CHAPTER 2
LITERATURE SURVEY

2.1 INTRODUCTION

This chapter deals with the brief work of the earlier researchers. Some of the related and important research articles are listed and discussed below:

SelbasR. et al. [10] suggested that genetic algorithms (GA) can be effectively applied for the optimal design of shell and tube heat exchanger by varying the design variables. From the study he inferred that the combinatorial algorithms such as genetic algorithms gave significant improvement in the optimal designs compared to the conventional designs. Genetic algorithm was significantly fast in determining global minimum cost and has greater advantage in obtaining multiple solutions over different methods of same quality.

Ortega J.M. et al. [11] carried out simple algorithm for the design and economic improvement of multi-phase 1-2 shell and tube heat exchanger in series. The design model planned utilizing the F routine strategy and inequality constraints that guarantee attainable and straightforward expressions were obtained for of 1-2 shells and tube arrangement.

Ozcelik Y. et al. [12] reported that many thousands of alternative shell and tube heat exchangers may be examined by varying the large number of parameters such as tube length, tube outer diameter, pitch size, layout angle, baffle space ratio, number of tube side passes for which a genetic based algorithm was developed, programmed, and applied to estimate the optimum values of discrete and continuous variables of the MINLP (mixed integer nonlinear programming) test problems. Finally, the genetic based algorithm was extended to make parametric studies and to find optimum configuration of heat exchangers by minimizing the sum of the annual capital cost and exergy cost.
Sanaye et al. [13] considered effectiveness and total cost are the two critical parameters as objective functions in heat exchanger design. Seven outline parameters are considered for optimal design. It was first thermally demonstrated utilizing NTU technique while Bell Delaware methodology was applied to fine its shell side heat transfer coefficient and pressure drop. Fast and elitist non-dominated sorting genetic algorithm (NSGA-II) with persistent and discrete variables was applied to get the greatest efficiency and the minimum total cost as two objective functions.

Fettaka et al. [14] discussed on multi-objective optimization of the heat transfer area and pumping force of a shell and tube heat exchanger was introduced to furnish the designer with various Pareto front arrangements which catch the trade-off between the two objectives. The enhancement was performed utilizing the quick and elitist non-dominated sorting genetic algorithm (NSGA-II) accessible in MATLAB. The algorithm was utilized to decide the effect of utilizing the continuous values of the tube length, diameter and thickness as opposed to utilizing discrete standard industrial values to get optimal area and pumping power. Moreover, it was found that discretization of the tube length, width and thickness had an exceptionally minor impact on the ideal cost plan.

Ahmadi P. et al. [15] formulated an optimal design for cross flow heat exchanger in order to minimize and entropy generation. An NTU method was applied for estimation of the heat exchanger pressure drop, as well as effectiveness. Fast and elitist non-dominated sorting genetic algorithm (i.e., NSGA II) was applied to minimize the entropy generation units and the total annual cost (sum of initial investment and operating and maintenance costs) simultaneously. It reveals that any geometrical changes, which decrease the number of entropy generation units, lead to an increase in the total annual cost and vice versa.

Hajabdollahi H. et al. [16] worked on thermo-economic optimization of a shell and tube condenser, based on two new optimization methods, namely genetic and particle swarm (PS) algorithms. It was found that GA provides better results for computer CPU running time, compared to PS algorithm. Finally, a sensitivity analysis of design
parameters at the optimal point was conducted. Results showed that an increase in the tube number leads to decrease in the objective function first then it leads to a considerable increment in objective function. It has better results as well as less CPU running time.

Costa L.H. et al.[17] carried out the optimization on shell and tube heat exchanger by minimizing of the surface area including discrete variables. The optimization was based on search count table where constraints were established in such way to eliminate non-optimal alternatives. It reduces the number of rating run executed. The work carried out for the reduction of computational by specifying feasibility tests and fathoming procedures.

Eryener et al. [21] investigated the determination of the optimum baffle spacing by using the thermo-economic analysis. He demonstrated the effect of optimum ratio of baffle spacing to shell diameter by varying the values of geometrical parameters. Hence optimum baffle spacing is a powerful tool for the thermo-economic analysis of heat exchanger.

Soltan B.K. et al. [22] analysed the optimum baffle spacing for segmentally baffled shell and tube condensers. Total costs of heat transfer area and pumping power were involved to perform objective function, using a weight factor, which depends on the economic conditions of the desired location. A set of correlation was presented in order to determine the optimum baffle spacing.

Huadong Li et al. [23] considered local heat transfer and pressure drop on the shell side were investigated for different baffle spacing. Increasing baffle spacing can increase the heat transfer coefficient in the whole baffle compartment both due to the reduction of the percentage of the leakage stream and due to the higher flow velocity through the baffle opening. The local heat transfer coefficient distribution at an individual tube was slightly affected by the baffle spacing.
Gaddis et al. [30] presented a procedure for evaluating the shell side pressure drop in shell and tube heat exchangers with segmental baffles. It takes into account the influence of leakage and bypass streams, and pressure drop in a window section from the Delaware method. The proposed equations were checked by comparing experimental measurements.

Serna M. et al. [32] reported an analytical expression that relates the pressure drop, the exchanger area and the film heat transfer coefficient for the shell side of a shell and tube heat exchanger was reported. The numerical equations were based on the Bell–Delaware method. The mathematical approach used for formulation can be extended to other heat exchanger systems to provide suitable compact pressure drop relationships.

Babu B.V et al. [33] studied that lakhs of configurations are possible for shell and tube heat exchanger with different variables for example outer diameter, pitch, and length of the tubes, tube passes, baffle spacing, baffle cut, etc. Differential evolution (DE) was an enhanced adaptation of genetic algorithms (GAs), has been effectively applied with various techniques for 1,61,280 outline designs utilizing Bell's method to determine the heat transfer area. In the utilization of DE, 9680 mixes of the key parameters were considered. It was found that DE, an especially straightforward advancement system, fundamentally quicker compared with GA and yields the global optimum for an extensive variety of the key parameters.

Srinivas N. et al. [34] discussed on tackling multi-objective issues, on an arrangement of Pareto-front rather than a single point. The author investigated Goldberg's notion of non-dominated sorting in genetic algorithm to find multiple Pareto-optimal points simultaneously. The method applied can be extended to higher dimensional and more multi-objective problems. The results revealed that a non-dominated sorting genetic algorithm (NSGA) can be applied to few multiple Pareto optimal solutions.
Kara. Y.A. et al. [35] studied the preliminary design of shell and tube heat exchangers with single phase fluid stream both on shell and tube side. The project covers segmental baffled U-tube, and fixed tube sheet heat exchangers one pass and two pass on tube side. The system decides the general measurements of the shell, the tube bundle, and ideal heat exchange surface area required to meet the predetermined reasonable shell side pressure drop. The exchanger covers fixed tube sheet with one pass and two pass, and U-tube for E-sort shell. The project can be stretched out to various exchanger designs, for example, square pitch, 4or 6 tube-pass, and so forth by embedding data from tube counts.

Muralikrishna K. et al. [36] analysed the procedure on Kern's technique, which gives a good model to tube side forecasts. Each point on the curves of shell side versus tube side pressure drop relates to a special outline as far as tube length, shell distance and baffle spacing. The area target guarantees an exchanger of the smallest size with least capital expense, while the cost target yields the ideal pressure drops representing the exchange off between power consumption and heat exchanger area. Kern's relationships for the shell side give sensible forecasts when the baffle cut was 25% and the ratio of baffle spacing to shell diameter was unity.

Mohanty et al. [37] deliberate the shell and tube heat exchanger optimization design with respect to the total annual cost by application of Firefly algorithm. The developed algorithm is applied to two case studies and the results shown that the operating cost can be reduced by 77% while the total cost can be reduced by 29% as compared to the original design.

Mizutani F.T. et al. [39] proposed the model that decides the heat exchanger network by minimizing the aggregate annualized cost representing area, pumping, and utility costs. The model depends upon disjunctive programming and was upgraded with the logic based external approximation strategy. Upper limits for the general heat exchange coefficients and LMTD were incorporated for target function. The application and handiness of the proposed technique have been appeared in three case
issues of expanding multifaceted nature. The outcomes show the strategy can legitimately represent the trade-offs between area, pumping, and utility expenses.

Abbass et al. [40] deliberated on differential evolution (DE) algorithm to handle optimization problems over continuous domains. The objective is to introduce a novel Pareto Differential Evolution (PDE) algorithm to solve Vector Optimization problems. The approach generates a step by mutation, where the step is generated from a Gaussian distribution and the approach is competitive to most other approaches.

Abdelaziz et al. [41] discussed the process of allocating the required load between the available generation units such that the cost of operation is minimized. The Economic Load Dispatch (ELD) problem is formulated as a nonlinear constrained optimization problem with both equality and inequality constraints. The dual-objective Combined Economic Emission Dispatch (CEED) problem is considering the environmental impacts that accumulated from emission of gaseous pollutants of fossil-fuelled power plants.

Agarwal et al. [42] analysed the single and multi-objective optimal design of a shell and tube heat exchanger then carried out using the new Jumping Gene adaptation of NSGA-II. The optimal design is carried out using a compact formulation of the Bell–Delaware method.

Gonidakis et al. [43] carried out simultaneous minimization of fuel cost and emission output, are the two objectives that collide. Furthermore the violation of specific constraints must be avoided. Environmental / economic dispatch is solved applying a new meta-heuristic optimization method, namely flower pollination algorithm. The multi-objective environmental / economic dispatch problem can be described by polynomial objective functions.

Lee et al. [44] reported harmony search (HS) meta-heuristic algorithm-based approach for engineering optimization problems with continuous design variables.
If there is more than one local optimum in the problem, the result may depend on the selection of an initial point, and the obtained optimal solution may not necessarily be the global optimum. It uses a stochastic random search instead of a gradient search so that derivative information is unnecessary.

Dubey et al. [45] presented a solution of dynamic multi objective optimal dispatch (DMOOD) for wind-thermal system using a hybrid flower pollination algorithm (HFPA). Simultaneous minimization of cost, emission and losses is carried out with complex constraints like valve point loadings, ramp limits, prohibited zones and spinning reserve. The cost of wind power uncertainty is also included in the cost function by using a probability density function model.

Lee et al. [46] proposed an efficient optimization method for structures with discrete-sized variables based on the harmony search (HS) heuristic algorithm. The recently developed HS algorithm was conceptualized using the musical process of searching for a perfect state of harmony. It uses a stochastic random search instead of a gradient search so that derivative information is unnecessary. The HS algorithm can also be applied to other types of structural optimization problems, including frame structures, plates, and shells.

Madhavan et al. [47] suggest the Differential Evolution algorithm can be extended to multi-objective optimization problems by using a Pareto-based approach. The approach incorporates a non-dominated sorting and ranking selection. It combines the robust and effective DE strategy as the key elements of the NSGA-II algorithm.

Mishra et al. [48] analysed the genetic algorithm takes care of large number of continuous as well as discrete variables in the presence of given constraints. The optimization program aims at minimising the number of entropy generation units for specified heat duty under given space restrictions. A genetic algorithm based optimisation technique has been developed for crossflow plate-fin exchangers using offset-strip fins.
Sayadi et al. [49] proposed firefly algorithm is basically for continuous optimization problems. But lots of practical problems are formulated in discrete methods hence discrete optimization is required. The main purpose of is to present the discrete firefly algorithm (DFA) to solve discrete optimization problems. The cell formation problems were solved by using this algorithm.

Queipo et al. [50] electronics cooling, where it is required to find optimal or nearly optimal arrangements for convectively cool components placed in-line on the bottom wall of a ventilated two-dimensional channel. The study shows that genetic algorithms allow a cost-effective approach for investigating highly complex numerical or experimental thermo sciences problems where it is desirable to obtain an acceptable problem solutions.

Saravanan et al. [51] focus on concentrates on optimising the machining parameters for turning cylindrical stock into continuous finished profile. The machining performance is measured by the production cost. Due to high complexity of this machining optimisation problem, a simulated annealing (SA) and genetic algorithm (GA) are applied to resolve the problem.

Udaiyakumar et al. [52] chosen Firefly algorithm (FA) for Job shop scheduling problem and to find the minimization of makespan using 1-25 Lawrance problems. Most of them are categorised into non polynomial deterministic (NP) hard problem because of its complexity.

Schmit et al. [53] predicted the performance of compact high intensity cooler (CHIC) units, permitting design optimization. Most optimization techniques depend on continuous variables, while in the design of CHIC unit many of the critical geometrical variables must assume discrete values. A genetic algorithm that looks for an optimum by simulating an evolutionary process was found to be satisfactory for this problem with its mixture of discrete and continuous variables.
Vasebi et al. [54] discussed the optimal utilization of multiple combined heat and power (CHP) systems and it is a complicated problem that needs powerful methods to solve. This presents a harmony search (HS) algorithm to solve the combined heat and power economic dispatch (CHPED) problem.

Wisittipanich et al. [55] reported a multi-objective differential evolution algorithm, called MODE, to search for a set of non-dominated solutions on the Pareto front. During the iterative search process, the non-dominated solutions found are stored as the ‘Elite group’ of solutions. Five potential mutation strategies with distinct search behaviour are proposed to obtain the high quality Pareto front.

Zarei et al. [56] presented a harmony search (HS) algorithm to determine the optimum cutting parameters for multi-pass face-milling. The optimum value of machining parameters number of passes, depth of cut in each pass, speed and feed is obtained to minimize total cost while considering technological constraints such as allowable speed, feed, surface finish, tool life and machine tool capabilities.

Yang et al. [57] developed the algorithms needed to solve multi-objective problems. Multi-objective optimization problems are typically very difficult to solve. Cuckoo search uses a combination of vectorized mutation, crossover by permutation and Le´vy flights and selective elitism among the best solutions.

Yang et al. [58] proposed a new meta-heuristic method, the bat algorithm, based on the echolocation behaviour of bats. The fine adjustment of the parameters $\alpha$ and $\beta$ can affect the convergence rate of the bat algorithm. Though the implementation is more complicated than many other meta-heuristic algorithms; however, it does show that it utilizes a balanced combination of the advantages of existing successful algorithms with innovative feature based on the echolocation behaviour of bats. New solutions are generated by adjusting frequencies, loudness and pulse emission rates, while the proposed solution is accepted or not depends on the quality of the solutions controlled or
characterized by loudness and pulse rate which are in turn related to the closeness or the fitness of the locations/solution to the global optimal solution.

Yang et al. [59] reported the firefly algorithm has expanded dramatically with diverse applications and have gained popularity due to dealing with nonlinear global optimisation problems. Firefly algorithm finds optimal balance, and it can provide a good balance of exploitation and exploration. However, firefly algorithm requires far fewer function evaluations.

Khosravi R. et al. [60] studied the optimization performances of genetic algorithm, firefly algorithm, and cuckoo search method were comprehensively examined for the design of shell and tube heat exchangers. NTU method and Bell-Delaware procedure were used for thermal modelling of shell and tube heat exchanger. It was found that genetic algorithm cannot find permissible design configurations in the majority of simulation replicates. In contrast, firefly algorithm finds permissible and optimal values design variables regardless of search start in point. The results pointed out the ranges for design variables so as to get minimum number of iterations and minimum computational time.

Yang et al. [61] described the flower pollination is an intriguing process in the natural world. Its evolutionary characteristics can be used to design new optimization algorithms. For simplicity, it is assumed to be that each flower only produce one pollen gamete, this simplifies the implementation greatly. However, to assign each flower with multiple pollen gametes and each plant with multiple flowers can have some advantages for some applications such as image compression, multi-objective optimization, and graph colouring.

Benoît et al. [62] developed the procedure of first using the pinch analysis to maximize heat recovery for a given minimum temperature difference. Using a genetic algorithm (GA), each exchanger of the network was designed in order to minimize its total annual cost. Combining every exchanger minimized cost with the cost of hot utility and cold utility gives the total cost of the heat exchanger
network for a particular $\Delta T_{\text{min}}$. The minimum temperature difference yielding the more economical heat exchanger network was chosen as the optimal solution.

**Poddar T.K. et al. [63]** discussed the relationships between heat duty and tube length, pressure drop and tube length, etc. for a range of diameters. The data is then used obviously demonstrate the full range of geometries that were appropriate for a given heat duty and given limitations. The linear relationship between design margin and tube length were considered for reducing design space and also the relationship between pressure drops and design space was found to be linear. The philosophy was first to use the constraints placed upon the design to reduce the possible design space quickly and systematically.

**Tremblay P. et al. [65]** has given a procedure for minimizing the cost using genetic algorithm (GA) for shell and tube heat exchanger. Eleven design variables were associated with shell and tube heat exchanger geometries such as tube pitch, tube layout patterns, number of tube passes, baffle spacing at the centre and so on. Evaluations of the heat exchangers performances were based on an adapted version of the Bell–Delaware method and pressure drops constraints were included in the procedure.

**Ozkol I. et al. [66]** analysed the design for the best-fitting heat exchanger in energy-converting systems. In order to obtain the optimum heat exchanger, the geometry, the number of heat transfer units (NTU), and the pressure drop must be in harmony such that the requirements will be satisfied. The most important feature of the study, which makes it distinguishable from others, was the determination of optimum geometry, given performance limits, using a genetic algorithm.

**Patel V.K. et al. [67]** study explores the use of a non-traditional optimization technique called particle swarm optimization (PSO), for design optimization of shell-and-tube heat exchangers from economic view point. Minimization of total annual cost was considered as an objective function. The results of optimization using PSO technique were compared with those obtained by using genetic algorithm (GA).
Sadeghzadeh H. et al. [68] discussed both the genetic and particle swarm algorithms in the design of techno-economically optimum shell and tube heat exchangers. A comparison of the results obtained by the two algorithms showed that results obtained with the particle swarm optimization method were superior to those obtained with the genetic algorithm method.

Sahin et al. [69] considered Artificial Bee Colony (ABC) algorithm to minimize the total cost of the shell and tube heat exchanger. The total cost decrease in all the case studies for similar operating conditions. Artificial Bee Colony (ABC) method was found to be the most accurate and quick according to traditional methods. The method used was Bell method for numerical analysis.

Chaudhuri. P.D. et al. [70] deliberated that simulated annealing (SA) was found to be well suited for a large-scale discrete optimization problem of a heat exchanger. The analyses were performed using two different objective functions namely, total heat transfer area and a linearized purchased cost index. It was observed that, in almost all cases, the optimum designs obtained using the simulated annealing algorithm yield better performance or cost functions compared to the base case (Amoco) designs. It has also been shown that an improvement in heat exchanger designs was achievable by extending the variable set to include a larger set of design alternatives. Simulated annealing offers great computational savings (in terms of CPU time) as a search strategy and has been found to be a robust technique for the optimal design of heat exchangers subject to process infeasibilities and vibration constraints.

Fesanghary et al. [71] explored the use of global sensitivity analysis (GSA) and harmony search algorithm (HSA) for design optimization of shell and tube heat exchangers (STHX’s) from the economic viewpoint. To reduce the size of the optimization problem, non-influential geometrical parameters which have the least effect on total cost of STHX’s are identified using GSA. The HSA was applied to optimize the influential geometrical parameters.
Xie et al. [75] investigated a plate fin type Compact Heat Exchanger (CHE) for optimization using Genetic Algorithm (GA). The minimum total volume or total annual cost was taken as objective function. Performance of the CHE was evaluated according to the conditions of the structure sizes that the GA generated, and the corresponding volume and cost were calculated. The results shown that with pressure drop constraints compact heat exchanger was 30% lower volume and without pressure drop constraints the heat exchanger was 49% lower volume.

Belanger S. et al. [92] developed a model to simulate a cross flow heat exchanger including fins and thermoelectric generators were provided in the wall. The model was optimized based on several objective functions they were total volume, total number of thermoelectric modules, power output and pumping power. Pareto fronts were achieved with a multi-objective genetic algorithm and the result showed that the number of sub-channels has larger impact on the overall performance than the fin geometry in cross flow heat exchanger.

Asadi et al. [103] considered annual cost as the objective function for improvement of economic heat exchanger structures. The ideal results acquired by the CSA calculation were vastly improved than the best arrangements got by the existed strategies GA and PSO. The results showed that using the CSA algorithm saving energy was possible by 77%. Reduction of investment cost was 9.4% and 13.1% in CSA compared to GA and PSO. The approach carried out was Kern method.

Antonio C. Caputo et al. [104] reported optimal configuration for shell and tube heat exchangers which uses a genetic algorithm to minimize the total cost which includes pumping cost and capital investment. The lessening in capital investment can be acquired furthermore the best results were obtained through the decrease of working costs identified with pumping losses. The strategy can be exploited and energy can be saved in industrial plants.
Taal M. et al. [106] analysed the cost estimation of a heat exchanger and its influences on profitability and on man power. It showed the relevance method and source of energy price forecast choosing between alternative re-fit projects or when attempting to determine the stability of a retrofit job. The measure of time accessible to make the assessment was influencing the nature of the result.

Jiangfeng et al. [107] deliberated that in shell and tube heat exchanger optimization the dimensionless entropy generation rate was taken as an objective function. The function was scaled in the ratio of the heat transfer rate to the inlet temperature of cold fluid. The heat exchanger effectiveness was increased significantly and the pumping power was decreased dramatically. The benefit from the increase of the heat exchanger effectiveness was much more than the increasing cost of the pumping power. Therefore the modified entropy generation number was preferred in the heat exchanger optimization design applications.

Kapale et al. [114] developed a theoretical model for shell side pressure drop. The model incorporates the effect of pressure drop in inlet and outlet nozzles along with the losses in the segments created by baffles. The results of the model for Reynolds numbers lying between 103 and 105 match more closely with the experimental results available in the literature compared to analytical models developed by other researchers for different configurations of heat exchangers.

Halle H. et al. [116] examined to predict pressure drop and heat transfer accurately. He gave experimental results of the shell side pressure drop for 24 different segmentally baffled bundle configurations in a 0.6-m (24-in.) diameter by 3.7-m (12-ft) long shell with single inlet and outlet nozzles. The experimental results were given and correlated with a pressure drop versus flow rate relationship. It provides the basis for the evaluation of various pressure drop prediction models.

Hadidi at al. [120] investigated the traditional design approaches were time consuming and do not guarantee the reach of an economically optimal
solution. Hence a new shell and tube heat exchanger optimization design approach was developed based on biogeography based optimization (BBO) algorithm. The result revealed reduction of capital investment up to 14% and savings in operating costs up to 96% were obtained, with an overall decrease of total cost up to 56.1%, showing the improvement potential of the proposed method.

Sun S. et al. [124] developed a mathematical simulation for transient heat in shell-tube heat exchanger and a model for optimization design was proposed in which the objective function was the total entropy generation rate (TEGR), with consideration giving to both heat transfer and flow resistance. The value of the TEGR was reduced by a factor of 45.21%, and the pressure loss was decreased in the tube side.

Moita R.D. et al. [125] demonstrated that the flow arrangement in 1-2 multiple shell and tube heat exchangers involves part counter-current flow and part co-current flow. The fact was accounted for in the design by introducing a correction factor. Also a new strategy design algorithm was introduced to allow the best choice between the existing XP approaches based on the heat exchanger cost minimisation.

2.2 SUMMARY OF THE LITERATURE

On reviewing the literature, it is found that the optimization can be carried out by numerous configurations for a shell and tube heat exchangers. Different researchers were used different heuristic and meta-heuristic algorithms which follows the behaviour of biological systems to obtain closer solutions towards the exact ones. Mohanty at el. [37] used fire fly algorithm for optimization of shell and tube heat exchanger using Kern method. The same problem is investigated using different meta-heuristic method called flower pollination algorithm in order to find out better optimal solution and to attain more closeness towards exact solution.

Many researchers have demonstrated the usefulness of multi-objective function using GA and compared with other algorithms like PSO, ABC, BBO etc. In this regard, Sanaye et al. [13] has chosen a case study from the open literature and he optimized using genetic algorithm for 45° tube layout but not shown the effect of
other tube layouts. In the present research work, the reason for choosing 45° tube layout and the effects of other tube layouts 30° and 90° are discussed using genetic algorithm. Further, the comparison of Pareto front from multi-objective optimization with single objective optimization has not been carried out by any of the researchers. Hence a new meta-heuristic algorithm called cuckoo search algorithm is used for comparison with genetic algorithm in the present work. From the literature survey, it is found that application of bat algorithm for optimization of shell and tube heat exchangers has not been carried out so far. Hence, bat algorithm is chosen for multi-objective optimization based on Bell-Delaware method and single objective optimization based on Kern method in the present work.

Most of the researchers have used either Bell-Delaware or Kern method for optimization of pressure drop. But, Bell-Delaware method itself does not predict the pressure drop values close to experimental values. Kern method is simple in calculations, does not account any leakages at all. FEM based pressure drop model developed by Parikshit et al. [38] predicts the theoretical pressure drop more close to experimental values. Till now no paper has been found on optimization of pressure drop using FEM method for a shell and tube heat exchanger. Hence in the present work for optimization a pressure drop model based on FEM is considered.