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Design and CFD analysis of hair pin heat exchanger at different nano-fluids

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ABSTRACT

In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the hair pin heat exchanger. The nano fluids are Aluminium Oxide and Titanium carbide for two volume fractions 0.4, 0.5. Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis.

3D model of the hair pin heat exchanger is done in CREO parametric software. CFD analysis is done on the hair pin heat exchanger for all nano fluids and volume fraction and thermal analysis is done in Ansys for two materials Aluminum and Copper

INTRODUCTION

Heat exchangers are one of the mostly used equipment in the process industries. Heat Exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change. Different heat exchangers are named according to their application. For example, heat exchangers being used to condense are known as condensers, similarly heat exchanger for boiling purposes are called boilers. Performance and efficiency of heat exchangers are measured through the amount of heat transfer using least area of heat transfer and pressure drop. A better presentation of its efficiency is done by calculating over all heat transfer coefficient. Pressure drop and area required for a certain amount of heat transfer, provides an insight about the capital cost and power requirements (Running cost) of a heat exchanger. Usually, there is lots of literature and theories to design a heat exchanger according to the requirements.

Heat exchangers are of two types:-

Where both media between which heat is exchanged are in direct contact with each other is Direct contact heat exchanger, Where both media are separated by a wall through which heat is transferred so that they never mix, Indirect contact heat exchanger.

TUBULAR HEAT EXCHANGERS

Plate Heat Exchangers

In plate heat exchangers fluids flow alternately between stacked plain or cross-corrugated

Plates that can be sealed and held together in two different ways. Either gasket are placed

Near the plate edges as shown in Figure 1.3 and the stack is held together by a frame or

The plates are brazed or welded thus forming a single element. Spiral heat exchangers (see

Figure 1.4), being fundamentally identical, generally contain only two coiled plates

Air-Cooled Heat Exchangers

Air-cooled heat exchangers, commonly employed e.g. for condensing vapours, have several major advantages. They are cheap and very simple, thus little maintenance is necessary. No intricate piping or pumping system is required and, in most cases, fouling or corrosion do not occur at a significant rate (Hewitt et al., 1994, Sec. 9.2.1). On the other hand, there are disadvantages that must be considered, namely heat transfer coefficient being relatively low and hence these exchangers tend to be larger (Hewitt et al., 1994, Sec. 9.2.2). We must also bear in mind that embedded fans may be noisy and that temperature difference available for cooling may be lower in some locations due to warmer climate.

Advantages:

Tube bundle is removable; therefore mechanical cleaning is possible on the shell side.

The U shape bundle is free for expansion and contraction inside the Hairpin shell eliminating the need for expansion joint.

Are capable of carrying the maximum pressure allowable by ASME Code per given wall thickness. (Up to 14600 psi with no corrosion allowance). Higher pressure ratings are possible using materials with higher stress values

For processes that require frequent mechanical cleaning, bare tube offers ease of cleaning and accessibility.

Bare Multi-Tube and Double-Pipe Exchangers offer the least pressure drop among most exchangers

LITERATURE SURVAY

DESIGN AND EXPERIMENTAL ANALYSIS OF PIPE IN PIPE HEAT EXCHANGER

CFD ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER

THERMAL ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER BY CHANGING THE MATERIALS USING CFD

DESIGN AND ANALYSIS OF PIPE HEAT EXANGERS WITH INSIDE FINS

INTRODUCTION TO CAD

Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CREO

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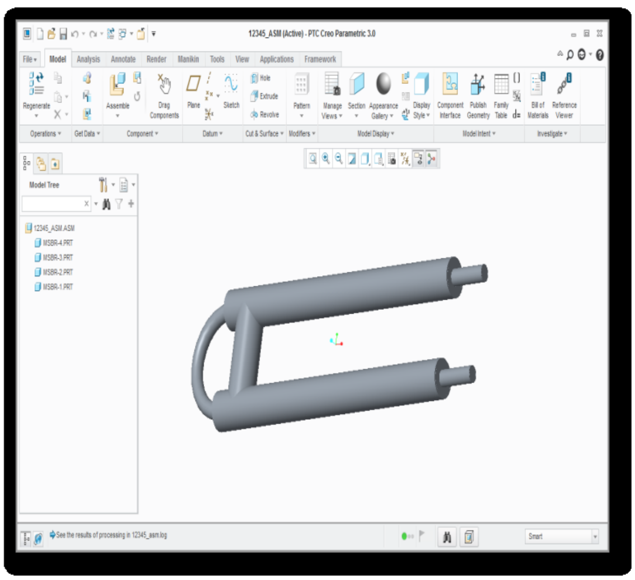
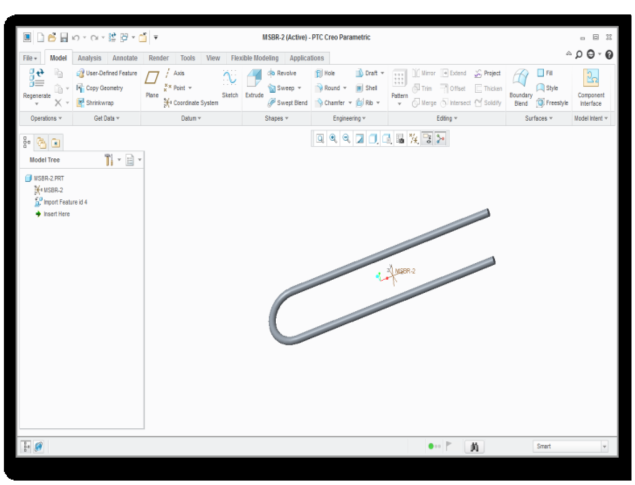
PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

3d model of hair pin heat exchanger





INTRODUCTION TO FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Top established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

Types of Engineering Analysis

Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in.

Vibrational analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibrational

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frequency of the material which, in turn, may cause resonance and subsequent failure.

Fatigue analysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

Heat Transfer analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of a steady-state or transient transfer. Steady-state transfer refers to constant thermo properties in the material that yield linear heat diffusion

Results of Finite Element Analysis

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested

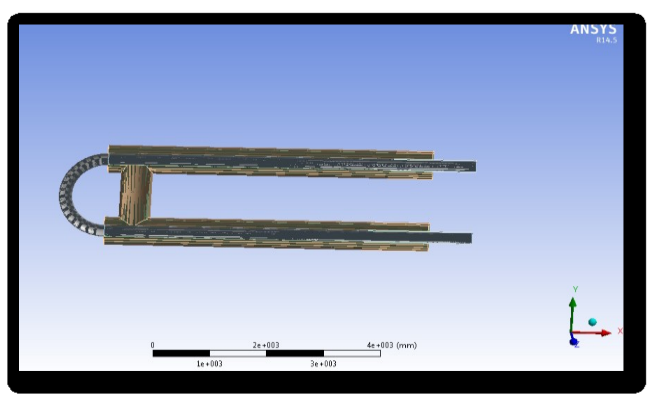
INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

INTRODUCTION TO CFD

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses ,mnumerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial experimental validation of such software is performed using a wind tunnel with the final validation coming in full-scale testing, e.g. flight tests

CFD ANALYSIS OF HAIR PIN HEAT EXCHANGER
ALUMINUM OXIDE NANO FLUID VOLUME FRACTION - 0.4



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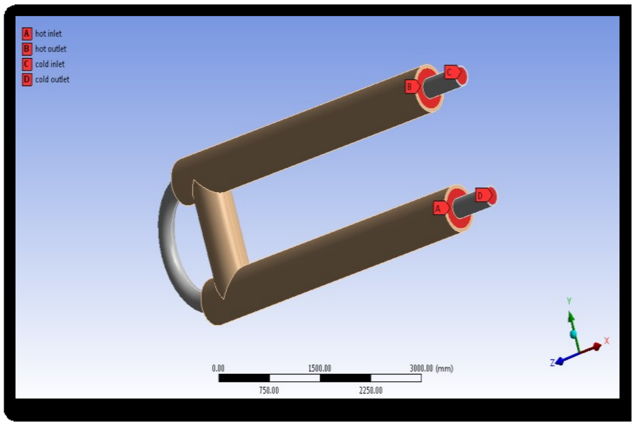
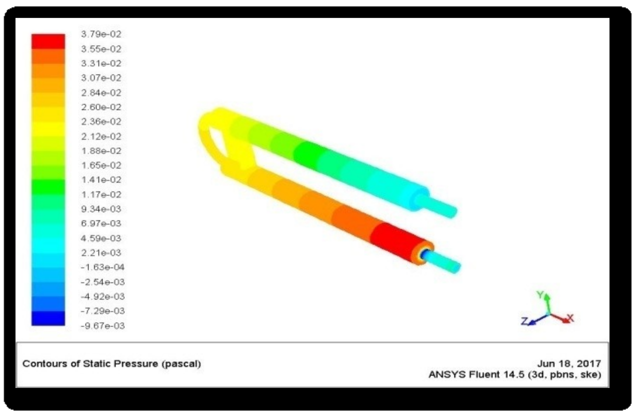
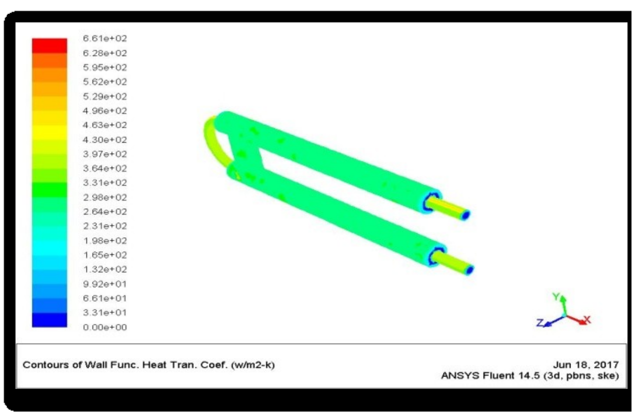


STATIC PRESSURE

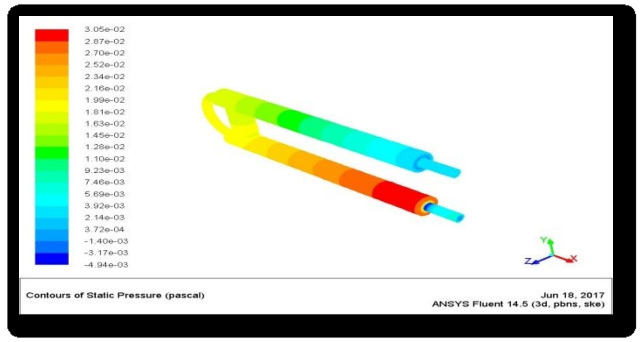


HEAT TRANSFER CO-EFFICIENT



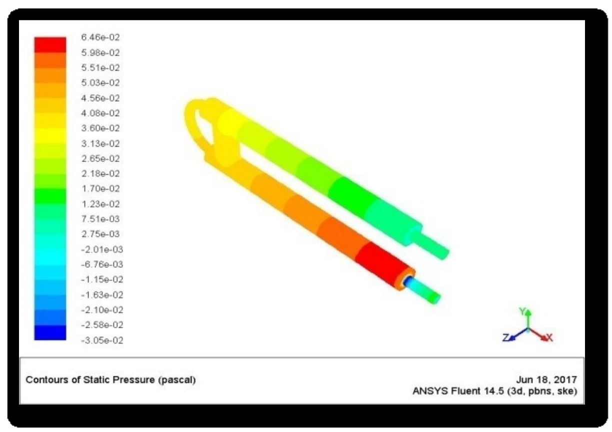
VOLUME FRACTION - 0.5

STATIC PRESSURE



FLUID- WATER

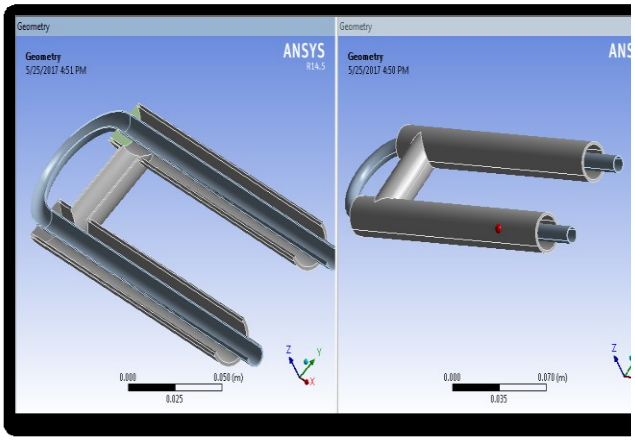
PRESSURE



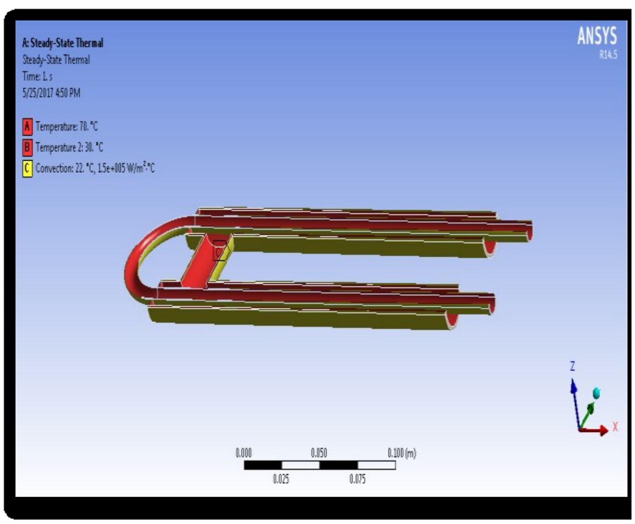
THERMAL ANALYSIS OF HAIR PIN HEAT EXCHANGER

MATERIAL-ALUMINUM ALLOY

IMPORTED MODEL



APPLIED TEMPERATURE& CONVECTION



CONCLUSION

In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the hair pin heat exchanger. The nano fluids are Aluminium Oxide and Titanium carbide for two volume fractions 0.4, 0.5. Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis.

Hairpin Exchangers are available in single tube (Double Pipe) or multiple tubes within a hairpin shell (Multitude), bare tubes, finned tubes, U-tubes, straight tubes (with rod-thru capability), fixed tube sheets and removable bundle.

By observing the CFD analysis results the heat transfer rate value more at titanium carbide volume fraction 0.4.

By observing the thermal analysis results the heat flux value more for copper material compare with aluminum alloy.

So it can be concluded the titanium carbide nano fluid at volume fraction 0.5 fluid is the better fluid for hair pin heat exchanger and material is copper.

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