Research Article

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Study on the random walk classification algorithm of polyant colony

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Abstract: With the sustained and healthy development of economy, saving energy and reducing consumption and improving energy utilization rate is a major task that enterprises need to solve. With the complex and large-scale chemical process, the heat exchange network has become complex and diverse. For more and more complex and large-scale industrial heat exchange networks, there are many different kinds of heat exchangers, the flow is complex, so the heat exchange network presents a high degree of complexity, a node status change; its disturbance transfer will influence the stability of other nodes associated with it, because of the system coupling, thus affecting the controllability and reliability of the whole heat exchanger network. Process optimization design of heat exchange network is one of the main methods of energy saving in the industrial field. As a typical simulated evolutionary algorithm in swarm intelligence algorithm, ant colony algorithm combined with random walk classification algorithm, this article proposes an optimized heat transfer network based on multi-ant colony random walk classification algorithm. The heat exchanger was abstracted as a node, and the heat exchanger pipeline was abstracted as a side. According to the maximum geometric multiplicity of the eigenvalue of the adjacency matrix and the linear correlation row vector of the matrix, and combining the importance of the edge of the heat exchange network with the controllable range of the driving edge, the optimal control driving edge of the heat exchange network is identified. The results show that compared with the traditional heat exchanger, the size of the enhanced heat transfer equipment and the influence of pressure drop change. Compared with the results of the size of the heat exchanger strengthening heat transfer equipment and the stepwise optimization of the heat exchange network in this study, the cost of public engineering is reduced by 5.98% and the total cost is reduced by 8.83%.

Keywords: ant colony algorithm, random walk classification, heat exchange network, optimize

1 Introduction

Heat exchange network is one of the important subsystems of a chemical process. Its importance is mainly reflected in security. With the large-scale and complicated heat exchange network, the research on its safe operation and control becomes more and more important. Due to the coupling of the system, if there is a problem in some key heat exchangers or critical heat exchange pipelines, the disturbance fluctuation caused by the problem will affect a wide range, and in serious cases, the whole process may be paralyzed [1–3]. In order to prevent the occurrence of accidents, it is necessary to identify the key heat exchanger and the key heat exchange pipeline, carry out key protection and monitoring, and timely control and reduce the impact caused by disturbance fluctuation [4]. Research on heat exchange network control has gone through two development stages, and these two stages are the initial stage and the mature stage, but so far it has not been well applied in industry. The main reason is that the implementation of control measures on heat exchange networks often greatly increases production cost. The current research on heat exchange network control cannot give consideration to economy and effectiveness.

The heat exchange network is one of the important subsystems of a chemical process. The chemical process includes the processing of chemical substances or the processing of chemical materials and the like. With the large-scale and complicated heat exchange network, the research on its safe operation and control becomes more and more important. Due to the coupling of the system, the research on the first stage of the network control of heat exchange for some key heat exchangers or critical heat exchange pipes is mainly about the design and

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research of the heat exchange network control margin, and the main purpose is to leave some operating space for the later production control [5,6]. Hot facilities are heated by low-pressure, medium-pressure, and high-pressure steam, while cold facilities are cooled by circulating water, deep water, and chilled water, which work together in a cycle. Heat exchange network synthesis is involved in logistics and heat transfer, and heat transfer structure is a reasonable arrangement of the heat transfer between hot and cold logistics, identifying a minimum equipment investment cost and operation cost of logistics in the heating system; at the same time to meet the process requirements in heat flow stream temperatures [7–9], the equipment investment cost mainly depends on the quantity of heat exchanger and the heat transfer area, and operating cost depends on the utility consumption. Utility is the logistics of providing heat (hot utility) or cold (cold utility) to the production process outside the system. The most common thermal utilities include low-, medium-, and high-pressure steam, while cold utilities include circulating water, deep well water, and chilled water [10]. Broadly speaking, the network of heat exchangers consists of two parts, one is the logistics that requires heat transfer, and the other is the public works that participate in heat transfer. When the heat transfer logistics in the system have heat transfer, but cannot meet the process requirements, it needs to call the public works from the outside to participate in heat transfer, so the public works involved in heat transfer also belong to the whole system. From the perspective of system engineering, the production system is an integral part of a multi-system structure composed of a process system, heat exchange network system, and public engineering system. In the optimization and synthesis of it, both the production process system and public engineering system should be considered to make the three matches [11–14]. Therefore, the optimization and synthesis are to take the overall consideration of the production system, take energy saving and consumption reduction as the purpose, and study these systems with reasonable optimization and synthesis methods, so as to achieve the system's optimal or sub-optimal, which is the system optimization and synthesis. Based on the dynamic elasticity of the heat exchange network, Zhou and Li [15] proposed the DOF analysis method for the number of bypasses. Onishi et al. [13] further proposed the optimization solution method for the heat exchange area and bypass opening of the heat exchanger. The calculation process of his research is relatively complicated, and the practical operation is not strong. Hou et al. [16] adopted a GA/SA hybrid algorithm to optimize the shunt heat transfer network and improved the optimization accuracy of the algorithm by dynamically adjusting algorithm parameters and population size. Laborde et al. [17] adopted a two-layer (improved particle swarm optimization) algorithm to optimize the outer layer structure. The inner layer was used to optimize the shunt ratio and heat transfer according to the outer layer structure.

Some people also suggest that Antcolonyoptimization heat exchange network. Lahiri and Khalfe [18] suggest that NACO–FMD algorithm is based on Antcolonyoptimization. The heuristic function of ant colony optimization was redesigned based on network topology information and Geneontology. Gene ontology is an ontology widely used in the field of bioinformatics, which covers three aspects of biology: cellular components, molecular functions, and biological processes, and good detection results were obtained. The algorithm first generates a large number of agents and puts them into the evolutionary environment. Then, the population evolution is realized by random walk and three kinds of evolution operators and good results are obtained. Mulani et al. [19] proposed the application of an artificial fish swarm algorithm in the detection of functional modules. This method simulates the foraging, rear-end, and clustering behavior of artificial fish to complete the clustering and obtains better precision and recall rate. Cao and Wang [20] improved the artificial bee colony and applied it to the function module detection, adding mechanisms such as inertia weight and disturbance factor. His research has a relatively high probability of finding loopholes and overall lack of accuracy. Compared with the standard artificial bee colony algorithm, they achieved higher accuracy. The basic idea of applying ant colony algorithm to the optimization problem is as follows: the ant's walking path is used to represent the feasible solution of the problem to be optimized, and all paths of the entire ant colony constitute the solution space of the problem to be optimized [21–23]. Ants with shorter paths release more pheromones. As time goes on, the concentration of pheromones accumulated on shorter paths gradually increases, and the number of ants choosing this path also increases. Finally, the whole ant will focus on the optimal path under the action of positive feedback, and the corresponding optimal solution of the problem to be optimized will be. Therefore, improving the optimization efficiency and precision of the shunt heat transfer network is the key to research.

Many researchers have studied the bypass design of a heat exchange network, but the bypass design is still not well applied in industrial practice, mainly because the bypass design needs to improve the heat exchanger's heat exchange area, and the bypass that has been opened reduces the energy utilization efficiency, increases the production cost, and the economic benefit is not ideal [24,25]. Bypass design research has opened up a new direction of research on the controllability of heat exchange networks, which has certain practical significance. However, the limitations of this method in terms of economic benefits make it unable to be well applied to actual industrial production. For this reason, it is necessary to find another heat exchange network control method that takes into account both economy and controllability. In this article, the heat exchanger is abstracted as a node, and the heat exchanger pipeline is abstracted as a side. Considering the local importance of nodes, based on the theory of ant colony algorithm and random walk classification algorithm, a heat exchange network node importance evaluation method based on a multi-colony ant colony random walk classification algorithm was proposed to obtain the local importance evaluation data of nodes. Combining the results of two different algorithms, the key heat exchanger is identified. Finally, based on the theory of multi-colony ant random walk classification algorithm, according to the maximum geometric multiplicity of the eigenvalue of the adjacency matrix and the linear correlation row vectors of the matrix, and combining the importance of the edge of the heat exchange network with the controllable range of the driving edge, the optimal control driving edge of the heat exchange network is identified. The results show that this method is feasible and can effectively evaluate the importance of each node and edge of the heat exchange network, and can further identify the optimal control driving edge group of the heat exchange network, providing theoretical guidance for improving the safety and stability of the heat exchange network.

2 Proposed method

2.1 Ant colony optimization

In the process of searching for food, the ant colony communicates with each other through a pheromone substance, so as to find the shortest path to the food source. Through this behavior, the researchers proposed the ant colony optimization algorithm. Ant colony optimization is derived from the foraging behavior of real ant colonies. Biologists have found through a large number of studies that the shortest path between the food source and the nest of an ant colony can be found during the foraging process because the individual of the ant colony can leave a special substance – pheromone – on the path and becomes a clue for other ants to find food or nest. When subsequent ants encounter pheromones, not only the content of pheromone can be detected, but also the basic idea of LF algorithm is as follows: firstly, the data to be clustered are randomly scattered in a two-dimensional grid. The ants then walk through the grid, picking up and dropping rules to pick up data that is isolated or less similar to the surrounding elements and placing it near data that is similar to them. The collective action of an entire colony results in the aggregation of objects belonging to the same category. After several iterations, the ant colony gets the final clustering result. Ants can move into a square of a dXd centered on itself. When moving, the similarity between data element I and surrounding data elements is calculated as follows:

$$f(i)\begin{cases}\dfrac{1}{d^2}\sum_j\left(1-\frac{s(i,j)}{\alpha}\right), & \text{if} \quad f(i)>0,\\ 0, & \text{otherwise,}\end{cases} \tag{1}$$

where j refers to the data element within the visual range dXd of ants, $s(i,j)$ represents the similarity between data element I and data element j, and the constant α is the population similarity coefficient. α is used to adjust the average density coefficient of clustering results. If α is very small, many sparse small classes may be formed to cluster elements that should belong to the same class into different classes. If α is very large, it may cause confusion among classes and cluster elements that should not belong to the same class into the same class. Therefore, α has a direct impact on the number of clustering centers and the convergence rate of the ant colony.

After the ant moves, the probability of picking up and dropping is calculated according to the similarity. The formula is as follows:

$$p_{\text{pick}}(i)=\left(\frac{k_{\text{p}}}{k_{\text{p}}+f(i)}\right)^2, \tag{2}$$

$$p_{\text{drop}}(i)=\begin{cases}2*f(i), & \text{if} \quad f(i)<k_{\text{d}},\\ 1, & \text{otherwise,}\end{cases} \tag{3}$$

where k_{p} and k_{b} are both adjustable parameters used to adjust the value range of pick-up and drop probability. The pick-up and drop rule is defined as follows: randomly generate a probability value, if the value is less than the probability of pick-up and drop model, then the ant performs the corresponding operation.

Ant colony optimization algorithm has the following characteristics: (1) self-learning habit: ant colony optimization algorithm has strong self-learning ability and can adjust its knowledge base or an organizational structure according to the change of environment, so as to realize the evolution of algorithm solving ability; (2) the parallelism: ant colony optimization algorithm has the ability of parallel computing, each ant search process independently; there is no dependency between each other, and only by residual pheromones to communicate with each other, this process of independent search the optimal solution of ants, not only increases the reliability of the algorithm, but also makes the algorithm has the stronger global searching ability; (3) positive feedback: it can be seen from the foraging process of individual ants that the shortest path for ants to finally find food is directly dependent on the accumulation of pheromones in the shortest path, and the accumulation of pheromones is a process of positive feedback; (4) validity: in the ant colony optimization algorithm, when deciding the state transition probability of ant walking direction, the introduction of a random search process, namely the heuristic factor, is related to the problem solving specific, generally defined as the specific characteristics of demanding problem space, so that we can give ant colony optimization algorithm is an initial boot, the ant individual access to random, but on the whole direction toward a solution, and greatly increase the time effectiveness of the proposed algorithm, making it possible to effective application of ant colony algorithm. Ant colony algorithm tends to choose randomly when choosing the next node. Although random selection can explore a larger task space and help to find the potential global optimal solution, it takes a long time to play the role of positive feedback, resulting in slow initial convergence of the algorithm.

2.2 Population random walk algorithm

Random motion is a general term for a series of irregular motions, Brownian motion, Markov chain, etc. In some real-world environments, these random walk states or vertices move too randomly or are completely unconstrained. The concept is close to Brownian motion, which is the ideal mathematical state of Brownian motion. Sometimes, such a completely unbiased walk in solving specific machine learning problems is not necessarily able to obtain the optimal solution, or the cost of obtaining the optimal solution is large. Therefore, this article proposes the concept of a population random walk. In short, a population random walk is a random process with constraints. In fact, similar concepts and ideas have been reflected in some traditions; it is in practical application considering the traditional random walk weak or no memory of inconvenience, proposed a “smart” migration strategy, make it in a patch of terrain environment can be biased, related, and avoid too much useless. In addition, swarm random walk makes it easy to associate us with swarm intelligence. In this aspect, combining ant colony optimization and random walk proposed an integrated method to solve the load balancing problem on the network. Most importantly, the individual ant is path-memory, able to store the points and edges it has walked. The simple intelligence of the leech is embodied in these behaviors with constraints. Above all, we are random walking on the graph of vertices gives some constraints, constraints of vertices can be a similar day slave, bees, such as artificial main body, also can have a certain intelligence, in all their behavior makes overall migration showed higher intelligence, thus more conducive to solve the problem of constraint with different strength. For different types of classification problems, we can derive different classification models according to different constraints of vertices in our population random walk learning. The random walk algorithm can be used in global optimization, so it will be helpful for us to follow in this article.

This article assumes that the order of the group of tags in L is fixed. Then, no matter what value the specific tag l is (character or numeric), the element in an integer vector Y can be used to represent the position of each tag in the corresponding tag set. In other words, $y_t = j$ means that the label of sample x_i is the fifth label in the original L, which is l_j. Given the above-mentioned conditions, the classification problem in this article emphasizes prediction Y_u. In order to be able to be combined with the random walk of, an undirected connected graph $G = (V, E, W)$ is defined. The vertex set V only corresponds to the data set (X, Y); that is, the element v_i of V corresponds to (x_i, y_i); edge set E represents connected vertex pairs, and W represents edge weights, also known as the similarity matrix in this paper. Figure 1 shows a simple example of building a graph, which contains three labeled vertices and three unlabeled vertices. Since it is a building graph, whether there is a connection between the vertices is unknown beforehand, we assume that edge set E is trivial, but the actual existence of the upper edge is closely related to whether there is a weight on the edge.

From the perspective of whether a node is labeled, a partially labeled Figure 1 can be divided into labeled and unlabeled parts, corresponding to training set X_m and test set 2, respectively. As shown in figure X_u, the basic framework of the population random walk model is that X_m can

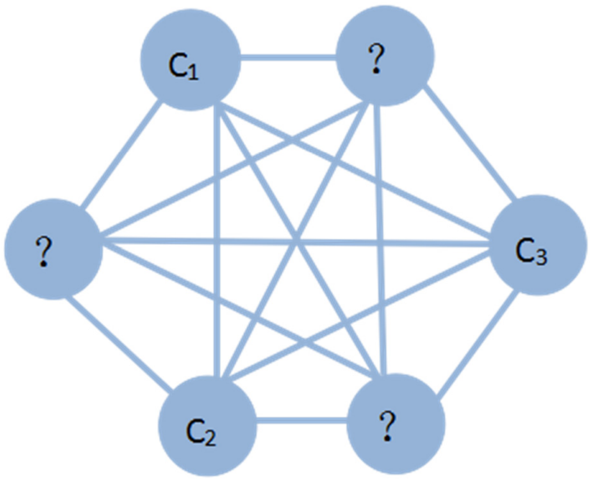

Figure 1: An example of a build diagram for a basic classification problem.

be regarded as a population and X_u as the resources required by the population.

Think of labeled vertices as simple individuals that can move around and pass along their label information, and these nodes form a community. Members of the group can move around under the guidance of the probability transition matrix P. Generally, P is calculated as follows:

$$P = D^{-1}W, \tag{4}$$

where $D_{n\times n}$ is a diagonal matrix and d_u is the sum of the i row element values in W. In other words, P is the matrix of similarity matrix 3 after row normalization. In Figure 2, P is decomposed into four submatrices, and in this

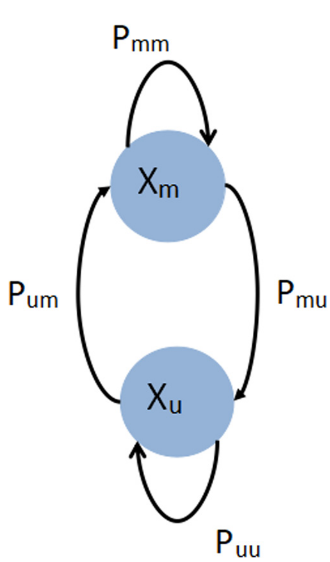

Figure 2: Basic framework of population random walk learning.

article, it is defined as the heuristic probability value of the individual walk, P_{mm} is the probability transfer submatrix that guides the population individuals to travel within the population, P_{uu} is the probability transfer submatrix that guides the population members to explore surrounding resources, and P_{mu} and P_{um} are the probability transfer submatrix that guides the population members to leave and return to the original residence (also known as nest), respectively.

2.3 Heat exchange network node

The flow pattern of the heat exchange network is complex, and there is serious coupling between heat exchangers. The operating condition of a heat exchanger fluctuates violently, and the disturbance fluctuation will spread rapidly, affecting the stability of the production process. In addition to this condition, production equipment and manual operations have an impact on the stability of the production process. In industrial production, energy transfer is an important part of the process system, and heat transfer is one of the main forms of energy transfer, heat exchanger is the key heat transfer equipment in the industrial process. Take the boiler equipment of power plant as an example, the main air preheater, economizer, superheater, condenser, cooling tower, deaerator, high and low pressure heater; air preheating in steelmaking process in the metallurgical industry, hot blast furnace; evaporators and condensers in refrigeration and air conditioning industries. The thermal calculation of the heat exchanger is the basis of designing a heat exchanger and researching its performance. When two streams of fluid pass through the heat exchanger for heat transfer, the main parameters are the inlet and outlet temperature of cold and hot fluid and the heat capacity flow rate, the area of the heat exchanger, and the heat transfer coefficient of the heat exchanger. The purpose of the thermodynamic calculation of heat exchangers is to find the relationship between these variables. The heat calculation of the heat exchanger is based on physics. The basic formulas of thermodynamic calculation are heat transfer equation and heat balance equation. The general form of the heat transfer equation is:

$$Q = \int_0^A k\Delta t \mathrm{d}A. \tag{5}$$

In the calculation of the heat transfer equation, the average heat transfer coefficient K and the average temperature difference Δt_m over the whole heat transfer area are adopted. The heat transfer equation is:

$$Q = KA\Delta t_m. \tag{6}$$

Without considering the heat loss, when the heat transfer between the two flows reaches a stable state, according to the law of conservation of energy, the heat released by the hot flow is equal to the heat absorbed by the cold flow; that is, the heat balance equation is:

$$Q = \int_{t_{Ho}}^{t_{Hi}} W_H \mathrm{d}t = \int_{t_{C1}}^{t_{Co}} w_C \mathrm{d}t, \tag{7}$$

where w_H and W_C are respectively the average heat capacity flow rate of hot fluid and cold fluid within the temperature range of dt, W/°C.

Assuming that N_C cold fluid needs to be heated and N_H hot fluid needs to be cooled, the heat exchange network is to use the matching of cold and hot logistics to recover the energy of the fluid in the process. The inlet temperature, target temperature, heat capacity flow rate, and heat transfer coefficient of each heat exchanger of the cold and hot logistics are known. At the same time, the heat and cold utility works are set for the fluids that have not reached the target temperature, and the inlet and outlet temperatures of the public works are known. A heat exchange network is formed according to the matching sequence of cold and hot fluids, and the investment cost and operation cost of the heat exchange network are minimized when all network fluids reach the target temperature. The investment expense includes the fixed investment expense of the heat exchanger and the area expense of the heat exchanger.

3 Experiments

In this study, three data sets were used to test our model. These data sets have related content that we need to do the hot swap between trials and training. The specific information of the data is shown in Table 1.

Table 1: Test data set

DS	Data size	Number of attributes	Class identification number
Twomoons	1,242	3	3
Mushroom	4,412	41	3
Hyperplane	10,401	14	3

Unlike previous tests of dynamic data sets, we do not know when the actual data set will change or what will happen. Moreover, we do not fix the proportion of marked samples in each data block. Instead, we just give a total tag rate for the entire data set and randomly distribute all labeled samples into each data block, so that the number of labeled samples in each data block is different, and even some blocks have no labeled data at all. In order to verify the classification performance of the algorithm, the accuracy of local and global classification was observed. Local accuracy is the accuracy of the real-time prediction of the input data in a specific time step. The global accuracy is the proportion of all correctly divided samples after the sub-local prediction. In order to make the results more reliable, the test is repeated for each data to obtain the average global classification accuracy. And based on the heat exchange network superstructure model, algorithm process, and the calculation program written in MATLAB environment, the case is analyzed. The hierarchical node superstructure model is applied to the optimization design and transformation of the heat exchange network to verify the applicability and rationality of the hierarchical node superstructure model.

This heat transfer enhancement of heat exchanger equipment size and heat exchange network optimization method of step by step, through the heat exchanger intensified heat transfer equipment design model and the heat exchanger performance evaluation indicators, to determine the heat exchanger performance is the optimal size of strengthening heat transfer equipment and converting the proceeds numerical generation to the next dimension of heat transfer enhancement considering heat exchanger in the heat exchange network optimization equipment use. At the same time, when using the heat exchanger type, it is necessary to consider the improved heat transfer equipment and the optimized heat exchange network structure, use the ant colony algorithm based on the better solution of random walk, and consider the synergy between the optimization and strengthening of the heat exchange network, to optimize the effect. Although this algorithm can solve the problem, it has disadvantages such as slow operation speed and easy problems.

4 Discussion

In this article, the heat exchange network consists of four heat flow strands and one cold flow strand. The initial data of the flow strand are shown in Table 2. The unit prices of hot and cold utilities are C_{hu} = 400\$/kw · yr and C_{cu} = 5.5\$/kw · yr, respectively. Here, the heat exchange area and the cost parameters of the pump a = 5,000, b = 300, c = 1.5, and α = 0.7. After optimization, the structure of the heat exchange network does not change, and the structure diagram of the heat exchange network after optimization is shown in Figure 3.

The sensitivity analysis method and area ratio method are used to determine the heat exchangers that need to use enhanced heat transfer equipment. Five heat exchangers are equipped with enhanced heat transfer equipment, and all of them are equipped with spiral tube ties. In the optimization results of this study, the spiral bond is used in tube one of the heat exchanger, the outer fin is used in shell side, spiral bond is used in tubes two and five of the heat exchanger for heat transfer enhancement, and the fin is used in tubes three and four of heat exchanger for heat transfer enhancement. The heat exchangers six to ten is the heat exchange equipment used in public works. Since the heat exchanger adopts the enhanced heat transfer equipment, the heat transfer efficiency is enhanced, so that the heat load of the heat exchanger increases, and the outlet temperature of the heat exchanger is changed, then the target temperature of the flow unit where the heat exchanger is located can be reached, and the heat load of the required public works will be reduced. The optimized heat transfer coefficient, pressure drop, and heat transfer results were compared with the traditional results, as shown in Table 2, and the optimized cost results and the use of the enhanced equipment were compared with the traditional results, as shown in Table 3.

Therefore, it can be seen from Tables 2 and 3 that before and after optimization, the heat load calculation of public works has been optimized step by step, and the

Table 2: Data before and after heat exchanger optimization

	U/(kW/m^2°C)		ΔP_s/(kPa)		ΔPt/(kPa)		Q (kW)	
	Traditional	Textual	Traditional	Textual	Traditional	Textual	Traditional	Textual
EX1	0.53	0.61	78.48	87.42	167.26	170.12	6131.41	6145.97
EX2	0.49	0.52	100.11	100.05	131.1	129.4	6124.23	6201.96
EX3	0.17	0.20	76.14	73.14	80.13	81.51	5513.46	5614.12
EX4	0.11	0.14	5.61	5.41	46.14	54.51	2741.87	3141.41
EX5	0.09	0.09	4.21	4.19	45.31	51.22	2294.52	2294.12
EX6							652.54	513.46
EX7							915.51	714.75
EX8							851.67	643.94
EX9							992.62	851.14
EX10							13431.73	12431.57

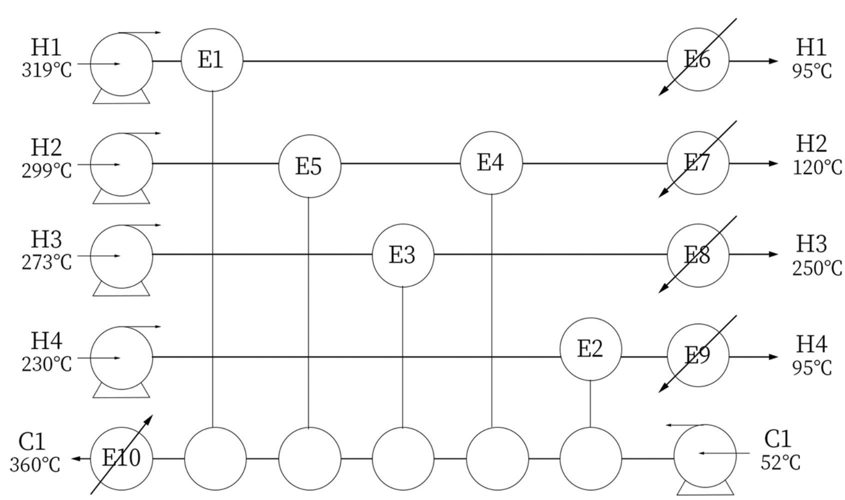

Figure 3: Heat exchange network optimized by the random walk algorithm of multiant colony.

Table 3: Cost comparison

	Traditional	Textual
Public project costs	5,901,391	5,190,779
Cost of heat exchanger equipment	638,504	586,676
Pump operating costs	—	24,264
Additional bypasses incur costs	2,000	—
Cost of enhanced heat transfer equipment	26,289	28,958
Total cost	6,568,184	5,801,719

cost of public works has been reduced by 5.98% compared with the traditional one. Moreover, the total cost after optimization in this article is reduced by 7.01% compared with the traditional one. Proving this article heat exchanger improved heat transfer equipment size and heat exchange network optimization strategy step by step, first of all, through the heat exchanger intensified heat transfer equipment design model, the optimal heat exchanger performance evaluation index to determine the heat exchanger performance dimension numerical heat transfer enhancement of equipment, to a certain extent, considering the changes affect the performance of heat exchanger to strengthen equipment size. Heat transfer enhancement in step-by-step optimization of the second step is to consider the heat exchanger in the heat exchange network optimization equipment use, taking into account the heat exchanger improved heat transfer equipment use and improved heat transfer device type and heat exchange network synthesis of synergy, better able to weigh the heat exchanger equipment cost, utility cost, operation cost of pump heat transfer enhancement and equipment costs; it is concluded that using optimal heat exchanger intensified heat transfer equipment, traditional optimization effect is relatively more obvious.

According to the parameters of the heat exchanger and the physical parameters of the hot and cold flow through the heat exchanger, the performance of the heat exchanger is calculated. When fins are added into the tube, the changes of friction factor, corresponding heat transfer coefficient, and pressure drop with the variable value within the range of changes in the height, thickness, and inclination angle of fins within a certain range are calculated, respectively, and corresponding broken line diagrams are made for the calculation results, as shown in Figures 4 and 5.

Figure 4 shows that as the dimensionless height of the fin increases, the friction coefficient and the corresponding pressure drop of the tube increase, and the

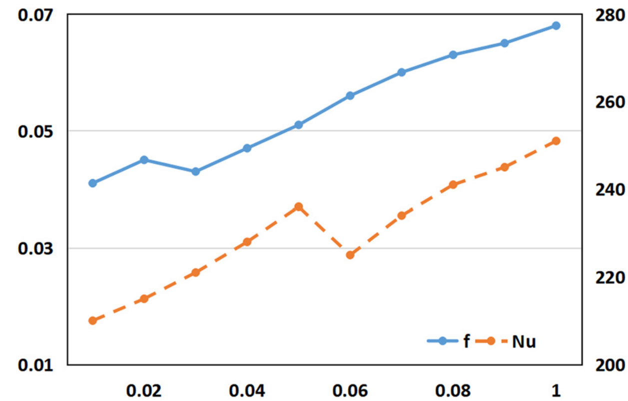

Figure 4: Polyline diagram of performance parameters of heat exchanger changing with dimensionless fin height inside the tube.

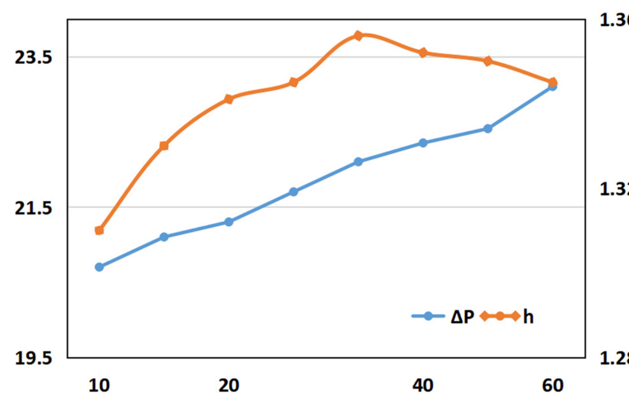

Figure 5: Line diagram of performance parameters of heat exchanger changing with the inclination angle of fin inside the tube.

Nusselt number and the corresponding heat transfer coefficient of the tube increase first and then decrease slightly. The reason for this phenomenon is that under the premise of fixed fin number and fin spacing; if the fin height is too high, there will be a "water bridge" phenomenon and a turbulent dead zone, which will reduce the theoretical effective heat transfer area and cause a small reduction in heat transfer coefficient. The dimensionless height of the fin in the tube is 0.05; that is, when the fin height is 0.45 mm, the performance of the heat exchanger is relatively high. The corresponding fin height at this time is selected as the initial parameter to optimize the heat transfer network considering heat exchanger strengthening.

As can be seen from Figure 5, with the increase in the fin inclination angle, the friction coefficient and the corresponding pressure drop on the pipe path increase, and the Knudsen number and the corresponding heat transfer coefficient on the pipe path also increase. The reason for this phenomenon is that the fluid flow in the central area of the tube will hit the top of the fin at an angle, causing the eddy motion of the fluid to wash against the wall of the tube to enhance heat transfer and increase the resistance at the same time. After the optimization of the heat exchanger strengthening heat transfer equipment, the heat transfer efficiency is enhanced, the heat load of the heat exchanger is increased, and the outlet temperature of the heat exchanger is changed; then the target temperature of the flow unit where the heat exchanger is located can be reached, and the heat load of the required public works will be reduced. Therefore, by calculating the thermal load of public engineering, it can be concluded that compared with the stepwise optimization, the thermal load of the same stepwise optimization of public engineering reduces by 9.15%. This shows that heat transfer enhancement heat exchanger equipment size and heat exchange network, synchronous optimization, considering the strengthening heat transfer equipment size and heat exchange network optimization of synergy, can be heat exchanger improved heat transfer device type, improved heat transfer equipment multiple ant colony algorithms based on the random walk to adjust the size, expand the search scope, and make the optimization results more comprehensive, more in line with the actual situation.

5 Conclusions

Global optimization of heat exchange networks has become a difficult and hot spot in the field of system engineering. For the mixed integer nonlinear optimization problem of large-scale heat exchange network systems, the traditional deterministic optimization algorithm is often subject to the local optimal solution problem and cannot obtain satisfactory results. Aiming at the shortcomings of deterministic method and heuristic method in heat exchange network optimization, this article proposes an improved method and applies it to heat exchange network optimization. In addition, based on the analysis of the temperature difference uniformity factor, a hierarchical superstructure model of internal public works was proposed, and the multi-ant random walk hybrid algorithm and a new superstructure model were used to optimize the heat exchange network. The following conclusions were drawn:

(1) Through the establishment of multiple ant behavior rules, the use of bottom-up modeling methods, the evolution process of ant colony foraging behavior to carry on the system modeling and simulation, and through the analysis of the important parameters in the model implements the parameter adaptive determine, at the same time adding two new rules of behavior, enhance the simulation results of the model. According to the similarity between the established model and the heat exchange network path planning, the improved ant colony foraging behavior model was used to solve the local thermal network path planning in a complex dynamic and static environment.

(2) In view of the time performance deficiency of ant colony clustering algorithm in the detection of functional modules in a heat exchange network, a fast detection algorithm of functional modules in a heat exchange network based on multi-ant colony random walk algorithm was proposed. The similarity of each heat exchange network is calculated, and clustering is carried out according to the pick-up and drop model. The similarity between functional modules in the initial clustering result is very small, which saves the merging and filtering operations in the original ant colony clustering algorithm and shortens the solving time. At the same time, according to the key of the heat exchange network, the multi-ant colony random walk algorithm imposes stricter constraints on the picking and dropping operations in ant colony clustering, which reduces the number of picking and dropping and accelerates the clustering process. Experiments on different heat exchange network data sets show that compared with the original ant colony clustering method, the polyant random walk algorithm has greatly improved the time performance and achieved better detection quality. Moreover, compared with some classical algorithms in recent years, the polyant colony random walk algorithm performs better on a number of performance indicators.

(3) The size of heat exchanger and heat transfer network is optimized simultaneously. The type, size, and heat transfer network of heat exchanger strengthening heat transfer equipment were simultaneously optimized, and the influence of pressure drop caused by the use of heat exchanger strengthening heat transfer equipment was considered. The results show that compared with the traditional heat exchanger to strengthen the heat transfer equipment size and pressure drop changes, before and after the optimization of public engineering heat load calculation, it can be concluded that the total heat load of public engineering is reduced by 9.15% compared with the traditional. Compared with the results of the size of the heat exchanger strengthening heat transfer equipment and

the stepwise optimization of the heat exchange network in this article, the cost of public engineering is reduced by 5.98% and the total cost is reduced by 8.83%. Due to the limited space, the article cannot cover all the details in the methods and experiments section. In the future, the author looks forward to conducting more in-depth research on this topic in a more streamlined way.

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