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EXERGOECONOMIC ANALYSIS OF CAPTIVE POWER PLANT

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Abstract
This evolution is carried out for exergoeconomic analysis of captive power plant of 33mw which is establish at bharuch which is help to generate balance between exergy and exonomic evolution. By that calculate the exergy of plant and also we get losses of plant which is enable to find with first law of thermodynamic.

Keywords-*component; formatting; style; styling; insert (key words) (minimum 5 keyword require) [10pt, Times new roman,Italic, line spacing 1.0]*

I. INTRODUCTION

The power sector in India faces peculiar problems. With highly subsidized agricultural rates, most electricity boards are making heavy losses. The electricity boards have no money to invest in new power plants, while foreign investors as well as institutions like the World Bank are reluctant to lend to loss making electricity boards. To a certain extent, energy efficiency improvement can help this matter. From 151 to 400 units, the tariff is Rs 4.20 per kWh and for above 400 units the tariff is Rs 4.40 per kWh in nearest future it may touch Rs 5 per kWh.The above fact will realize everyone that the world's energy resources are finite and fast depleting energy reserves has simulated interest in the efficient use of existing resources. This renewed interest has led to a greater emphasis on concepts of thermodynamics and kindled efforts to apply these principles to improve industrial process efficiency. The efficiency improvements have initiated in most of industry. Even though there is a awareness in India today than that show the importance of energy conservation measures and its efficient use, the result achieved are insignificant. The fact of the matter is that the former involves the conversion of chemical energy of fuel to sensible enthalpy of steam to mechanical work while latter's involve work to heat, but limits the efficiency of conversion of heat to work to a value which is less than 100%, the actual value being dependent primarily on heat source and sink temperatures. It is only when both the outputs and inputs are energies of the same quality, as in the case of electric motors and generators, that the concept of efficiency may be expected to be valid. So in determining the efficiency of energy utilization, we are aided by the thermodynamic concept that every transformation requires an energy exchange, whose minimum amount is precisely assessable.Exergoeconomic analysis takes into account both fuel and capital costs, and allows determining the product's cost on the basis of exergy criteria. This requires the determination of a functional quantitative interdependence between equipment, operations costs and efficiency. Captive systems are analyzed by exergy and exergoeconomic. Exergy analysis, which is the combination of first law and second law of thermodynamics, helps to find the thermodynamic losses of a system. Now that showsthat increase a system thermodynamically by ignoringthe economic point of view is not feasible. Hence researchers have started exergy and economics. That created area called thermoeconomics or exergoeconomic.

II. Plant Description

- *Gujarat Narmada Valley Fertilizers Company Ltd. (GNFC) is a joint sector company promoted by the Government of Gujarat and Gujarat State Fertilizers and Chemicals Ltd. (GSFC) at Narmadanagar, Bharuch District of Gujarat, which is well connected on the national rail and road network that knits the country. GNFC is located in a very prosperous industrial belt consisting of refineries, petrochemicals, fertilizer and Asia's biggest industrial estate at Ankleshwar. Dahej port is just 40 km from the GNFC site. GNFC is in the field of manufacturing and selling of fertilizers such as Urea, Ammonium Nitro phosphate and Calcium Ammonium Nitrate under the umbrella "NARMADA". GNFC also manufactures industrial chemicals such as Methanol, Formic Acid, Nitric Acid and Acetic Acid, aniline and TDI. Much power is needed to run such a big plant and also process steam at different temperature and pressure levels. For satisfying the demand of process steam, a whole Steam & Power Generation Department is established which generate 83.3 MW (25 + 25 + 33.3) power.*

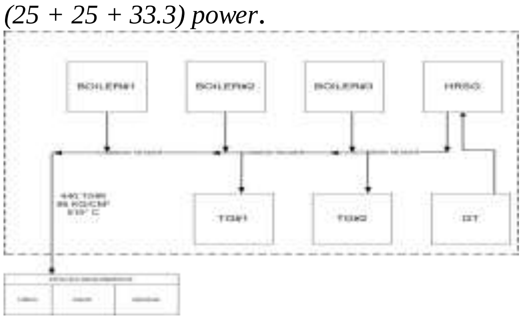

Fig.1

- *3 pulverized coals fired steam boiler of BHEL design generating 180 TPH each at 96 Kg/cm2, 510°c.*

- *1 oil and gas fired Thermax design boiler generating 180 TPH steam at 96 kg/cm2 and 510° c.*
- *1 gas turbine generates 33.3 MW power and flue gases are utilized in HRSG.*
- *2 steam turbine generating 25 MW each.*
- *1 HRSG generating 62 TPH of HP steam at 102 kg/cm2 and 16.5 TPH of LP steam at 4 kg/cm2.*

- *Boiler*

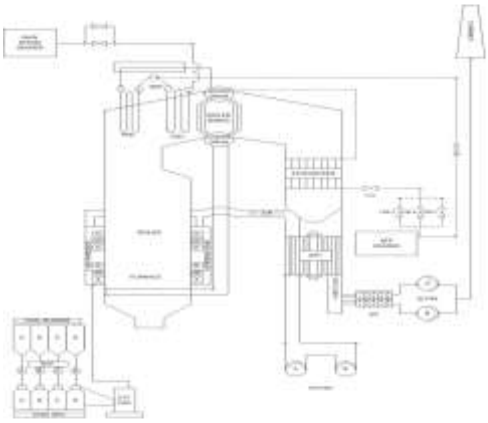

Fig.2

- TG

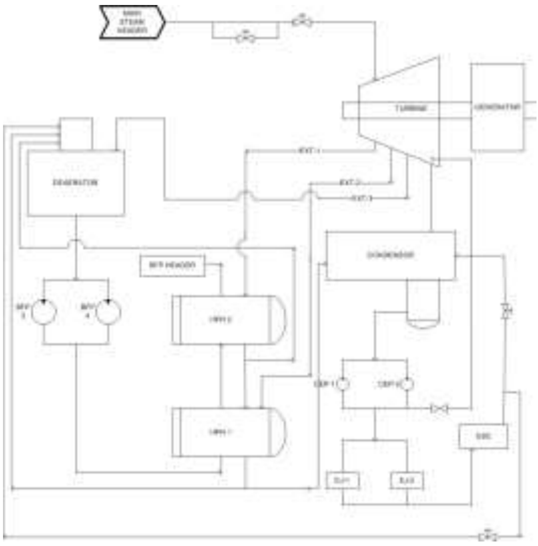

Fig.3

Fig.4

Above shown a plant fig which exergogoeconomic wants to carried out.now after that there will be plant data will be shown below. For carried out analysis there data is collected from plnat is taken for analysis.

III. plant data collacted

- **Boiler -1**

  For analysis of plant different data is collected from plant is given fro analysis which help to improve performance of plant.

Component	Inlet Temperature (°C)	Inlet Pressure (bar)	**Outlet Temperature (°C)**	**Outlet Pressure (bar)**
Air in APH	33.5	-	294	-
Furnace	294	-	923	-
Economizer	176	139	258	139
Boiler drum	258	139	293	103.2
SuperHeater1	293	103.2	394	103
De-SuperHeater	394	103	369	88
SuperHeater2	369	88	514	96.8

TABLE .1

- **Boiler -2**

Component	Inlet Temperature (°C)	Inlet Pressure (bar)	**Outlet Temperature (°C)**	**Outlet Pressure (bar)**
Air in APH	294	-	278	-
Furnace	278	-	945	-
Economizer	180	141	265	141
Boiler drum	265	141	301	108
SuperHeater1	301	108	384	104
De-SuperHeater	384	104	331	91
SuperHeater2	351	91	502	97.02

TABLE .2

- **Boiler -3**

Component	Inlet Temperature (^oC)	Inlet Pressure (bar)	**Outlet Temperature (^oC)**	**Outlet Pressure (bar)**
Air in APH	320	-	298	-
Furnace	298	-	965	-
Economizer	170	136	251	136
Boiler drum	251	136	288	95
SuperHeater1	288	95	374	93.4
De-SuperHeater	374	93.4	350	82.4
SuperHeater2	350	82.4	496	96

TABLE .3

- **TG-1**

COMPONENT	TEMPERATURE (°C)	PRESUURE (bar)	MASS FLOW RATE (kg /s)
TURBINE INLET	496	96.02	20.83
Extraction -1	285	17.8	7.84
Extraction	214	7.51	2.11
Extraction	172	2.31	3.21
Extraction	98	0.98	5.10

TABLE .4

- **TG-2**

COMPONENT	TEMPERATURE (°C)	PRESUURE (bar)	MASS FLOW RATE (kg /s)
TURBINE INLET	496	96.02	20.1
Extraction -1	298	14.9	6.4
Extraction	123	6.4	4.53
Extraction	132	3.1	1.08
Extraction	91	0.93	10.79

TABLE .5

III. Research Methodology

In all the industries, energy is the running force which cost a considerable amount of money. Therefore it is essential to conserve the energy and make most of it. Different components of the plants produce desirable output by consuming energy in different forms. It is necessary that this output is produced using optimum energy input. By energy analysis of a plant component, one can quantify how much amount of energy is utilized by component for useful output. In thermal power plants, main components are boiler, turbine and condenser. In this project, attention is focused on the components which deal with steam and water. In this chapter, energy or 1st law analysis and 2nd law analysis of these components is done. Process diagram of procedure is shown below.

- $Energy_{in} = Energy_{out} + Energy_{loss}$

$$\eta_I = \frac{ENERGY\ OUTLET}{ENERGY\ INLET}$$

$$\eta_I = \frac{m_s(hg - hf)}{m_f * G.C.V}$$

$$\eta_{II} = \frac{exergy\ recoverd}{exergy\ supplied}$$

$$\eta_{II} = 1 - \frac{E_d}{E_{IN}}$$

$$E_x = mc_p \int_{T_0}^{T} (1 - \frac{T_0}{T})\ dT$$

$$E_D = T_0^* S_{GENERATED}$$

$$xv = \frac{v_{fg} \times 1.005 \times NCV_{fg} \times 4.187}{3600}$$

$$C_p Ex_k = C_f Ex_f - C_f Ex_d + Z_k$$

$$CRF = \frac{i \times (1+i)^n}{(1+i)^n - 1}$$

IV. RESULT AND DISCUSSION

- **Boiler-1**

COMPONENT		ENTHALPY (KJ/Kg)	ENTROPY (kJ/Kg. K)	ENERGY (kJ/Kg)
ECONOMISER	IN	752	2.08	32516
	OUT	1124	2.84	49017
BOILER DRUM	IN	1124	2.58	49017
	OUT	1409	3.18	59487
PSH	IN	2747	3.18	115978
	OUT	3076	6.16	129868
DSH	IN	3076	6.16	129868
	OUT	2786	5.29	117624
FSH	IN	3059	5.29	129150
	OUT	3416	6.06	144223

TABLE .6

	QUALITY IN KW	QUALITY IN UNIT
ENERGY OF FUEL SUPPLY	171782	100
PSH	24839	14.44
FSH	24710	14.38
BOILER DRUM	20077	11.68
ECONOMISER	22809	13.27
APH	10127	5.06
EP	15598	9.08
LOSS	53622	37.57

TABLE .7

COMPONENT	Ex_{in} (KJ/Kg)	Ex_{out} (KJ/Kg)	Ex_d(KJ/Kg)
Economizer	10677	5569	5108
Boiler drum	21026	7380	13546
PSH	22482	6372	16110
DSH	22457	19239	3218
FSH	15614	5398	13730
TOTAL Boiler	69799	24719	45080

TABLE .8

COMPONENT	Ex_{in} (KJ/Kg)	Ex_{out} (KJ/Kg)	Ex_d(KJ/Kg)
Economizer	10677	5569	5108
Boiler drum	21026	7380	13546
PSH	22482	6372	16110
DSH	22457	19239	3218
FSH	15614	5398	13730
TOTAL Boiler	69799	24719	45080

COMPONENT	η_I	η_{II}
Economizer	65%	52%
Boiler drum	52%	35%
PSH	55%	28%
DSH	92%	85%
FSH	60%	34%
Boiler	71%	35%

TABLE .9

- **Boiler-2 :**

COMPONENT	ENTHALPY (KJ/Kg)	ENTROPY (kJ/Kg. K)	ENERGY (kJ/Kg)	
ECONOMISER	IN	769	2.122	34605
	OUT	1158	2.906	52110
BOILER DRUM	IN	1158	2.906	52110
	OUT	1448	3.325	65160
PSH	IN	2748	4.48	118466
	OUT	3031	6.10	136395
DSH	IN	3036	6.10	136620
	OUT	2957	6.03	133065
FSH	IN	2963	6.03	133065
	OUT	3386	6.62	152370

TABLE .10

TABLE .11

	QUALITY IN KW	QUALITY IN UNIT
ENERGY OF FUEL SUPPLY	171782	100
PSH	27764	18.55
FSH	27634	18.04
BOILER DRUM	17514	15.37
ECONOMISER	24910	14.63
APH	7544	11.34
EP	13002	5.35
UNACCOUNTED LOSS	53414	31.40

TABLE .12

COMPONENT	η_I	η_{II}
Economizer	70%	41%
Boiler drum	74%	34%
PSH	64%	35%
DSH	93%	88%
FSH	69%	54%
Boiler	68%	44%

TABLE .13

- **Boiler-3:**

COMPONENT	ENTHALPY (KJ/Kg)	ENTROPY (KJ/Kg. C)	ENERGY (KJ/Kg)
ECONOMISER	IN	769	2.02
	OUT	1158	2.78
BOILER DRUM	IN	1158	2.78
	OUT	1477	3.13
PSH	IN	2747	3.18
	OUT	3035	6.14
DSH	IN	3075	6.14
	OUT	2825	6.11
FSH	IN	2986	6.11
	OUT	3372	6.60

TABLE .14

	QUALITY IN KW	QUALITY IN UNIT
ENERGY OF FUEL SUPPLY	171782	100
PSH	20106	11.70
FSH	23093	13.44
BOILER DRUM	17724	10.31
ECONOMISER	20991	12.21
APH	14930	8.69
EP	17964	10.45
UNACCOUNTED LOSS	56971	33.16

TABLE .15

COMPONENT	Ex_{in} (KJ/Kg)	Ex_{out} (KJ/Kg)
Economizer	6991	2531
Boiler drum	11092	6872
PSH	14730	7290
DSH	18929	16408
FSH	20900	11428
Boiler	63713	28121

TABLE .16

COMPONENT	η_I	η_{II}
Economizer	76%	36%
Boiler drum	75%	61%
PSH	60%	49%
DSH	91%	88%
FSH	70%	54%
Boiler	68%	44%

TABLE .17

- ***TG-1 Result***

COMPONENT	η_I	η_{II}	Ex_{avi} (KJ/Kg)	Ex_d (KJ/Kg)
Turbine	89	81	21105	4010
Condenser	51	43	5859	3340
HPH-1	47	52	3062	1472
HPH-2	62	38	1254	778
Dearator	46	36	2393	1532
BFW	92	81	1364	256

- ***TG-2 Result***

COMPONENT	η_I	η_{II}	Ex_{avi} (KJ/Kg)	Ex_d (KJ/Kg)
Turbine	89	74	21646	5628
Condenser	75	36	4972	1802
HPH-1	68	60	6905	2762
HPH-2	79	68	4068	1302
Dearator	43	31	1652	1140
BFW	90	73	1046	279

TABLE .18

EXERGOECONOMIC ANALYSIS:

Component	FUEL FLOW RATE (kg/s)	PRODUCT EXERGY (kj/s)	COST PER EXERGY UNIT (Rs/mw)
BOILER-1	7.22	33965	1.64
BOILER-2	7.22	34230	1.73
BOILER-3	7.22	33786	1.73

COST OF FUEL (Rs /S)	INVESMENT COST (Rs/s)	OPERATING &MAINTENANCE COST (Rs/s)	COST OF PRODUCT (Rs /s)
6.38	11.26	38.92	55.86
6.38	11.26	38.92	59.43
6.38	11.26	38.92	58.56

TABLE .19

V. *SUMMARY*

After doing analysis finds that there is higher exergy loss in overall power plant and specially ccpp. In boiler-1, boiler-2 and boile-3, there are higher losses in boiler drum, PSH and FSH respectively. Its has as compare to boiler and TG. There are so many factors which are affecting likewise stack gas temperature, fuel quality, heat transfer ration of gases to steam.Also there are some points take into consideration there are higher exergy efficiency found in gas turbine and steam turbine. .So there is chance of getting improvement of exergy efficiency with using this exergoeconomic technique .There are some point that could help to improve exergy efficiency.Most found that components are not working at their higher efficiency level.It's also concluding that exergy efficiency is lower than energy efficiency.

VI. *Conclusion*

- *By doing all calculation find that there is energy efficiency is higher compare to exergy efficiency in all unit.As above overall captive power plant has very high exergy destruction. Here respectively boiler-1 (45080 kJ/kg) , boiler-2 (35600 kJ/kg) and boiler-3 (35592 kJ/kg).*
- *Also find that cost per exergy unit in boiler 1, boiler 2, boiler 3 and GT respectively is 1.64 Rs/MW, 1.73 Rs/,MW, 1,73 Rs/MW and 0.76 Rs/MW.*
- *boiler-1 there is 71% energy efficiency and only 35% exergy efficiency found but in actual design 78% energy efficiency mention so boiler -1 working So here can be improving performance.*

REFERENCES

[1] Frank Czieslaa, George Tsatsaronis and Zengliang Gao ,"Avoidable thermodynamic inefficiencies and costs in an externally fired combined cycle power plant."2006.

[2] Seyed Reza Hosseini, Majid Amidpour and Seyed Ehsan Shakib,"Cost optimization of a combined power and water desalination plant with exergetic, environment and reliability consideration." 2012.

[3] Ali M. El-Nashar," Exergy and cost accounting of the UANE cogeneration plant." 1990.

[4] Masoud Taghavi , Mohsen Abdollahi, and Gholamreza Salehi," Thermodynamic and Thermo Economic Optimization of Combined Cycle Power Plant".2013.

[5] Osman A. Hamed, Hamed A. Al-Washmi and Holayil A. Al-Otaibi ,"Thermoeconomic analysis of a power/water cogeneration plant."2006.