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Comparative Study of Economizer with Thermal Analysis for Improving Heat Transfer Rate

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Abstract: *Economizer is used in thermal power plant with boiler and used to preheat the feed water. Economizer helps in increases overall efficiency of power plant. Economizer consists of number of tubes attached in parallel, instead of feeding the water in boiler drum, the water first feed in the economizer which increases the temperature. The economizer in present research work is modeled in creo parametric 2.0 software and is imported to ANSYS software for the purpose of thermal analysis.*

Keywords: *Economizer, Thermal analysis, heat flux, heat transfer, Economizer efficiency, Boiler efficiency.*

1. INTRODUCTION

An **economizer** is a mechanical device which is used as a heat exchanger by preheating a fluid to reduce energy consumption. They may waste energy are not maintained and running properly economizers are applied to use heat which is generated from the combustion process and is waste for system, utilization of waste heat improves overall boiler. Exhaust flue gas from combustion chamber are found at high temperature and feed water can be pre heated using these exhaust flue gas temperature.

An economizer is a heat exchanger which raises the temperature of the feed water leaving the highest pressure feed water heater to about the saturation temperature corresponding to the boiler pressure. This is done by the hot flue gases exiting the last super heater or reheated at a temperature varying [1].Economizers are considered as expire and not usable if experts and technicians cannot maintain them at economical cost. The location and wind direction for Air cooled Steam condenser in thermal power plant plays a very vital role in their performance as earlier said its efficiency is inversely proportional to the ambient temperatures As the air passes from various heated equipment like Boiler, Air Pre-heater, Economizer[6].The last heating surface at the boiler if we not consider air heater it is economizer, this economizer is made by plain tubes with inline arrangement because of fouling which impact in additional resistance to heat transfer[4].

Function of Boiler Economizer

The function of Economizers saves remarkable amount of energy. In a steam boiler, it is a heat ex-changer device that heats up fluids or recovers residual heat from the combustion product i.e. flue gases in thermal power plant before being released through the chimney. Flue gases are the combustion exhaust gases produced at power plants consist of mostly nitrogen, carbon dioxide, water vapor, soot carbon monoxide etc. The Economizer in Boiler works on the principle of Heat Transfer. Heat transfer usually takes place from high temperature to low temperature. In the case of Boilers, flue gases or exhaust from the boiler outlet are at high temperature and water that needs to be preheated is at low temperature. So, this temperature difference between water and flue gases helps to increase the feed water temperature. Depending on the type of operations, design of Economizers can be smoke tube type or water tube type. In smoke tube type flue gases are inside the tubes and water is on the shell side while in the water tube type, water is in the tube and flue gases are on the shell side.

Advantages and Benefits of Economizer

i. It recovers more heat of flue gases which normal air pre-heater cannot do.
ii. Due increase in fuel prices, all power plants are facing pressure for increasing boiler efficiency. So by using economizer, this pressure can be minimized.
iii. Power plants where it is not used, large quantity of water is required to cool the flue gas before desulphurization which is minimized by using economizers.
iv. The efficiency of power plant reduced when steam air pre-heater required steam.

2. LITERATURE REVIEW

Economizer used in many companies the famous case which happened in-

R Boopathi, G.V. Ganapathyraman, P. Manimaran, A. Prabakaran and S.Prabakaran, (2016) Performance Analysis of Economizer, Air Pre-Heater and Electrostatic Precipitator of 210MW Power Plant Boiler[1], Arian shoshi, Xhevat berisha, (2016) analysis of velocity of flue gases in economizer of coal power plant in kosova B[2], Sundarrajan.S, S.Mohammed Shafee,(2015) "Energy Conservation in Power plant Electrostatic Precipitator (ESP) by Using Waste Heat Recovered from Boiler[3], M.D. Paepe, C.T. Joen, H. Huisseune, M.V. Belleghem, V.Kessen,(2013) Comparison of different testing methods for gas fired domestic boiler efficiency determination[4], Ruoxu Jia, Junling Hu, and Abubaker E.M Elbalsohi (2014) Analysis of a Counter Flow Parallel-plate Heat Exchanger[5], J. Manivel, Performance Analysis of Air Preheater in 210mw Thermal Power Station[6].

There are major cause of economizer is major finding –

1) Future scopes of waste reduction are not specified.
2) Water is suggested for storage purpose but the proper location is not given.
3) No proper technique is supply of water and flue gasses for inlet or outlet.

Objective and Scope of the Study

Tubes are critical for any of the heat exchanger design and performance of heat exchanger depends on efficiency up to great extent. Following are some objectives which are considered for the research purpose.

- To analyze some tube shapes such as circular, triangular or square.
- To vary distance between tubes in Economizer to simulate and obtain the variation in thermal efficiency.
- To change number of tubes and test to achieve desired optimum level.
- To design Economizer with varying dimensions to optimize heat rejection.
- To consider new materials, alloys or composites as economizer or tube material.

Combinations tube shapes, tube distances, number of tube and various materials can be modelled and result can be tested for their performances to achieve new standards of tube design.

3. PROBLEM FORMULATION

In present research work the modal is to be created using cero parametric 2.0. The research is focused to the thermal analysis of the economizer using ANSYS simulation software. It will also include the economizer performance and problem solution like deformation, erosion and depreciation of economizer. Following is the part modelled geometry and dimensions in creo parametric.

The major problem reported is that the economizer tube is repetitively failing due to deformation, erosion and depreciation effect. As the economizer tube is subjected to high temperature under operating condition, internal thermal impact and stresses are continuously affecting the life and performance of economizer tube. The tubes are to be changed every failure time. Same is causing high cost to organizations operating Boiler and economizer operations.

Shell-and-tube economizer

A common economizer is the shell-and-tube economizer. In this kind of economizer one fluid flows inside a tube bundle and the other fluid flows in a shell surrounding this tube bundle. Shell-and-tube economizers are often used in process industries such as oil refineries. A few properties make the shell-and-tube economizer favorable. The geometry allows for high pressure and flexibility concerning phases as well as the possibility to use finned tubes for increased heat transfer, which makes the shell and tube heat economizer in many applications. A disadvantage of the shell-and-tube economizer is the risk of tube vibrations caused by the flow

Parallel flow: - A double pipe heat exchanger can be operated in parallel flow mode as shown in the diagram at the left. Similarly a shell and tube economizer can be operated in approximately parallel flow by having both fluids enter at one end and exit at the other end.

Counter flow: - Each of the three types of economizer (Parallel, Cross and Counter Flow) has advantages and disadvantages. But of the three, the counter flow economizer design is the most efficient when comparing heat transfer rate per unit surface area. The efficiency of a counter flow heat exchanger is due to the fact that the average (difference in temperature) between the two fluids over the length of the heat exchanger is maximized, a counter flow.

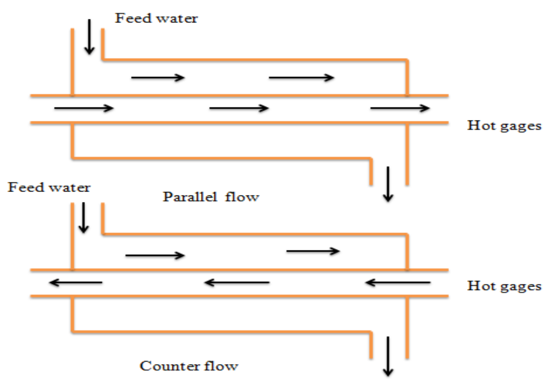

Fig 1**:** parallel and counter flow Economizer

4. DATA COLLECTION AND ANALYSIS

Your research methods may include the collection of information (data) which can be interpreted or analyzed to frame answers to your research questions or increase knowledge of your research topic. You can collect this information in a variety of ways (interviews, surveys, experiments, observations, critical appraisal of texts, literature or works of art or other) Different collection methods.

Data collection: Acquisition involves collecting or adding to the data holdings. There are several methods of acquiring data-

- Collecting new data.
- Using your own previously collected data.
- Reusing someone others data.
- acquired from Internet (texts, social media, photos)

Copper Tube Properties:

Modulus of elasticity, E=205,000 N/mm²

Shear modulus, G = E/[2(1 + ν)] N/mm², often taken as 76,000 N/mm²

Poisson's ratio, ν = 0.267

Density: = 8.8 kg/m^3

Coefficient of thermal expansion, α = 9x 10^{-6}/°C (in the ambient temperature range)

Steel Tube Properties:

Density: 7.8 kg/m^3

Modulus of elasticity, E = 210,000 N/mm²

Shear modulus, G = E/[2(1 + ν)] N/mm², often taken as 81,000 N/mm²

Poisson's ratio, ν = 0.3.

Coefficient of thermal expansion, α = 12 x 10^{-6}/°C (in the ambient temperature range).

Shell tube properties:

Density = 8.44kg/m^3

Melting point = 916^0c

Modulus of elasticity = 103.4Gpa

Thermal conductivity = 116w/mk

Thermal expansion = $20.5x10^{-6}/^0$c

Tensile strength = 300-550Mpa

Inlet tube side temp. $T_1 = 253^0$c

Outlet tube side temp. $T_2 = 185^0$c

Inlet shell side temp. $t_1 = 30^0$

Outlet shell side temp. $t_2 = 70^0$c

Area of shell side = $\pi(R- r)^2L$

= 1.161 m^2

Surface area of per tube = πdl

= 0.05 m^2

No of tube

N = Heat transfer area / surface area of per tube

1.161/ 0.050

= 23.22

N = approximate 24 tube

Specific heat (water)

$Q = m.Cp. (t_2 - t_1)$

Q = 3.27* 4.186* 40

Q = 643.34kw

Economizer efficiency

Location of economizer is somewhere between boiler and chimney and objective is to utilize flue gases heat which are generally released outside system through chimney.

$= ma (t_2 - t_1) / mf \times Cp (T_1 - T_2)$

= 44.62%

Boiler efficiency without economizer

$= \{m_s (h_s - h_w)/ (m_f * cv)\}100$

= 72.91%

Boiler efficiency with economizer

= $\{m_s (h_s - h_w)/ (m_f * cv)\}100$

= 73.46%

5. METHODOLOGY

Here the analysis is done using CREO parametric 2.0 software.

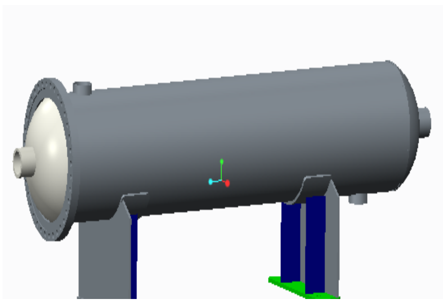

Fig 2: CAD model of Economizer

1. Geometrical modeling
2. Meshing
3. Material selection
4. Defining zones
5. Boundary conditions
6. Solution methods
7. Solution initialization
8. Plot results and contours

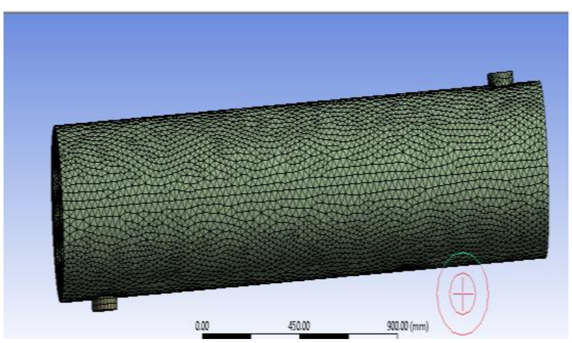

Fig 3:-Meshing

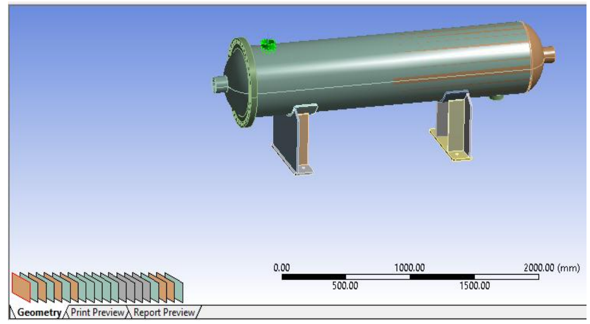

Fig 4:- Boundary conditions

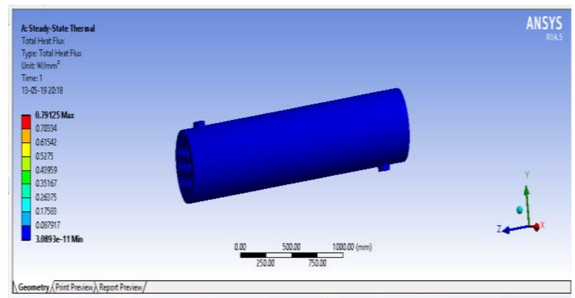

Fig 5:-heat flux

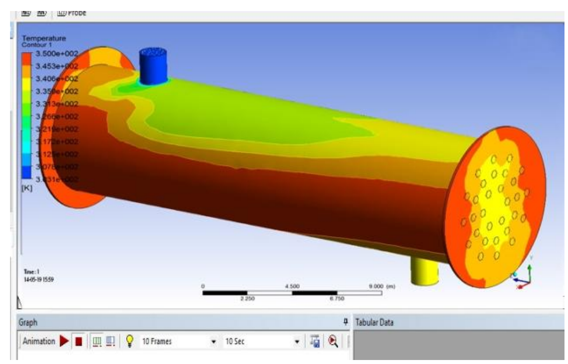

Fig 6: Flue gas temp

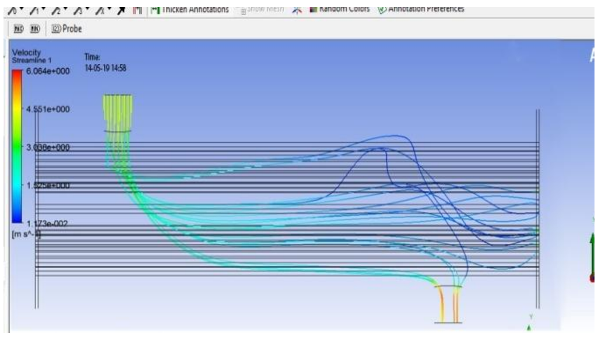

Fig 7: Water flow velocity

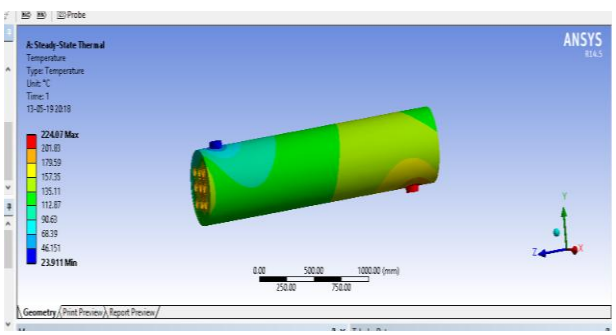

Fig 8: Temp. Losses of flue gasses

Table 1 Compression of steel tube and copper

S.no	**Steel tube**	
1.	Heat flux	0.79 W/mm2
2.	Heat losses of flue gas	(253-185) ^{0}c = 68^{0}c
	Copper tube	
1.	Heat flux	0.240w/mm2
2.	Heat losses of flue gas	(253-216)^{0}c = 37^{0}c

6. RESULT

Temperature distribution in the surface of the 3D computational domain and in the x-y planes along channel length directions. It can be clearly seen that the cold water enters the top channel with a uniform temperature of 30^{0} C and hot flue gas flow along the length of X- axis at 253^{0}

C. Hot gases temperature transfer to water and hot gas temperature are decrees and water temperature are increases 30^{0} C to 70^{0} C show in fig.

Table 2 Result

S.no.		**Inlet**	**Outlet**
1.	Water temperature	30^{0}c	70^{0}c
2.	Flue gas temperature	253^{0}c	185^{0}c

Table 3 Result

Boiler efficiency without economizer	72.91%
Boiler efficiency with economizer	73.46%
Economizer efficiency	44.62%

7. CONCLUSION

Heat exchangers are widely used in industries for heating large scale industrial processes. The type and size of economizer used can be tailored to suit a process depending on the type of fluid, its phase, temperature, density, viscosity, pressures, chemical composition and various other thermodynamic properties. Choosing the right economizer requires some knowledge of the different economizer types, as well as the environment in which the unit must operate. Typically in the manufacturing industry, several different types of economizer are used for just one process or system to derive the final product. With sufficient knowledge of economizer types and operating requirements, an appropriate selection can be made to optimize the process.

8. FUTURE SCOPE OF ECONOMIZER

- Boiler efficiency and losses should be calculated after installing economizer
- Number of tubes in hot gases should b optimized increases to save energy.
- Application of thermal simulation software could be the area of future studies so as to provide authentication to

the outcomes and search out for the possibilities by altering variables.

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