# ALUMINIUM ALLOYS 6061 AND 7075 ARE USED IN 3D MODELLING AND THERMA ANALYSIS OF THE ECONOMIZER IN FIRED BOILERS

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## ABSTRACT

*Economizers are heat exchange devices that are often found in boilers. These devices heat fluids, most commonly water, up to but typically not beyond the temperature at which that fluid would boil. Economizers are given their name due to the fact that they are able to make use of the enthalpy in fluid streams that are hot, but not hot enough to be utilised in a boiler. As a result, they are able to recover more useable enthalpy and improve the efficiency of the boiler. A simulation of the economizer zone is presented in this research. This simulation makes it possible to investigate the flow patterns formed in the fluid as the fluid moves down the length of the economizer. The facts of previous failures reveal that U-bend sections of the Economizer Unit are more susceptible to erosion as a result of an increase in the velocity of flue gas near these bends. However, it has been shown that, unexpectedly, the velocity of the flue gases rises at the lower bends in comparison to the ones that are higher up. The purpose of this thesis is to investigate, using CFD and thermal analysis, how heat is transferred by convection in an economizer while the mass flow rates fluctuate. Copper and aluminium alloys, namely 6061 and 7075, are being evaluated for use in tube construction. The three different mass flow rates that are going to be used are going to be 100, 90, and 70 kg/second. By altering the mass flow rates, a CFD study may be carried out to establish the distribution of temperatures and the rates of heat transfer. In order to determine which material is superior, a heat transfer study is performed on the economizer. CATIA is used for the 3D modelling, while ANSYS is used for the analysis.*

*CFD analysis, economizer, burned boiler, aluminium alloy 6061, and aluminium alloy 7075 are some of the keywords that might be used here.*
*o*

## 1. INTRODUCTION

### 1.1. fire-tube boiler

Sectioned fire-tube boiler from a DRB Class 50 locomotive. Hot flue gases created in the firebox (on the left) pass through the tubes in the centre cylindrical section, which is filled with water, to the smokebox and out of the chimney (stack) at far right. The steam collects along the top of the boiler and in the steam dome roughly halfway along the top, where it then flows into the large pipe seen running forward. It is then divided into each side and runs downward in the steam chest (at the rear of the smoke box), where it is then admitted into the cylinders by means of valves. A fire-tube boiler is a type of boiler in which hot gases from a fire pass through one or (many) more tubes running through a sealed container of water. The heat of the gases is transferred through the walls of the tubes by thermal conduction, heating the water and ultimately creating steam. The fire-tube boiler developed as the third of the four major historical types of boilers: low-pressure tank or "haystack" boilers, flued boilers with one or two large flues, fire-tube boilers with many small tubes, and high-pressure water-tube boilers. Their advantage over flued boilers with a single large flue is that the many small tubes offer far greater heating surface area for the same overall boiler volume. The general construction is as a tank of water penetrated by tubes that carry the hot flue gases from the fire. The tank is usually cylindrical for the most part—being the strongest practical shape for a pressurized container and this cylindrical tank may be either horizontal or vertical. 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 gases are chilled to 38°C and there is 15% excess air, then the efficiency will be 94%. The condensing conomizer 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 aluminum 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.

**Economizer setups in refrigeration:** Several displays permit the refrigeration cycle to work as economizers, and benefit from this idea. The design of this kind of systems demands certain expertise on the matter, and the manufacture of some of the gear, particular finesse and durability. Pressure drop, electric valve controlling and oil drag, must all be attended with special caution.

**Two Staged System:** Two staged systems may need to double the pressure handlers installed in the cycle. The diagram displays two different thermal expansion valves (TXV) and two separate stages of gas compression.

**Two staged systems and boosters:** A system is said to be in a two staged set up if two separate gas compressors in serial display work together to produce the compression. A normal booster installation is a two staged system that receives fluid that cools down the discharge of the first compressor, before arriving to the second compressor's input. The fluid that arrives to the interstage of both compressors comes from the liquid line and is normally controlled by expansion, pressure and solenoid valves.

## 2. MODELING AND ANALYSIS

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. Engineering drawing entails the use of graphical symbols such as points, lines, curves, planes and shapes. Essentially, it gives detailed description about any component in a graphical form.

**Background:** Engineering drawings have been in use for more than 2000 years. However, the use of orthographic projections was formally introduced b y the French mathematician Gaspard Monge in the eighteenth century. Since visual objects transcend languages, engineering drawings have evolved and become popular over the years. While earlier engineering drawings were handmade, studies have shown that engineering designs are quite complicated. A solution to many engineering problems requires a combination of organization, analysis, problem solving principles and a graphical representation of the problem. Objects in engineering are represented by a technical drawing (also called as drafting) that represents designs and specifications of the physical object and data relationships. Since a technical drawing is precise and communicates all information of the object clearly, it has to be precise. This is where CAD comes to the fore. CATIA is an acronym for Computer Aided Three-dimensional Interactive Application. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

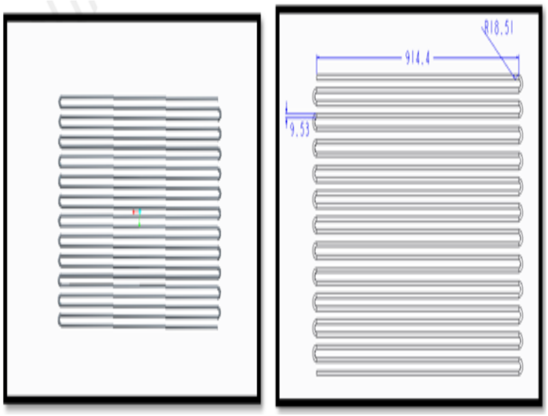


**Fig. 1: 3D Model (left). 2D Drafting (right).**

CATIA is a multi platform 3D software suite developed by Dassault Systems, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modeling tool that unites the 3D parametric features with 2D tools and also addresses every design-to- manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi- directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

**3. CFD ANALYSIS FOR ECONOMIZER**

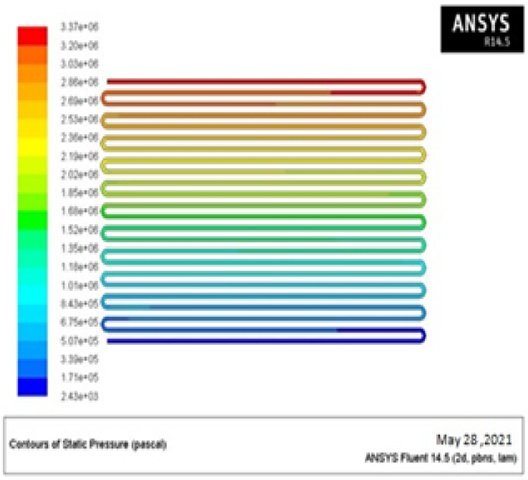


**Fig. 2: Contours of Static Pressure.**

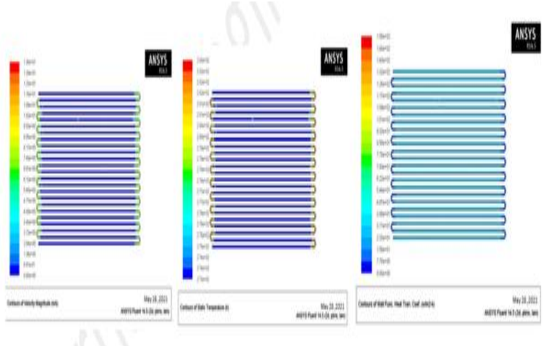

Fig. 3: Contours of Velocity Magnitude (left). Static Temperature (center). Wall Function Heat Transfer Coefficient (right).

**5.THERMAL ANALYSIS OF ECONOMIZER**

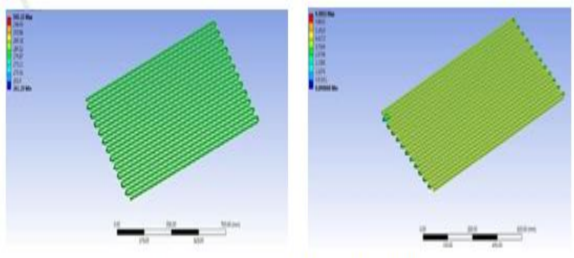

**Fig. 4: Temperature (left) Heat flux (right)**

## RESULTS AND DISCUSSION CFD ANALYSIS

| Mass flow rate (Kg/sec) | Pressure (Pa) | Te | Velocity (m/Sec) | Heat transfer coefficient (W/m$^2$-K) | Mass flow rate (Kg/Sec) | Total heat transfer rate (W) |
|---|---|---|---|---|---|---|
| | 3.12e+06 | 2.80e+02 | 1.26 e+01 | 1.08e+02 | -0.0278429 | 855.549 |
| | 3.37e+06 | 2.83e+02 | 1.36 e+01 | 1.56e+02 | 0.013374329 | -181.78711 |
| | 1.52e+06 | 2.83e+02 | 1.47 e+01 | 1.47e+02 | -0.0142 3645 | -48.704102 |

## THERMAL ANALYSIS

| Materials | Fluids | Convection (W/m2 K) | Temperature (°C) | Heat flux (W/mm2) |
|---|---|---|---|---|
| | 100 | 108 | 303.15 | 7.5558 |
| | 90 | 156 | 303.15 | 6.5842 |
| ALUMINIUM 6061 | 70 | 147 | 303.15 | 6.5831 |
| | 100 | 108 | 303.15 | 7.2285 |
| | 90 | 156 | 303.15 | 6.2986 |
| ALUMINIUM 7075 | 70 | Journal of E nginee 1ring S ciences 47 | 303.15 | 6.2976 |
| | 100 | 108 | 303.15 | 13.137 |
| COPPER | 90 | 156 | 303.15 | 11.457 |
| | 70 | 147 | 303.15 | 11.454 |

## 6. CONCLUSION

In this project, 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 resolve 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.

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