of air (kg $kmol^{-1}$)
M_e	Nozzle exit Mach number
$\dot{m}_f$	Mass flow rate of fuel ($kg\ s^{-1}$)
M_f	Molecular mass of fuel (kg $kmol^{-1}$)
$\dot{m}_{plasma}$	Mass flow rate of plasma ($kg\ s^{-1}$)
$\dot{m}_{seed}$	Mass flow rate of seeding material ($kg\ s^{-1}$)

p_e	Exit pressure (bar)
p_0	Stagnation pressure (bar)
$\dot{Q}_{th}$	Rate of thermal heat input (MW)
$\mathrm{R_u}$	Universal gas constant (8.314 kJ kmol^{-1}K^{-1})
$\bar{S}$	Absolute molar entropy (kJ kmol^{-1}K^{-1})
$\bar{s}$	Molar specific entropy (kJ kmol^{-1}K^{-1})
$\bar{s}^0$	Standard molar specific entropy (kJ kmol^{-1}K^{-1})
T_{adia}	Adiabatic flame temperature (K)
T_e	Nozzle exit temperature (K)
V_e	Nozzle exit velocity (m s^{-1})
$\dot{w}_{AC}$	Rate of air compressor work (MW)
$\dot{W}_{cv}$	Work done rate of the control volume (MW)
$\dot{w}_e$	Rate of electrical work output of the generator (MW)
$\emptyset_{dry}$	Ratio of chemical exergy to net calorific value of dry coal

Greek Letters and symbols

∇	Del operator
ϕ_B	Magnetic flux (Tesla)
$\rho_{n,e}$	Electron number density (cm^{-1})
ω_s	Statistical weight (atoms/electrons/ions per cubic centimeter)
σ	Electrical conductivity (Siemens/m)
Σ	summation

κ	Boltzmann constant (J K^{-1})

Subscripts

a	atoms
ACT	actual
$comb$	combustion
CV	control volume
e	electrons
f	formation
F	fuel
i	ions
H	hypothetical
$\mathcal{H}$	heavy particles
L	loss
min	minimum
P	product
tot	total
y	instantaneous

Abbreviation

AC	Air Compressor
APH	Air Preheater
CC	Combustion Chamber
CCPP	Combined Cycle Power plant

CV	Control Volume
DSU	Desulphurization Unit
EA	Excess Air
GEN	Generator
GT	Gas Turbine
GTCC	Gas Turbine Combined Cycle
HHV	Higher Heating Value
HPT	High Pressure Turbine
HRSG	Heat Recovery Steam Generator
ICE	Internal Combustion Engine
LES	Large Eddy Simulation
LHV	Lower Heating Value
LMMHD	Liquid Metal Magnetohydrodynamic
MHD	Magnetohydrodynamic
MHDCC	MHD Combustion Chamber
MHD-GT	MHD-Gas Turbine
MHD-GT-ST	MHD-Steam Turbine-Gas Turbine
MILD	Moderate or Intense Low oxygen Dilution
NCV	Net Calorific Value
ORC	Organic Rankine Cycle
OTSG	Once Through Steam Generator

PaSR	Partially Stirred Reactor
PERC	Pittsburgh Energy Research Center
SSSF	Steady State Steady Flow
SRU	Seed Recovery Unit
TIT	Turbine Inlet Temperature