THE RESEARCH OF PUBLIC TRANSPORT ENTERPRISES QUOTA FLOATING FUEL

National Standard GB4353 Fuel Consumption for Passenger Vehicles in Operation Applied to the Public Transport Enterprise

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Abstract: The research of fuel floating quota is an important innovation for unban public transport fuel quota management. In this paper ,based in national standard GB4353 Fuel consumption for passenger vehicles in operation, carried out the study of how to make fuel quota scientifically in urban public transport enterprises ,and combined with actual data to confirm. Many years of practice, research results have proved highly scientific and feasible.

1 INTRODUCTION

The evaluation on the fuel consumption of public transport enterprises is in a quota assessment mode for a long time. That is, when the plan is issued at the beginning of the year, set a fuel consumption quota for one bicycle in a month, and then carry the assessment into execution. In general, the planned quota is se down by combining historical experiences with measured data. This practice has a few drawbacks as follows:

Firstly, quota data based on experiences lacks credibility. Once historical experiences have deviation, the quota data will be in error.

Secondly, since there are no experiences in new routes and new models, we take the measurement by stimulating full load or laying down a quota data based on the constitutor's experiences. After commissioning after some time, make correction in according to the real data. With the changes of passenger flow volume and climate, the fuel assumption of passenger vehicles also changes. No matter for passengers, drivers or companies, the quota quantitative assessment is neither scientific nor reasonable. At the same time, it is possible for most of the drivers who are in responsible for new routes and new models to drive in a higher fuel consumption way, just in order to get a relatively loose quota policy.

Therefore, the traditional quota customization method is unable to solve the questions such as how to establish fuel consumption when passenger flow volume, roads or climate change. So one of the most important problems in transit enterprises management is the establishment of a scientific and reasonable fuel plan quota.

2 THE MAIN FACTORS THAT AFFECT BUS FUEL CONSUMPTION

Most of Chongqing buses use natural gas. Combined with national standard GB4353 Fuel consumption for passenger vehicles in operation, the author deems that the following factors exist:

Firstly, the factor of LPG station: the accuracy of gas-send machine's measurement, the amount of water and sulphur cut in natural gas, pressure in sending gases, etc.

Secondly, the factors of roads: quantities and grades of slopes in urban lines, traffic jam situation, the amounts of stops, traffic lights and pedestrian crossing, the frequency of vehicle's starting.

Thirdly, the factors of vehicle situation: the bus's weight, engine displacement, vehicle's working life, repairing degree, etc.

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Fourthly, the factors of drivers' corporation: the same road line and the same vehicle, differences between old and new drivers, and differences of Energy-saving consciousness.

Fifthly, passenger turnover: the quantity of passengers load and the frequency of passenger transfer.

Sixthly, influences of climate: as gas fuel, climate has a great influence on gas density, some abnormal conditions as ice blocking also occurs.

Seventhly, influences of altitude: altitude has an effect on fuel consumption as well as on engine's influx of air.

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3 PROBLEM ANALYSIS AND SOLUTION

According to national standard GB4353 Fuel Consumption for passenger vehicles in operation, at the same operation condition, the fuel consumption of a large passenger-car is

$$Q_i = (q_a \times S/100 + q_b \times N \times S/1000 + q_c \times (G - G_0) \times S/100) \times Kr \times K_t \times K_h \quad (1)$$

In this formula,

Q——vehicle's operation fuel consumption，L；

q_a——The basic car fuel consumption，L/100km；

q_b——Basic additional fuel consumption of passenger turnover，L/1000p·100km;

q_c——Basic additional fuel consumption of the vehicle's own weight，L/100t·km;

S——The distance that the bus runs in the same operation condition，km;

N——the amount of passengers，p;

G——the bus's own weight；

G_0——buses' standard weight；

K_r——Road correction coefficient

K_t——Temperature correction coefficient；

K_h——the altitude correction coefficient；

According to the theoretical data provided by Engine manufacturer: 1 M^3 natural gas can replace 1.08L gasoline, but due to its uncompleted combustion, the actual computation is 1 M^3 =1L.

Compared with the vehicle running environment in national standard formula, the vehicle running environment in transit enterprises has many drawbacks. It can not meet S's (the vehicle's travelling distances in the same condition) design conditions, mainly in several aspects as follows:

1, because buses need to stop in many settled stops, they must moor and start many times;

2, because passengers get on and off the bus in different stops, the amount of passengers in different stops are not the same, thus causes bigger loading section difference.

3, the Index test environment in national standard formula is the standard running fuel consumption, experimenters will not save or waste fuel intended. However, bus companies often have a quota appraisal on drivers, in order to strengthen their energy saving consciousness and effects. Therefore, in calculating bus route data, it is necessary to consider the condition when drivers save fuel intended.

In view of these factors and national standard data, this essay makes an analysis of historical fuel consumption data

Firstly, it makes an analysis and comparison of three factors' influences on fuel consumption, which are

Illustration: the statistical proportion of per-bicycle passenger throughout is 1:10000; the statistical proportion of per-bicycle income statistics 1:10000；the statistical proportion of per-bicycle natural gas consumption is 1:1000.

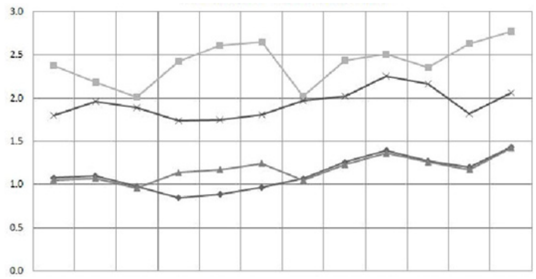

Figure 1: The average.

Note: the account form of per-bicycle passenger throughout: 1, income in IC card

From chart one, we can see that per-bicycle passenger throughout changes in accordance to per-bicycle natural gas consumption. So there is a relatively stable relationship between passenger throughout and natural gas consumption. Meanwhile, because of the influences of the discount in IC card and chartered cars, the curve of passenger transport income and distance income changes irregularly. Therefore, it is possible to regard per-bicycle passenger throughout as one of the parameters of fuel consumption quota.

Secondly, Chongqing has four distinct seasons. In summer the temperature is often above 37℃, in winter it is below 5℃. According to relevant material, the ideal temperature of gasoline is between 5℃ and 28℃. Natural gas has a lower density than gasoline, so it is more greatly influenced by temperature.

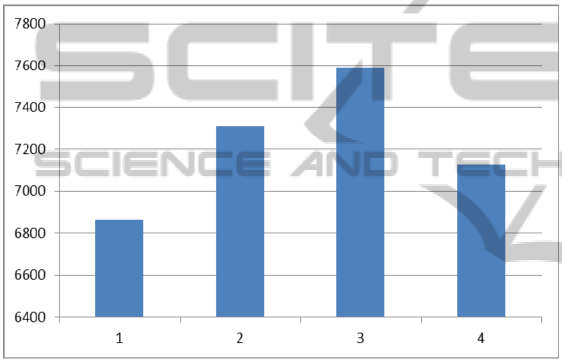

Figure 2: The automobile.

From chart two we can see that temperature has an influence on fuel consumption. In Chongqing, passenger capacity in different seasons has marked differences. Especially in summer, the high temperature and summer vacation makes less people go outward by bus, and also bring an effect on fuel consumption. In chart two, the amount of passenger capacity has not been taken into consideration, so it is not accurate. Therefore, it is necessary to bond passenger capacity together to analyze the effect that is brought by temperature. As shown in figure 3:

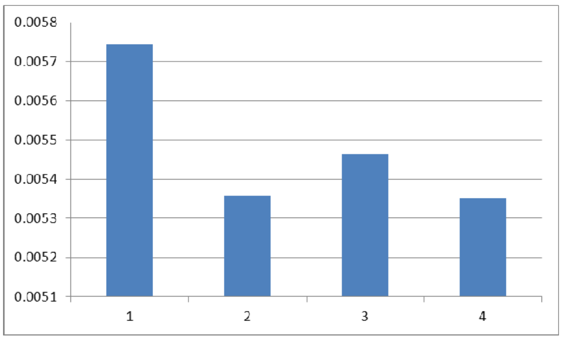

Figure 3: The nature gas.

Chart three analyses passenger capacity's influence on natural gas consumption. It seems that this chart corresponds with rules. In summertime per capita natural gas consumption is the highest, winter is in the second place and spring and fall is the lowest. According to the analysis results and practical experience, the high temperature in summer has a big influence on natural gas consumption, which causes the highest consumption proportion. The consumption in winter is influenced by some factors such as temperature, the consumption proportion is higher than which in spring and fall.

Thirdly, the experimental environment of transit enterprises is different from national standard environment, which cannot be operated in the same environment for a long time. But due to the buses' fixed line, there is a law to observe. Use a line for a unit, and ascertain corresponding modulus based on fuzzy average method, and then make a comparison of the coefficient in national standard data.

In national standard data, fuel consumption consists of four sections: totally basic consumption, passenger turnover, the empty bus's weight, environment condition. Basic operating conditions: monthly average temperature is between 5℃ and 28, the altitude is no more than 500m.

- **Totally Basic Consumption**

Totally basic consumption refers to the fuel consumption when the vehicle runs per kilometre in basic running conditions. In national standard, there is a standard for some modes. However, what we need to notice in actual process is that vehicles in the same type have different basic consumption if they have distinctive engine displacements. For instance, Dongfeng cycling vehicles' engine displacement is 5.42L, totally basic consumption is 23. But if it has a NQ160 fitting, the engine displacement is 5.96L. it increases 11 percent when compared with EQ6100 engine. Correspondingly, basic consumption should be added to 25.3.

The following chart is the totally basic consumption of different types in national standard:

Table 1: National standard.

Vehicle's types	Jiefang		Dongfeng		Huanghe	
	bicycle	hinge	bicycle	bicycle	hinge	bicycle
q_a L / 100km	23.5	28	23	23.5	28	23

- **Passenger Turnover**

The national calculation of fuel consumption needs to meet several factors, that is, at the same distance, the environment same as passenger turnover and load level should accorded with each other. But the vehicle operation is affected by several factors such as stops intensity, passengers' get-on-and-off frequency and road changing conditions. Because the operation environment in every section has significant changes, these factors should be considered reasonably.

Suppose there are buses A and B, which are the same type, run in the same section and load the same amount of passengers and their drivers' operation level are the same. If passengers in bus A get on and off the bus frequently, then A has fewer passengers in united time, and it is loose in the bus, thus causes a low fuel consumption: in contrast, B has more passengers in united time, and it is crowded in the bus, thus causes a high fuel consumption. Analogize in turn, for buses which have the same amount of passengers and same distances, the longer they run, the lower fuel they consumed. It is corresponded with the notion that every section in the formula uses kilo consumption as a unit and uses person/ kilometres method.

The following chart is the basic additional fuel consumption of different vehicles' passenger turnover:

Table 2: The consumption of turnover.

Vehicle's types	Jiefang		Dongfeng		Huanghe	
	bicycle	hinge	bicycle	hinge	bicycle	hinge
q_b L / 1000p • km	1	0.75	0.8	0.7	0.75	0.55

- **The Empty Bus's Weight**

In calculating fuel consumption, it is necessary to take the empty bus's weight into account. In this respect, buses' application is the same with national calculating method. The vehicle's weight increment （△G） minus standard vehicle weight G_0 (see chart two). Because the numerous number of buses, it is necessary to use some simple skills in calculating. For example, people collection bus and automated collection bus can increase or decrease attendants' weights, and CNG vehicle buses can calculate bottles' weight together. For the same type, the bus with air conditioners and those without air conditioners can be calculated together.

The following chart is the basic additional fuel consumption of different vehicles' standard weight and weight changes:

Table 3: The consumption of standard weight.

Vehicle's types	Jiefang		Dongfeng		Huanghe	
	bicycle	hinge	bicycle	hinge	bicycle	hinge
G_0（吨）	6	9.3	6.2	10.5	8.3	13.5
q_c L / 100t • km	1.5	1.2	1.25	1	1.15	0.85

- **The Correction Coefficients of Roads, Altitudes and Seasons**

The application of buses should use every line as a unit and test it based some factors such as the amount of slopes, the density of stops and traffic lights, traffic jam situation, closed situation and standard ruining speed. At the beginning, it is feasible to imitate historical data and test and modify it gradually.

The following chart is the reference road correction coefficient of different levels of highways and urban roads.

Table 4: The reference road correction coefficient.

Road category	The first category	The second category	The third category	The fourth category	The fifth category	The sixth category
Highway levels	Plains, rolling terrain, highways of first, second and third level	Plains, rolling terrain, highways of the fourth level	Ridges and weigh grave、highways of second and third level	The Highways beyond plains and weigh grave	The fourth level highways beyond plains and weigh grave	Highways beyond ridges and heavy high
Urban road levels		Plains, rolling terrain, highways of the first, second, third and fourth level	Heavy ridges' highways of the first, second, third and fourth level	Roads beyond levels		
Road correction coefficient Kr	1.00	1.10	1.25	1.35	1.45	1.70

As we said above, natural is more greatly affected by temperature than gasoline. According to the operation of this system in Chongqing, the experiences are that in specific operation, the median should be obtained by monthly temperature changes.

Table 5: The median.

Monthly average temperature	Lower than 5℃	5－12℃	12－35℃	Higher than 35℃
Temperature correction coefficient Kt	1.03	1.01	1.00	1.02

The national standard provides altitude correction coefficient

Table 6: Correction coefficient.

altitude	≤ 500	>500-1500	>1500-2500	>2500-3500	>3500
altitude correction coefficient Kh	1.00	1.03	1.07	1.13	1.20

According to the former analysis and vast actual data simulation computation, the fuel consumption formula which is applied to buses is obtained:

$$Q_i = (q_a \times S/100 + q_b \times N \times S/1000 + q_c \times (G - G_0) \times S/100) \times K_r \times K_t \times K_h \qquad (2)$$

In this formula,
Q ——vehicle's operation fuel consumption，L；
q_a ——the basic car fuel consumption，L/100km；
q_b —— Basic additional fuel consumption of passenger turnover，L/1000p·100km;
q_c ——Basic additional fuel consumption of the vehicle's own weight，L/100t·km;
S—— the distance that the bus runs in the same operation condition，km;
N ——the amount of passengers，p;
G ——the bus's own weight；
G_0 ——buses' standard weight ;
K_r ——Road correction coefficient
K_t ——Temperature correction coefficient；
K_h ——The altitude correction coefficient；

In order to verify the method, especially the influences of persons, we select some representative lines to make s comparison. In chart six, lines A, B and C have similar environment:

1, ring cars in the same region, small operation limit, same section
2, operated by the same branch office, repaired in the same warranty factory
3, because of the same operation date, their types are the same, drivers' conditions, skills and working ages are similar.

The three lines are mainly different in directions, lines and especially in passenger capacity; the following chart is their operation in November:

Table 7: The three line.

llines	Quota Q （cube/100 km)	Actual quotab Q_0 （cube/100 km）	actual difference	basic consumption in empty q_a	Basic additional consumption of passenger turnover q_b	Daily passenger amount of a bus N_d
Aline A	35.83	35.97	-0.14	23	0.8	944.5
Lline B	34.92	35.03	-0.11	23	0.8	898.5
Cline C	33.36	33.12	0.24	23	0.8	762
Bus passenger flow section coefficient FN	Daily distance SN	basic consumption of the bus's weight q_a	The bus's e weight G （ton）	Road correction coefficient Kr	Season correction coefficient K_t	The altitude correction coefficient K_h
2	217.9	1.25	7.55	1.1	1	1
2	234.2	1.25	7.55	1.1	1	1
2	256.5	1.25	7.55	1.1	1	1

According to the former analysis, line A and B, which has more passengers, consume more natural gas, and C, which has fewer passengers, consume less natural gas. The highest deviation of calculation quota is 7.19 ‰. So the formula can reflect fuel consumption in a relative genuineness

This kind of fuel planning system has proved a strong manoeuvrability after several years' operation in bus limited company in New City, Chongqing and has received extensive approve. The foundation of this mathematical model is a reformation and innovation of bus energy management. It provides new thinking patterns at the same time. For example, it can applied in a large extent, and it can be perfected gradually, and make more contribution to public transport enterprise's scientific management.

REFERENCE

National Standard GB4353 *Fuel Consumption for passenger vehicles in operation*