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Thermal analysis on heat exchanger tubes with varying various materials

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Abstract:

In this paper, a simplified model for the study of thermal analysis of shell-and tubes heat exchangers.this can be designed for high pressures relative to environment and high-pressure differences between the fluids One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two tubes. The set of tubes is called a tube bundle.

An attempt is made in this paper is for the Design of shell and tube heat exchangers by modelling in CATIA V5 by taking the proper dimensions and Shell material as zirconium, alloys steel. Tube material as copper alloy Cu 65.0, nickel alloys. This material is good corrosion resistance and good thermal behaviour. By using ANSYS software the thermal analysis of Shell and Tube heat exchangers is carried out by varying the Tube materials. Comparison is made between the results, ANSYS. With the help of the available numerical results, Analysis has been carried out for this material and on the basis of results made which one give the best heat transfer rates. The model design of Shell vessel and Tube heat exchangers can be altered for better efficiency with the help of catia.

Keywords: heat exchanger tubes, shell, zirconium, copper, thermal analysis, ANSYS.

1. INTRODUCTION:-

HX is one of the major components common in a wide variety of thermal energy handling processes, such as conversion, transport, consumption and storage. Improvement of HX performance affects both directly and indirectly the performance of various devices and systems.

Especially in the aerospace industries, these environmental issues and airlines require gas turbine manufacturers to produce environmentally friendly gas-turbine engines with lower emissions and improved specific fuel consumption. These requirements can be met by incorporating HX into gas turbines for intercooling and recuperation.

In order to satisfy this goal, the next-generation aero-engine should adopt a regeneration system with HX that compact and ultra light weight, high effectiveness, minimum pressure loss to maintain performance benefit, very high pressure & temperature capability, structural integrity to cope with large temperature difference, and low cost are required. Hence, the object of this work is an optimal design and a performance analysis of high-performance HX used in a high temperature and high pressure system.

1.1 HEAT TRANSFER

The flow of the heat is all-pervasive. It is active to some degree or another in everything. Heat flows constantly from our bloodstream to the air around us. Such processes go on in all plant, animal life and in the air around us. They occur throughout the earth, which is hot at its core and cooled around its surface.

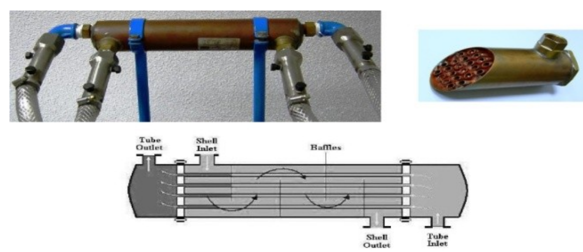
- Heat transfer describes the exchange of thermal energy, between physical systems depending on the temperature and pressure, by dissipating heat.
- The exchange of kinetic energy of particles through the boundary between two systems which are at different temperatures from each other or from their surroundings. Heat transfer always occurs from a region of high temperature to another region of lower temperature.
- Heat transfer changes the internal energy of both systems involved according to the First Law of Thermodynamics. The Second Law of Thermodynamics defines the concept of thermodynamic entropy, by measurable heat transfer.
- Thermal equilibrium is reached when all involved bodies and the surroundings reach the same temperature. Thermal expansion is the tendency of matter to change in volume in response to a change in temperature.

The science of thermodynamics deals with the quantitative transitions and rearrangements of energy as heat in bodies of matter. Heat transfer is the science that deals with the rate of exchange of heat between hot and cold bodies called the source and receiver. When one kg of water is vaporized or condensed, the energy change in either process in identical However, the rates at which either process proceeds is different, vaporization being much more rapid than condensation.

1.2 SHELL-AND-TUBE HEAT EXCHANGERS

The shell-and-tube heat exchanger (STHE) is the most common type of heat exchanger. It originated from the jacketed-coil distiller, and is used in heavy industries (steam condensers, boilers), and residential hot-water and heating systems (fire-tube water heaters). Several details of STHEs are presented in Fig. 2.3.

As can be seen in Fig. 3, each fluid can flow along several passes. In the tube-side, every set of tubes that the fluid travels through, before it makes a turn, is considered a pass. In the shell-side, a pass accounts for each main flow direction change. A standard code of practice in heat exchanger design and operation is that of TEMA (Tubular Exchangers Manufacturers Association). Other important source of standards are ASME (American Society of Mechanical Engineers; Boiler and Pressure Vessel Code), and, for heating and cooling loads, ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers).



1.3 USES OF HEAT EXCHANGERS

1. **HVACR { Heating- Ventilation- Air Conditioning- Refrigeration}**

Heat transfer is one of the most important industrial processes. Throughout any industrial facility, heat must be efficiently added, removed or moved from one process stream to another. In massive organizations human comfort is the big thing to tackle with in order to obtain maximumoutput from their employees. For employee's comfort all industries no matter whether it's small or big, install HVACR

Typical Applications are:-

- Community heating
- District heating
- Geothermal heating
- Solar heating
- Steam heating
- Swimming pool heating
- Tap water heating
- Condenser protection
- District cooling
- Free cooling
- Glycol saving
- Pressure breaker
- Thermal storage

Chapter-2:

THERMAL DESIGN DATA (PROVIDED BY B.H.E.L)

Heat duty = 65000 *kcal/hr (Input data)*

Quantity of water = $50m^3/hr$ *(Assumed)*

Quantity of oil = $14.75m^3/hr$ *(Input data)*

Water inlet temperature = 33 ℃ *(Input data)*

Oil outlet temperature = 45 ℃ *(Input data)*

Allowable pressure drop on water side = 0.6 kg/cm^2 *(Input data)*

Allowable pressure drop on oil side = 0.6 kg/cm^2 *(Input data)*

Fouling factor on water side = 0.0004 $hr\text{-}m^2\text{-}$ ℃/kcal

Fouling factor on oil side = 0.0002 $hr\text{-}m^2\text{-}$ ℃/kcal *(Input data)*

Tube material

= Admiralty brass

Thermal conductivity of tube material = 66 $BTU/hr\text{-}ft^2\,{}^0F$ *(From TEMA)*

Number of tubes = 90

Number of tube passes = 2

Length of tube = 3300*mm*=3.300 *m*

Outside diameter of the tube = OD=19.05*mm*=0.01905*m*

Thickness of tube = 1.650*mm*=0.00165*m*

Inside diameter of tube= *OD-2*Thick* = 15.75*mm*=0.01575*m*

Tube type =Plain type

Tube pitch = 25.4*mm*=0.0254*m*

Ratio of outside to inside surface area= $A_o/A_i = \pi d_o L/\pi d_i L$ = 1.2095

Number of baffles = 33

Baffle cut = 22%

Type of heat exchanger = Shell and tube AEW type heat

Exchanger (floating rear tube sheet)

Baffle thickness = 6*mm*=0.006*m*

Shell inside diameter = 307*mm*=0.307*m*

Shell outside diameter = 323.8*mm*=0.3238*m*

Shell thickness = 8.4*mm*=0.0084*m*

Baffle spacing = 86*mm*=0.086*m*

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Chapter-3

3.1 DESIGN:

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse

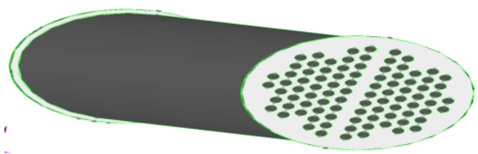

fig 2.Schematic Diagram Showing The model of a heat exchanger

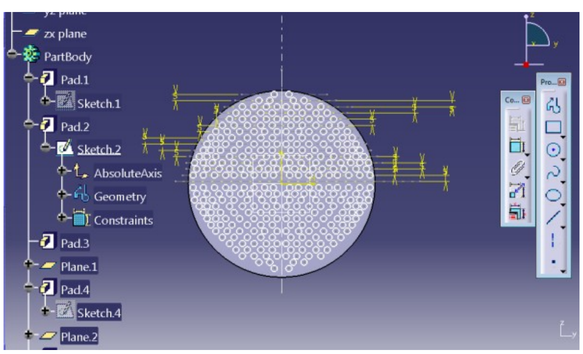

Fig 3: Schematic Diagram Showing the creating a model

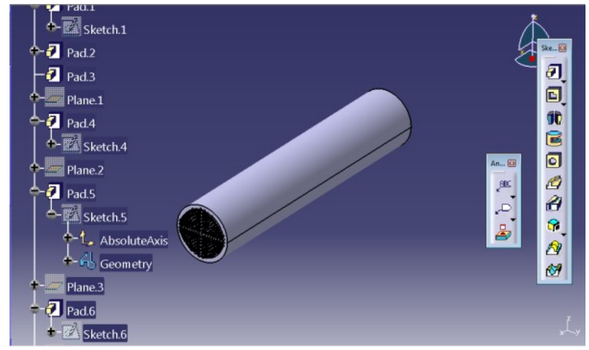

Fig4: Schematic Diagram Showing The complete solid a model

Chapter-4

ANALYSIS OF HEAT EXCHANGER

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

6. Pre Processor (Build the Model).

ANALYSIS OF RESULTS:

- **Material Data**

Copper

Copper

Thermal Conductivity	400 W m^-1 C^-1
Density	8933 kg m^-3
Specific Heat	385 J kg^-1 C^-1

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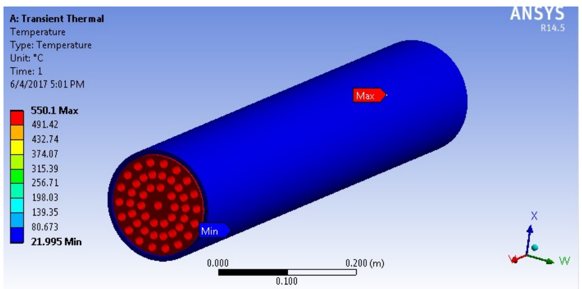
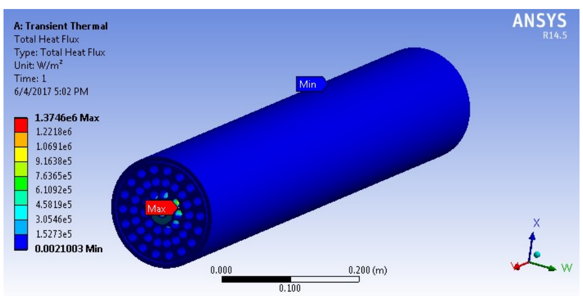
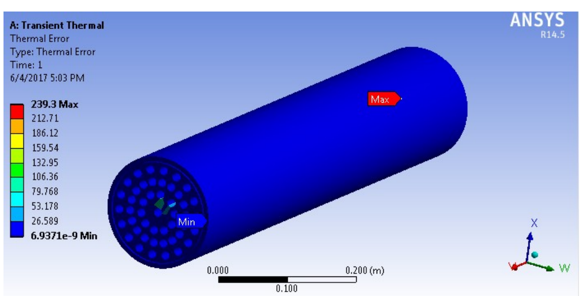
Zirconium

Zirconium	
Density	5700 kg m^-3
Thermal Conductivity	3 W m^-1 C^-1
Specific Heat	900 J kg^-1 C^-1







Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*	*Thermal Error*
Minimum	21.995 °C	2.1003e-003 W/m²	-2.8274e+005 W/m²	6.9371e-009
Maximum	550.1 °C	1.3746e+006 W/m²	2.8274e+005 W/m²	239.3

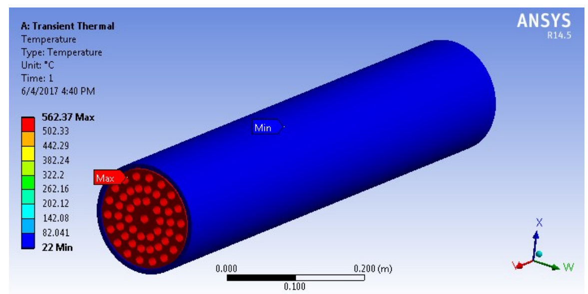
- Material Data

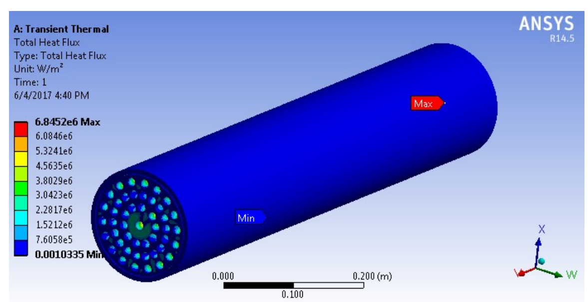
Steel 1008

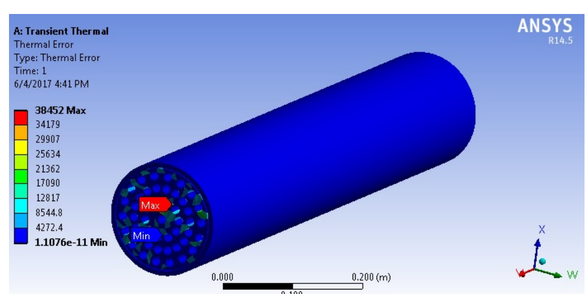
Thermal Conductivity	45 W m^-1 C^-1
Density	7872 kg m^-3
Specific Heat	481 J kg^-1 C^-1

Brass

Thermal Conductivity	111 W m^-1 C^-1
Density	8600 kg m^-3
Specific Heat	162 J kg^-1 C^-1







Object Name	Temperature	Total Heat Flux	Directional Heat Flux	Thermal Error
Minimum	22. °C	1.0335e-	-	1.107

m		003 W/m²	2.8434e+ 006 W/m²	6e- 011
Maximum	562.37 °C	6.8452e+ 006 W/m²	2.8434e+ 006 W/m²	38452

CONCLUSION

- In mechanical design, important minimum dimensions of different parts of the equipment to suit the design pressures and temperatures. The design standard ASME codes for pressure vessel constructions are used.
- The maximum temperature induced is **562.37 °C.** Total Heat Flux maximum value **6.8452e+006** W/m². Thermal Errormaximum value **38452** Hence the design is safe based on the strength.
- From the theoretical modeling the convection heat transfer coefficients along with the bulk temperature and imposed as a boundary conditions to predict the temperature distribution in heat transfer analysis in both the shell and tube.
- Nodal temperatures are also less for both materials. Finally we conclude that the Heat exchanger with steel 1008 pipes is better than Heat exchanger with copper pipes.

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