

Improving Performance of Thermal Power Plant by Exergy Analysis

Zala Sanjay Harishchandrasinh¹, Dave Vatsal Bhadreshkumar², Ambasana Hitendra Manharbhai³, Chauhan Kamlesh Khushalbai⁴, Vaghela Bhavesh Virsangbhai⁵

Assistant Professor, Dept of Mechanical Engineering, Govt. Engg. College, Bhavnagar, Gujrat, India¹

Students, Dept of Mechanical Engineering, Govt. Engg. College, Bhavnagar, Gujrat, India^{2,3,4,5}

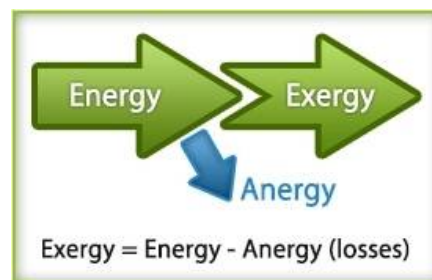
ABSTRACT: In this work, a thermodynamic analysis of a coal based thermal power plant has been carried out. The energy supply to demand narrowing down day by day around the world, the growing demand of power has made the power plants of scientific interest, but most of the power plants are designed by the energetic performance criteria based on first law of thermodynamics only. The real useful energy loss cannot be justified by the first law of thermodynamics, because it does not differentiate between the quality and quantity of energy. The present study deals with the comparison of energy and exergy analysis of thermal power plants.

KEYWORDS: Energy, Exergy, Efficiency, Entropy

I. INTRODUCTION

Exergy: Exergy is related to a work potential of any system. Exact definition of Exergy in thermodynamics is, "Maximum Work obtainable from a system when it interacts with surroundings and comes to dead state."

Broadly speaking, there are two forms of energy in nature: (1) High grade energy (2) Low grade energy. High grade form of energy is highly organized in nature and conversion of such energy to some other high grade form ($W \rightarrow W$) is not of so important in thermodynamics.



On the other hand, Conversion of high grade energy to low grade energy is not desirable. However, there may be some conversion to low grade energy as work is converted into other useful form. This is because of dissipation of heat due to friction (example: mechanical work \rightarrow Electricity, some losses are there due to the friction in bearing of machineries).

Thus both the first and the second law of thermodynamics are to be considered for analysis. Low grade energy such as heat due to combustion, fission, fusion reactions as well as internal energies are highly random in nature. Conversion of such form of energy into high grade energy ($Q \rightarrow W$) is of interest. This is due to the high quality of organized form of energy obtained from low quality energy. Second law of thermodynamics dictates that conversion of 100% heat into work is never possible. That part of low grade energy which is available for conversion is termed as available energy, availability or exergy. The part, which according to the second law of thermodynamics, must be rejected is known as unavailable energy.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Importance of Exergy Analysis:-Let us take an example. In case of coal fired power plant, the first law indicates that the condenser greatly affects the power plant efficiency as large amount of heat is transferred to the cooling water without providing any clue on the real usefulness of this relatively low temperature fluid. Also, energy balances do not provide information about the internal losses such as throttling valve and heat exchanger. Second law or exergy balance, however indicates that there is hardly 1% exergy loss in the condenser with more than 60% in the boiler. The contribution in the boiler exergy loss accounts for irreversibility associated with combustion and finite temperature differences. Hence, analysis of exergy plays a deterministic role in identification of processes and rectifying the components.

II. METHODOLOGY

Calculation for second law efficiency:-

Parameters

Ψ_{in} = Exergy in (kJ/s)

Ψ_{out} = Exergy out (kJ/s)

Second Law Efficiency = $\frac{\Psi_{in}}{\Psi_{out}} \times 100$

Exergy Destruction = $\Psi_{in} - \Psi_{out}$

$\Psi = h - T_0 S$

Where, h = Enthalpy of medium (kJ/kg)

T_0 = Ambient Temperature (K)

S = Entropy of Medium (kJ/kg K)

III. EXERGY ANALYSIS

BOILER:-

$\Psi_{in} = \epsilon_f + \epsilon_{pa} + \epsilon_{sa}$

$\Psi_{out} = \epsilon_g + \epsilon_{sg}$

Where,

$\epsilon_f = \dot{m}_f (h_f)$ KJ/sec

$\epsilon_{pa} = \dot{m}_{pa} (h_{pa} - T_0 S_{pa})$ KJ/sec

$\epsilon_{sa} = \dot{m}_{sa} (h_{sa} - T_0 S_{sa})$ KJ/sec

$\epsilon_g = \dot{m}_g (h_g - T_0 S_g)$ KJ/sec

$\epsilon_{sg} = \dot{m}_{sg} (h_{sg} - T_0 S_{sg})$ KJ/sec

➤ ACTUAL PARAMETERS ON 55 MW

| \dot{m}_f | \dot{m}_{pa} | \dot{m}_{sa} | \dot{m}_g | \dot{m}_{sg} |
|-------------|----------------|----------------|-------------|----------------|
| 43.33 | 84.6 | 108.4 | 204.1 | 204.16 |
| h_f | h_{pa} | h_{sa} | h_g | h_{sg} |
| 12561 | 333.66 | 317.58 | 518.54 | 720.29 |
| S_f | S_{pa} | S_{sa} | S_g | S_{sg} |
| 0.03 | 0.4 | 0.38 | .412 | 118.3 |

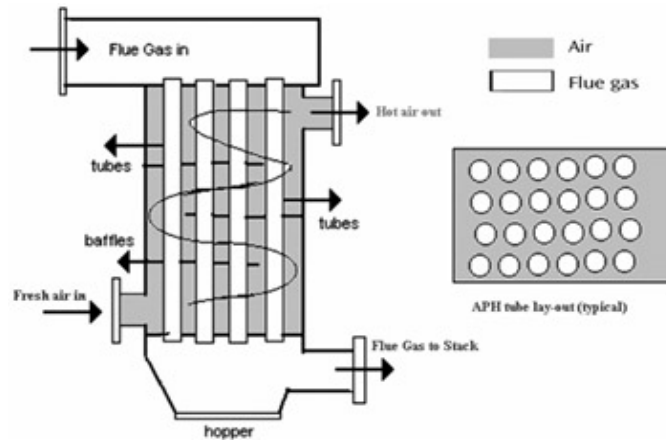
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

AIR PREHEATER:-



$$\Psi_{in} = \dot{m}_g[(h_{gi}-T_0S_{gi}) - (h_{go}-T_0S_{go})]$$

$$\Psi_{out} = \dot{m}_{pa}[(h_{pao}-T_0S_{pao}) - (h_{pai}-T_0S_{pai})] + \dot{m}_{sa}[(h_{sao}-T_0S_{sao}) - (h_{sai}-T_0S_{sai})]$$

➤ ACTUAL PARAMETERS ON 55 MW

| \dot{m}_g | \dot{m}_{pa} | \dot{m}_{sa} |
|-------------|----------------|----------------|
| 204.16 | 302 | 392 |
| h_{gi} | h_{pai} | h_{sai} |
| 521.63 | 328.6 | 317.3 |
| h_{go} | h_{pao} | h_{sao} |
| 369.7 | 464.33 | 462.01 |
| S_{gi} | S_{pai} | S_{sai} |
| 3.001 | 2.59 | 2.377 |
| S_{go} | S_{pao} | S_{sao} |
| 2.71 | 2.96 | 2.947 |

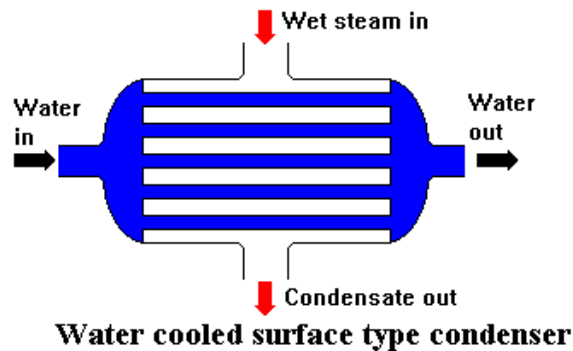
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

CONDENSER:-



$$\Psi_{in} = \dot{m}_h[(h_{hi}-T_0s_{hi}) - (h_{ho}-T_0s_{ho})]$$

$$\Psi_{out} = \dot{m}_w[(h_{wo}-T_0s_{wo}) - (h_{wi}-T_0s_{wi})]$$

➤ ACTUAL PARAMETERS ON 55 MW

| | |
|-------------|-------------|
| \dot{m}_h | \dot{m}_w |
| 46.66 | 7448 |
| h_{hi} | h_{wi} |
| 2574.4 | 113.1 |
| h_{ho} | h_{wo} |
| 167.5 | 142.4 |
| S_{hi} | S_{wi} |
| 8.252 | 0.395 |
| S_{ho} | S_{wo} |
| 0.572 | 0.491 |

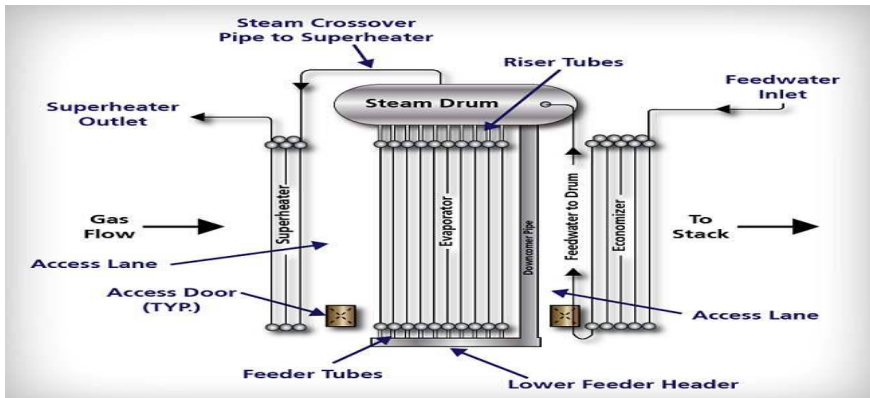
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

SUPER HEATER:-



$$\Psi_{in} = \dot{m}_g[(h_{gi} - T_0 s_{gi}) - (h_{go} - T_0 s_{go})]$$

$$\Psi_{Out} = \dot{m}_{sup}[(h_{supo} - T_0 s_{supo}) - (h_{supi} - T_0 s_{supi})]$$

➤ ACTUAL PARAMETERS ON 55 MW

| \dot{m}_g | \dot{m}_{sup} |
|-------------|-----------------|
| 204.6 | 52.5 |
| h_{gi} | h_{supi} |
| 928.20 | 2868.91 |
| h_{go} | h_{supo} |
| 615.33 | 3343.76 |
| s_{gi} | s_{supi} |
| 0.971 | 4.260 |
| s_{go} | s_{supo} |
| 0.854 | 6.011 |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

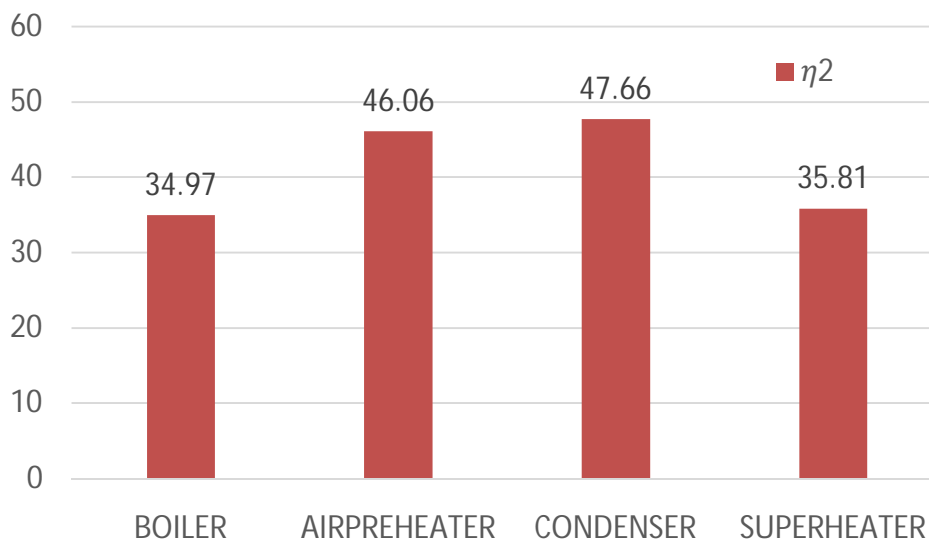
Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

IV. RESULTS AND CONCLUSION

Results:-

| Sr. NO | COMPONENT | EXERGY LOSS (%) |
|--------|------------------|-----------------|
| 1. | Boiler (Furnace) | 65.03 |
| 2. | Ari preheater | 53.94 |
| 3. | Condenser | 52.37 |
| 4. | Superheater | 64.19 |



V. CONCLUSION

There is a very vast difference between 1st and 2nd law efficiency.

Highest 1st law efficiency is found in APH which equals to 85%.

Lowest 2nd law efficiency is found in superheater which equals to 28.91%.

Highest exergy loss occurs in Boiler While lowest exergy loss occurs in Condenser.

As per 1st law criteria, APH is more efficient among all.

As per 2nd law criteria, Condenser is more efficient among all.

As we seen that boiler has more losses so by doing soot blowing operation we can increase the heat transfer and it also helps in increase its efficiency and due to which coal consumption decrease.

So economical optimization of plant can achieve.

REFERENCES

- [1]M.A. ROSEN and D.A. HORAZAK, "Energy and exergy analyses of PFBC power plants" (1995)
- [2] M.A. ROSEN, "SECOND-LAW ANALYSIS: APPROACHES AND IMPLICATIONS" (1999)
- [3] T. Ganapathy, N. Alagumurthi, R. P. Gakkhar and K. Murugesan1, "Exergy Analysis of Operating Lignite Fired Thermal Power Plant" (2009)
- [4]S.C. Kaushik, V. Siva Reddy, S.K. Tyagi, "Energy and exergy analyses of thermal power plants: A review" (2010)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

- [5]Vundela Siva Reddy, Subhash Chandra Kaushik, Sudhir Kumar Tyagi, Naraya Lal Panwar, "An Approach to Analyse Energy and Exergy Analysis of Thermal Power Plants: A Review" (2010)
- [6] Amirabedin Ehsan, M. Zeki Yilmazoglu, "Design and Exergy Analysis of a Thermal Power Plant Using Different Types of Turkish Lignite" (2011)
- [7] Mali Sanjay D, Dr. Mehta N S, "EASY METHOD OF EXERGY ANALYSIS FOR THERMAL POWER PLANT" (2012)
- [8] Raviprakash kurkiya, Sharad chaudhary, "Energy Analysis of Thermal Power Plant" (2012)
- [9] Dr. Mohammed Yunus, Mohammed Asadullah, Dr. Hamza A. Ghulman, Dr. J. Fazlur Rahman, Mohammed Irfan, "Energy Based Analysis of a Thermal Power Station for Energy Efficiency Improvement" (2014)
- [10] Parmar Hitendra, Ketan N Jambu, "Energy and Exergy Analysis of Thermal Power Plant: A Case Study of DCM Shriram Ltd" (2015)