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3D MODELLING AND THERMO ANALYSIS OF THE BOILER'S OPTIMIZER IN FIRED BOILERS USE ALUMINIUM ALLOYS 7075 AND 6061.

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ABSTRACT

Heat exchangers called economizers are often seen in boilers. These apparatuses warm substances, most often water, to a temperature that normally does not get beyond boiling. The ability to employ the enthalpy in hot fluid streams—streams that aren't hot enough to be used in a boiler—is what gives economizers their name. They are able to recover more usable enthalpy as a consequence, increasing the boiler's efficiency. In this study, an economizer zone simulation is provided. Examining the fluid's flow patterns as it travels down the economizer's length is made feasible by this simulation. The Economizer Unit's U-bend portions are more prone to erosion due to an increase in flue gas velocity at these bends, as shown by the facts of past failures. It has been shown, nonetheless, that the flue gases' velocity unexpectedly increases at the lower bends compared to the bends higher up. This thesis looks at how heat is transmitted by convection in an economizer when mass flow rates change, utilising CFD and thermal analysis. Alloys 6061 and 7075 made of copper and aluminium are being considered for use in tube production. There are three distinct mass flow rates that will be utilised: 70, 90, and 100 kg/second. A CFD analysis may be performed to determine the rates of heat transfer and temperature distribution by varying the mass flow rates. A heat transfer research is done on the economizer to find out which material is better. ANSYS is utilised for analysis, while CATIA is used for 3D modelling.

Among the terms that might be employed here are CFD analysis, economizer, burnt boiler, aluminium alloy 6061, and aluminium alloy 7075.

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.

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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 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 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.

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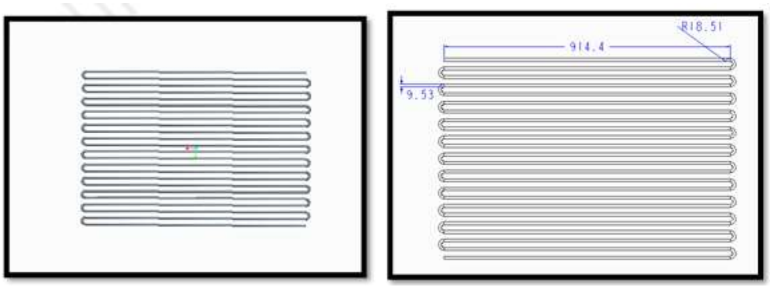

Fig. 1: 3D Model (left). 2D Drafting (right).

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

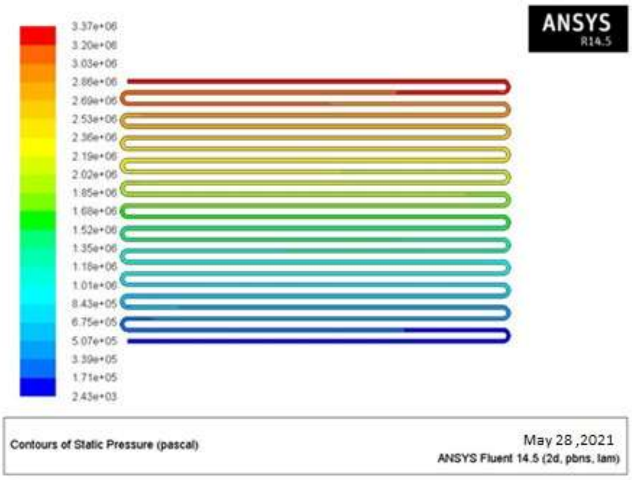

Fig. 2: Contours of Static Pressure.

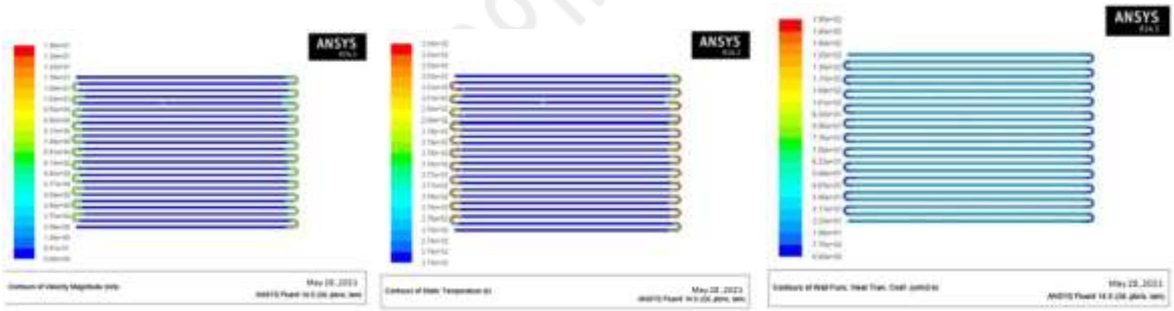

Fig. 3: Contours of Velocity Magnitude (left). Static Temperature (center). Wall Function Heat Transfer Coefficient (right).

5.THERMAL ANALYSIS OF ECONOMIZER

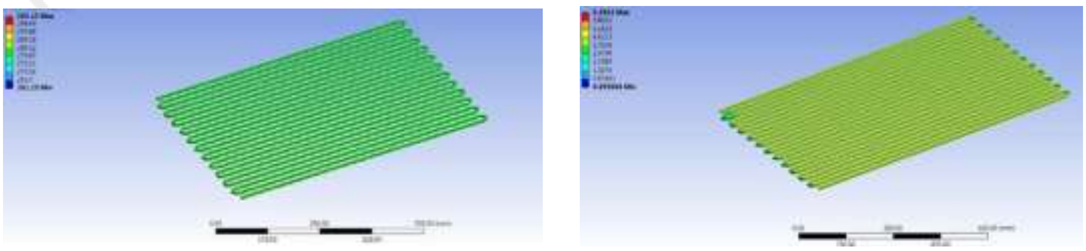

Fig. 4: Temperature (left) Heat flux (right)

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6. RESULTS AND DISCUSSION

CFD ANALYSIS

Mass flow rate (Kg/sec)	Pressure (Pa)	Temperature (K)	Velocity (m/Sec)	Heat transfer coefficient (W/m^2-K)	Mass flow rate (Kg/Sec)	Total heat transfer rate (W)
100	$3.12e^{+06}$	$2.80e^{+02}$	$1.26e^{+01}$	$1.08e^{+02}$	-0.0278429	855.549
90	$3.37e^{+06}$	$2.83e^{+02}$	$1.36e^{+01}$	$1.56e^{+02}$	0.013374329	-181.78711
70	$1.52e^{+06}$	$2.83e^{+02}$	$1.47e^{+01}$	$1.47e^{+02}$	-0.01423645	-48.704102

THERMAL ANALYSIS

Materials	**Fluids**	**Convection (W/m^2 K)**	**Temperature (°C)**	**Heat flux (W/mm^2)**
ALUMINIUM 6061	100	108	303.15	7.5558
	90	156	303.15	6.5842
	70	147	303.15	6.5831
ALUMINIUM 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

7. CONCLUSION

This project includes an economizer zone simulation that makes it possible to see the fluid's flow patterns as they evolve across the economizer's length. The historical failure data clarifies that erosion is greater in the economizer unit's U-bend regions due to an increase in flue gas velocity close to these bends. The alloys 6061 and 7075 of copper and aluminium are taken into consideration for tubes. There will be three different mass flow rates: 100, 90, and 70. By altering the mass flow rates, CFD analysis is used to calculate temperature distribution and heat transfer rates. In order to assess whether material is superior, heat transfer study is performed on the economizer. Based on the findings of the CFD simulation, using R22 over other fluids resulted in a higher heat transfer rate and a higher heat transfer coefficient of 90 kg/sec. The heat flux is greater when fluid is utilised at a speed of 100 kg/sec and material Copper is used, meaning that the heat transfer rate is higher when these conditions are met, according to the thermal analysis findings.

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