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STUDY OF BUS DRIVING PARAMETERS ON URBAN ROUTE

Summary. The article deals with bus traffic time and speed on stage and route in the whole. The factors affecting bus driving parameters are divided into groups. The factors of significant impact are found in each group. The method of consideration of such factors impact on driving parameters in timetable making, is proposed. The extent of impact of selected factors on bus driving time and speed is studied.

ИЗУЧЕНИЕ ПАРАМЕТРОВ ДВИЖЕНИЯ АВТОБУСА НА ГОРОДСКОМ МАРШРУТЕ

Аннотация. В статье изучено время и скорость движения автобуса по перегонам и по маршруту в целом. Факторы, влияющие на параметры движения автобусов, подразделены на группы. Выявлены значительно влияющие факторы из каждой группы. Предложена методика учета влияния этих факторов на параметры движения при составлении расписания движения. Изучено степень воздействия каждого из выбранных факторов на время и скорость движения автобусов.

1. INTRODUCTION

The nature of an urban bus route functioning depends on many factors. The number of passenger flow, its daily, seasonal variations as well as information on transportation of passengers are most important factors to specify performance parameters of a bus route. Finally, just such two factors specify the number of traffic units and efficient by-route traffic condition.

By-route bus driving time depends on many random factors such as bus replenishment rate, bus roominess, traffic length, crossing available in different level or signaled crossing, road cover condition, bus maneuverability, engine capacity and many other constructive parameters of bus. All such factors to some extent have an influence on bus traffic time. It is important to specify the extent of impact of such factors on this time and to consider the most sufficient of them to schedule route timetable. Such approach, or rather specifying each traffic time will enable to make more effective bus traffic timetable.

2. BY-ROUTE BUS TRAFFIC PARAMETERS

In some sources the optimal value of stage city bus route is assumed to be 0.4 km [1]. But in real conditions, this value varies in the range 0,3-1,0 km. Investigations showed that time to overcome the bus of the same stage of the forward and backward in most cases do not match. It is also associated with influence on the above factors.

In urban bus routes which is using different types of buses. Therefore we cannot accurately estimate the speed of buses on the stage not including trailer brake performance bus. In general, the time immobile on the bus and stage along the route affected by three factors: factors resist the motion of the bus, the factors did not resist the motion of the bus, but forcing slow motion, the factors included in the system driver-vehicle [2]. The first group should include the type of pavement and other road conditions. The second group includes traffic volume, composition of transport flow, meteorological conditions, the presence of turns, width of roadway, the presence of fork of road and methods of regulating them. The third group includes the technical condition of the bus, the psychological state and professional drivers.

It is obvious that changes in these factors, while driving the bus on the stage and throughout the journey will exchange within wide limits.

To assess the impact on the bus while driving factors, the first group to determine the following indicators:

- road resistance on the stage,
- crossing the length of road section on each transfer,
- the movement of each transfer,
- the overall speed and travel time.

Given the complexity of the aspects of real movement takes some facilitating conditions, but not affect the final result [3]:

1. In a certain section of the route, provided the bus is moving only in the gear «i», where D_{i+1} and D_i the dynamic factors of the bus, respectively, for the $i+1$-th and i-th transmission;
2. Provided $D_{i+1} \le \psi < D_i$ that a bus will speed engines $V_{i-1} \le V_a \le V_i$, where V_{i-1} and V_i is speed on respectively gear;
3. When you go to higher speeds take $D_{i+1} = \psi$, and the transition to the speed below $D_i = \psi$;
4. Not taken into account during the transition from one program to another. If we denote the time $t_1, t_2, ..., t_m$ to overcome at individual programs, while ferrying be overcome:

$$t = \sum_{i=1}^{m} t_i$$

Then the average speed on the stage can be determined by the formula:

$$V_{mid} = \sum_{i=1}^{m} V_{midi} \frac{t_i}{t}$$

where: V_{midi} - speed of the bus on i-th gear.

During acceleration and braking at each of the spans is determined by the obvious formula [4]. Many studies have shown a hundred violations of the schedule of buses is mainly due to the impossibility for an appropriate speed limit. To identify the most accurate values of the rate needed to take into account many factors. To facilitate this process we have compiled and used a special PC program. Thus, by introducing indicators of the route (the length of the stages, the longitudinal slope of roads, the number of traffic lights) and buses (length, width, height, track width of rear wheels, a full and proper weight, type and maximum power, engine speed, the number of gear transmission, the number of transmission main gear, the coefficient of smoothness) is possible with sufficient accuracy to determine the time to overcome the individual buses and stage the route as a whole.

The main purpose of each bus transport enterprise to achieve greatest benefit to the implementation of the quality of passenger service. Improving the quality of care increases, in turn, competition solidity of transport enterprise. The high level of service quality may provide a choice of efficient rolling stock. The proposed method makes it possible to solve this question and choose the stock that best suits your specific needs.

Now consider the degree of influence factors on the parameters of buses in particular.

3. TRAFFIC TIME VARIATIONS FOR STAGES

3.1. Bus replenishment impact on bus driving time

Bus replenishment varies according to hour and route areas. As soon as the bus is replenished the bus full mass changes and, thus, dynamic factor changes, too [5, 6]. The results of studies hold in bus route №106 in Baku are shown in table 1 for different buses.

Table 1

Changing the time of turnover, depending on the replasement of the bus

№	Type of bus	Coefficient of replasement of the bus γ	time of turnover, min		
			In motion with minimal speed	In motion with maximal speed	In motion with middle speed
1	Otoyol M24	0	83,33	71,97	76,08
		1	91,35	72,06	77,5
2	PAZ-32051	0	129,8	74,0	90,01
		1	131,5	74,47	91,35
3	PAZ-4230	0	106,4	72,46	83,52
		1	114,8	74,28	87,13
4	BMC 220-BC	0	105,48	72,61	83,3
		1	117,24	75,39	88,35
5	DAEWOO BS212	0	103,26	71,34	81,9
		1	112,42	73,05	85.51

The values in the table show that in spite of a bus type, as soon as the bus replenished the turn-round time increases. It should be noted that the turn-round time has different values in accordance with variations in constructive characteristics of buses. The replenishment impact becomes tangible at minimum traverse speed values. As soon as the replenishment rate is increased, the traffic time increases 0,15…3,8% in maximum speed traffic, and 7,3…10,1% in minimum traffic speed.

3.2. Intensity impact on bus traffic time

When public transport traffic line is not provided in the street, bus driving speed depends on traffic flow nature. In such situation, traffic flow intensity and content that are the basic parameters characterizing the traffic flow should be taken into consideration. As soon as the traffic intensity is increased, the traffic speed of vehicle driving in the same direction is decreased. Insufficient road capacity causes vehicle blocks. To estimate the intensity impact on bus driving speed it is reasonable to consider road load factor [7, 8].

Table 2 shows the results of studies of road load rate variations ($z = 0{,}25...0{,}5$ to $z = 0{,}75...1{,}0$) impact for different buses in minimum and maximum speed driving.

According to the table as soon as traffic flow intensity is increased, the traffic time increases too. Such increase depends on bus type and speed. Such dependence is appreciable in minimum speed bus driving. When traffic intensity is increased, the traffic time is increased 0,5…3,5% at maximum speed, and 2…8% at minimum speed.

Table 2

Changing the time of turnover, depending on traffic

№	Type of bus	Loading coefficient of road	Speed of motion	t_{route} , min.
1	Otoyol M24	$z = 0{,}25\ldots0{,}5$	$V_{\min}$	83,32
			$V_{\max}$	71,97
		$z = 0{,}75\ldots1{,}0$	$V_{\min}$	90,47
			$V_{\max}$	73,46
2	PAZ-32051	$z = 0{,}25\ldots0{,}5$	$V_{\min}$	129,8
			$V_{\max}$	73,55
		$z = 0{,}75\ldots1{,}0$	$V_{\min}$	135,12
			$V_{\max}$	75,75
3	DAEWOO BS212	$z = 0{,}25\ldots0{,}5$	$V_{\min}$	103,21
			$V_{\max}$	71,35
		$z = 0{,}75\ldots1{,}0$	$V_{\min}$	111,76
			$V_{\max}$	73,84

3.3. Bus technical state impact on bus traffic time

As soon as a bus technical state becomes worse, the bus traffic time increases. Table 3 shows the results of studies hold for different buses at normal values of other parameters (little intensity traffic, $\gamma = 0{,}75$ capacity use rate, dry road cover).

Table 3

The influence of the technical condition to the time of turnover of bus on route

№	Type of bus	technical condition of the bus	Time of motion, min.		
			In $V_{\max}$	In $V_{\min}$	In V_{mid}
1	Otoyol M24	excellent	71,7	87,95	76,66
		satisfactory	72,06	91,35	77,58
2	PAZ-32051	excellent	73,91	130,58	90,53
		satisfactory	74,48	131,52	91,35
3	PAZ -4230	excellent	73,24	110,0	84,93
		satisfactory	74,32	114,88	87,13
4	BMC 220-BC	excellent	74,08	112,25	86,31
		satisfactory	75,39	117,24	88,39
5	DAEWOO BS212	excellent	72,05	108,24	83,51
		satisfactory	73,05	112,42	85,51

The results shown in the table enable to conclude that bus traffic time increases in various ways for different buses. The studies have shown that the optimal value of traffic flow for urban streets varies 40 km/h to 50 km/h [1]. In urban conditions, the maximum bus speed is limited (generally, to 60 km/h). So, at maximum speed the traffic time doesn’t considerably differ for different bus types.

3.4. Road condition impact on bus traffic time

Traffic safety may be ensured when pulling power in the driving and braking wheels is less than the wheel traction value. Such value, in its turn, depends on the road conditions besides constructive parameters of the bus. To estimate road conditions impact on bus traffic time, two traction coefficient values have been considered:

1. $\varphi = 0{,}75$ - dry asphalt coverin,
2. $\varphi = 0{,}35$ - road under snow.

The results calculated are shown in table 4.

Table 4

Changing the time of turnover, depending on road conditions

№	Type of bus	time of turnover, min.			
		$\varphi = 0{,}75$		$\varphi = 0{,}35$	
		In $V_{\max}$	**In** $V_{\min}$	**In** $V_{\max}$	**In** $V_{\min}$
1	Otoyol M24	71,97	83,33	72,06	87,57
2	PAZ-32051	73,55	129,85	72,91	130,78
3	PAZ-4230	72,46	106,48	73,17	109,85
4	BMC 220-BC	72,61	105,48	74,08	111,97
5	DAEWOO BS 212	71,35	103,21	71,92	108,09

The analysis of the results given in the table shows that when the traction coefficient is decreased and the roominess capacity is increased, by-route traffic time increases considerably. When the traction coefficient is decreased 0.75 to 0.35, the traffic time increase 0…2 % at maximum speed, and 1,3…6,2 % at minimum speed.

The studies have shown [9, 10] that to design delays in certain area of the city, along with other factors, the longitudinal slope of the road is of specific importance. It is known that [9] when the longitudinal slope varies - 6^0 to 6^0 the transmission capacity of one traffic lane increases 530 auto/h to 1356 auto/h, that is about 2.5 times. The studies have also supposed the method of calculation of time losses in the signaled crossing depending on the road slope [10]. Table 5 shows the results of studies of the longitudinal slope impact on the bus traffic time.

Table 5

Influernce of longitudinal slope of the road the time of turnover for haul for different buses

№	Type of bus	Time of rider, min.			Percent of increaseof expendituring time	
		longitudinal slope of the road			In rise from $\alpha = 0$ to 5^0	In rise from $\alpha = 0$ to 15^0
		$\alpha = 0$	$\alpha = 5$	$\alpha = 15$		
1	PAZ - 4230	41.82	60.63	83.22	45	99
2	DAEWOO BS 212	41.2	57.54	75.22	40	83

The longitudinal slope of road is a considerable road factor impacting on bus route traffic speed and time. Such factor significantly varies for average and large capacity buses. When the longitudinal slope of road is changed to 5^0, the traffic time of the PAZ-4230 bus changes to 45%, and the DAEWOO BS 212 – to 40%, and the slope is changed to 15% their traffic time changes to 99 and 83%, accordingly.

3.5. The automobile-driver factor impact on bus traffic time

As the driver is a biological being, he can drive a bus at any speed to the extent of its technical feasibilities. But it should be noted that the traffic speed restriction and the traffic flow density in urban street network prevent it. In addition, the analyses carried out have shown [11] that drivers' experience significantly impacts on the traffic schedule compliance extent. When a driver's experience is enlarged, the situation is improved. Therefore, the bus traffic speed is considered as minimum, maximum and average. The figure 1 shows the comparative turn-round time rates in route №106 for different buses at different speeds calculated by applying the software.

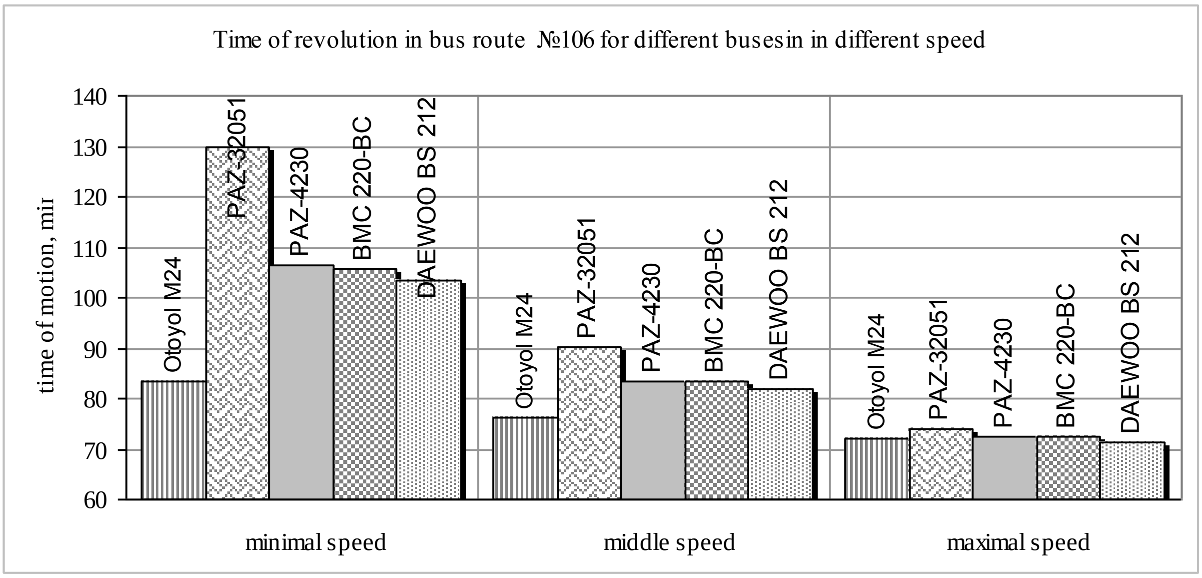

Fig. 1. The turn-round time in route №106 for different buses at different speeds
Рис. 1. Время оборота на маршруте №106 для различных марок автобусов на различных скоростях

When such factors are taken into consideration, it is possible to select appropriate (most advantageous from the vehicle park) and to specify the turn-round time with reasonable accuracy both for existing and scheduled routes. Moreover, such method to be introduced may be applied in other passenger and freight transportations. It should be noted that in such case, the street traffic intensity impact and the speed restriction will lose their importance.

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