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Research on New Energy Saving Control Method for the Environmental Control System of Rail Transit Station

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Abstract: With the development of economy and the acceleration of life rhythm, the city is becoming more and more congestion. The concept of green commuting and environmental-friendly travel has deeply rooted in people's minds. Rail transit has been popularized and used by more and more people. The energy consumption problem of rail transit is becoming even more highlighted, environment control systems of rail transit system is the core part of the subway system and the most energy consumption part, it's energy consumption accounts for about 45% to 55% of the entire subway system. In order to save energy and protect environment, we need to optimize and upgrade the original environment control system. First of all, the distribution frequency of the frequency converter should be optimized. Secondly, the Petri net overall operation mode should be optimized. Finally, optimize the heat exchange system with fluid mechanics software. Through practical verification, the improve of these parts will greatly advance the utilization of energy, reduce waste and extend the service life of machine, achieve many things at one stroke.

Keywords: rail transit; environment control system; energy conservation and environment protection

1. Introduction

At present, our country is in a period of rapid development of urbanization, a large amount of urban population floods into city. The increasing population in big cities is a "double-edged sword". On one hand, the increased labor force promoted the development of city's economy, on the other hand, it also leaded to urban traffic congestion and increasingly serious automobile exhaust pollution. The use of rail transit can solve these problems. On one hand, it can reduce traffic pressure, on the other hand, it can save energy, reduce emissions and control automobile exhaust pollution effectively which kills two birds with one stone.

Setting environment control system in subway station is indispensable. Our researchers have done a survey as following, 8 investigators test air quality with air monitors at different periods of time in the subway. According to the results, the air quality in subway is poor, the PM2.5 concentrations reached to 65mcg. The large and complex flow rates in subway and the bad air circulation requires the subway station to equip with corresponding environment control system[1]. But the complete application and coverage of environment control system also poses a problem: the high energy consumption, 50% of the energy consumption comes from the environment control system. So the research of new energy saving control methods has become a hot topic. The optimization of the rail transit station's environment control system can not only reduce energy consumption, but also greatly reduce operating costs, so it is imperative.

2. The Optimization of Distribution Frequency of the Frequency Converter in Rail Transit Station's Environment Control System.

At present, the rail transit adopts single-unit parallel model. There is no corresponding mode conversion and energy saving control program. Due to the difference visitors flow rate in subway station in different periods of time, the difference of air temperature and the humidity and the difference of outdoor weather conditions, the energy consumption of the environment control system should be different. It should be changing with the change of the external factors. But, since there is no corresponding distribution frequency conversion of frequency converter, the environment control equipment consumes a lot of power and cannot achieve the purpose of energy consumption reduction. In order to solve this problem, the single-unit parallel model is converted into multiple-unit conversion model which will greatly solve the problem of high energy consumption and waste[2].

In practice, the optimization of multiple-unit frequency converter's frequency distribution is a complicated process. In order to achieve the comfortable environment when passengers waiting in the station, we should not only set the operation mode and parameters according to

the actual situation of the crowd density and the temperature humidity, but also consider the setting of variable frequency distribution parameter. Ensure the high efficiency and energy saving when the air conditioning unit operating. The combination of distributed intelligent control system theory and the theory of multiple-objective optimization algorithm will be able to effectively solve the above problem.

First of all, control parameters. The air conditioning parameters used in rail transit station is based on the temperature of the outdoor environment. The parameter of current environment control system used in China is fixed. No matter how much the outside temperature is, the temperature that the system set is constant. Although this method can save time and labour, it waste resources. If it is possible to change the parameters according to real-time air conditioning frequency converter, it will greatly improve the efficiency of air conditioning and reduce energy consumption. For example, in summer, the adjustment of the air conditioning should based on 28.1℃. At this mode, the maximum temperature difference should be less than 8℃when the air conditioning supply air. The air quality in platform: CO2 concentrations should be less than 1.5 per thousand. Secondly, calculate the multiple-unit's frequency rate. In the whole air conditioning control system, ac fan and water pump are the biggest energy consumption parts. So the use of frequency converter on the distribution of frequency adjustment will reasonably adjust the flow rate and air volume which will reduce energy consumption.

Among them, k is a constant. From the above formula we can conclude that the fan and water pump's frequency conversion and energy-saving feature is proportional to its running speed and the cube of its frequency. Thus, we can get a directly proportional relationship between the air conditioning unit's energy saving rate and unit operation frequency. Thirdly, control unit's start & stop by frequency converter. It has been proved through the practice that air conditioning cost much more energy at the time of start and stop than that when running smoothly, basically it is 25% of the rated power, therefore, frequently start, stop, loading and unloading instructions for the air conditioning unit should be avoided when train running smoothly. At present, the large-scale fan in our country universal has the intermittent operation of regularly automatic start and stop. This will need a reasonable optimization for the initiator by its frequency converter. Keep running when there is no need to stop it according to the actual situation. Therefore, on one hand, it can reduce the abrasion and prolong the equipment's service life, on the other hand, more energy can be saved. Fourthly, optimize the frequency converter's parameters when the train running smoothly. Through the research and analysis of the operation mode we can preliminary conclude that at different periods of time, in the process of running, the work area of each unit has more than one control parameter which ensure the single-unit and parallel-machine can work normally under overload condition, and in the operation process of multiple frequency converter, in order to achieve the goal of reducing energy consumption, different unit can output different control information. Therefore, multiple-unit frequency converter can find an energy-saving parameter to output among numerous operating parameters so as to achieve the purpose of saving energy and reducing consumption[3].

3. The Optimization of the Overall Petri nets Operation Mode of the Rail Transit Station' Environment Control System.

Petri net is invented in 1960s by Karl ·A· Petri. It's a kind of automation theory which can express the concurrent events and is suitable to describe the asynchronous, concurrency computer theoretical system model. The application of Petri nets in rail transit's environment control system make it possible to intuitively and clearly describe the structure of the new environment control system through a simple network graphics, describe the dynamic properties of the system, sophisticated calculate system's maneuverability, stability, systemic and invariance[4]. Therefore, Petri nets is an ideal means for describing the environment control system. This network structure can provide more adequate theoretical data to its users and analysts, and let them make the most accurate judgment and implementation. Next, we will start from the modeling of Petri nets, then making simulation practice and verification, apply the theory of Petri nets to track traffic environmental control system to achieve the goal of optimizing operation of the system and energy saving.

According to the running features of the rail transit at different times, the whole control system can be divided into several different models according to the season, by studying the characteristics of energy saving operation in different period of time, different Petri net energy-saving control models can be created. For example, under morning prepare mode, the station should cold or hot the air in advance, open outdoor air ventilation for orbital station; under the peak mode, the station should discharge air timely, make good switch between small new wind and all new fresh air mode because the passengers flow volume is high and crowded and the air circulation is bad, under the night off stage mode, the station should shut hot water unit in advance, using afterheat to energy saving; the winter mode should stop cold water group and open humidification heating function because of the low and dry temperature; under the summer mode, due to the high temperature and the use of air-conditioning, the station should open chiller water unit to cool temperature rapidly so as to let the subway run without excess burden[5]. Through the establishment of Petri net model, tar-

geted use of different equipment and the overall study on modeling the different equipment, we should find a correlation between equipment which can reduce unnecessary energy consumption when use equipment.

4. The Optimization of the Heat Exchange System of Rail Transit's Environment Control System.

The working model of a heat exchange system a kind of energy conservation and environmental protection principle which can filter and purify outdoor fresh air and then send into indoor after heat treatment, at the same time, discharge indoor contaminated harmful gas to outdoor after heat treatment, and this system basically do not effect indoor temperature when the new wind come into indoors.

Original exchangers used in rail transit station only can do a simple replacement of air without any processing. But the heat exchange processor is a kind of high efficiency and energy saving equipment, the application in rail transit's environment control system can greatly reduce energy consumption and the heat exchange rate of its inbuilt static heat exchanger can reach to 80% which can reduce the effect of fresh air to the cold and hot load and reduce the energy consumption in processing fresh air so as to achieve the high efficiency and energy saving. The internal of the heat exchanger adopts low noise design and internal noise reduction processing which can prevent the interference to the station and the car and save energy. The fresh air replacement and treatment equipment has no other parts outside it, no hang equipment and do not need separate operation room which can reduce corresponding equipment expenditure and a building area. It barely needs repair and maintenance but can ensure stable long-term work which can save the cost. With the heat recovery technology, the heat exchange processor greatly reduces the operating cost of environment control system, saves more than 40% energy in the consumption of fresh air. Besides, it do not need additional heat and cold source supply which can conserve energy and protect environment[6]. Heat exchangers are mainly used in air conditioning system, so the mainly material used in the heat exchanger's core body are all of good heat conductivity and penetration performance which lower the burden of the environment control system when processing new wind. In summer, it can dry hot air in advance. In winter, it can preheat the humidifying cold air. Thus, it can save the energy used in the cold & heat exchange system and usefully save operating cost and reduce power. High-low temperature water straight-mixed type heat exchanger is high efficient in thermal exchange and its manufacturing cost is low, the device in it includes mixing tank, circulating pump, high pressure water pump device, etc. High and low temperature water can be mixed in mixing tank directly. It can accomplish heat exchange by once water pressure, avoiding multiple water circulation and reducing the energy consumption to the full extent. The high and low temperature water can achieve completed mixing at once and there is no temperature difference when backwater, so no thermal resistance will come into being through scaling, therefore, the heat exchange efficiency can up to as high as 100% and no energy will be waste.

5. Conclusion

Due to the continuous expansion of city, urban traffic is becoming more and more congested. With its rapid, convenient, efficient features and other advantages, urban rail transit earns a rapid development. More and more people choose rail transit as the commuting mode which also requires rail transit develop in a better direction such as more comfortable, more energy conservation and environmental protection when providing efficient, convenient service. According to this research, through the optimization of frequency converter frequency distribution, the operation system of overall Petri net mode and the heat exchange system, not only the need of reduce the operation cost, but also the requires of low carbon environmental protection way to commuting in China's 11th five-year plan. Reduce energy consumption and improve equipment utilization rate should begin from the whole system, optimizes the allocation of system resources, and strengthen the monitoring of energy consumption in each period, each part, adjust the mode of the optimization to the most reasonable one when finding high local energy consumption, overall arrangement, in order to effectively realize energy-saving efficiency of railway traffic control system.

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