Indian J.Sci.Res. 17(2): 289 - 292, 2017
ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

THERMAL ANALYSIS OF TANGENTIAL FIRE TUBE BOILER ECONOMIZER

[1]Kothakapu Mahender Reddy , [2]Gurustal Somnath Swamy, [3]Amardeep.S.Nirnekar, [4]M Arun kumar
[1,2,3,4]Department of Mechanical Engineering, Aurora's Scientific, Technological and Research Academy, Telangana

Abstract -In this project Thermal analysis for different material done on economizer will determine convective heat transfer rates under different mass flow rates. Past investigations done by various researches found that there are chances of failure which takes place at the U-bends cross-section of the economizer tubes. The velocities at that different bends will varry which are maximum at lower bends compared to the higher bends. Economizers are used as accessories in the boiler which play Important role for improving the efficiency of boiler. In this project Thermal analysis done after feed water which is coming from the cooling pond is heated up to certain temperature by using exhaust gases coming out from the boiler, by this the heat addition in the boiler reduces slightly because raising feed water temperature in the economizer and that hot water is converted to streem.

keywords- Economizer, Firetube Boiler, CFD.

I.Introduction

Economizers are mechanical devices intended to reduce energy consumption, or to perform useful function such as preheating a fluid. The term economizer is used for other purposes as well. Boiler, power plant, heating, Refrigeration, ventilating, and air conditioning (HVAC) uses are discussed in this article. In simple terms, an economizer is a heat exchanger. In boilers, economizers are heat exchange devices that heat fluids, usually water, up to but not normally beyond the boilingpoint of that fluid. Economizers are so named because they can make use of the enthalpy in fluid streams that are hot, but not hot enough to be used in a boiler, thereby recovering more useful enthalpy and improving the boiler's efficiency. They are a device fitted to a boiler which saves energy by using the exhaust gases from the boiler to preheat the cold water used to fill it (the feed water).

The boiler room is a huge energy guzzler. It consists of thermal fluid boilers or steam boiler, with exhaust gases through a common chimney. An indirect contact or contact condensing economizer will recover the residual heat from the combustion products. A series of dampers, an efficient control system, as well as a ventilator, allow all or part of the combustion products to pass through the economizer, depending on the demand for make-up water and/or process water. The temperature of the gases can be lowered from 200 °C to 10 °C, while preheating the process water from 8 °C to 80 °C. On average over the years, boiler combustion efficiency has risen from 80% to more than 95%. The efficiency of heat produced is directly linked to boiler efficiency. The percentage of excess air and the temperature of the combustion products are two key variables in evaluating this efficiency.

The combustion of natural gas needs a certain quantity of air in order to be complete, so the burners need a flow of excess air in order to operate. Combustion produces water steam, and the quantity depends on the amount of natural gas burned. Also, the evaluation of the dew point depends on the excess air. Natural gas has different combustion efficiency curves linked to the temperature of the gases and the excess air. For example, if the gasesare chilled to 38 °C and there is 15% excess air, then the efficiency will be 94%, The condensing economizer can thus recover the sensible and latent heat in the steam condensate contained in the flue gases for the process. The economizer is made of an aluminium and stainless steel alloy.The gases pass through the cylinder and the water through the finned tubes. It condenses about 11% of the water contained in the gases.

II.Material Selection

1) 6061 Aluminium Alloy

It is a precipitation-hardened aluminum alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties, exhibits good weldability, and is very commonly extruded (second in popularity only to 6063). It is one of the most common alloys of aluminum for general-purpose use.

It is commonly available in pre-tempered grades such as 6061-O (annealed), tempered grades such as 6061-T6 (solutionized and artificially aged) and 6061-T651 (solutionized, stress-relieved stretched and artificially aged). Annealed 6061 (6061-O temper) has maximum tensile strength no more than 310 MPa (45,000 psi), and maximum yield strength no more than 55 MPa (8,000 psi).

[1]Corresponding Author

The material has elongation (stretch before ultimate failure) of 25–30%.

Aluminium 6061 material properties

Thermal conductivity of aluminum = 15.1W/mk

Specific heat =356J/Kg K

Density = 0.00000412 Kg/mm^3

2) 7075 Aluminium Alloy

It is an aluminium alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminium alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use.

7075 Aluminium alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are 7075-0, 7075-T6, 7075-T651.

The first 7075 was developed in secret by a Japanese company, Sumitomo Metal, in 1943.[1] 7075 was eventually used for airframe production in the Imperial Japanese Navy. Due to their high strength-to-density ratio 7000 series alloys such as 7075 are often used in transport applications, including marine, automotive and aviation. These same properties lead to its use in rock climbing equipment, bicycle components, inlineskating-frames and hang glider airframes are commonly made from 7075 aluminium alloy. Due to its high strength, low density, thermal properties, and its ability to be highly polished, 7075 is widely used in mold tool manufacturing.

7075 Aluminium alloy material properties

Thermal conductivity of aluminum = 130 W/mk

Specific heat =960 J/Kg K

Density =0.102 lb/in^2

3) Copper

It is a chemical element with symbol Cu

(from Latin: *cuprum*) and atomic number 29. It is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a reddish-orange color. Copper is used as a conductor of heat and electricity, as a building material, and as a constituent of various metal alloys, such as sterling silver used in jewelry, cupronickel used to make marine hardware and coins, and constantan used in strain gauges and thermocouples for temperature measurement. Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Other desirable properties of copper in heat exchangers include its corrosion resistance, biofouling resistance, maximum allowable stress and internal pressure, creep rupture strength, fatigue strength, hardness, thermal expansion, specific heat,antimicrobial properties, tensile strength, yield strength, high melting point, alloyability, ease of fabrication, and ease of joining.

The combination of these properties enable copper to be specified for heat exchangers in industrial facilities, HVAC systems, vehicular coolers and radiators, and as heat sinks to cool computers, disk drives, televisions, computer monitors, and other electronic equipment. Copper is also incorporated into the bottoms of high-quality cookware because the metal conducts heat quickly and distributes it evenly.

Copper material properties

Thermal conductivity of aluminum = 401 w/(m-k)

Specific heat = 380 J/(kg K)

Density = 8.96 g/cm^3

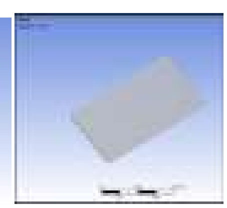
III. Experimental Procedure

Thermal Analysis with Aluminum 6061 Material, Thermal Analysis with Aluminum 7075 Material and Thermal Analysis with copper Material at different mass flow rates are done on Ansys software below given graphs and details are the procedure to finish the experiment

1) Thermal Analysis of Material

Open work bench 14.5>select steady state thermal in analysis systems>select geometry>right click on the geometry>import geometry>select IGES file>open

Fig1.Imported model Fig2. Meshed model



Boundary conditions

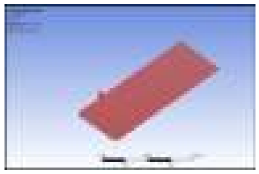
Select steady state thermal >right click>insert>

Select steady state thermal >right click>insert>select heat flux

Select steady state thermal >right click>solve

Solution>right click on solution>insert>select temperature

Fig3.Convection Fig4.Temperature

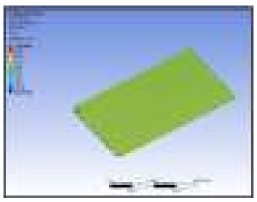


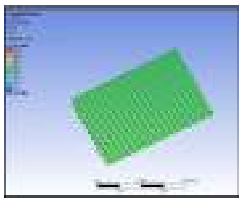
IV.Results

a) Aluminum 6061 Material

1) At Mass Flow Rate-100Kg/sec

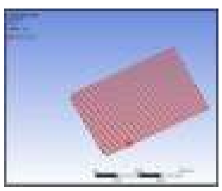
Fig5.Temperature Fig6. Heat flux





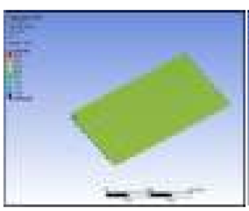
2) At Mass Flow Rate-90Kg/sec

Fig7.Temperature Fig8.Heat flux



3) At Mass Flow Rate-70Kg/sec

Fig9.Temperature Fig10.Heat flux

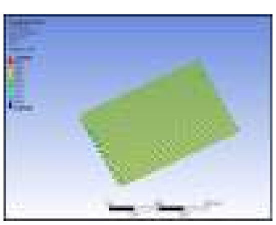


b) MATERIAL –ALUMINIUM 7075

1) At Mass Flow Rate-100Kg/sec

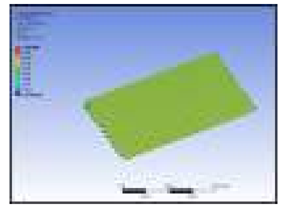
Thermal conductivity of aluminum = 59.1W/mK , Specific heat =421 J/Kg K ,Density = 0.00000771Kg/mm^3

Fig11.Heat flux



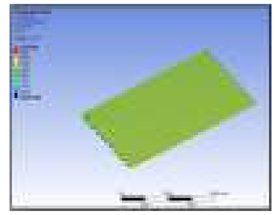
2) AT MASS FLOW RATE-90Kg/sec

F12.Heat flux



3) AT MASS FLOW RATE-70Kg/sec

Fig13.Heat flux



c) Thermal Analysis for copper:

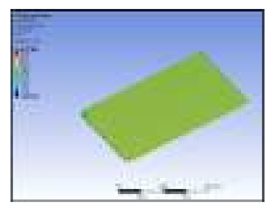
1) At Mass Flow Rate-100Kg/sec

Thermal conductivity of aluminum = 59.1W/mK

Specific heat =421 J/Kg K

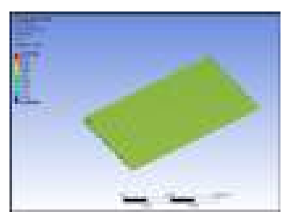
Density = 0.00000771Kg/mm^3

Fig14.Heat flux



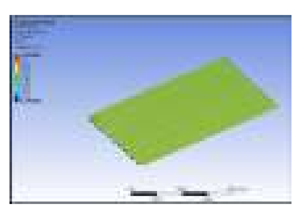
2) At Mass Flow Rate-90Kg/sec

Fig15.Heat flux



3) At Mass Flow Rate-90Kg/sec

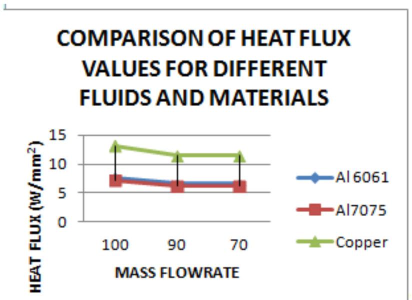
Fig16.Heat flux



Thermal analysis

Materials	Fluid	Convecti	Temperatu	Heat

	s	on (W/m^2 K)	re (°C)	flux (W/mm^2)
ALUMINIU M 6061	100	108	303.15	7.5558
	90	156	303.15	6.5842
	70	147	303.15	6.5831
ALUMINIU M 7075	100	108	303.15	7.2285
	90	156	303.15	6.2986
	70	147	303.15	6.2976
COPPER	100	108	303.15	13.137
	90	156	303.15	11.457
	70	147	303.15	11.454



V.Conclusion

In this thesis, a simulation of the economizer zone, which allows studying the flow patterns developed in the fluid, while it flows along the length of the economizer. The past failure details revels that erosion is more in U-bend areas of Economizer Unit because of increase in flue gas velocity near these bends..The materials considered for tubes are Copper and Aluminum alloys 6061 and 7075. The mass flow rates are varied will be 100,90 and 70. CFD analysis is done to determine temperature distribution and heat transfer rates by varying the mass flow rates . Heat transfer analysis is done on the economizer to evaluate the better material.By observing CFD analysis results, the heat transfer coefficient is more when 90 kg/sec is used and heat transfer rate is more when R22 is used than other fluids. By observing thermal analysis results, the heat flux is more when 100 kg/sec is used and when material Copper is used. (i.e) The heat transfer rate is more when fluid 100 kg/sec and material Copper is used.

References

[1] Krunal P. Mudafale & Hemant S. Farkade CFD analysis of economizer in a tengential fired boiler, International Journal of Mechanical and Industrial Engineering (IJMIE) ISSN No. 2231–6477, Vol-2, Iss-4, 2012.

[2] A.D.Patil, P.R.Baviskar, M.J.Sable, S.B.Barve to optimize economizer design for betterperformance, New aspects of fluid mechanics, heat transfer and environment isbn: 978-960- 474-215-8.

[3] A.D.Patil, P.R.Baviskar, M.J.Sable, S.B.Barve Optimization of Economiser Design for theEnhancement of Heat Transfer Coefficient, International Journal of Applied Research InMechanical Engineering (IJARME), ISSN: 2231 –5950 Volume-1, Issue-2, 2011.

[4] TSUNG-FENG WU Failure Analysis for the Economizer Tube of the Waste Heat Boiler.

[5] Deendayal Yadav, Dr. G. V. Parishwad, P. R. Dhamangaonkar*, Dr. S. R. Kajale, Dr. M. R.Nandgaonkar, Dr. S. N. Sapali Effect of Arresters on Erosion in Economizer Zone and itsAnalysis, AMAE Int. J. on Production and Industrial Engineering, Vol. 01, No. 01, Dec 2010.

[6] Temperature Model of Economizer Using Bond Graph and Genetic Algorithm, Internationa lJournal of Engineering & Technology IJET-IJENS Vol: 12 No: 01.

[7] N.S. Venkatesh Kumar and Prof. K. Hema Chandra Reddy, "CFD Analysis of Wind DrivenNatural Cross Ventilation for a Generic Isolated Building", International Journal of MechanicalEngineering & Technology (IJMET), Volume 4, Issue 5, 2013, pp. 200 - 207, ISSN Print: 0976 –6340, ISSN Online: 0976 – 6359.

[8] Sanjay Kumar Patel and Dr. A.C. Tiwari, "Performance Analysis of Supercritical Boiler",International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 2,2012, pp. 422 - 430, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.