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A Design and Implementation of Heat Exchanger using Genetic Algorithm

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Abstract – **The purpose of the study outlined in this is to identify major energy loss areas in India's thermal power stations and develop a plan to reduce them using energy and exergy analysis as the tools. The energy supply to demand is narrowing down day by day around the world due to the growing demand and sometimes due to ageing of machinery. Most of the power plants are designed by the energetic performance criteria based not only on the first law of thermodynamics , but the real useful energy loss cannot be justified by the fist law of thermodynamics, because it does not differentiate between the quality and quantity of energy. Considering the high capital cost involved in new generation "clean technologies" developing countries like India having an abundance of cheap fossil fuel reserves have to give a major thrust to improvement in fossil-fired power technologies. Steam turbine based generating plants form the backbone of power generation in many countries in our country too, Base load is presently largely generated by fossil fuel based power plants. Most of these plants employ sub-critical coal fired boilers driving steam turbines to generate power. The adoption of "Supercritical cycles" for thermal plants on a wide scale has the ability to improve overall system efficiency, as well as provide benefits of lower emissions both on land & in air. Steam cycles for supercritical application operate at very high pressure & temperatures; these are thus characterized by features that take full advantage of the advanced parameters like higher expansion in turbines, more stages of feed heating & higher input levels to boilers, contributing to higher system efficiency.**

Keywords– **Energy, Exergy, Effective, Efficiency, Improvement, Thermal Power Station, Different types of power plants.**

I. INTRODUCTION

The heat exchanger is an important component of any energy system. Development of design techniques for a heat exchanger with minimized cost is a vital task. Transfer of heat between two process streams is the most commonly encountered operation in process plant design. In heat exchanging equipment's, heat is transferred primarily by convection from one fluid to another and the fluids are separated by a wall through which the heat is transferred. Such equipment takes many forms, of which the double pipe and the shell and tube type is the most common. Heat transfer equipment's are used in essentially all process industries, and there are many different types of equipment's employed for transferring heat. It is important to decide for what type of equipment is suitable for a given process. It is necessary to consider the basic process design variables and also many other factors for selection of heat transfer equipment. However, it is important to consider both process design and mechanical design while preparing the specifications for heat exchangers.

Process information includes type of fluid to be used, flow rates and amount of fluids, entrance and exit temperature, amount of vaporization or condensation, operating pressures and allowable pressure drops, fouling factors, and rate of heat transfer. Mechanical information includes size of tubes, tube layout and pitch, maximum and minimum temperatures and pressures, necessary corrosion allowances, special codes involved, recommended materials of construction.

II. DOUBLE PIPE HEAT EXCHANGER

A double pipe heat exchanger, in its simplest form is just one pipe inside another larger pipe. One fluid flows through the inside pipe and the other flows through the annulus between the two pipes. The wall of the inner pipe is the heat transfer surface. The pipes are usually doubled back multiple times as shown in the diagram at the left, in order to make the overall unit more compact. The term 'hairpin heat exchanger' is also used for a heat exchanger of the configuration in the diagram. A hairpin heat exchanger may have only one inside pipe, or it may have multiple inside tubes. The principal disadvantage to the use of double pipe exchangers lies in the small amount of heat-transfer surface contained in a single hairpin. The time and expense required for dismantling and periodically cleaning are prohibitive compared with other types of equipment. However, the double pipe exchanger is of greatest use where the total required heat-transfer surface is small, 100 to 200 ft2 or less. [3]

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Fig.1.Double Pipe Heat Exchanger.

III. FUNCTIONALITY OF A THERMAL POWER PLANT

Thermal power plant (TPP) is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser. The greatest variation in the design of TPPs is due to the different fuel sources. Some prefer to use the term energy center because such facilities convert forms of heat energy into electrical energy [3-5]. In TPPs, mechanical power is produced by a heat engine which transforms thermal energy, often from combustion of a fuel, into rotational energy. Most TPPs produce steam, and these are sometimes called steam power plants. TPPs are classified by the type of fuel and the type of prime mover installed (Figure 1).

The electric efficiency of a conventional TPP, considered as saleable energy produced at the plant bus bars compared with the heating value of the fuel consumed, is typically 33 to 48% efficient, limited as all heat engines are by the laws of thermodynamics. The rest of the energy must leave the plant in the form of heat. Since the efficiency of the plant is fundamentally limited by the ratio of the absolute temperatures of the steam at turbine input and output, efficiency improvements require use of higher temperature, and therefore higher pressure, steam.

This overheated steam drags the HP rotor (high pressure) of the turbine in rotation and relaxes to the exit of the HP body of the turbine, so it comes back again in the furnace to be until 540°

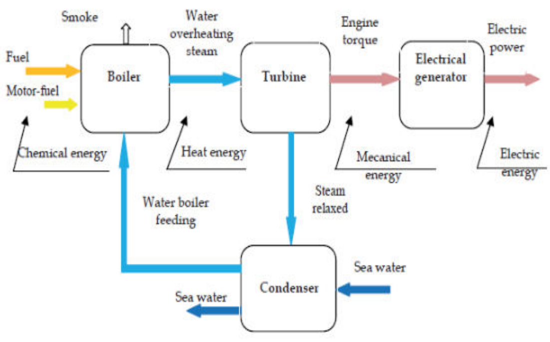


Fig. 2. Functionality of a TPP.

IV. LITERATURE REVIEW

"OPTIMAL DESIGN OF DOUBLE-PIPE HEAT EXCHANGERS, COMPARISONS" Petrik Máté, Dr. Szepesi L Double pipe heat exchangers are the simplest heat transfer devices. There are two concentric pipes with different diameters: the smaller tube inside the bigger tube. One of the medium flows inside of the smaller tube, while the other medium flows in the annulus. With the help of the solid wall the heat can be changed between the two fluids, without of their direct contact.

"A double pipe heat exchanger design and optimization for cooling an alkaline fuel cell system" L. Ariyanfar, H. Ghadamian In the presented research heat transfer of a mobile electrolyte alkaline fuel cell (AFC) (where the electrolyte has a cooling role in the system) has been considered. Proper control volumes of system with specific qualifications have been chosen. Accordingly, heat and mass transfer in the control volumes have been assessed. Considerations of heat and mass transfer plus contributed models led to the use of a double tube heat exchanger as an energy sink. Design of this heat exchanger was dependent on heat transfer conditions and related equations.

"OPTIMIZATION OF COMPRESSED HEAT EXCHANGER EFFICIENCY BY USING GENETIC ALGORITHM", M. GHORBANI Due to the application of coil-shaped coils in a compressed gas flow exchanger and water pipe flow in airconditioner devices, air conditioning and refrigeration systems, both industrial and domestic, need to be optimized to improve exchange capacity of heat exchangers by reducing the pressure drop. Today, due to the eduction of fossil fuel resources and the importance of optimal use of resources, optimization of thermal, mechanical and electrical devices has gained particular importance. Compressed heat exchangers are the devices used in industries, especially oil and petrochemical ones, as well as in power plants. So, in this paper we try to optimize compressed heat exchangers.

"Thermal and hydraulic optimization of plate heat exchanger using multi objective genetic algorithm", Muhammad Imran, Nugroho AgungPambudi In this paper thermal and hydraulic optimization of water to water chevron type plate heat exchanger is presented. The optimization is performed using the multi objective genetic algorithm in MATLAB optimization environment. Constrain matrix is a set of different geometrical parameters of plate heat exchanger within the logical bounds. The two objective functions are pressure drop of hot side and heat transfer. Due to conflicting nature of these objective functions, no single solution can satisfy both of the objective function simultaneously. The increase in heat transfer will results in increase in pressure drop, therefore, optimization results are presented as Pareto Front. Multi objective genetic algorithm tool was employed to find a set of optimum solution which was trade-off between pressure drop and heat transfer. At the end, sensitivity analysis was performed to analyse the effect of geometrical parameters of heat exchanger on thermal and hydraulic performance. The sensitivity results show that the heat transfer and pressure drop are greatly affected by the vertical port centre distance, plate spacing and number of thermal plates.

Designing and Optimizing Heat Storage of a Solar-Assisted Ground Source Heat Pump System in China, Yan Gao, Zhi Sun, Xinxing Lin The cold accumulation problem can lead to performance degradation of heat pumps. This paper presents the design and optimization of a solar-assisted storage system to solve this issue. A ground source heat pump (GSHP) project was established using the transient system simulation program (TRNSYS) based on a ground heat exchange theoretical model, which was validated by a previously established experiment in Beijing. The Beijing, Harbin, and Zhengzhou regions were used in numerical simulations to represent three typical cities where buildings require space heating (a cold region, a severe cold region, and a hot summer and cold winter region, respectively). System performance was simulated over periods of ten years. The simulation results showed that the imbalance efficiencies in the Beijing, Harbin, and Zhengzhou regions are 55%, 79%, and 38%, respectively.

V. RESEARCH METHODOLOGY

1. Genetic Algorithm

Genetic Algorithm (GA) works on the theory of Darwin‟s theory of evolution and the survival-of-the fittest [1]. Genetic algorithms guide the search through the solution space by using natural selection and genetic operators, such as crossover, mutation and the selection. Professor John Holland of the University of Michigan envisaged the concept of these algorithms in the mid-sixties.

GA encodes the decision variables or input parameters of the problem into solution strings of a finite length. While traditional optimization techniques work directly with the decision variables or input parameters, genetic algorithms usually work with the coding. Genetic algorithms start to search from a population of encoded solutions instead of from a single point in the solution space. The initial population of individuals is created at random. Genetic algorithms use genetic operators to create Global optimum solutions based on the solutions in the current population. The most popular genetic operators are (1) selection, (2) crossover and (3) mutation. The newly generated individuals replace the old population, and the evolution process proceeds until certain termination criteria are satisfied.

2. Selection

The selection procedure implements the natural selection or the survival-of-the fittest principle and selects good individuals out of the current population for generating the next population according to the assigned fitness. The existing selection operators can be broadly classified into two classes: (1) proportionate schemes, such as roulette-wheel selection and stochastic universal selection and (2) ordinal schemes, such as tournament selection and truncation selection. Ordinal schemes have grown more and more popular over the recent years, and one of the most popular ordinal selection operators is tournament selection. After selection, crossover and mutation recombine and alter parts of the individuals to generate new solutions.

3. Crossover

Crossover, also called the recombination operator, exchanges parts of solutions from two or more individuals, called parents, and combines these parts to generate new individuals, called children, with a crossover probability. There are a lot of ways to implement a recombination operator. The well-known crossover operators include one-point crossover. When using one- point crossover, only one crossover point is chosen at random, for example let there be two parent string A1 and A2 as:

A1= 1 1 1 1| 1 1
A2 = 0 0 0 0|0 0

Then, one-point crossover recombines A1 and A2 and yields two off springs A-1 and A-2as:

A-1 =1 1 1 1|1 1
A-2 =0 0 0 0|1 1

VI. RESULTS AND DISCUSSION

1. Autocad 3D View Heat Exchager Design:

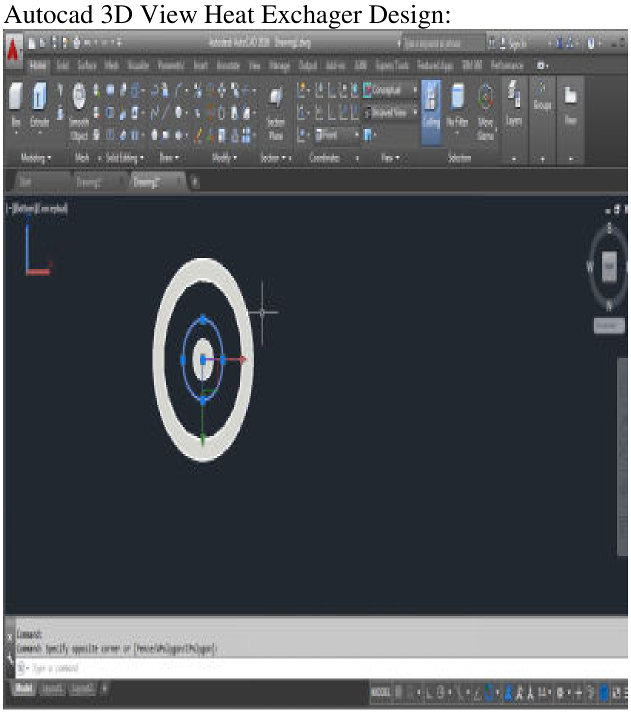


Fig.6.1 Top view.

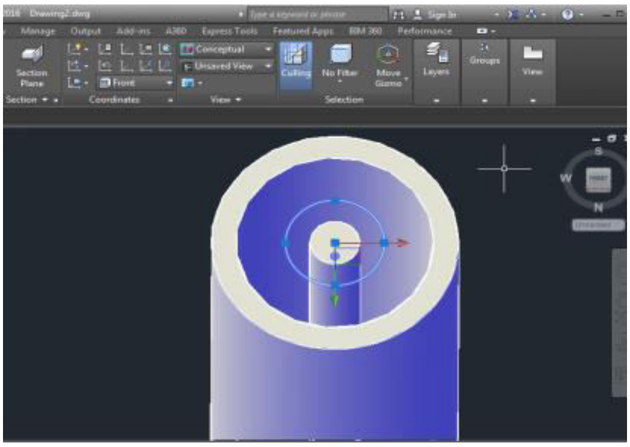


Fig. 6.2 Right view.

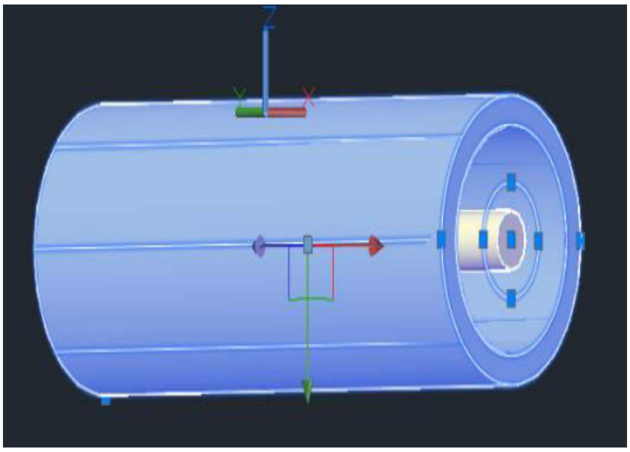


Fig.6.3 Side view.

1.MATLAB Simulink:

The Condenser Evaporator (2P-MA) block can operate as either a condenser or an evaporator. In the condenser case, heat flows from the refrigerant to the moist air. This causes the refrigerant to condense from a superheated vapor to a two-phase mixture to a subcooled liquid, resulting in up to three fluid zones along the length of the condenser tubes. In the evaporator case, heat flows from the moist air to the refrigerant. If the moist air is sufficiently wet, water vapor condenses on the surface and is removed from the rest of the moist air flow.

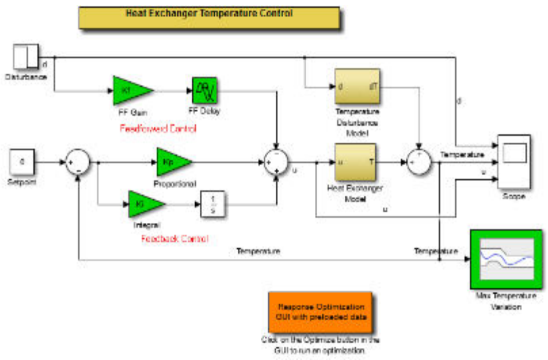


Fig .6.4 MATLAB simulation modelling Optimize plotting.

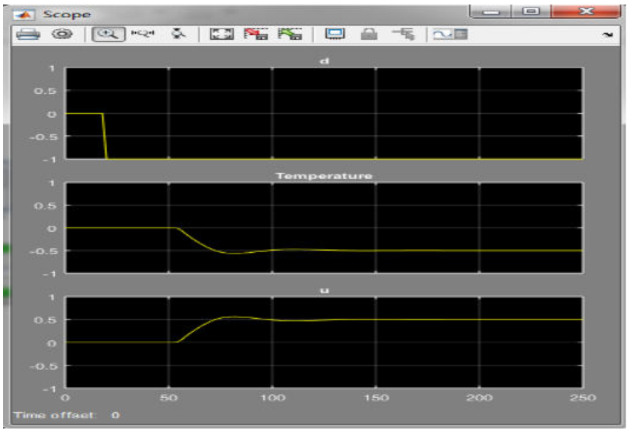


Fig.6.5 Temperature and Heat flow Rate across time scale.

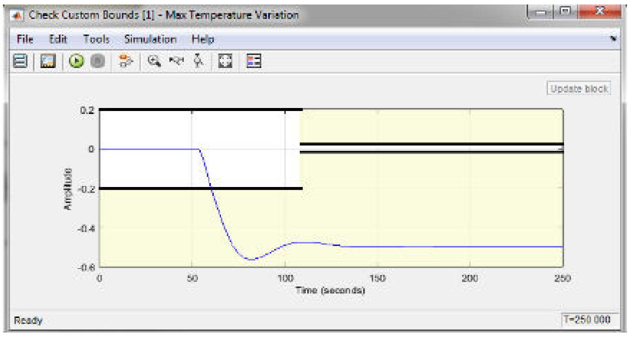


Fig.6.7. Temprature variation across time shows constant time period at 120s otherwise shows steady state time scale.

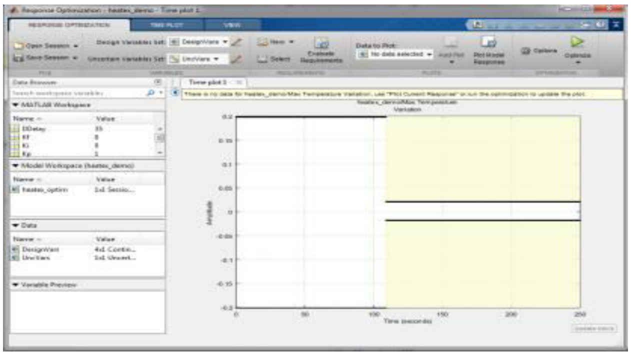
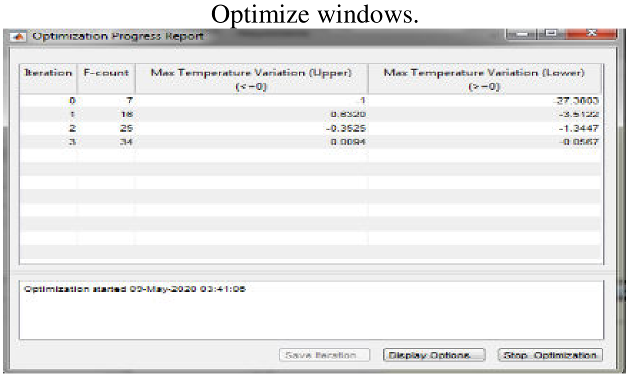


Fig.7.7 Theses windows are indicates Optimize windows.



Iteration	F-count	Max Temperature Variation (Upper) (<=0)	Max Temperature Variation (Lower) (>=0)
0	7	1	-27.3603
1	18	0.8320	-3.5122
2	25	-0.3525	-1.3447
3	34	0.0084	-0.0567

Fig.6.8 GA based iteration and optimization of temperature scale.

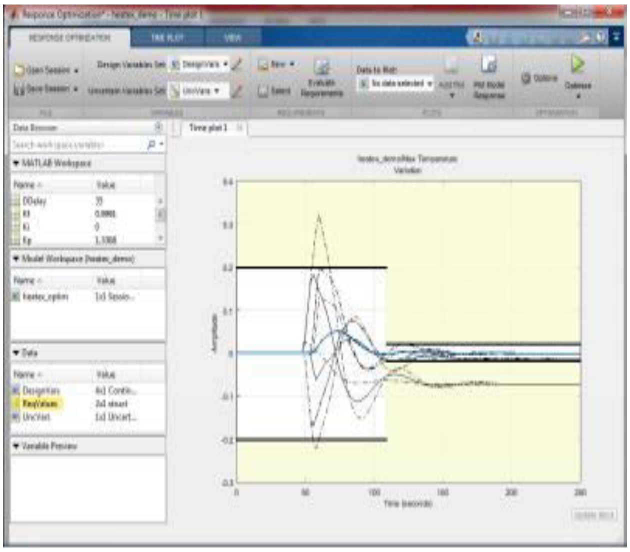


Fig.6.9 Optimization of time scale and reduction of fluctuation at blow of 120 second.

VII. CONCLUSIONS

In this thesis, are improvement of double tube heat exchanger performance and optimization of temperature fluctuation using Genetic algorithm. We optimization of temperature steady state time 100s Blow. The dynamic operation of a thermal plant generator-battery plant in off grid power supply is simulated in Power Factory. The primary and secondary control of active power is considered to compensate the active power fluctuations, which result from the variations of the load and PV field power. Four control strategies are proposed to represent different contribution to the primary and secondary control between the battery energy storage system (BESS) and the diesel generators.

1. Control strategy (1): the primary control is provided by the diesel generators and the BESS in parallel, and the secondary control is provided only by the BESS.
2. Control strategy (2): the primary and secondary control is provided by the diesel generators and the BESS in parallel.
3. Control strategy (3): the primary and secondary control is provided mainly by the BESS.
4. Control strategy (4): the primary control is provided mainly by the BESS, while the secondary control is provided by the diesel generators and the BESS in parallel.

The control strategies are compared according to four criterions; the frequency deviations, fuel consumption, the expected lifetime of the batteries and the performance of the diesel generators.

The results show that each control strategy leads to a different level of variations in the output power of the diesel generators and the BESS. Control strategy (3) leads to more constant output power close to the nominal value of the diesel generators, whereas control strategy (2) leads to a higher level of variations in the output power of the diesel generators, while control strategy (4) and (1) lead to the second and third higher levels of the variations in the loading of the diesel generators respectively.

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