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Modelling Of Heat Exchanger with Shell and Tube by Using Finite Element Analysis

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Abstract:

A computational study for the optimal design of heat exchangers (HX) used in a high temperature and high pressure system is presented. Two types of air to air HX are considered in this study. One is a single-pass cross-flow type with straight plain tubes and the other is a two-pass cross-counter flow type with plain U-tubes. These two types of HX have the staggered arrangement of tubes. In order to design compact light weight HX with the minimum pressure loss and the maximum heat exchange rate, the weight of HX core is chosen as the object function. Dimensions and tube pitch ratio of a HX are used as design variables. Demanded performance such as the pressure loss (ΔP) and the temperature drop (ΔT) are used as constraints. The performance of HX is discussed and their optimal designs are presented with an investigation of the effect of design variables and constraints.The heat exchanger contains tubes and shell. In the present attempt these tubes are modeled in modeling software (PRO-E) by using a material Al2O3 and Stainless Steel and their thermal analysis of the tubes is analyzed by using simulation software ANSYS. For the result the heat flux of Al2O3 is much more when compared to Stainless steel material

I.INTRODUCTION:

As the importance of global environmental problems is growing, efficient energy managementbecomes an urgent target in science and technology. In further detail, ACARE (Advisory Council for Aerospace Research in Europe) demands that air transportations must have the environment-friendly aero engine in which the amount of CO2 and NOx emissions should be 50% and 80%, respectively less than the present amounts 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 systemwith HX that compact and ultra-light weight, high effectiveness, minimum pressure loss tomaintain 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.

II.HEAT EXCHANGERS:

Shell and tube heat exchanger:

Shell and tube heat exchangers consist of a series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are beingheated or cooled so that it can either provide the heat or absorb the heat required. A set of tubesis called the tube bundle and can be made up of several types of tubes: plain, longitudinallyfinned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C). This is because the shell and tube heat exchangers are robust due to their shape. Several thermal design features must be considered when designing the tubes in the shell and tube heat exchangers. Tube diameter: Using a small tube diameter makes the heat exchanger both economical and compact. However, it is more likely for the heat exchanger to foul up faster and the small size makes mechanical cleaning of the fouling difficult.

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Tube thickness:

The thickness of the wall of the tubes is usually determined to ensure:There is enough room for corrosion, that flow-induced vibration has resistance.

Plate heat exchanger:

Another type of heat exchanger is the plate heat exchanger. One is composed of multiple, thin, slightly separated plates that have very large surface areas and fluid flow passages for heat transfer. This stacked-plate arrangement can be more effective, in a given space, than the shelland tube heat exchanger. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical. In HVAC applications, large heat exchangers of this type are called plate-and-frame; when used in open loops, these heat exchangers are normally of the gasket type to allow periodic disassembly, cleaning, and inspection. There are many types of permanently bonded plate heat exchangers, such as dip-brazed, vacuum-brazed, and welded plate varieties, and they are often specified for closed-loop applications such as refrigeration. Plate heat exchangers also differ in the types of plates that are used, and in the configurations of those plates. Some plates may be stamped with “chevron”, dimpled, or other patterns, where others may have machined fins and/or grooves.

Adiabatic wheel heat exchanger:

A fourth type of heat exchanger uses an intermediate fluid or solid store to hold heat, which is then moved to the other side of the heat exchanger to be released. Two examples of this are adiabatic wheels, which consist of a large wheel with fine threads rotating through the hot and cold fluids, and fluid heat exchanger.

Plate fin heat exchanger:

This type of heat exchanger uses “sandwiched” passages containing fins toincrease the effectivity of the unit. The designs include crossflow and counter flow coupled with various fin configurations such as straight fins, offset fins and wavy fins. Plate and fin heat exchangers are usually made of aluminium alloys, which provide high heat transfer efficiency. The material enables the system to operate at a lower temperature and reduce the weight of the equipment.

Plate and fin heat exchangers are mostly used for low temperatureservices such as natural gas, helium and oxygen liquefaction plants, air separation plants and transport industries such as motor and aircraft engines.

Direct contact heat exchangers:

Direct contact heat exchangers involve heat transfer between hot and cold streams of two phases in the absence of a separating wall. Thus such heat exchangers can be classified as:
Gas – liquid
Immiscible liquid – liquid
Solid-liquid or solid – gas
Most direct contact heat exchangers fall under the Gas-Liquid category, where heat is transferred between a gas and liquid in the form of drops, films or sprays.
Such types of heat exchangers are used predominantly in air conditioning, humidification, and industrial hot water heating, after cooling and condensing plants.

III.SPIRAL HEAT EXCHANGERS:

A spiral heat exchanger (SHE), may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. Pair of fluid ports are connected tangentially to the outer arms of the spiral, and axial ports are common, but optional.The main advantage of the SHE is its highly efficient use of space. This attribute is oftenleveraged and partially reallocated to gain other improvements in performance, according to well-known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost).A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an over-sized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

Construction:

The distance between the sheets in the spiral channels are maintained by using spacer studs that were welded prior to rolling. Once the main spiral pack has been rolled, alternate top and bottom edges are welded and each end closed by a gasket flat or conical cover bolted to the body. This ensures no mixing of the two fluids occurs. Any leakage is from the periphery cover to theatmosphere or to a

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passage that contains the same fluid.

Self-cleaning:

SHEs are often used in the heating of fluids that contain solids and thus tend to foul the inside ofthe heat exchanger. The low pressure drop lets the SHE handle fouling more easily. The SHE uses a "self-cleaning" mechanism, whereby fouled surfaces because a localized increase in fluid velocity, thus increasing the drag (or fluid friction) on the fouled surface, thus helping to dislodge the blockage and keep the heat exchanger clean. "The internal walls that make up the heat transfer surface are often rather thick, which makes the SHE very robust, and able to last a long time in demanding environments." They are also easily cleaned, opening out like an ovenwhere any buildup of foulant can be removed by pressure washing.
Self-Cleaning Water filters are used to keep the system clean and running without the need to shut down or replace cartridges and bags.

IV.Sketchs of Heat Exchanger:

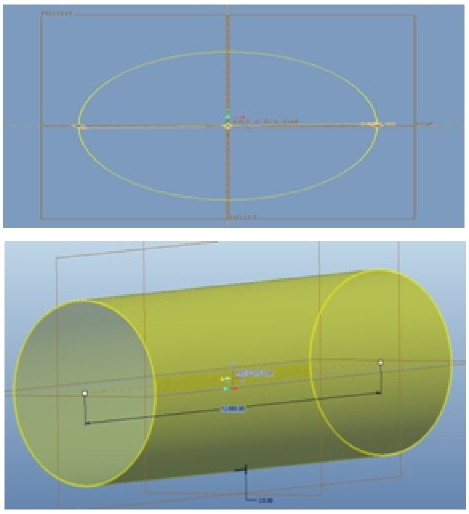

Fig 1: Heat exchanger sketches.

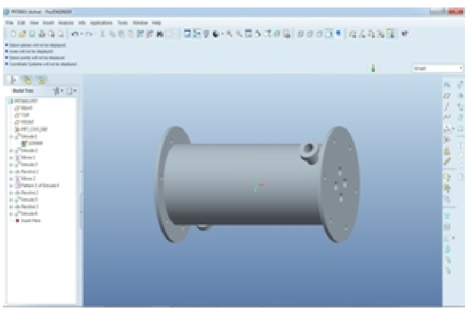

Fig 2: Heat exchanger shell.

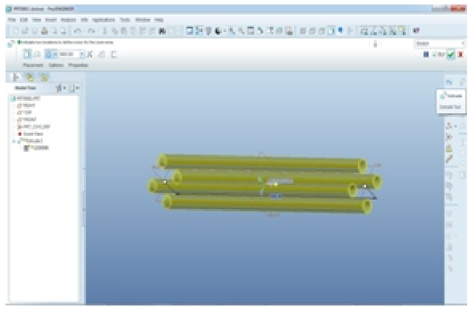

Fig 3: Extrude 2d profile of the tubes

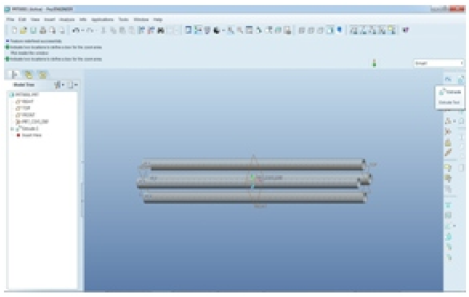

Fig 4: Heat exchanger tubes

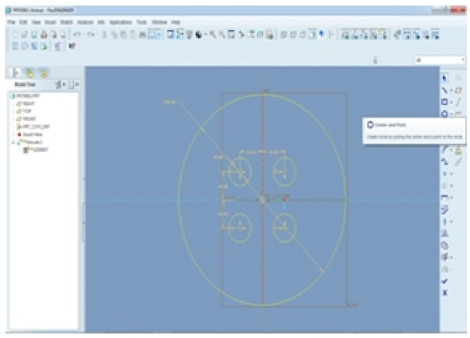

Fig 5: 2d profile of baffles

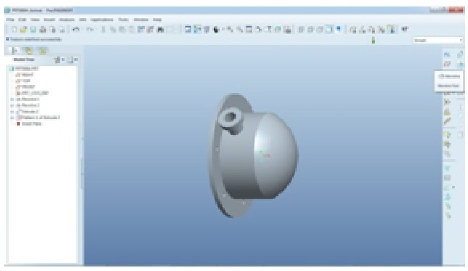

Fig 6: Dome

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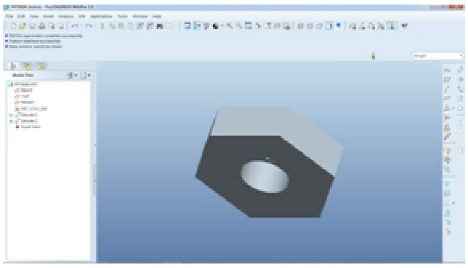

Fig 7: Nut

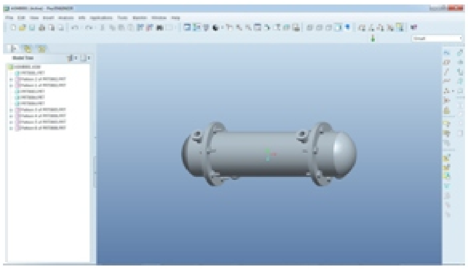

Fig 8: Assembled of heat exchanger

V.SIMULATION RESULTS
Material: Steel 316

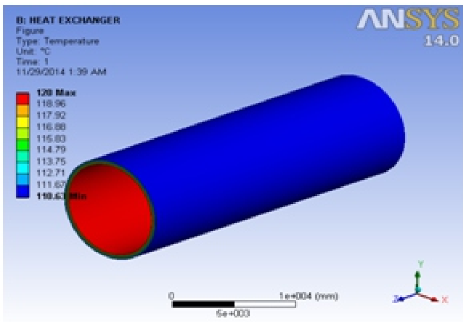

Fig 9: Steady-State Thermal-Temperature

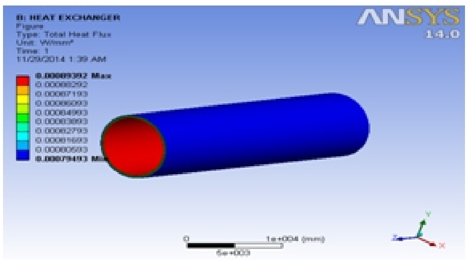

Fig 10: Steady-State Thermal-Total Heat Flux

TABLE 1 Steel 316 > Constants

Thermal Conductivity	4.5e-002 W mm^-1 C^-1
Density	7.872e-006 kg mm^-3
Specific Heat	4.81e+005 mJ kg^-1 C^-1

Aluminum Oxide:

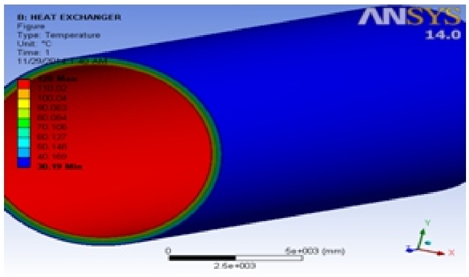

Fig 11: Steady-State Thermal-Temperature

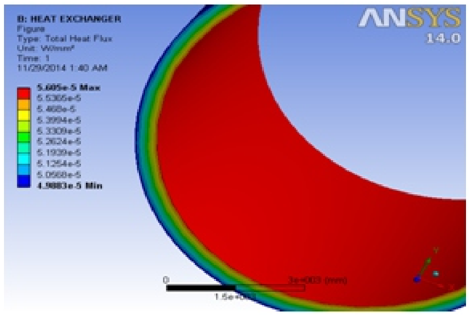

Fig 12: Steady-State Thermal-Total Heat Flux

Flux
Aluminum Oxide: > Constants

Thermal Conductivity	2.94e-004 W mm^-1 C^-1
Density	1.9e-006 kg mm^-3
Specific Heat	1.15e+006 mJ kg^-1 C^-1

Results and Discussion
All Set-ups for the Analysis:

Shell and Tube heat exchanger used in this projectanalysis, is a single pass four tube and one shell with aparallel flow feature. During the analysis the tubematerial changed basically I three types of is steel,second one is an aluminum and third one is a copper.By the analysis the effect of material has been examined.

Set-up ad boundary condition

	Temperature	Mass flow rate	Pressure at outlet
Hot water in tube	90 c	2 kg/s in each tube	1 atm
Cold water in cell	27 c	40 kg/s in cell	1 atm

In this analysis the two types of water are passedthrough the shell ad tube type heat exchanger, hot wateris passed with the 90 degree C with the 2 Kg/sec eachtube mass flow rate and the cold water is passedthrough the shell with the 27 degree C with the 40Kg/Sec mass flow rate. As show in the figure the fluid passed with the parallel-flow heat exchanger ad the solution is run In the Ansys CFX.

VI.CONCLUSION:

Various analyses required to analysis for operating pressure loads and transient thermal analyses together with mechanical loads. The analyzing of Total Heat Flux using ANSYS on both materials SS-316 and Al2O3 the results are noted and the material having the highest heat transfer rate is Aluminium Oxide (Minimum heat flux = 0.0020331 W/mm2 and Maximum heat flux = 0.0023677 W/mm2) and the material having good physical and mechanical properties. Aluminium oxide is more malleable and elastic than steel. Better to do analysis in realistic actual methods for both shell side and tube for to get optimum shell and tube heat exchanger.

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