EVALUATING THE HEAT RECOVERY OPTIONS FROM THE GENERATED OILY SLUDGE IN THERMAL POWER PLANTS

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Degree of Master of Engineering

Department of Mechanical Engineering

University of Moratuwa
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Declaration

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Abstract:

Oily sludge is a process waste of thermal power plants that use heavy fuel oil for power generation. At present, the oily sludge is sold or incinerated from the power stations belonging to Ceylon Electricity Board. Since the waste heat generated from the incineration process is disposed to the environment without harnessing for effective work, the operation and maintenance cost of incineration is not cost-effective. In this study, the waste heat recovery options were considered based on the sludge treatment methods used in thermal power stations.

The possibility of using the sludge as fuel for micropower generation, hot water generation, and waste heat recovery from the oily sludge incineration was investigated. The study was carried out to determine the potential of recovering the waste heat of the oily sludge incineration process and to investigate the design parameters for a suitable heat recovery steam generator. Furthermore, the calorific value and the constituents in the sludge sample were investigated. As a result of this study, Heat Recovery Steam Generator was found as the most suitable heat recovery method.

The proposed HRSG was modeled, simulated, and optimized using the Engineers Equation Solver (EES) software. From the trial runs, the maximum power output that could be recovered from HRSG is 96.04 kW of energy at a rate of 222.1 kg/h sludge incinerating. Considering the steam mass flow rate for commercially available steam turbines, implementing a micropower generation plant with a capacity of 93.63kW is a feasible project with a payback period of 2.70 years to recover the cost of the investment. Furthermore, the feasibility of the sludge using as a fuel to a sludge fired boiler for power generation and hot water generation were investigated. 107.0 kW of power could be harnessed by burning of sludge at a rate of 204.48 kg/h and 13.36 kg/h of hot water could be generated by burning sludge at a rate of 1kg/h.

Waste heat recovery, Oily Sludge, Micropower generation, HRSG, EES.

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List of abbreviations

CEB	- Ceylon Electricity Board
PHC	- Polycyclic aromatic hydrocarbons
UJPS	- Uthuru Janani Power Station
HFO	- Heavy Fuel Oil
LFO	- Diesel fuel
OEM	- Original Equipment Manufacturer
CPC	- Ceylon Petroleum Corporation
CPSTL	- Ceylon Petroleum Storage Terminals Limited
EES	- Engineering Equation Solver software package
HRSG	- Heat Recovery Steam Generator
ITI	- Industrial Technology Institute
EGT	- Exhaust gas temperature

Subscript

apr	-Approach point
shs	-Superheated steam
gs	-Flue gas
sw	-Saturated water
go	-Gas out
gi	-Gas in
st	-Steam
f	-Fuel
g	-Gas
t	-Temperature
pt	-Pinch point temperature

Nomenclature

Q	-Heat content(J)
V	-Flowrate of the matter(m^3/s)
m_f	-Mass of the required fuel (kg)
Q_g	-Energy absorbed (kJ)
t_{go}	-Flue gas out temperature (^0C)
m_{st}	-Mass flow rate of steam (kg/s)
t_{g1}	-Flue gas in temperature of HRSG (^0C)
t_{pt}	-Pinch point temperature difference (^0C)
t_{g2}	-Economizer exit temperature (^0C)
h_{apr}	-Enthalpy - approach point (kJ/kg)
h_{sw}	-Feed water enthalpy (kJ/kg)
h_{shs}	-Enthalpy – superheated steam (kJ/kg)
h_{ouis}	-Isentropic enthalpy of steam (kJ/kg)
Q_e	-Heat required (kJ)
C_f	-Calorific value of sludge
η_{stm}	-Turbine mechanical efficiency
h_{sw}	-Enthalpy of saturated water (kJ/kg)
t_s	-Saturation temperature of the water
Δt	-Temperature difference in the substance
h_{s2}	-Enthalpy of steam evaporator(kJ/kg)
h_{ou}	-Enthalpy of steam at turbine out (kJ/kg)
Q_{ex}	-Extracted energy percentage
h_{lo}	-Heat loss from the HRSG
P_{stm}	-Steam turbine power output (kW)
η_{Is}	-Turbine - isentropic efficiency
ρ	-Density of flue gas (kg/m^3)
C_{pg}	- Value of specific heat - flue gas
h_{shs}	-Turbine inlet enthalpy (kJ/kg)

η_b	-Efficiency of the boiler
t_{gi}	-Flue gas in temperature (^0C)
$\dot{m}_f$	-Mass flow rate of sludge (kg/h)
m_g	-Mass flow rate of flue gas (kg/s)
m_{gs}	-Mass flow rate of gas (kg/s)
t_{g1}	-Temperature - flue gas in (^0C)
t_{g4}	-HRSG exit temperature (^0C)
t_{g3}	-Evaporator exit temperature (^0C)