Research on Optimization of Urban Electric Bus Timetable Based on Computer Technology for Energy-saving Objectives

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Abstract. Energy saving and environmental protection has always been a new innovation goal of various industries in China in the new era. At present, a lot of energy-saving and environmental protection concepts and related design have been put forward. The traditional city bus energy is gasoline¹. In order to meet the requirements of energy conservation and environmental protection, the energy of city buses has been changed into electricity. The dispatching work of urban electric bus is the core of bus enterprise management and related operation. Under the goal of energy saving, the arrangement and optimization of urban electric bus timetable has become the main concern of urban public transport.

Keywords: Energy Saving, City, Electric Bus, Timetable

1. Introduction

In recent years, with the introduction of electric buses, the pollution of urban traffic in China has been significantly improved². We are closer to the goal of energy conservation and emission reduction. Since the emergence of electric buses, people are more willing to go away from private cars and prefer to take buses. We know that the operation of the city bus section has a more strict control. However, its operation will still be affected by the signal control of the intersection. This kind of influence makes the running time reliability of electric bus unable to be guaranteed. At the same time, with the emergence of the concept of green city and the emergence of energy conservation and emission reduction issues, it is absolutely necessary for us to take effective timetable optimization method to improve the efficiency of tram operation.

At present, the design of our city subway's Jean can timetable is relatively mature. However, this does not mean that our electric bus timetable design will be more perfect. On the contrary, the optimization design of electric bus timetable in Chinese cities is scarce³. Due to the different sections of subway and bus, the traditional optimization design of subway timetable can not meet the bus...
schedule. Generally speaking, the design of electric bus timetable should take the minimum travel time as the main goal. In this way, we can greatly reduce the energy consumption of train operation. The reduction of energy consumption will also ensure the continuation of environmental energy conservation and emission reduction.

2. Description and hypothesis of the problem of electric bus timetable optimization

2.1. Description of the problem

Generally speaking, the optimization of bus timetable in cities generally takes the minimum travel time as the specific objective of optimization. Because the periodicity of train speed and distance is in dynamic balance, speeding up the speed of electric bus can not guarantee the reduction of vehicle travel time. According to the theoretical analysis, the maximum speed of the bus will affect the energy consumption and operation practice of the electric vehicle under the premise of the same line environment and operation strategy.

2.2. Hypothesis of the problem

In fact, there are many unexpected factors in the operation of urban electric buses. Electric bus has the condition of two-way departure, and the optimization process of timetable can not change the number of vehicles passing through the road section[4]. It needs to change the running time of the vehicle. The process of bus operation includes three stages: acceleration, cruise and stop. The guiding speed of each stage is different. In the braking stage, the bus should use the maximum braking force to brake as fast as possible (see Figure 1).

![City Electric Bus](image)

**Figure 1.** City Electric Bus

3. Establishment of energy saving optimization model for electric bus timetable optimization

On the running track of the bus, its running process is closely related to the location of the station and the location of the toll station. In order to effectively improve the efficiency of bus operation and reduce the energy consumption of bus operation, we need to consider the bus operation environment comprehensively. For our next budget, we need to establish an optimization model to guide energy conservation.

3.1. Description of operation environment of electric bus

Due to the corresponding signal of the bus will reduce the passing time of vehicles with non limited
parking spaces, during the commuting time, buses may be forced to have congestion due to this situation. Due to the complexity of the signal problem, this paper does not need to consider the congestion problem when designing the bus timetable. The opening time of green light of bus arriving at departure station and passing traffic signal should be synchronized.

3.2. Analysis of the complexity of the environmental interval of bus operation

In fact, the structure of electric bus lines is very complex. According to the speed limit condition of the vehicle operation interval, we can divide the electric bus operation sub section into five parts. They are the first station and the second station, the station and the intersection, the inside of the intersection, the intersection and the station and the intersection and intersection.

3.3. Driving constraints

The stop time of electric bus consists of the time of getting on and off the bus and the time and action of opening and closing the door.

\[ t_s = [\tau_3 + \max(Q_s, \tau_1, Q_s, \tau_2)] \]  

(1)

\[ Q_s = \frac{q_s D}{f_n} \]  

(2)

\[ M = \text{mod}(R_i + c - Q, c) \]  

(3)

3.4. The establishment of objective function

In this paper, we should establish the corresponding guidance model to adjust the running speed of vehicles in the interval. In this way, we can reduce the running time of the bus and reduce the energy consumption of its operation.

\[ \min T = \sum_{k=1}^{n} T_k + \sum_{s=1}^{u} t_s \]  

(4)

\[ \min E = \sum_{k=1}^{u} E_k \]  

(5)

4. An algorithm for optimization of urban electric bus timetable based on computer technology for energy saving

According to the analysis of mathematical function model, the optimization of bus timetable design is a typical nonlinear optimization problem. It is difficult to solve this problem by traditional analytical method. We can use the genetic algorithm of simulation to solve the problem of bus timetable optimization. After that, we use computer simulation method to describe the operation process of each section of the vehicle. Finally, we use genetic algorithm to optimize the guidance speed of the interval. After that, we will get the optimized train timetable (see Table 1).
Table 1. Optimization scheme design of electric bus timetable based on energy saving plan

| Index                | Option 1 | Option 2 | Option 3 | Option 1 | Option 2 | Option 3 |
|----------------------|----------|----------|----------|----------|----------|----------|
| Time                 | 1324.4   | 1344.1   | 1395.1   | 1168.8   | 1354.5   | 1125.1   |
| Energy loss          | 29.4     | 12.8     | 11.3     | 27.2     | 8.9      | 11.1     |
| Parking times        | 7        | 6        | 5        | 5        | 3        | 1        |
| Signal waiting time  | 266.1    | 247.1    | 67.1     | 100.1    | 66.4     | 5.5      |

4.1. Computer information input

The designers need to input the space structure of nodes, the spatial structure of lines, the number of passengers getting on and off, the parameters of signal configuration, and the basic information of the time when the bus stops fighting and departs into the computer simulation environment. It should be noted that the error of input parameters should not be too large.

4.2. Initial solution generation and parameter adjustment

Genetic coding is realized by the principle of binary coding. The computer will randomly generate a set of initial solutions. The interval is brought into the simulation subroutine. If the randomly generated partial solution can not meet the parameter constraints, the computer needs to code the subinterval repeatedly. If we can't get a successful solution, we need to adjust the parameter setting properly[5].

4.3. The processing of objective function

The design model of electric bus is a double objective optimization model. In order to facilitate the designer to solve your problem, we should use the programming method of fuzzy mathematics to transform the multi-objective optimization problem into a single objective optimization problem.

4.4. Research on genetic algorithm

The genetic algorithm takes the comprehensive target as the search information, and carries on the gene reservation operation to the high quality feasible solution through the fitness evaluation. Through the operation of gene replication and mutation, the computer can screen out the optimal individual solution.

5. The importance of the research on the optimization of urban electric bus timetable under the energy-saving goal oriented computer technology

5.1. It can improve the operation efficiency of electric buses

The standard of traditional timetable is blind. Some buses don't even follow the schedule. The
The optimized design of timetable can omit some unnecessary bus time. This can greatly improve the efficiency of bus operation.

5.2. *It can reduce the driving energy consumption to achieve the effect of energy saving and emission reduction*

According to the above description, the optimization of timetable can improve the efficiency of bus operation. The improvement of bus efficiency can ensure the certainty of the route in the process of driving. This can reduce the energy consumption of driving. The reduction of energy consumption will reduce the consumption of electricity. This will achieve the effect of energy saving and emission reduction in the side.

5.3. *Reduce passenger complaints and dissatisfaction*

The optimization of timetable ensures the accuracy of driving time. Passengers don't have to waste a lot of time waiting for a bus. In addition, after the energy consumption of buses is reduced, the cost of taking buses will also be reduced accordingly. This will reduce passenger complaints and dissatisfaction[6].

6. Conclusion

The goal of energy conservation and emission reduction has always been the task that city buses want to complete. At present, the city's gasoline energy buses have been replaced by electric energy buses. The next step we need to do is to optimize the schedule of urban electric bus under the computer technology oriented to energy-saving goal. This will make the city bus faster to complete the task of energy conservation and emission reduction.

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