THERMAL PERFORMANCE ENHANCEMENT OF ALUMINUM CASTING PROCESSES IN FOUNDRY OPERATIONS: A CASE STUDY AT CEYLON ELECTRICITY BOARD

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Degree of Master of Engineering

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree Master of Engineering in Energy Technology

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Prof. Saliya Jayasekara

This work is lovingly dedicated to my dear wife, Manoja, and my two wonderful children, Sandamini and Sajan, whose unwavering love, support, and encouragement have been my constant source of strength and inspiration.

ABSTRACT

The Ceylon Electricity Board (CEB) foundry plays a vital role in Sri Lanka's energy sector by producing aluminum components for the national grid. However, reliance on outdated sand casting methods and inefficient oil-fired furnaces has led to low energy efficiency, high operational costs, and environmental concerns. This study addresses these challenges by designing and implementing a waste heat recovery system integrated with a welded plate heat exchanger to enhance energy efficiency and optimize foundry operations.

The research evaluated the performance of existing furnaces, revealing significantly low Specific Fuel Consumption (SFC) compared to the initial fuel consumption values , with the pit furnace operating performing at 0.681 *l/kg* and the tilting furnace operating at 0.294 *l/kg*. A welded plate heat exchanger was fabricated and integrated into the combustion system to preheat combustion air using exhaust gases. Computational Fluid Dynamics (CFD) simulations were employed to optimize the heat exchanger design and predict performance. Experimental results showed a 29.5% reduction in fuel consumption and a 32% decrease in melting time, with the heat exchanger achieving an energy recovery rate of 40%.

The findings demonstrate the feasibility of waste heat recovery in improving thermal efficiency and reducing emissions, providing a scalable solution for small and medium-scale foundries. This study recommends further modernization, including advanced monitoring systems and renewable energy integration, to enhance sustainability. By reducing reliance on imports and promoting local production, this research aligns with Sri Lanka's economic and environmental goals, offering a robust framework for energy-efficient aluminum casting practices.

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As	Area	m^2
c_p	Specific heat capacity	J/kg·K
E	Energy	J (Joules)
h	Specific enthalpy	kJ/kg
h_c	Convective heat transfer coefficient	$W/m^2 \cdot K$
k	Thermal conductivity	W/m·K
m	Mass	kg
$\dot{m}$	Mass flowrate	kg/s
NTU	Number of Transfer Units	--
Nu	Nusselt Number	--
P	Pressure	Pa (Pascals)
Q	Thermal Energy	J
Re	Renold Number	--
t	Time	s (seconds)
T	Temperature	K
U	Overall heat transfer coefficient	$W/m^2 \cdot K$
v	Velocity	m/s
$\dot{V}$	Volume flowrate	m^3/s
ΔT	Temperature difference	K
ε	Heat exchanger Effectiveness	--
η	Efficiency	--
ρ	Density	kg/m^3

LIST OF ABBREVIATIONS

AFR	Air to fuel ratio
AL	Aluminum
CAD	Computer aided design
CAM	Computer aided manufacturing
CEB	Ceylon Electricity Board
CFD	Computational Fluid Dynamics
HE	Heat Exchanger
FDSI	Foundry Development and Services Institute
GCV	Gross Calorific Value
HPHE	High Pressure Heat Exchanger
HTHE	High Temperature Heat Exchanger
IDB	Industrial Development Board
KCCP	Kelanitissa Combined Cycle Power Plant
kWh	Kilowatt hour
NTU	Number of Transfer Units
ORC	Organic Rankine Cycle
PHE	Plate Heat Exchanger
WHR	Waste Heat Recovery
WPHE	Welded Plate Heat Exchanger