Group control elevator dispatching system based on S7-1200 PLC

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***Abstract*—With the social progress and the acceleration of the pace of life, the traditional elevator has not been able to meet people's needs. At present, most group control elevators simply distinguish the single or double layers, and their efficiency is slightly improved compared with the traditional elevators, but the problem has not been fundamentally solved. Based on Siemens S7-1200 PLC, TIA portal and WinCC, group control elevator dispatching system is designed, using six ten-floor group control elevators as model, to analyze the model of group control elevator, implementation method of the software system and the algorithm of group control elevator dispatching system. This system not only makes up for the large computation and difficulty of the dispatching system based on neural network design; Moreover, it avoids the difficulty of modifying the rule base of dispatching system based on fuzzy control design. Through the simulation test data, it is found that the system can improve the elevator riding time, waiting time, long waiting rate and other indicators. And the conclusion can be drawn that group control elevator can reduce the energy consumption and improve the efficiency of elevator operation.**

Keywords—dispatching, S7-1200 PLC, group control elevator, WinCC

Ⅰ. PREFACE

Group control elevator dispatching system is a system that many elevators are centralized and arranged side by side in some occasions with a large flow of people. All the elevators share the call button of the floor, and each elevator has an independent internal button panel. All the signals from call button and internal button are collected by a controller, and then allocated to each elevator after processing, so that the operation of the elevator can achieve energy conservation, high efficiency and optimization [1].

With the development of society, people have higher requirements for elevators. Traditional elevators cannot meet the needs of people. At present, there is a group control elevator dispatching system based on neural network and fuzzy algorithm, but the neural network has a large amount of computation but slow response .Fuzzy control cannot keep up with the changes of buildings and transport, and its performance greatly depends on the quality of experts' knowledge. It is difficult to modify the rule base, and the realization of the both is low. There is a big gap with practical application [2].In order to solve these problems, under the premise of safety, a group control elevator dispatching system with small program quantity, fast response, high realization ability and automatic formulation of optimal dispatching strategy is designed, which can minimize passengers' waiting time, riding time and energy consumption.

This system is mainly composed of Siemens S7-1200 PLC, SIMATIC TIA PORTAL V14, WinCC and six ten-floor elevator models. It adopts Profinet Ethernet for configuration connection [3].S7-1200 PLC has the advantages of modular and compact design, powerful function and completely

This work was supported by Inner Mongolia Natural Science Foundation under Grant 2017MS0603.

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suitable for various applications, so that it can be used as the controller of the system. At the same time, TIA portal is used for programming, WinCC is used to monitor the running state of elevators, and a group control elevator dispatching system with the core of way of equivalent and pre-allocation method is designed, and the group control elevator model, group control elevator dispatching algorithm and software implementation method are analyzed. Through the elevator simulation software, the group control elevator dispatching system is tested a lot, and compared with the traditional elevator, the group control elevator has the advantages of high efficiency and low energy consumption.

II. GROUP CONTROL ELEVATOR MODEL

Table 1 shows the parameters of group control elevators.

TABLE I. PARAMETERS OF GROUP CONTROL ELEVATOR MODEL

Name	Parameter	Name	Parameter
Number	6	**Floor**	10
Deadweight	1050KG	**Personnel quota**	14

Group control elevator dispatching system is designed on the purpose of shortest waiting time and riding time and dynamically dispatched according to the running direction of the elevator and, elevator capsule's floor and the distance between the elevator capsule and call button to make system fast respond so as to give full play to the elevator transport capacity, improve the efficiency of the operation of the elevator.Specific control principles are as follows:

- Priority queues: multiple priority queues are adopted according to the location and running direction of the elevator, and different elevators provide optimal response according to the actual situation. The started elevator gives priority to respond to a certain floor, and the system judges whether the waiting time for passengers is too long if the elevator standing by is not started and make other elevator respond. If it is not long, other elevators will respond instead of starting the waiting elevator [4].
- Return function of base station: once there is no elevator in the base station, and the nearest elevator has no call signal, then, the elevator will return to the base station and close the door for loading, so as to improve the transport capacity of the elevator in the base station.
- Energy-saving operation: when an elevator does not operate for a long time, it will be in a waiting state with the fans and lighting closed. And it will start up after the system assigns signals to it, so as to achieve the purpose of energy saving and consumption reduction.
- Distance principle: when the group control elevator system receives the call signal in the same direction at different floors, the elevator closest to the call signal will respond.

Evaluation indexes of elevator module are mainly average waiting time(AWT), elevator energy consumption (EEC), minimum waiting time (T) and long waiting ratio (LWR).

Average waiting time: refers to the average waiting time of all passengers within a period of time, which is an important index to evaluate the performance of elevator control system. The main factors that affect the average waiting time are passenger arrival rate and the remaining space of the capsule. When there is less room left in the capsule, the elevator may not have enough room to carry new passengers, which will make the waiting time for passengers longer. WT(i) is the waiting time, which refers to the time from the time when the passenger presses the call button to the time when the elevator reaches the floor and responds to the call signal. The calculation formula is:

$$AWT = \frac{\sum_{i=1}^{n} WT(i)}{n(i = 1,2,3...n)} \tag{1}$$

The energy consumption of the elevator is related to the number of times the elevator starts and stops and the total weight of the passengers in the capsule. The calculation formula is:

$$\sum_{i=1}^{n} f_e(i,k)(i = 1,2,3...n) \tag{2}$$

fe (i，k) is the number of times the elevator k needs to start/stop in response to the number i call signal.

Minimum waiting time: Time (min)= LTs+KTd

K is the sum of all the instructions in the running process from the current floor to the target floor, and only one is calculated when the call signal and internal signal are the same; Td is the total time of the additional acceleration and deceleration time required by a stop and the time for the passengers to get in and out; Ts is the time required for the

elevator to rise one floor at high speed; L is the number of floors.

Long waiting ratio: the percentage of passengers whose waiting time exceeds 90s in a certain time in the total passengers. The main factors affecting the LWR are: the frequency of elevator calling, waiting time and the remaining capacity of the capsule.

III. GROUP CONTROL ELEVATOR DISPATCHING ALGORITHM

This algorithm is designed based on the optimal distance, that is, the elevator with the shortest actual distance from the call signal responds, so that passengers spend the shortest time to wait for the elevator and take the elevator. At the same time, according to different occasions, the reasonable dispatching can further improve the operation efficiency of the elevator. The core of this dispatching algorithm is way of equivalent and pre-allocation.

A. Common dispatching

Seven arrays are defined in the data block, the 1-6 array is the 1-6 elevator button storage area, and mumber 7 array is the call signal storage area. Each button storage area of 1-6 elevators has 28 bits (1-28), of which 1-10 bits corresponds to 10 internal buttons, and 11-28 bits corresponds to 18 external call buttons of each elevator. When a passenger presses the internal button or PLC assigns the call signal to a certain elevator, the corresponding bit in the array will be assigned to the key value (the key value of the external call button is the number of floors); the storage area of external call buttons has 18 bits, corresponding to 18 external call buttons [5].

The way of equivalent convert both dimensions of distance and time into distances. Elevator in operation, includes the following stages: closing phase, acceleration phase, high-speed operation phase, deceleration phase, door open phase. With a large number of experiments on the elevator models used for the purpose of this article, conclusions are drawn: out of the high-speed running stage, the time consumed by the rest of the stage is equal to the time of rising two layers under the high-speed stage, so we can assume time spent by the door open and close of each elevator and acceleration and deceleration equivalent to the distance running with high speed (equivalent distance). The actual distance between each elevator and the passengers is the straight-line distance plus the equivalent distance, and the equivalent distance of two floors will be increased for each additional call signal between the current position of the elevator and the call signal. For example, if there is an external call signal on the seventh floor, then elevator 1 is on the ninth floor and there is an internal signal on the eighth floor, then the straight-line distance between elevator 1 and the external call signal is two floors, and the equivalent distance is four floors, that is, the actual distance is six floors.

Pre-allocation method is that when there is an external signal, PLC first assign the corresponding key value of the external call signal to the corresponding bit in the external call storage area. After the PLC assigns the signal to a certain elevator, then assign the key value of the external call signal to the corresponding bit in the elevator button storage area, and at the same time erase the corresponding bit in the external call storage area.

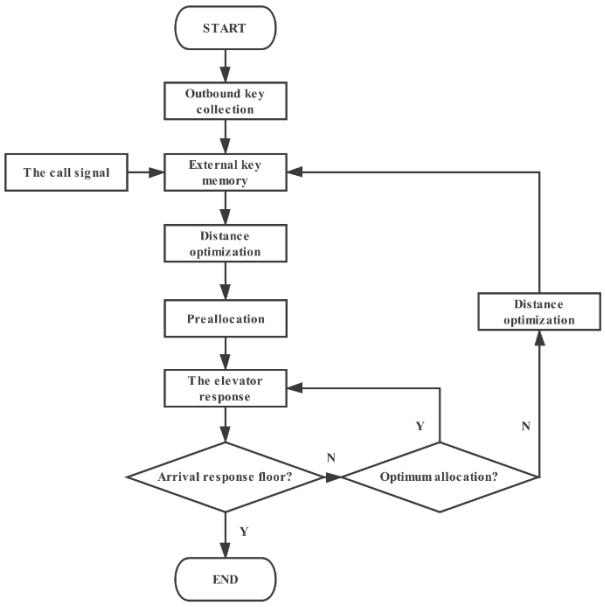

Fig. 1. Common dispatching flow chart

Due to the uncertainty of the call elevator, PLC may continue to assign signals to the elevator in the process of responding to an external call signal. For each signal assigned, the actual distance will be increased by two floors, and the elevator may no longer be the optimal elevator. PLC continuously calculates the actual distance between each elevator and the external call signal. Once it is found that the elevator is no longer the optimal elevator, PLC will erase the corresponding position of the button storage area and then allocate the external call signal to other elevators. By using the pre-allocation method, the elevator that responds to the

external call signal must have the shortest actual distance, thus achieving the optimal distance target. Figure 1 is the flow chart of the common dispatching algorithm.

B. Partition dispatching

Partition dispatching is to divide six elevators into several parts, each part has different priority for different floors. In the elevator model of this paper, the first floor is the restaurant, the second and third floors are shopping areas, and the fourth to tenth floors are office areas. At different time periods, the PLC will implement different partition dispatching methods. For example, from 11:30 to 12:00 on weekdays, elevators 1-4 only respond to the down signals on the 4th to 10th floors, while elevator 5 and 6 respond to other signals, ensuring fast access to the restaurant for office workers.

IV. IMPLEMENTATION OF SOFTWARE SYSTEM

The software system includes elevator diagram programming and WinCC screen, both of which use TIA portal software. This software is the basis of all future software engineering configuration packages, which can configure, program and debug all automation and driver products involved in Siemens fully integrated automation. Using a new, unified software framework, TIA portal can configure all the programmable controllers, human-machine interfaces and drivers of Siemens in the same development environment. The Shared task established in communication between controller, driver and human-machine interface can greatly reduce the connection and configuration cost [6].

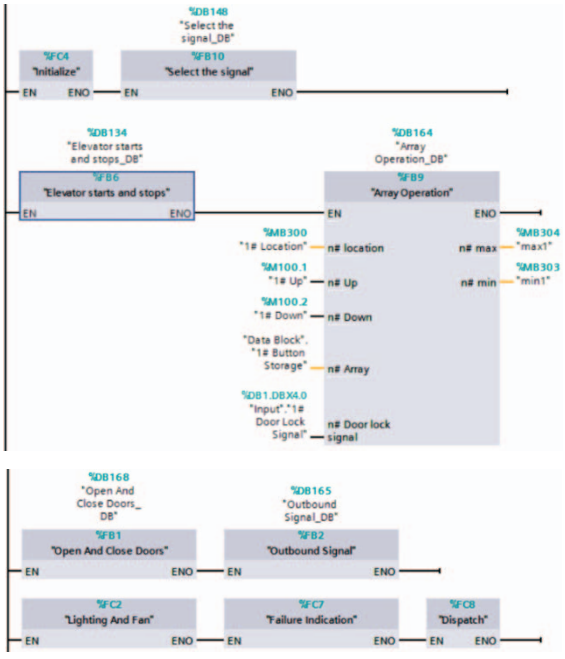

Fig. 2. Part of main function

A. Modular programming

Using modular programming methods, namely, the basic function of the single elevators and dispatching modular and can be called directly in the main function, greatly decrease the program amount, improve the running speed of the program [7], the main function mainly includes the initialization module, select signal module, outbound signal module, failure indication module, lighting and fan module, open and close doors module, etc. [8], figure 2 is part of the main function.

B. WinCC user interface

WinCC human-machine interaction interface includes login, single elevator monitoring, overview of elevator status, outbound monitoring, etc. [9].

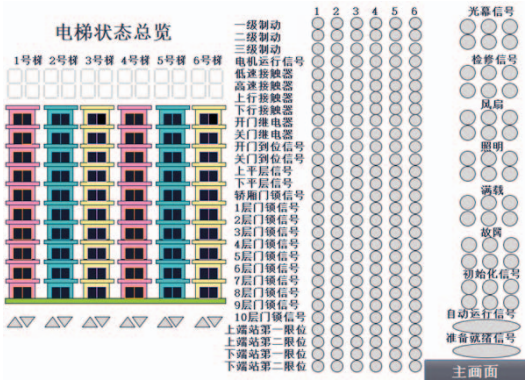

Fig. 3. Elevator overview interface

The elevator monitoring system has two kinds of accounts: administrator and common user. Different accounts have different permissions. The administrator account can set the initialization floor of the elevator, change the user password, and view the operation data report of each elevator. Common users do not have these permissions. Through the single elevator monitoring interface, it can monitor the running direction of a single elevator, internal signals, running status (normal, full load, maintenance) and the current floor of the elevator; Figure 3 shows the elevator overview interface[10], which can monitor the status of all sensors in the six elevators, the current floor of each elevator, lighting and fan system in the capsule, the opening and closing status, and the getting up and down, etc.

V. THE SIMULATION VERIFICATION

Ordinary dispatching algorithm, partition dispatching algorithm and traditional elevator dispatching algorithm are

tested by elevator simulation software, and the results are shown in figure 4, figure 5 and figure 6.

The simulation software scores based on delivery of the number of passengers in the same period of time. It can be seen by the test data that group control elevator transports more passengers than traditional elevator. And the group control elevator using the partition dispatching algorithm has more capacity than the normal group control elevator dispatching algorithm, illustrates a higher efficiency than the traditional group control elevator.

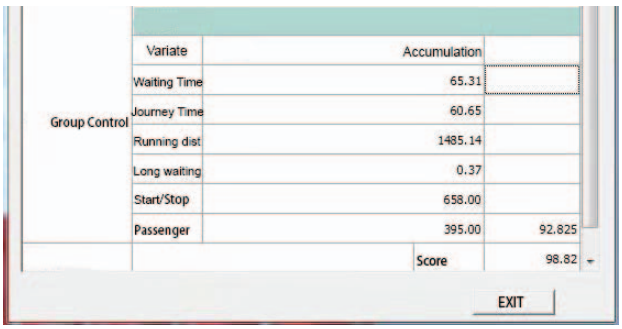

Fig. 4. Test of partition dispatching algorithm

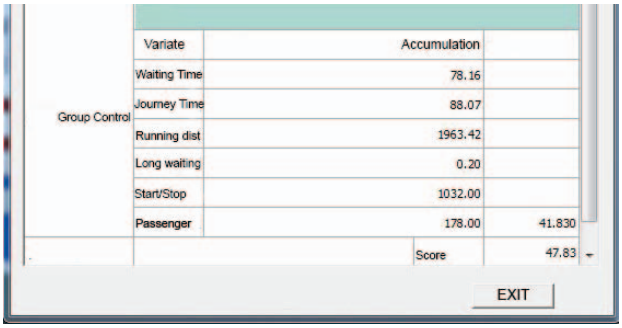

Fig. 5. Test of common dispatching algorithm

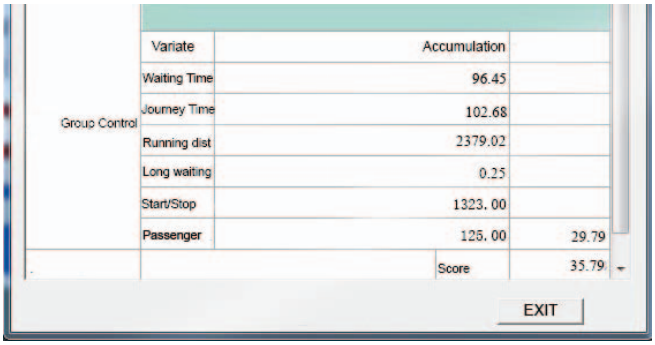

Fig. 6. Test of traditional elevator

VI. CONCLUSION

This paper from the situation that the traditional elevator's operation efficiency is low, and the group control elevator has not fundamentally realize group control, starts out. The group control elevator dispatching system is designed based on S7-1200 controller, WinCC monitoring interface, TIA portal programming software. On the analysis of group control elevator model, implementation method of the software system and group control elevator dispatching algorithm, further illustrate the working principle of the system and make simulation test on traditional elevator, common dispatching algorithm and partition dispatching algorithm. The test results show that compared with the traditional group control elevator this system has a big advantage, and the rational use of partition dispatching can also continue to improve the efficiency of the elevator. If the group control elevator dispatching system is improved and applied to real life, it will promote the development of China's elevator industry.

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