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Exergy Analysis Of 120 MW Coal Based Thermal Power Plant

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ABSTRACT

Exergy analysis provides a mean to evaluate the degradation of energy during a process, the entropy generation, thelost of opportunities to do work and offers an another approach for improvement of power plant performance. This paper present work Coal based Thermal power plant (TPP) the results of an exergy analysis performed on a 120MW Thermal power plant in Kothagudem. The results of the exergy analysis indicate that the boiler produces the highest exergy destruction .Exergetic efficiency is compared with Thermal Efficiency based on Energy) and it is observedthat thermalefficiency of the plant about 37%andexergeticefficiencyis 39.75%.

KEYWORDS:Exergy, Anergy, Coal, Boiler, Turbine, Condenser, Feed Pump.

NOMENCLATURE

H	Enthalpy
S	Entropy
E	Exergy
Q_R	Heat Input
Q_{CH}	Chemical Energy of Fuel
EQ_{CH}	Chemical Exergy
∇e_B	Loss of Exergy in Boiler
∇e_T	Loss of Exergy in Turbine
∇e_C	Loss of Exergy in Condenser
η_{th}	Thermal Efficiency of the plant
η_e	Exergy efficiency of plant
η_b	Efficiency of boiler
η_{eb}	Exergeticefficiency of the boiler

f=1.08(solid fuel as shown by szargut)

Subscripts (State Points in Rankine Cycle):

1. Boiler 2.Tubine
3. Condenser 4.Feed pump

I.INTRODUCTION

Thermal Power plants use fuels conventional fuels like coal. In this Thermal Power Plant Coal fired boiler is used to generate steam at high pressure.. The object of this paper is to discussRankine Cycle and to introduce exergy analysis of Rankine cycle to enable us to find exergetic efficiency and component-wise losses. The analysis uses parameters of a working Coal based Thermal power plant of 120 MW capacity

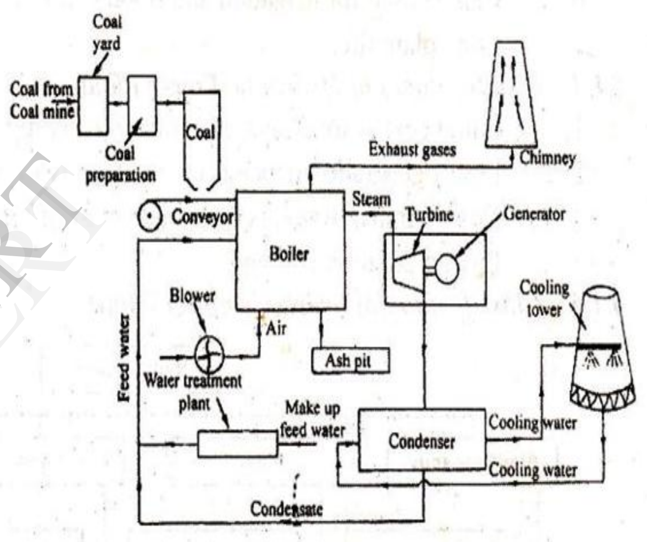

Figure 1: Layout of a TPP

II. LITERATURE SURVEY

Most of the plants are analyzed and reported in literature are pertaining to either plants of more than 100 MW capacity or it is less than 1MW capacity. Plants of the capacity less than 1 MW are mostly of academic interest and outcome of the reports indicate the total efficiency. As per the recent studies conducted on exergy analysis of plants are either directly coal fired plants or large capacity gas turbine plants [Kotas]. This project begins with a review of the concept of irreversibility, entropy generation ,orexergy destruction. Examples illustrate the accounting for exergy flows and accumulation inclosed systems, open systems, heat transfer processes, and power and refrigeration plants. Thediscussions were how to estimate the avoidable and unavoidable exergy destruction andinvestment costs associated with Boiler, Turbine, Condenser and Feed Pump. This generalprocedure, although based on many subjective decisions, facilitates and improves applications of exergy economics.

Direct firing of the coal in the boiler for generation of the steam is a commercially viable option for power plants engineers. Most of the literature published claims the thermal efficiency of the thermal plants are about 33% in India where as in the global scenario it is as high as 45% .Attaining higher efficiencies need investigation of available energy at all salient points of operation of the plant. The depletion of available energy (exergy) is due toincrease in entropy [van wylen] or more practically due to irreversibility in the thermodynamic system. This paper states the need of exergy analysis to TPP which helps in improving the efficiency of the plant

III. OPERATING PARAMETERS

For exergy analysis, the following operating parameters are used.

Table 1 : Operating Parameters

S. No	Component	Pressure (bar)	Temperature (^{o}c)
1	Boiler	148	192
2	Turbine	119	535
3	Condenser	0.1	51.4
4	Feed Pump	9	165

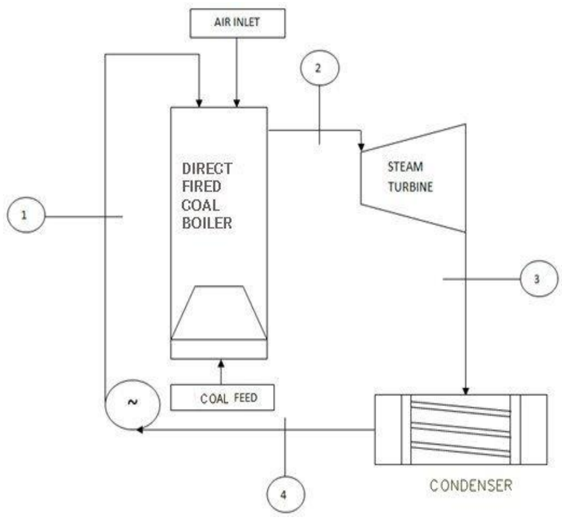

Figure 2: P&I Diagram

EXERGY ANALYSIS OF BIOMASS BASED STEAM POWER PLANT

When we study a thermal system, we would like to know how good the system is and how much energy it consumes. For this purpose, we can imagine an ideal system i.e. a system that uses reversible processes and compare it with the actual system to find its performance. According to Second Law of Thermodynamics we understand that energy can be divided into 2 parts:

1. Available Energy (Exergy)
2. Unavailable Energy (Anergy)

A. Boiler

Combustion of fuel is highly irreversible process. Moreover, the heat transfer from the flue gases to the water takes place with a large temperature difference. Hence, heat transfer also is a highly irreversible process. Therefore, considerable degradation of energy takes place in the boiler.

The loss of exergy in boiler is given by

Q_R =H2 - H1 (1)

∇E_S =E2 - E1(2)

EQ_{CH}=F*(Q_{CH}(3)

∇E_B=EQ_{CH} - ∇E_S(4)

$\eta_B = Q_R / Q_{CH}$(5)

$\eta_{EB} = Q_R/EQ_{CH}$ (6)

The Loss of exergy in boiler consists of 2 parts, i.e.

1. Due to incomplete combustion and incomplete recuperation of flue gases.
2. The temperature restriction of steam restricts the maximum exergy that can be given to the steam.

The Boiler Efficiency is about 85%. The exergetic efficiency of the boiler is 91.3%.

B.Turbine

The steam flowing through the turbine passages has to overcome friction. There is considerable turbulence in the high velocity stream. This results in loss of exergy. The efficiency of the turbine is the ratio of actual work done and the isentropic work done bturbine. The efficiency of the turbine comes out to be 88%.

The loss of Exergy in the turbine is given by

∇E_T= (E_2-E_3) –W_T(7)

C. Condenser

Large quantity of heat is removed from the condenser by cooling water. The heat rejected by the condenser is more or less worth less and cannot be judged for the performance of the condenser.

The Loss of Exergy in the condenser is given by

∇E_C= E4-E3 (8)

D. Feed Pump

Part of the work done by the pump is lost in friction. However pumping work itself is often negligible. Thus we assume the pumping losses to be negligible. The work done by pump is assumed to be zero.

RESULTS

Exergy analysis of a 120 MW TPP is performed and exergy values at all locations are investigated. It is observed that exergetic efficiency of the overall plant is 39.75% and overall thermal efficiency is about 37%. The difference of 2.75% is destruction of available energy is observed.

Table 2 : Properties Of Steam

State	Enthalpy (KJ/Kg)	Entropy (KJ/KgK)	Exergy (KJ/Kg)
1	822.8060	2.2352	14699.99832
2	3442.1855	6.6112	138078.37442
3	2595.3178	8.1837	14686.474236
4	697.4078	1.9918	9741.26132

In exergy analysis of TPP the exergies of boiler, turbine, and condenser are calculated and their losses in exergy are calculated as shown in table 3 and 4. It is observed that maximum loss of exergy (Anergy) occurs at the boiler. The boiler losses can be minimized by using Losses can be still reduced when the pumping all relevant air condensation process, i.e. by maintaining low vacuum and dissociating gases in condenser, the losses can be still reduced if proper condensation of flue gases cooling is adopted.It can be seen that the maximum exergy destruction occurs in the boiler with a value of 89.37% of the totalexergy destruction. It seems obvious from the data in that the irreversibility associated with chemical reactionsis the main source of exergy destruction.

Table 3 :Exergy and Anergy Calculations

S. No	Components	Condition		Exergy Destruction	Anergy (KJ/Kg)
		Exergy (Inlet)	Exergy (Outlet)		
1	Boiler	14699.9	138411	89.37	12371
2	Turbine	138078.	105725	23.43	32352
3	Condenser	14686.4	14636.44	0.34	50.02
4	Feed Pump	9741.2	10420	6.5	679.0

Graphical Representation of Exergy Destruction (%)

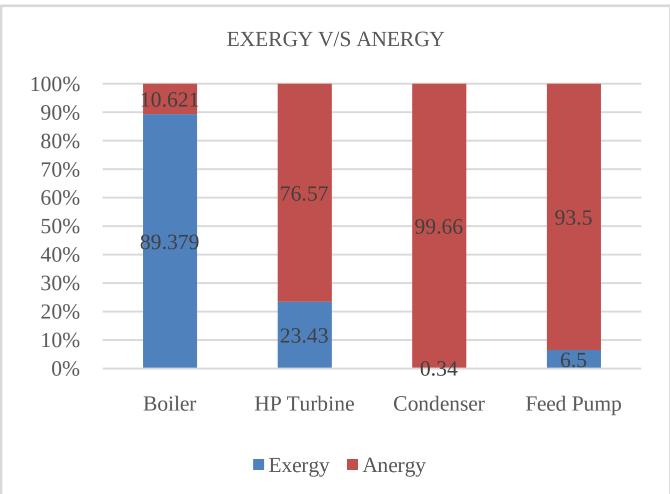

Table 4 : Overview Of Results

Heat Supplied By Fuel q_{ch}	15830.424 KJ/Kg
Exergy Supplied By Fuel eq_{ch}	17067.69792 KJ/Kg
Thermal Efficiency η_t	37%
Exergy Efficiency η_e	39.75%
Exergetic Efficiency of Boiler η_{eb}	91.3%
Total Loss of Exergy in Boiler ∇e_b	15748.60112 KJ/Kg
Loss of Exergy in Turbine ∇e_T	468.6077 KJ/Kg
Loss of Exergy in Condenser ∇e_C	75.7211 KJ/Kg

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