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Review Article of Heat exchanger performances comparison using Two variance ANOVA Method

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Abstract- Heat exchangers are one of the most important heat transfer apparatus that find its use in industries like oil refining, chemical engineering, electric power generation etc. Shell-and-tube type of heat exchangers have been commonly and most effectively used in Industries over the years. In this paper we see a review of Outline and Types of Heat exchangers , Thermal Design and Mechanical Design by the use of ASME,TEMA standard take a case study of Modern Shell & Tube type Heat exchanger.

Keywords- Modern Heat exchanger, Shell and Tube heat exchanger,

I. INTRODUCTION

A heat exchanger is a device, used to transfer enthalpy between two fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. Many scholars have shown great interest in the performance optimizations of various heat exchangers based on different optimization objectives. At present heat exchangers are available in many configurations. Depending upon their application, process fluids, mode of heat transfer and flow, heat exchangers can be classified. They can also be classified on the basis of shell and tube passes, types of baffles, arrangement of tubes and smooth or baffled surfaces.

Heat exchangers design is a continuous and ongoing process to satisfy the varying process requirements on a day-to-day basis. A good design is referred to a heat exchanger with least possible area and pressure drop to fulfill the heat transfer requirements. A primary objective in the heat exchanger design is the estimation of the minimum heat transfer area required for a given heat duty, as it governs the overall cost of the Heat exchangers. Many scholars have carried out constructional designs of various heat exchangers. The selection of a particular heat exchanger configuration depends on several factors including the area requirements, maintenance, flow rates, fluid phase. Performance and efficiency of heat exchangers are measured through the amount of heat transferred using least area of heat transfer and pressure drop.

II. LITERATURE REVIEW

MohammadShafieyDehaj, Fin and tube heat exchanger: Constructal thermo-economic optimization: In this study, constructal (branch type) fin and tube heat exchanger (FTHE) is modeled and optimized. Effectiveness and total annual cost (TAC) are selected as objective functions and 8 variables for each section of exchanger are considered as design parameters (16 design parameters in total). Then, multi objective form of genetic algorithm is used to find the optimal Pareto front. The optimization is implemented for conventional FTHE as well and their results are compared with branch type condition. The optimum results show 6.65% improvement in the maximum effectiveness in the branch type condition compared with conventional FTHE. In the constructal state, lower volume is selected in the second section as compared with the first section. The same trend is also found for heat transfer surface area. Finally, optimum design parameters in terms of effectiveness for the both studied conditions are illustrated and discussed.

VenkataRajeshSaranam, Feasibility of Using Diffusion Bonding for Producing Hybrid Printed Circuit Heat Exchangers for Nuclear Energy Applications: Hybrid printed circuit heat exchangers have been designed for Gen-IV nuclear power applications. While microchannel devices are commonly fabricated using diffusion bonding, diffusion bonding of these hybrid heat exchangers is challenging due to non-uniform stress distributions across its structure during bonding, which can lead to bonded regions with varied joint properties that can compromise the performance and safety of these devices.

In this paper, we delineate a method for determining whether diffusion bonding conditions exist for bonding hybrid printed circuit heat exchangers with maximum joint strength, minimum creep and without yielding or buckling. Diffusion bonding feasibility is determined in two steps. First, an improved pore elimination model is used to identify a feasible set of diffusion bonding parameters that can give acceptable bonded area and compressive creep. Second, a structural analysis is performed on regions in

the structure susceptible to yielding and buckling that can constraint the maximum permissible bonding pressure. Diffusion bonding conditions were experimentally validated for bond strength, porosity and creep based on shear test and metallographic examinations as per ASME standards. Two sets of bonding conditions were found to satisfy nuclear boiling and pressure vessel code requirements. Future efforts will involve the diffusion bonding of a hybrid device structure capable of meeting the hermeticity and dimensional integrity requirements of the device.

VikasKumar, Characterization and performance of nanofluids in plate heat exchanger: In the present study, the authors emphasized on characterization, heat transfer and exergetic performance of nanofluid in plate heat exchanger (PHE) experimentally. The characterization of nanofluid incorporates the systematic measurement of thermophysical properties of nanofluids. The heat transfer performance incorporate the heat transfer rate, convective heat transfer coefficient, pumping power, exergy loss and exergetic efficiency of nanofluids. In this work, two types of nanofluids namely CeO_2/water and ZnO/water are employed. The experimental outcomes are compared with water and between nanofluids. The experimental results revealed the best heat transfer performance is shown by ZnO/water nanofluid. The volume concentration of the nanofluids varied from 0.5 - 2.0%. Flow rate of coolant varied from 0.5.0-2.0 lpm at 2 lpm of hot fluid. The inlet temperatures of cold and hot fluid are 25° C and 50° C respectively.

ToshihiroWakabayashi, Verification of energy conservation for discretely heat integrated distillation column through commercial operation: The heat exchange among the stages in the rectifying and stripping sections increases the possibility of energy conservation for a distillation column. From that point of view, an internal heat integrated distillation column called HIDiC was proposed. In the conventional HIDiC structure, as the stripping section and the pressurized rectifying section are provided in parallel, it is difficult to supply and remove the heat to and from the stages so that those are similar to the case of the reversible distillation.

We showed in the previous paper that by executing the heat exchanges among the appropriately selected stages in the rectifying and stripping sections in discrete manner, the amount of enthalpy change to the composition change that is similar to the ideal form can be obtained. We also proposed a design methodology to achieve it, and demonstrated that the process designed by using the proposed methodology showed high energy conservation performance by process simulation studies. Here, such HIDiC is called “discretely heat integrated distillation column” (D-HIDiC).
RajeshRavi, Computational and experimental investigation on effective utilization of waste heat from diesel engine exhaust using a fin protracted heat exchanger: The present research investigates the energy recovery capability of exhaust gases in Internal Combustion Engines (ICEs) in order to reap low grade waste heat energy. In order to achieve this aim, a double pipe, Protracted Finned Counter flow Heat Exchanger (PFCHE) was designed, analysed, fabricated and experimented with binary (water-ethanol) mixtures as working fluids. In the current work, as a first step, the theoretical design was completed and the computational simulation of PFCHE was executed. From the experimental investigation and analytical results, a positive notion was observed about the overall efficiency of the heat recovery system. It was proved that when the number of fins increased along with its height, then the heat transfer rate also got increased which further resulted in the improved performance of heat recovery system and increased Brake Thermal Efficiency from 32% to 39.6%. The developed heat recovery system was able to produce 0.35 kW–0.76 kW of power when the turbines were made to run at 1700 rpm to 4800 rpm respectively. Overall, the study concludes that the PFCHE increased the working fluid outlet temperature, effectiveness, heat transfer rate as well as the overall Brake Thermal Efficiency when compared with traditional heat exchangers that lack fins.
MertSinanTurgut, Ensemble Shuffled Population Algorithm for multi-objective thermal design optimization of a plate frame heat exchanger operated with Al_2O_3/water nanofluid:

This study proposes a brand new optimization algorithm entitled Ensemble Shuffled Population Algorithm for solving multidimensional optimization problems. The proposed algorithm adopts the perturbation equations of the Crow Search and Differential Search algorithms with useful modifications on them and aims to maintain a reasonable balance between the intensification and diversification phases of the algorithm. A batch of 22 benchmark problems consisting of unimodal and multimodal unconstrained optimization test functions are applied using this algorithm to assess its performance on multi dimensional problems. Statistical results obtained from the proposed Ensemble Shuffled Population Algorithm are compared to those found by eleven well known metaheuristic optimizers.

The comparison results show that the Ensemble Shuffled Population Algorithm outperforms the compared optimizers with regards to solution accuracy and convergence speed. After that, the proposed algorithm is applied on a multi objective optimization of a plate frame heat exchanger operated with Al_2O_3 nanofluid. The optimization results show that utilizing nanoparticles instead of base fluid not only increases the overall heat transfer coefficient rates but also entails a huge decline in total cost values. A Pareto frontier is constructed for these two conflicting objectives to select the final optimum solution from the set of non-dominated solutions by virtue of three famous decision making methods of LINMAP,

TOPSIS, and Shannon's entropy theory. Then, sensitivity analysis is performed to observe the variational effects of the design variables on the optimization objectives.

SriAddepalli, Degradation Study of Heat Exchangers: This study mainly deals with the evaluation of various degradation mechanisms that heat exchangers are susceptible to with an aim of evaluating future design requirements. A heat exchanger is a heat management system that uses fluids to transfer heat from one medium to the other; the most common types of fluids being air, water, oil or specialised coolant mixtures. As part of this study a failure analysis of heat exchangers was carried out on selected heat exchangers used in both aerospace and automotive sectors. This study was then extended to designing test-rigs supporting two types of heat exchangers. For this study, an air-to-air and an oil-to-air heat exchanger test rigs were designed. Temperature, pressure and flow sensors were introduced in the test rig designs to monitor the flow characteristics in order to determine if degradations occurring as a result of operation have an impact on them. As part of the initial evaluation both visual inspection and pulsed thermography inspection were selected as suitable inspection methods to evaluate their in-service condition. Some heat exchanger units where then subjected to accelerated corrosion tests and their performance was monitored using scanning electron microscopy (SEM) measurements. The outcomes of the study presented in this paper confirm the suitability and adaptability of thermography in detecting degradations occurring in heat exchangers.

Hassan Hajab dollahi, Rotary regenerator: Constructal thermo economic optimization: In this research, rotary regenerator (RR) is optimized using constructal theory. For this aim, a heat exchanger with two branches is considered. RR effectiveness and total annual cost (TAC) are deliberated as objective functions and 9 design variables are selected. The multi-objective optimization algorithm is used to obtain the optimal values of objective functions and design variables. The optimum results in the case of constructal are contrasted with optimum results in the conventional RR. The optimum results showed better thermoeconomic results in the case of constructal than conventional RR for the effectiveness higher than 0.6572.

As an example, effectiveness improved by 6.98% in the case of constructal in comparison to conventional RR for the constant value of TAC=1821$/year. In addition, the optimum results showed 4.55% improvement in the maximum effectiveness in constructal compared with conventional RR. Finally, distribution of design parameters along with some important parameters such as heat transfer surface area and pressure drop for both studied cases are illustrated, compared and discussed.
SriAddepalli, Degradation Study of Heat Exchangers :This study mainly deals with the evaluation of various degradation mechanisms that heat exchangers are susceptible to with an aim of evaluating future design requirements. A heat exchanger is a heat management system that uses fluids to transfer heat from one medium to the other; the most common types of fluids being air, water, oil or specialised coolant mixtures. As part of this study a failure analysis of heat exchangers was carried out on selected heat exchangers used in both aerospace and automotive sectors. This study was then extended to designing test-rigs supporting two types of heat exchangers. For this study, an air-to-air and an oil-to-air heat exchanger test rigs were designed. Temperature, pressure and flow sensors were introduced in the test rig designs to monitor the flow characteristics in order to determine if degradations occurring as a result of operation have an impact on them. As part of the initial evaluation both visual inspection and pulsed thermography inspection were selected as suitable inspection methods to evaluate their in-service condition. Some heat exchanger units where then subjected to accelerated corrosion tests and their performance was monitored using scanning electron microscopy (SEM) measurements. The outcomes of the study presented in this paper confirm the suitability and adaptability of thermography in detecting degradations occurring in heat exchangers.

FleurLoveridge, Temperature response functions (*G*-functions) for single pile heat exchangers: Foundation piles used as heat exchangers as part of a ground energy system have the potential to reduce energy use and carbon dioxide emissions from new buildings. However, current design approaches for pile heat exchangers are based on methods developed for boreholes which have a different geometry, with a much larger aspect (length to diameter) ratio. Current methods also neglect the transient behaviour of the pile concrete, instead assuming a steady state resistance for design purposes. As piles have a much larger volume of concrete than boreholes, this neglects the significant potential for heat storage within the pile. To overcome these shortcomings this paper presents new pile temperature response functions (*G*-functions) which are designed to reflect typical geometries of pile heat exchangers and include the transient response of the pile concrete. Owing to the larger number of pile sizes and pipe configurations which are possible with pile heat exchangers it is not feasible to developed a single unified *G*-function and instead upper and lower bound solutions are provided for different aspects ratios.

SajedehRooholamini, Introducing a novel hybrid system for cogeneration of liquefied natural gas and hot water using ejector-compression cascade refrigeration system (energy, exergy, pinch and sensitivity analyses): Multi-component refrigerant compression refrigeration cycles have a high coefficient of performance and difficult controllability. In these systems, it is not easily possible to keep the ratio of stream compositions constant in the event of a leak. Also, due to high power consumption in compression refrigeration cycles, the use of compression-

ejector refrigeration systems can reduce energy consumption. In this paper, a novel integrated system for cogeneration of liquefied natural gas (LNG) and hot water using two stages ejector refrigeration system (ERC) and low-temperature organic Rankine cycle (ORC) is developed. The feasibility of using ejector refrigeration systems in the novel integrated structure as the compression refrigeration cycle alternative is investigated. The novel integrated structure produces 38.39 kg/s LNG as the main product and 575.5 kg/s hot water as a byproduct. In the novel integrated structure design, due to the elimination of some equipment in the compression refrigeration systems, high energy consumption is reduced in these units. HYSYS software and MATLAB programming are used to simulate the hybrid system. The specific power consumption and exergy efficiency of the present system are 0.3868 kWh/kg LNG and 36.42%, respectively. The results of exergy analysis illustrate that the most exergy destruction belongs to the heat exchangers, which alone accounts for 60.19% of the total destruction. The heat exchanger network related to each of the multi-stream heat exchangers used in the system is extracted through the pinch method. The sensitivity assessment illustrates that the specific power consumption decreases up to 0.3809 kWh/kg LNG and produced LNG mass flow rate increases up to 39.81 kg/h, respectively when the mole fraction of methane in natural gas increases from 83% to 90%.

III. CONCLUSION

It is studied from the published papers on heat exchangers design that most of the research works have been carried out by using different design methods and numerous optimization methods. Proper design of heat exchanger will result in better performance from all points of view. Moreover; it is observed that the optimization of numerous design variables in all research papers and none of the paper is taken alternate heat transfer fluid rather than water. Double pipe heat exchanger used in industries field as well as If diameter of tube as well as material of tube is changed its effect on heat exchange rate can be studied further.

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