DEVELOPMENT OF AN OPERATOR FRIENDLY BOILER PERFORMANCE CALCULATOR

Chamila Delpitiya

(108153J)

Degree of Master of Engineering

Department of Mechanical Engineering

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Thesis was submitted in partial fulfilment of the requirement for the degree Master of Engineering

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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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ABSTRACT

Saving fuel by optimising the equipment performance has become a goal for almost all global organisations and boilers which contribute to a major share of global recourses consumption was subjected to the present study. This study was conducted to develop a boiler performance evaluation tool. Different performance indicators and methods of evaluating those indicators were studied. Performance calculator was developed based on British Standard, which can estimate performance of steam, hot water boilers and thermal fluid heaters with limited inputs and standard measurements. The calculator was used to estimate direct efficiency, indirect efficiency and evaporation ratio of selected cases using secondary data. Calculated values of respective performance indicators were compared with measured values. Calculated results of indirect efficiencies have 0.897 to 0.950 correlation and the excess air percentages were 99.5% agreed with measured values. This can be developed using advance software including an expanded version of the steam table.

Keywords: Boiler performance, boiler efficiency

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LIST OF ABBREVIATIONS

A	Total external surface area of boiler	m^2
A_1	Water or steam backed external surface area of the boiler	m^2
A_2	Flue gas backed external surface area of the boiler	m^2
a_1	Carbon content of ashes and riddling, dry basis	%
a_2	Carbon content of dust and grit, dry basis	%
a_3	Combustion excess air	%
C	Carbon content of fuel as fired	%
Cp	Specific heat capacity of fluid	kJ/kg.K
GCV	Gross calorific value	kJ/kg
H	Hydrogen content of fuel	%
h_f	Enthalpy of water	kJ/kg
h_g	Enthalpy of steam	kJ/kg
K_1	Constant	--
k	Siegert constant	--
L_1	Dry flue gas loss	%
L_2	Loss due to enthalpy in water vapour	%
L_3	Loss due to moisture in fuel	%
L_4	Loss due to moisture in air	%
L_5	Loss due to unburned gases	%
L_6	Loss due to radiation, convection and conduction	%
L_7	Loss due to combustible matter in ashes and riddlings	%
L_8	Loss due to combustible matter in grit and dust	%
l_1	Thickness of insulation on water or steam backed area	mm
l_2	Thickness of insulation on gas backed area	mm
$\dot{M}_f$	Amount of fuel consumed in time t	kg
M_1	Quantity of ashes and riddling collected in time t	kg
M_2	Quantity of dust and grit collected in time t	kg
m_{H_2O}	Moisture content of fuel	%
$\dot{m}_s$	Steam flow rate	kg/h
p	Operating pressure of the boiler	Bar
Q_a	Actual rate of heat input during test	kW
Q_R	Rate of heat input at rated output of the boiler	kW
SFR	Steam to fuel (Evaporation) ratio	--

T_a	Ambient temperature	ºC
T_f	Temperature of the fuel	ºC
T_{fg}	Temperature of flue gas	ºC
T_g	Temperature of gaseous fuel	ºC
T_k	Heat carrier flow temperature	ºC
V_g	Volume flow rate of gaseous flue	m^3/s
w	Specific humidity of combustion air	kg/kg
W	Stoichiometric air for the fuel	kg/kg
X_f	Excess air factor	%
%CO	Volume of CO in flue gas	%
$\%CO_2$	Volume of CO_2 in flue gas	%
$\%O_2$	Volume of O_2 in flue gas	%
η	Efficiency	%

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