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Design and Analysis of Triple Pipe Heat Exchanger with Al_2O_3 Nanofluid ImproveHeat Transfer Coefficient

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ABSTRACT

The heat transfer in a heat exchanger involves convection on each sideof fluid and conduction taking place through the wall which isseparating the two fluids. In a heat exchanger, the temperature of fluid keeps on changing as it passes through the tubes and also the temperature of the dividing wall located between the fluids varies along the length of heat exchanger. The thermal behavior of Nano fluids could provide a basis for a huge innovation for heat transfer, which is a major importance to number of industrial sectors including transportation, power generation, micro manufacturing, thermal therapy for cancer treatment, chemical and metallurgical sectors, as well as heating, cooling, ventilation and air-conditioning.

Nano fluids are suspensions of nanoparticles in the base fluidwhich is a new challenge in the field of thermal science provided by nanotechnology. Heat exchanger performance is analyses by Al_2O_3 Nano fluid with the base fluid water. The triple pipe model creating in solid works and analysis based on computational fluid dynamics in Ansys software. To predict the temperature difference and comparedwith the results of base fluid (water)

Index Terms— Heat exchanger, Triple tube heat exchanger,nanofluid, Over all heat transfer coefficient.

1 INTRODUCTION

A heat exchanger is a device used to transfer heat between two ormore fluids. The fluids can be single or two phase and, depending onthe exchanger type, may be separated or in direct contact. Devices involving energy sources such as nuclear fuel pins or fired heaters arenot normally regarded as heat exchangers although many of the principles involved in their design are the same.

In order to discuss heat exchangers, it is necessary to provide some form of categorization. There are two approaches that are normally taken. The first considers the flow configuration within the heat exchanger, while the second is based on the classification of equipment type primarily by construction.

HEAT EXCHANGE METHOD

DIRCET HEATING SYSTEM

Direct systems have the advantage that the product is held at a high temperature for a shorter period

of time, thereby reducing the thermal damage for the sensitive products such as milk. There are two groups of direct systems:

- **Injection-based**, where the high-pressure steam is injected into the liquid, it allows fast heating and cooling, but is only suitable for some products. As the product comes in contact with the hot nozzle, there is a possibility of local overheating.
- **Infusion-based**, where the liquid is pumped through a nozzle into a chamber with high-pressure steam at a relatively low concentration, providing a large surface contact area, this method achieves near-instantaneous heating and cooling and even distribution of temperature, avoiding local overheating. It is suitable for liquids of both low and high viscosity.

INDIRECT HEATING SYSTEM

In indirect systems, the product is heated by a solid heat exchanger similar to those used for pasteurization. However, as higher temperatures are applied, it is necessary to employ higher pressures in order to prevent boiling. There are three types of exchangers in use:

- Plate exchangers,
- Tubular exchangers
- Scraped-surface exchangers

For higher efficiency, pressurized water or steam is used as the medium for heating the exchangers themselves, accompanied with a regeneration unit which allows reuse of the medium and energy saving.

PLATE HEAT EXCHANGER

A plate heat exchanger is a type of heat exchanger that uses metal plates to transfer heat between two fluids. This has a major advantage over a conventional heat exchanger in that the fluids are exposed to a much larger surface area because the fluids are spread out over the plates. This facilitates the transfer of heat, and greatly increases the speed of the temperature change. Plate heat exchangers are now common and very small brazed versions are used in the hot-water sections of millions of combination boilers. The high heat transfer efficiency for such a small physical size has increased the domestic hot water (DHW) flow rate of combination boilers. The small plate heat exchanger.

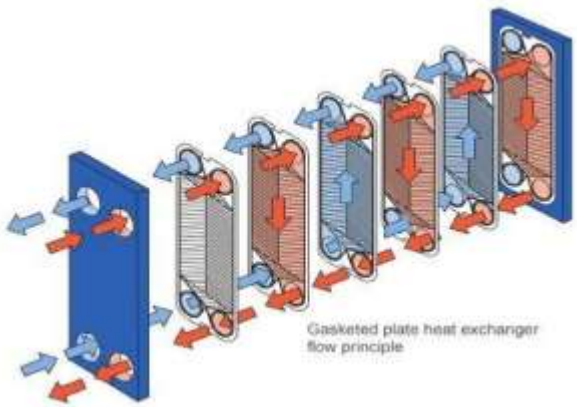

Fig. 1. Plate heat exchangers

TUBULAR HAET EXCHNGER

These exchangers are generally built of circular tubes, although elliptical, rectangular, or round/flat twisted tubes have also been used in some applications. There is considerable flexibility in the design because the core geometry can be varied easily by changing the tube diameter, length, and arrangement. Tubular exchangers can be designed for high pressures relative to the environment and high-pressure differences between the fluids.

Tubular exchangers are used primarily for liquid-to-liquid and liquid-to-phase change (condensing or evaporating) heat transfer applications. They are used for gas-to-liquid and gas-to-gas heattransfer applications primarily when the operating temperature and/ or pressure is very high or fouling is a severe problem on at least onefluid side and no other types of exchangers would work. Theseexchangers may be classified as shell-and tube, double-pipe, and spiral tube exchangers. They are all prime surface exchangers except for exchangers having fins outside/inside tubes.

Fig. 2 Tubular heat exchanger

PREPARATIONS OF NANOFLUIDS

The superior properties of Nanoparticle fluid mixtures relative to those of fluids without particle or with large sized particle include high thermal conductivities, stability and prevention of clogging in micro channels. A liquid suspended with particles of nanometre dimension is termed a Nano fluid. The nanoparticles used to produce Nano fluidsare aluminium oxide, aluminium, copper, copper oxide and silver. Nanoparticles can be produced from several processes such as gas condensation, mechanical attrition or chemical precipitation techniques.

Gas condensation processing has an advantage over other This is because the particles can be produced under cleaner conditions and its surface can be avoided from the undesirable coatings. However, the particles produced by this technique occurs with some agglomeration, which can be broken up with smaller clusters by supplying a small amount of energy.

The preparation of Nano fluid begins by direct mixing of the base fluid with nanoparticles. The delicate preparation of a Nano fluid is important because Nano fluids need special requirements such as an even suspension, durable suspension, stable suspension, low agglomeration of particles and no chemical change of the fluid. The reason for using Nano fluids are when the Nano-sized particles are properly dispersed Nano fluids are expectedto give many advantages.

Higher heat conduction is a major advantage of Nano fluids as the large surface area of Nano particles allow for more heat transfer. Particles finer than 20nm carry 20% of their atoms on their surface making then instantaneously available for thermal interaction and alsostability is another benefit of Nano fluid as the particles are small, they weigh less and their chances of sedimentation are also less. This reduced sedimentation can overcome one of the major draw backs of suspensions, the setting particles and make the Nano fluids more stable.techniques.

PROPERTIES OF NANOFLUIDS

The base fluids such as water, Ethylene glycol, oil, etc. are used for the need of heat transfer from the surfaces of the various equipment to reduce their core temperature. Normally the heat transfer rate of these fluids is sufficient for the conventional machines. But due to thedevelopment in the field of engineering, there has been lot of new inventions and also numerous developments and alterations to the conventional machines. These developments lead to the heightened increase in the core temperature of the machine, which can cause failure or breakdown in the functions of the machine.

The Nano fluids that are used in these machines acts 100 times fasterthan the base fluid. The metals and metal oxides present in the Nano fluids as Nano particles allows faster transmission of heat through thefluids.

3.1 LITERATURE REVIEW

Pavani & Ravi Kumar Heat exchangers play an important role in the field of energy conservation, conversion, and recovery. Shell and tube heat exchangers are most widely used in many engineering applications for the transfer of heat energy. They are widely adopted in many industries due to their ability to transfer large amounts of heat in relatively low cost, serviceable designs without mixing the hot and old fluids. They can provide large amounts of effective tube surfaces while minimizing the requirements of floor space, liquid volume and weight. For compacting the size of the heat exchangers, the heat transfer coefficient has to be increased. With the rapid development of modern nanotechn

ology, nanoparticles are used for dispersing in base liquids, which are called as Nano fluids. Nano fluids can be applied to improve the performance of heat exchanger. In this thesis, thermal performance of a shell and tube heat exchanger operated with Nano fluids has been analytically investigated at different volume concentrations and compared with water as the base fluid. Turbulentflow conditions are considered in the analysis.

Tamilselvan et al., the heat transfer analysis of corrugated plate heat exchanger using Nano fluid in milk pasteurization process. The heat transfer performance of corrugated plate heat exchanger using Al_2O_3 Nano fluid has been experimentally analyzed. By our analysis, on using 0.3% concentration of nanoparticles in the Nano fluid it yields a result of about 46% increase in heat transfer rate compared to usingcold water as a coolant. By using corrugated structure in heat transfer plates fouling will be reduced considerably. This research work can be further extended for heat transfer analysis and fouling reduction using nanoparticle coating on the plates of a heat exchanger

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PROBLEM IDENTIFICATION

The heat exchanger is the most critical. Its failure can have a profound impact on your system and your comfort as well. Prevent emergency breakdown of your heating system by understanding the common reasons of heat exchanger failure.

CRACKING

Over time, the metal of the heat exchanger may crack. When it happens, the combustion gases will be released into the air stream which can pose a risk to your health. A cracked heat exchanger may serve as an entry point for carbon monoxide. Cracks in the metal are visible with the naked eye making them easy to spot. But if you are unsure if there are cracks in the heat exchanger, it is best to ask for asecond opinion from the experts

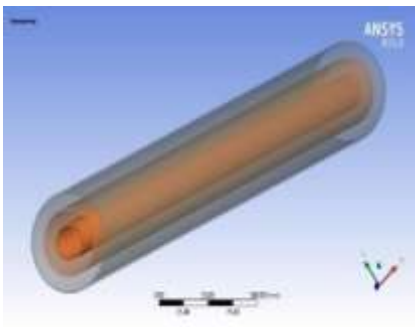
OVERLOADING

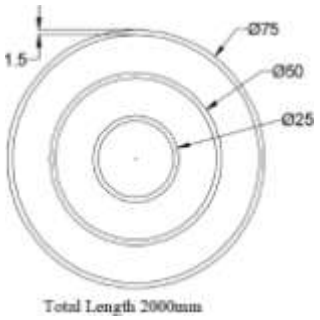
If the heat exchanger yields too much load, serious problems may arise. When there is a dramatically high volume of load running through the exchanger, your heating system may no longer work efficiently as it should. You may ask your HVAC contractor to upgrade the heat exchanger engineering to solve this issue. Other solutions may also be provided depending on the condition andrequirements of your heating system.

5.1 CHEMICALLY INDUCED CORROSION

Corrosion in the heat exchanger is caused by the complex interactionof chemicals between the fluids and other materials circulating in theexchanger. The corrosion may happen in the shell, over the tube, on the sheet and in other parts of the exchanger

TPHE MODEL





6.1 CONCLUSION

From the experiment results it was found that the overall heat transfercoefficient and heat transfer rate is more in Triple tube heat exchanger compare to the double concentric tube heat exchanger. With Triple tube heat exchanger, even we can save space and material with the triple tube heat exchanger compared to double concentric tube heat exchanger, also found that by increasing the volumetric concentrationof nanofluid the heat transfer rate increases.

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