Dedicated

To my parents, Kuladhar Bora, Rina Bora, and my brother

Debashis Bora

DECLARATION

I do hereby declare that the Thesis entitled **"STUDY ON PETROLEUM COKE AND BIOMASS CO-GASIFICATION IN DOWNDRAFT GASIFIER"** being submitted to the Department of Energy, Tezpur University, is a record of original research work carried out by me. All sources of assistance have been assigned due acknowledgement. I also declare that neither this work as a whole nor a part of it has been submitted to any other University or Institute for any other degree, diploma, or award.

Place: Tezpur **(ADITY BORA)**

Date: 31-12-2024

तेजपुर विश्वविद्यालय/ TEZPUR UNIVERSITY
(संसदकेअधिनियम द्वारा स्थापित केंद्रीय विश्वविद्यालय)
(**A Central University established by an Act of Parliament)**
तेजपुर-784028 **:: असम/ TEZPUR-784028 :: ASSAM**

Sadhan Mahapatra
Professor
Department of Energy
Tezpur University

Email:sadhan@tezu.ernet.in
Phone: +91-3712-275306

CERTIFICATE OF THE SUPERVISOR

This is to certify that the Thesis entitled **"Study on Petroleum Coke and Biomass Co-gasification in Downdraft Gasifier"**, submitted to the Department of Energy, School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Energy is a record of research work carried out by Ms. Adity Bora under my supervision and guidance.

All help received by her from various sources has been duly acknowledged.

No part of this Thesis has been submitted elsewhere for award of any other degree/diploma.

Sadhan Mahapatra

Signature of Supervisor
(Sadhan Mahapatra)
Date: 31-12-2024

TEZPUR UNIVERSITY

(A Central University Established by an Act of Parliament of India)
Napaam, Tezpur – 784028, Assam, India
Ph No. : **+**91 3712 27 5306 (O), Fax: **+**91-3712 267005/6

CERTIFICATE

This is to certify that the thesis entitled "**Study on Petroleum Coke and Biomass Co-gasification in Downdraft Gasifer**" submitted by **Ms. Adity Bora** to the Department of Energy, School of Engineering, Tezpur University in partial fulfillment for the award for the degree of **Doctor of Philosophy in Energy** has been examined by us on **18th July 2025** and found to be satisfactory.

The committee recommends the award of the degree of Doctor of Philosophy.

Supervisor
Date: 18-07-2025

External Examiner
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Nomenclature

Capital letters

A	Pre-exponential factor (min^{-1})
AAEM	Alkali and alkaline earth metal
BCC	Biochar generated under CO_2
BCN	Biochar generated under N_2
DTG	Derivative Mass Loss
D_i	Devolatilization Index (% K^{-3} min^{-2})
Ea	Activation energy (kJ mol^{-1})
EDX	Energy Dispersive X-ray Analysis
FC	Fixed carbon
FTIR	Fourier Transform Infrared Spectroscopy
FWO	Flynn–Wall–Ozawa
HHV	Higher heating value
K_2CO_3	Potassium Carbonate
KAS	Kissinger-Akahira-Sunose
MAC	Molten Alkali Carbonate
MC	Moisture content
MW_{co}	Molecular weight of CO
MW_{char}	Molecular weight of char
R	Universal gas constant (JK^{-1} mol^{-1})
R^2	Correlation coefficient
$-R_p$	Maximum weight loss rate (% min^{-1})
$-R_v$	Average weight loss rate (% min^{-1})
SEM	Scanning Electron Microscopy
T	Temperature (K)
T_i	Initial temperature of DTG curve (K)
T_p	Peak temperature of DTG curve(K)
T_f	Final temperature of DTG curve(K)
TGA	Thermogravimetric Analyser
VM	Volatile matter
XRD	X-ray Diffraction
$Z(\alpha)$	Mathematical expression for the master plots method

Lowercase letters

$f(\alpha)$	Differential reaction model
$g(\alpha)$	Integral reaction model
$k(T)$	Reaction rate constant
k	Arrhenius constant
$\dot{m}_{out}$	Mass flow rate of the outgoing gases
t	Time (min)
y_{co}	Mass fraction of CO in the product mixtures
$\Delta T_{1/2}$	Temperature range at half of DTG curve

Greek symbols

α	Conversion fraction
β	Heating rate (K min^{-1})
ρ	Density (kg m^{-3})
θ	Reaction progress factor
$\dot{\omega}_{CO}$	Mass production rate of CO