ANALYSIS OF INDUSTRIAL ECONOMIZER WITH DIFFERENT FIN SHAPES AND SPECIFICATIONS

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***Abstract*: An economizer is an accessory used with boiler to recycle or reuse the heat generated from boiler combustion and which improves the boiler efficiency. The hot outlet flue gases are reused to preheat boiler feed water. In present research the economizer is modelled and analyzed for its thermal performance. The software used is SolidWorks. Economizer is modeled with various fin shapes and changing radius. The aim is to improve heat transfer efficiency. Four different cases were taken and the CFD analysis is performed and results were obtained and compared for temperature flow trajectories-steam, temperature flow trajectories- flue gases, surface heat temp, velocity- steam, velocity- flue gases in this case.**

***Keywords*: Economizer, Thermal Performance, CFD, Steam / Flue Gases Inlet - Outlet Temperature, Steam / Flue Gases Inlet - Outlet Velocity.**

Introduction

Economizer is a device that is mechanically designed and is utilized to reduce and optimize energy consumption. It is installed with the aim to perform work such as preheating a fluid for boiler, power plant, heating, Refrigeration, ventilating, and air conditioning (HVAC). Economizers idea or say concept includes tubular heat transfer surfaces which act to preheat boiler feed water before it enters the steam drum. The energy is recovered from the flue gas before it is exhausted to the atmosphere. It increases overall boiler thermal efficiency.

In case of boiler system, economizer can be provided to utilize the flue gas heat for preheating the boiler feed water. Flue gases from boilers are typically in the range of 230 - 345°C depending upon boiler pressure. Stack Economizers recover some of this heat for pre-heating water. Economizers are available in a wide range of sizes, from small coil-like units to very large waste heat recovery boilers.

Literature Survey

Literature studied performed a survey of various researches performed regarding impacts of various baffles sorts on pressure loss and heat transfer in economizer. Various problems designed in research papers are considered while designing present problem with some different aspect.

A.N. Aziz et. al., This paper has presented a methodology for improving the performance of economizer temperature model using bond graph and genetic algorithm. The potentials of the proposed method to improve model performance are shown from simulation result compare to the designed data.

Adam Charchalis and Jerzy Krefft, Performed analyses of boilers for container ships show that the vast majority of these boilers produce steam with an operational pressure of 0.7MPaThe maximum value of efficiency and economizer power was set using the relations and approximation functions for low-speed two-stroke engines. The proper selection of a boiler to seagoing vessels in the preliminary design stage can lead to a reduction in the cost of construction and operation of the vessel, while maintaining the designed steam capacity of the boiler and a failure-free steam-water installation.

Ahmad Mahmoudi Lahijani and Eris E Supeni, In this paper, the effects of using economizer on efficiency of examined fire tube steam boiler are presented A MATLAB analysis with the comparison of different results is developed to evaluate the results produced by the live test. The results show the effect of using economizer for increase the feed water temperature and improving the efficiency of fire tube steam boiler.

Anees U et. al., This paper gives an account of the phenomenon of acid dew-point corrosion in power plants. It provides information about the cause(s) of corrosion, mechanism(s) involved and the ways to combat the problem. It is concluded that, the boiler economizer tubes failure could be attributed to the sulfuric acid dew point corrosion.

Gamze Karanfil Celep and Selmin Ener Rusen In the present work, the useful concept of energy utilization is analyzed and implemented to the steam boiler system. From the analysis results, it reveals that energy saving amount as natural gas is 21724,8 m3/year. Thus, applying of the condensing economizer in a profit of about 7760 $/year and a reduction of 27, 13 tons CO2 emission per year.

Igor Martić et. al., The primary aim of this study is to use waste thermal energy from EFG at 165˚C and lower its temperature to 120˚C before leaving to the atmosphere. Achieved heat power utilization is 120kW, due to plant is producing 209 kg/h less steam in boiler for degas at or needs. With ECO, overall efficiency of CHP plant is upgraded from currently 74.5% to 78%.

Kamlesh Dewangan et. al., A model of tube was developed and effect of erosion is investigated. An analysis of tube with different type velocity of fly ash, It have been carried out to reduce the erosive effect on water tube boiler with the help of CFD software we analyze and optimize the effect of erosion using data analyze by CFD , mass removing rate to different velocity of fly ash.

Marcin Trojan, and Mariusz Granda, The paper presents the boiler economizer mathematical model with distributed parameters, which can be used to simulate its operation. The developed mathematical model makes it possible to determine temperatures of the tube and working medium of the boiler economizer. The proposed mathematical model is suitable for modeling multi-pass boiler economizers and various flow systems.

Seonghyun Park and Janghoo Seo, This study analyzed the cooling-energy saving effects considering the EA-recirculation and supply-air (SA)-temperature conditions when direct and indirect air-side economizers were applied to a data center in Korea.

Tsung - Feng Wu, The failure analysis of the leakage of the economizer tube of the waste heat boiler in the energy factory is investigated in this study. The results show that although the material and mechanical properties of the failed tube, were inferior to those of the new one, most of them were still satisfactory to the criterion requirement.

Yong Sun et. al., This paper presents a practical approach to deciding the optimal renewal time for an economizer tubing system with consideration given to the failure rate of the tubing system, the repair cost, the renewal cost and the production loss.

Problem Formulation

The material properties are given in following table:

Table: Tube Material Details

Material:	Steel Stainless (ASTM F53 Grade –B)
Density:	7900.00 kg/m^3
Conductivity type:	Isotropic
Electrical conductivity:	Conductor
Path:	Solids Pre-Defined\Alloys
Specific heat:	500.0 J/(kg*K)
Thermal conductivity:	16.3000 W/(m*K)
Resistivity:	7.2000e-007 Ohm*m

Boundary Conditions

Table: Inlet Velocity 1 – Steam Inlet

Type	Inlet Velocity
Faces	Face<1>@LID1
Coordinate system	Face Coordinate System
Reference axis	X
Flow parameters	Flow vectors direction: Normal to face Velocity normal to face: 0.300 m/s Fully developed flow: No
Thermodynamic parameters	Temperature: 573.00 K
Turbulence parameters	Boundary layer parameters
Boundary layer type	Turbulent

Table: Inlet Velocity 2 – Flue Gases Inlet

Type	Inlet Velocity
Faces	Face<3>@LID2
Coordinate system	Face Coordinate System
Reference axis	X
Flow parameters	Flow vectors direction: Normal to face Velocity normal to face: 0.500 m/s Fully developed flow: No
Thermodynamic parameters	Temperature: 773.00 K
Turbulence parameters	Boundary layer parameters
Boundary layer type	Turbulent

Table: Initial Conditions

Thermodynamic parameters	Static Pressure: 101325.00 Pa Temperature: 293.20 K
Velocity parameters	Velocity vector Velocity in X direction: 0 m/s Velocity in Y direction: 0 m/s Velocity in Z direction: 0 m/s
Solid parameters	Default material: Steel Stainless 302 Initial solid temperature: 293.20 K

Geometry Details

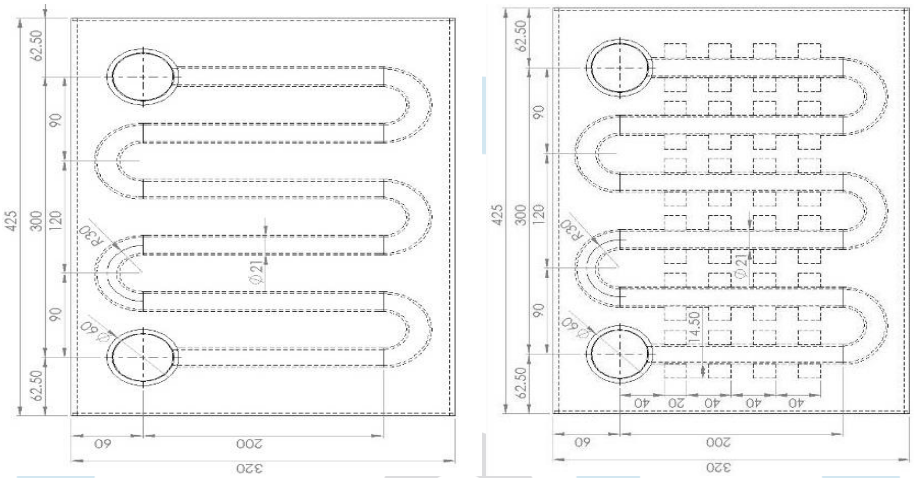


Figure: Plain Tube and Rectangular Tube Geometry

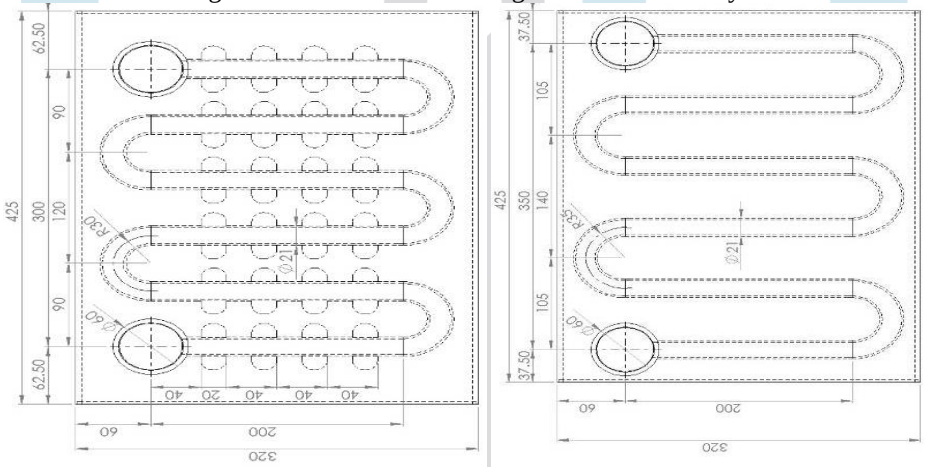


Figure: Circular Tube and Increased Radius Tube Geometry

Methodology

Methodology includes following steps:

- The research starts with survey of existing research performed by various researchers. All the cases theoretical and practical in existing researches are studies. It helps to understand the domain of the field.
- The problem then is to be identified from research survey. Case is generated as economizer specifications and variations in fins and radius of economizer tube. Next step is to create a model of economizer by considering all dimensions as per problem definition.
- CFD analysis type is required to select as analysis method. Meshing is one of the important phases prior to analysis using software's. Meshing type is required to be select while completing model generation.
- Thermal conductivity, velocity, inlet temperatures etc. are required to define as an input parameters for all considered problem models.
- Boundary conditions are required to define before performing or run CFD analysis. Once the analysis is run one can obtain results in the form of outlet parameters or variables.
- Temp. Flow trajectories- steam, temp. Flow trajectories- flue gases, surface heat temp, velocity- steam, velocity- flue gases are to be obtained as results for various cases considered.

Modeling and Analysis

All cases of economizer as per problem selected are modeled and analyzed in this section. The CFD analysis is performed to obtain Temp. Flow trajectories- steam, temp. Flow trajectories- flue gases, surface heat temp, velocity- steam, velocity- flue gases in this case.

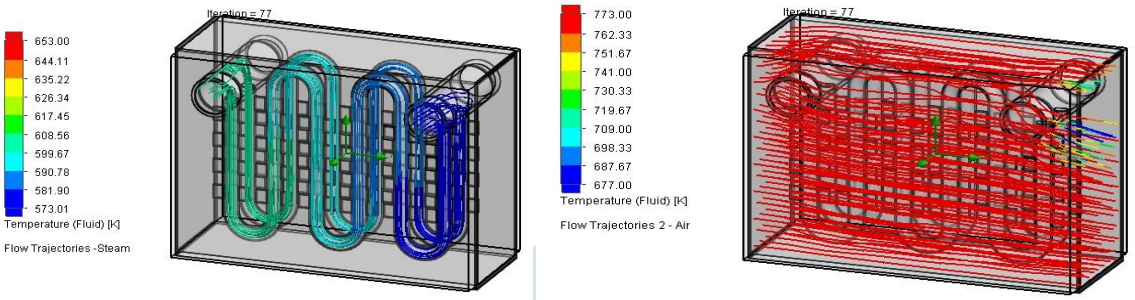


Figure: Temp. Flow Trajectories- Steam and Temp. Flow Trajectories- Flue Gases

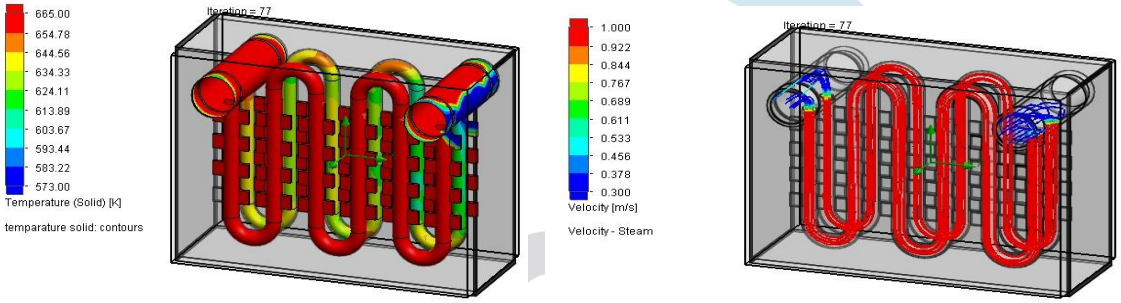


Figure: Surface Heat Temperature and Velocity - Steam

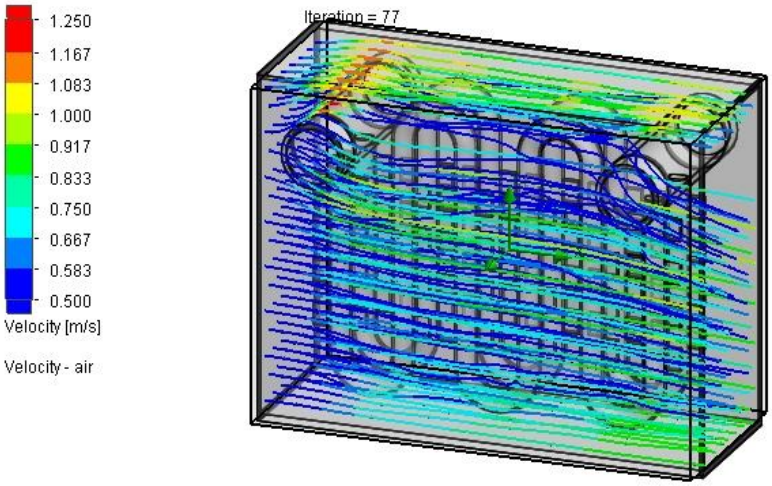


Figure: Velocity – Flue Gases

Results and Analysis

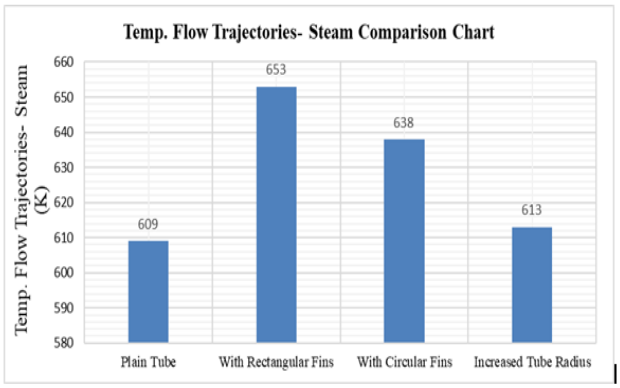
The results for all cases are tabulated in a single table and are supposed to be compared with each other.

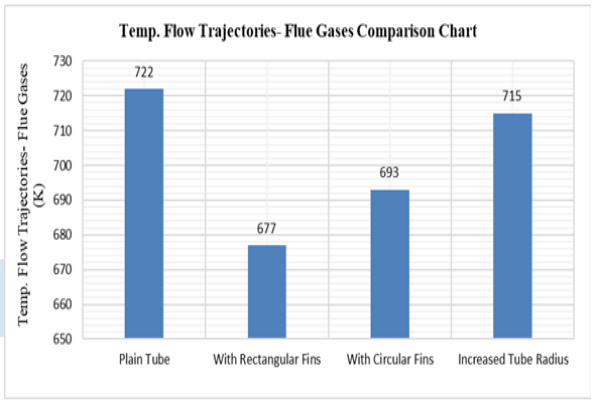
Table: Result Table

Sr. No.	Description	Temp. Flow Trajectories- Steam (K)	Temp. Flow Trajectories- flue cases (K)	Surface Heat Temp. (K)	Velocity- Steam (M/S)	Velocity- Flue Gases (M/S)
1	Plain Tube	609	722	620	0.9	1.2
2	With Rectangular Fins	653	677	665	1	1.25
3	With Circular Fins	638	693	653	0.95	1.22
4	Increased Tube Radius	613	715	628	0.7	1.1

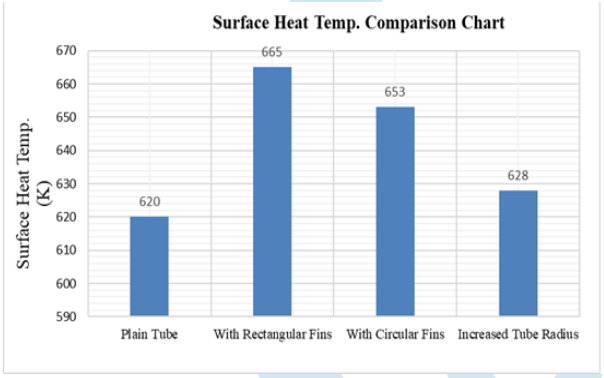
Comparison Graphs

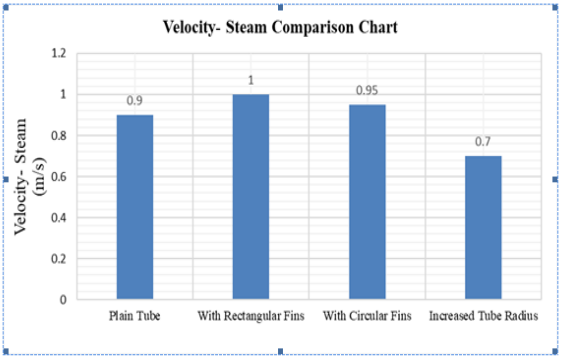
The comparison graphs are plotted for all values of outcomes for various cases considered.



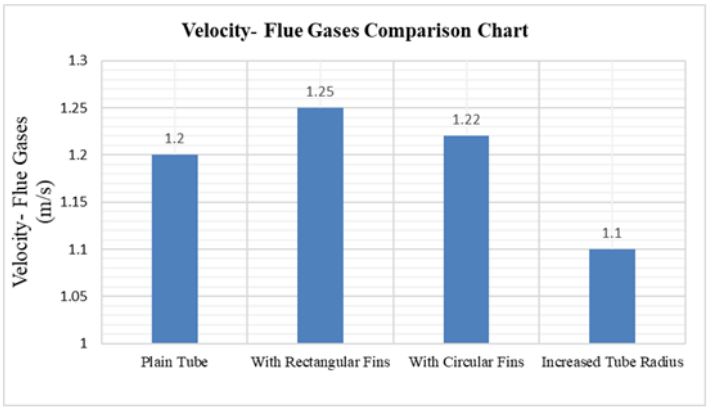


Temp. Flow Trajectories- Steam and Temp. Flow Trajectories- Flue Gases Comparison Chart





Surface Heat Temp. and Steam Comparison Chart



Velocity- Flue Gases Comparison Chart

Conclusion

1. It can be concluded that the rectangular fins possess maximum heat transfer rate which is desired for economizer system. Plain tube and increased tube radius cases were found with poorest result.
2. It can be concluded that the plain tube possesses minimum heat transfer rate which is undesired for economizer system. Rectangular fins case is found with maximum heat transfer rate.
3. Surface heat temperature is found maximum again in case of rectangular fin shape case, it is because surface area and friction with flue gases is maximum with rectangular shape which helps to increase steam temperature, which is highly desired.
4. It is concluded that the velocity of steam decreases with increased diameter of tube.
5. It is concluded that in this case the steam temperature is increased as compared to plain tube case; there is simultaneous decrease in velocity of steam. So, it is not a favorable case.
6. It is also concluded that the software is capable of performing research in the field of economizer and their analysis and hence performance improvement.

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