Numerical and Experimental Studies on Organic Rankine Cycle for Low-Medium Waste Heat Sources

Thesis submitted in partial fulfillment for the

Award of Degree

Doctor of Philosophy

By

Mayank Srivastava

DEPARTMENT OF MECHANICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(BANARAS HINDU UNIVERSITY)
VARANASI-221005
INDIA

20131510 **2024**

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Prof. Jahar Sarkar
(Supervisor)
Department of Mechanical Engineering
IIT (BHU) Varanasi

प्राध्यापक / Professor
यान्त्रिक अभियान्त्रिकी विभाग/Deptt. of Mechanical Engg
भारतीय प्रौद्योगिकी संस्थान/Indian Institute of Technology
(का०हि०वि०/B.H.U.)
वाराणसी-२२१००५/Varanasi-221005

Prof. Arnab Sarkar
(Co-supervisor)
Department of Mechanical Engineering
IIT (BHU) Varanasi

प्राध्यापक / Professor
यान्त्रिक अभियान्त्रिकी विभाग/Deptt. of Mechanical Engg
भारतीय प्रौद्योगिकी संस्थान/Indian Institute of Technology
(का०हि०वि०/B.H.U.)
वाराणसी-२२१००५/Varanasi-221005

DECLARATION BY THE CANDIDATE

I, **Mayank Srivastava**, certify that the work embodied in this thesis is my own bonafide work carried out by me under the supervision of **Prof. Jahar Sarkar** and **Prof. Arnab Sarkar** for a period of 4 years from January 2021 to December 2024 at IIT (BHU), Varanasi. The material contained in this thesis has not been submitted for the award of any other degree. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not wilfully copied any others work, paragraphs, text, data, results, etc. reported in journals, books, magazines, reports, dissertations, thesis, etc. or available at website and have not included them in this thesis and have not cited as my own work.

Date: 16/12/2024

Place: IIT (BHU), Varanasi

(Mayank Srivastava)

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Prof. Jahar Sarkar

(Supervisor)

प्राध्यापक / Professor

यांत्रिकी विभाग/Deptt. of Mechanical Eng

भारतीय प्रौद्योगिकी संस्थान/Indian Institute of Technology

(का०हि०वि०/B.H.U.)

वाराणसी-२२१००५/Varanasi-221005

Prof. Arnab Sarkar

(Co-supervisor)

प्राध्यापक / Professor

यांत्रिकी विभाग/Deptt. of Mechanical Eng

भारतीय प्रौद्योगिकी संस्थान/Indian Institute of Technology

(का०हि०वि०/B.H.U.)

वाराणसी-२२१००५/Varanasi-221005

Head of the Department

Mechanical Engineering Department, IIT (BHU), Varanasi

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Candidate's Name: Mayank Srivastava

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Date: 16/12/2024

Place: IIT (BHU), Varanasi **(Mayank Srivastava)**

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Abbreviation

EEORC	Ejector Enhanced Organic Rankine Cycle
OFC	Organic Flash cycle
ORC	Organic Rankine cycle
PLR	Pressure Lift Ratio
PPTD	Pinch point temperature difference
TFC	Trilateral flash cycle
WHT	Waste Heat source Temperature

Nomenclature

A	Area [m^2]
Bo	Boiling number
C	Cost [USD]
c	Velocity [m/s]
c_p	Specific heat [kJ/kg]
CRF	Capital recovery factor
D	Diameter [m]
Ex	Exergy [kW]
F	Fuel cost [USD]
G	Mass velocity (kg/s-m^2)
h	Specific enthalpy [kJ/kg]
i	Interest rate
I	Irreversibility [kW]
k	Thermal conductivity [W/m-K]
l	Length/height [m]
LMTD	Log mean temperature difference [K]
$\dot{m}$	Mass flow rate [kg/s]
n	Number of years
OM	Operation and maintenance cost [USD]
P	Pressure [kPa]
Pr	Prandtl number
Q	Heat interaction [kW]

Re	Reynolds number
s	Specific entropy [kJ/kg-K]
SP	Size parameter
t	Thickness [m]
T	Temperature [°C]
$T\dot{C}$	Total cost rate [USD/h]
U	Overall convective heat transfer coefficient [W/m^2-K]
v	Specific volume [m^3/kg]
W	Work transfer [kW]
x	Dryness fraction
z	Annual working hour [h]
Z^{CI}	Capital investment cost [USD]

Greek letters

∑	Sigma (sum notation)
α	Convective heat transfer coefficient [W/m^2-K]
β	Chevron angle
η	Efficiency
μ	Dynamic viscosity [$N\text{-}s/m^2$]
ρ	Density [kg/m^3]
ω	Entrainment ratio

Subscripts

1,2…12	State points
alt	Alternator
amb	Ambient
blr	Boiler
cf	Cold fluid
con	Condenser
d	Diffuser section of ejector
dp	Two-phase fluid
eje	Ejector
ele	Electricity
eq	Equivalent
evp	Evaporator

ex	Exergy
hf	Hot fluid
in	Inlet
ise	Isentropic
j	Any selected component
l	Saturated liquid state
liq	Liquid state
m	Mixing chamber of ejector
mix	Mixture
nz	Nozzle section of ejector
o	Outlet
pre	Preheater
pri	Primary
rec	Recuperator
req	Required
sec	Secondary
sep	Separator
sl	Saturated liquid state
sp	Single phase fluid
sub	Subcooled region
sup	Superheated region
sv	Saturated vapor state
t/tur	Turbine
th	Thermodynamic
thrt	Throttling
v	Saturated vapor state
vap	Vapor state
wet	Wet region (phase change)
wf	Working fluid