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DESIGN AND ANALYSIS OF HEAT EXCHANGER FOR CONVENTIONAL STOVE

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ABSTRACT:*In today's world, Roadside hotels are prevalent in India. A Report from Lodging stated "Hotels Must Cut Carbon 90 Per cent to Meet Climate Threshold". In order to burn wood, saw dust, charcoal, etc., effectively and also to reduce the heating of surroundings, the heat wasted into the atmosphere through the flue gases are reused. This is achieved by a heat exchanger biased on fire tube boiler. Though the steam is not generated, it helps us to heat the water. The setup consists of copper tubes immersed in a water bath held within the shell of Polyvinyl Chloride with an inlet and an outlet. The flue gases which are normally released through the chimney is allowed to be passed through the copper tubes which are surrounded by the water jacket. The waste heat from the flue gas gets converted to the inner surface of the copper tubes due to temperature difference. The thermal equilibrium occurs between the copper and the flue gas. At the same time, the difference in temperature of the cold water and the copper tubes results in further heat transfer at the solid-fluid interface. This raises the water temperature. The hot water thus generated can be used for domestic purposes like washing, cooking, etc. Main advantage of adding the heat exchanger is to preserve the surroundings and to prevent global warming.*

KEYWORDS: *eco-improvement, reuse, flue gas, convection.*

1.INTRODUCTION

Traditional ovens can trace their roots as far back as 3200 B.C., when members of the Indus civilization invented a cooking method to form breads from their wheat harvest. Since then, ovens have been present throughout evolving societies and civilizations, becoming more advanced, more reliable cooking devices. The conventional oven, inspired by the traditional oven, was created in the early 1900s as a way to better consolidate the energy used by stoves and traditional ovens.

In ancient days, ancestors used wood as a source of heat in an open hearth.Before cook stoves came into existence, fireplaces were commonly used. A cook knew how to prepare the fire for a day of planned cooking. The cook would rise early in order to start the fire for the day's cooking. Dry Hardwoods were the best for fuel.

"The two essential properties of the best cooking woods are that they generate an even, intense heat and that they produce a good supply of red hot coals as combustion proceeds."

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2. METHODOLOGY

A Heat Exchanger is designed to absorb the maximum amount of heat released from the process of combustion. Heat transfer within Exchanger is accomplished by three methods: radiation, convection, and conduction. The heating surface in the furnace area receives heat primarily by radiation. The remaining heating surface in the steam boiler receives heat by convection from the hot flue gases. Heat received by the heating surface travels through the metal by conduction Heat is then transferred from the metal to the water by convection. The relative percentage of each heat transfer within steam boiler is dependent on the type of steam boiler, the designed transfer surface, and fuels.

It is also based on the principle zeroth law of Thermodynamics. The heat is carried to the water from the flue gas through the copper tubes. Initially, Wood, saw dust or charcoal is fed on the grate surface with uniform layer of fuel material. The atmospheric air is admitted below the grate surface. When the fuel is ignited manually, the combustion of fuel takes place in the combustion chamber automatically. The smoke is generated from the burning of fuel. As the fuel burns, natural drought is created allowing a continuous flow of atmospheric gas. The flue gas, thus generated contains maximum amount of heat energy, which can be utilized for future purposes. The gas is circulated through the copper tubes which are immersed in a water bath. By continuous flow of hot flue gas through the copper tubes, heat is convicted to the fluid (Water). Due to density variation of the water, hot water moves to the top surface and the cold water is at the bottom surface. This process continues until the water gets heated and the temperature reaches a steady state. The thermal equilibrium occurs in the solid-fluid-solid interface. It is an eco-friendly unit to cope up the need of small bakery, tea-stall and mini hotels for various purposes.

3. CRITERIA FOR SELECTION

Heat exchangers represent the most widely used vehicle for heat transfer in process applications. They frequently are selected for duties such as:

- Process liquid or gas cooling.
- Process or refrigerant vapour or steam condensing.
- Process liquid, steam or refrigerant evaporation.
- Process heat removal and preheating of feed water.
- Thermal energy conservation efforts and heat recovery.

4. DESIGN OF HEAT EXCHANGER

The heat exchangers generally have the flue gases pass through the tubes surrounded by water jacket. The efficiency of the stove can be increased by means of diameter of the tubes and the thickness of the tube as well as the film thickness of the contact surface related to the flow medium such as liquid and gas. The efficiency of the flow medium can be controlled by circulating the fluids by means of gravity feed. The flue gas supplied from the bottom of the combustion chamber to top of the chimney. By recirculating the partial amount of flue gas to the grate surface is used to eliminate the moisture content in the wood or fuel. The stove is designed to maximize the heat energy utilization and minimize the production cost for heat generation.

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The bottom side of the vessel is provided with cast iron grate surface with natural draught air flow system. The stove has a number of having a number of baffles for the circulation of flue gas with uniform velocity and pressure of the gas. The top surface is covered by steel plate of size ranging from 3mm to 6mm. This assembly is known as heat generating unit. A separate unit of heat exchanger is specially designed to cope up with the heat generation unit. The drum is filled with water. The drum has an inlet and an outlet opening for filling and collecting water. A system of copper tubes is immersed in the water. The flow of gases is allowed to be counter flow to maximize the heat efficiency.

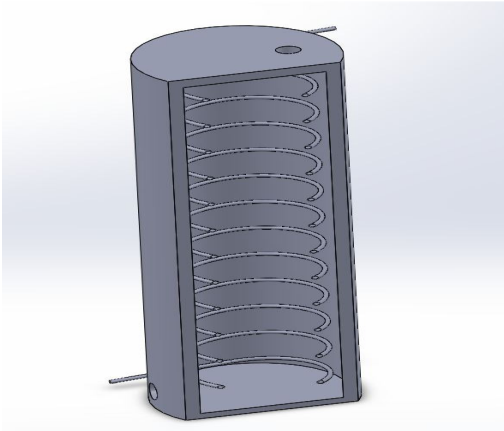
5. ASSUMPTIONS

- ✓ Minor losses are neglected.
- ✓ Circulation pressure and temperature of fluid are not considered.
- ✓ Heat carried away by the flue gases through the chimney are not taken into account.

6. 3D MODELING

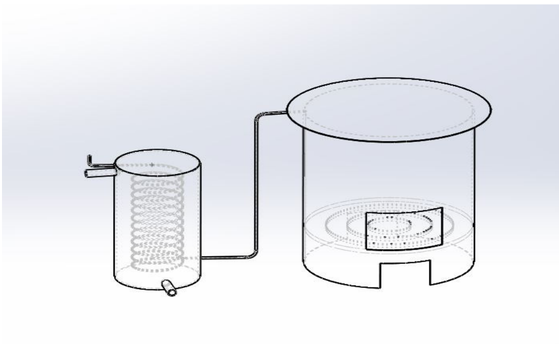
The essential difference between the SOLIDWORKS and traditional CAD systems is that models created in SOLIDWORKS exists as three dimensional solids. Others 3D modelers represent only the surface boundaries of the model. SOLIDWORKS models the complete solid and is user friendly. This not only facilities the creation of realistic geometry, but also allows for accurate model calculations, such as those for CFX and FLUENT.

7. PARAMETRIC DESIGN



HEATEXCHANGER

Dimensions such as angle, distance and diameter control SOLIDWORKS model geometry. It can create relationships that allow parameters to be automatically calculated based on the value of other parameters. When it modifies the dimensions, the entire model geometry can update according to the relations created.



STOVE ASSEMBLY

8. FEATURE BASED MODELING

Create models on SOLIDWORKS by building features. These facilities have intelligence, in that they contain knowledge of their environment and adapt predictably to change. Each feature asks for user to specific information based on the feature type.

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9. ASSOCIATIVITY

SOLIDWORKS is a fully associative system. This means that as and when change in the design model is made, it automatically propagates the design details including assemblies, drawings and manufacturing data. Associativity makes concurrent engineering possible by encouraging change, without penalty, at any point in the development cycle. This enables downstream functions to contribute their knowledge and expertise early in the development cycle.

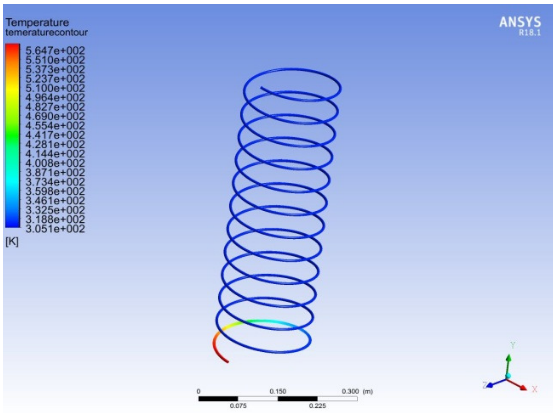
10. COMPATIBILITY

SOLIDWORKS is a user friendly system with most compatibility and also reduces complexity of the design. It guides the designer to check and alter a design much easier than any other design software. It also has the auto-detect function in case of missing constraints. It reduces NURBS surfaces comparatively and so, the compatibility of the design is high.

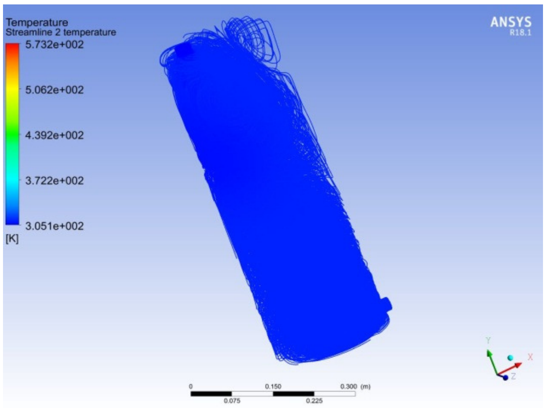
11. RESULTS AND ANALYSIS

The experiment and simulation studies are carried out in the heat exchanger by the help of ANSYS CFX. The various parameters such as continuous fluid properties, heat transfer and mass and velocity properties were studied with the help of k-epsilon, convective coefficient and the speed of flow in the experimental work. The effects of different input variables on output variable are discussed in detail in the following report:

Region	Temperature	Pressure
Inlet flue gas	5.732e+02 [K]	1.240e+01 [Pa]
Outlet flue gas	3.423e+02 [K]	1.142e-03 [Pa]
Copper	3.422e+02 [K]	undefined
Inlet Water	3.051e+02 [K]	2.670e-01 [Pa]
Outlet Water	3.424e+02 [K]	3.950e-02 [Pa]



Temperature Contour (Copper Tubes)



Temperature Contour (Water)

Output Table

12. CONCLUSION

The Computational Fluid Analysis is carried out in the simulation software 'ANSYS 18.1'. The model has been created in 'SOLIDWORKS' software and the three stages of simulation such as pre-processing, processing and post- processing are carried out.

For this study the several tests in ANSYS CFX were conducted. The convection of heat in the CFX Analysis is higher than the heat convected by conventional experimental method. The performance of material based on the properties of the material selected as solid interface. The interactions between the Fluid-Air-Fluid interfaces result in convection at a co-efficient of .045 W m^-2 K^-1 and the temperature of 300°Cat inlet was convected to a temperature of 69°C with water at 32°C attaining steady state.

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