

Application of Air-conditioning and Energy-saving Design in Modern Subway Vehicles

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Abstract: The design of air conditioning and energy saving is very critical for the high quality operation of modern subway vehicles. It mainly realizes the regulation of environmental temperature and humidity in subway traffic system, ensures the objective analysis and prediction of the causes of heat load in the tunnel, and finally realizes the effective discussion of the calculation parameters of air regulation of subway vehicles. Based on the design of air-conditioning and energy-saving, this paper analyzes the environmental control problems in modern subway traffic vehicles, and carries out scientific research on the air-conditioning of subway vehicles.

1. Introduction

Subway is a kind of urban transportation track, which has high operation speed, large transportation capacity and low operating cost, and has shown good safety and comfort on the whole, and has even become an important symbol of urbanization construction to a certain level of scale. In order to further improve the environmental control level of subway vehicle system and cater to the national energy saving production and operation standard, it is also necessary to analyze the design of air conditioning and energy saving for subway vehicles.

2. Subway Vehicle Traffic Control Issues

Subway system vehicles have many mechanical and electrical equipment, including vehicle running heating equipment, passenger heat dissipation equipment, fresh air heat circulation equipment and so on, which makes the subway system temperature and humidity gradually rise and tend to balance state. However, due to the high wind speed interference and large passenger flow, it may lead to the loss of balance of the ring control system of subway vehicles, resulting in insufficient ventilation and gas exchange, which is actually a major problem that must be solved in the traffic ring control work of subway vehicles. The current metro traffic systems are pursuing the environmental control system designed for vehicles to ensure that the subway system has a good temperature and humidity environment and sufficient fresh air, ensuring that subway passengers always have a good body temperature.

Based on this, a temperature measurement system has been established on every line of the subway, such as the Japanese battalion. According to the results of the actual temperature and humidity test for many years, the temperature and humidity of the subway platform are higher than that outside the tunnel, so the sultry feeling in the subway increases obviously, and the internal environment of the subway car needs to be improved.

3. Analysis of Basic Causes of Heat Load in Subway Vehicles

The basic causes of the heat load in MTR vehicles can be summarized as follows:

3.1. The Operation of the Metro Vehicle System Generates a Lot of Heat

Surveys and analyses of subway lines in some large cities show that their vehicles emit about

74% of the total heat, while ancillary equipment emits about 14% and passengers emit about 12%. If it is calculated at a train interval of 3 min ,3000 people/h per train, it will produce about 3000×10 in a distance of 20 km 3kJ of heat, which eventually stays in the subway tunnel for a long time in the form of heat, and eventually spreads to the wall of the tunnel, the entrance and exit of the station, and the carriage. And an analysis of the vast amount of heat in subway tunnels will find that because a large number of passengers exhale carbon dioxide and inhale oxygen, the oxygen content in subway tunnels will continue to decrease. detailed calculation, if the average of each passenger absorbs 10m³ of fresh air per hour, according to the 3000 passenger flow, it needs to replenish about 303400m³/h of fresh air. At this time, if the external temperature is higher than the temperature inside the tunnel, the heat in the tunnel can be converted to positive value by ventilation, otherwise it should show negative value.

3.2. Understanding and Analysis of Heat Load

According to the above estimate, the heat load per kilometer in the subway tunnel is about 200kW, and if its ventilation is relatively small, its heat load will certainly become larger. If there is no ventilation system, it is necessary to rely on subway refrigeration and air conditioning to overcome the negative effects of large heat load. If it is hoped that the temperature and humidity in the subway vehicle will be effectively reduced to the normal parameters close to the outside of the subway, it is also necessary to cool the air conditioning equipment, that is, to implement the air conditioning and energy saving measures. Considering that the heat load of the air conditioning in the subway station corresponds to the heat dissipation capacity, passenger flow, ventilation and even the solar radiation intensity of the station equipment, it is necessary to carry out the concrete calculation and analysis according to the concrete engineering conditions before the heat load calculation and the air conditioning energy saving measures are carried out to ensure that the air conditioning in the vehicle is in place, mainly according to the actual air parameters in the subway tunnel and the passenger capacity and the temperature requirement in the vehicle.[1].

4. Implementation of Air-conditioning and Energy-saving Measures in Subway Vehicles

The implementation of air-conditioning and energy-saving measures in metro vehicles needs to be carried out on a scientific basis, including a number of measures, which will be analyzed in detail below.

4.1. Determination and Analysis of Calculation Parameters of Air-Conditioning Energy Saving in Subway Vehicle Air-Conditioning System

Taking the air-conditioned vehicles of the subway trunk line in beijing as an example, the calculation of the energy-saving parameters of the air conditioning system of its vehicles needs to carry out the relevant regulations of "general technical conditions of railway passenger cars ", and its specific calculation parameters are shown in table 1.

Table 1 Internal and external air calculation parameters for air-conditioned vehicles in main line of MTR railway

Outside the car air		Air in the car				
Calculate temperature/°C	Calculation of relative humidity/%	Average temperature /°C	Temperature difference along the direction of height and length /°C	Average relative humidity /%	Average breeze speed /m.s-1	Fresh air supply per passenger/m ³ ·h-1
35	60	25~29	≤3	40~80	≤0.45	20~25

As shown in Table 1, the internal and external meteorological parameters of subway vehicles in Beijing are basically normal, but the above parameters need to be adjusted in summer and winter,

especially to ensure that the relevant meteorological parameters of their vehicles are widely used.[2].

4.2. Analysis of External Weather Parameters for Air Conditioning of Subway Vehicles

Combined with the relevant standards of "outdoor meteorological parameters of air conditioning in major cities in China ", the related indexes of subway vehicles in Beijing are analyzed. When subway vehicles are in the early stage of underground tunnel operation, the temperature in the tunnel will be obviously lower than the ground temperature, but with the gradual increase of subway operation time, these two temperature indicators will gradually approach. If the subway vehicle is equipped with air conditioning system, it can only maintain the temperature in the tunnel platform to some extent, and ensure that the temperature in the tunnel is about 5~7°C, and the temperature in the tunnel is closer to the ground temperature at this time. In the case of subway vehicles without any air conditioning equipment, the external heat discharge of their air conditioning units can only stay completely in the tunnel, resulting in a rapid rise in tunnel temperature. Therefore, we should choose to adjust the external air temperature in summer, and do a good job of summer ventilation calculation. Referring to the operating conditions of Beijing Line 1 here, if its vehicle internal base temperature increases by 1.5°C, its vehicle internal relative moderation will increase by at least 3%, as shown in Table 2.

Table 2 Outdoor weather parameters of air-conditioning line 1 of Beijing metro line

Beijing	Outdoor Calculation Temperature						Outdoor calculation of relative humidity%		
	Heating -9	Winter ventilation -5	Summer ventilation 30	Winter air conditioning -12	Summer air conditioning 33.5	Daily average of summer air conditioning 28	Winter air conditioning 42	Hottest monthly average 78	Summer ventilation 62

4.3. Analysis of Air Conditioning Parameters of Subway Vehicles

The analysis of internal meteorological parameters for air conditioning of subway vehicles is mainly based on the relevant regulations of General Technical Conditions for Railway Passenger Cars. If the outdoor air temperature of the MTR vehicles exceeds 35°C in summer, the internal average temperature of the vehicles shall be calculated: t_B

$$t_B = 20 + 0.5(t_H - 20)$$

t_B t_H In the formula, mean internal temperature (°C) and external air temperature (°C) are expressed. According to the actual temperature of the subway vehicles in Beijing in Table 2, the internal temperature of the vehicles is 30°C under the condition of summer ventilation, and the summer air conditioning temperature is controlled at 33.5°C. These two data can be used as the standard indoor parameters for the air conditioning of subway vehicles. In the car, the temperature in the car can be 26°C, and the relative humidity can be controlled at about 60%.[3].

4.4. Other Measures of Air Conditioning and Energy Saving for Subway Vehicles

In addition to the above technical analysis of the regulation of subway vehicle air conditioning system class courage adjustment energy-saving measures, but also use other measures, such as subway shield door intelligent air-conditioning system. The system builds an independent system that can both ventilate and exhaust smoke, establishing a correlation between the two, as shown in Figure 1.

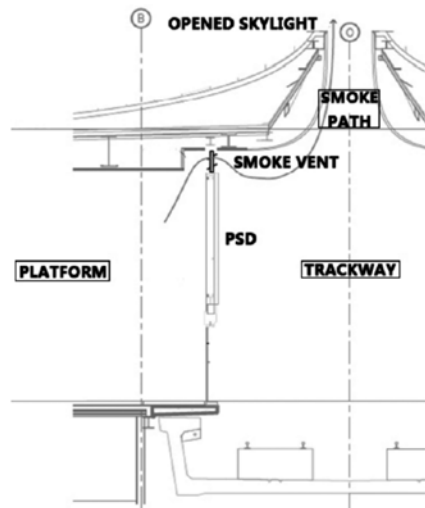


Figure 1 Schematic diagram of exhaust ventilation for MTR vehicles

Combined with the above figure 1, a set of intelligent air conditioning system and smoke exhaust system can be constructed for subway vehicles.

First of all, it should establish a set of closed-loop control loop, which includes a main control unit and several sub-control units. The main control unit mainly carries out complete control, and the sub-control unit mainly carries out local control.[4].

A special two-channel structure should be set up in the main control unit, on the one hand, the redundant design should be carried out, and after the problem of the one-way control circuit, it is necessary to automatically switch to the other way to record the fault, so as to effectively improve the safety, reliability and stability of the main control unit. In addition, the sub-control unit monitoring record system should be set up in the main control part, the sub-control unit control product should be optimized intelligently, and the sub-valve switch should be established to achieve the optimal effect of energy saving.

Another is the design of heat insulation and sealing, which is equipped with a subway air valve opening and closing device, which is resistant to high temperature. Once the disaster occurs, the ambient temperature rises rapidly, and the opening and closing device will fail, which can not meet the normal opening and closing of the ventilation system, and the equipment can not be used normally. In this process, it is necessary to add high temperature protection measures to establish a complete set of intelligent ventilation system to keep the opening and closing device with high temperature resistance. This is in line with the current national standard on subway design, the Subway Design Code, which ensures that subway vehicles can make effective use of heat insulation sealing systems even in case of disaster[5].

Summary

As discussed in this paper, the design of air-conditioning and energy-saving in metro vehicles can optimize the driving environment, realize the rational calculation and upgrade of air-conditioning heat load of vehicles, and ensure that the subway system can operate normally under unusual conditions and conditions.

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