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ALGORITHM FOR OPTIMIZATION OF PRODUCTION PROCESSES AND PASSENGER TRANSPORTATION OPERATIONS

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Abstract. Research of transport processes are closely related to the economic and operational performance of road transport. When planning road transport, the most important factor is the cost of transport services. It is known that improper organization of the vehicles work taking into account the type, size, modes of vehicle stock operation of, quantitative composition, qualifications and responsibilities of personnel, along with other organizational measures leads to unjustified costs. In general, this reduces the attractiveness of the business to its owner, as well as reducing motivation for staff. Therefore, research related to improving the efficiency of vehicles by reducing costs is appropriate and relevant.

The article presents the results of research on the planning of transport processes in the performance of public passenger transport on urban and suburban routes. The proposed method is aimed at optimizing the number of vehicle stock and its passenger capacity depending on the capacity of passenger traffic and the recommended traffic interval, and also allows you to calculate economic and financial indicators based on the optimization model.

The article presents the results of research to determine the transport mobility of cities and suburbs residents. On the basis of research data of the population survey a number of qualitative indicators of passenger transport work important from the point of its user's view is established. Also, according to the results of research, the probability of increasing passenger traffic due to the redistribution of the population (potential user of public transport), who uses individual transport and taxis.

Therefore, the main purpose of the research is a multicriteria task, which is to ensure adequate forecasting of fixed and variable costs in the performance of passenger road transport on public transport. As well as obtaining a constant and projected profit due to the algorithm for optimizing the work of vehicle stock, the work of driving crews, the elimination of unproductive costs.

Key words: passenger road transport, public transport, optimization of business processes in motor transport, rational solutions in the field of passenger transport.

Introduction

Motor-vehicle transport companies that provide passenger car services very often do not receive a reasonable income due to unbalanced management of business processes and the introduction of irrationally designed operations. This affects the quality of motor-vehicle transport and passenger service. Almost all companies face the issue of improving efficiency, saving resources and more.

Formulation of problem

Every carrier is interested in the efficiency of passenger transport on public transport. The main criteria set by carriers are the optimization of transport costs while maintaining maximum profit.

Vehicle owners are increasingly thinking about how to use their vehicles efficiently and rationally. Is it profitable to build a business on passenger transportation and what needs to be done to make this idea work perfectly?

When performing passenger motor-vehicle transport, cost optimization is the process of reducing the total level of carrier costs. It is achieved by improving management, reducing or eliminating costs from a number of unproductive items. However, the optimization of costs in the enterprise must be carried out on the basis of articles that do not affect the main business processes on which the carrier's profits depend and, at the same time, do not impair the qualitative and quantitative performance.

In order to ensure adequate forecasting of fixed and variable costs in the performance of passenger Motor-vehicle transport and obtaining a steady profit, an algorithm is proposed to solve this problem. To optimize the work of vehicle stock, driving crews, eliminate unproductive costs for medium and small businesses, a cost-effective and efficient mechanism is proposed to achieve this goal with the help of technical means (automated systems for monitoring passenger flows and optimizing technical and operational performance) and management system implementation of business processes and quality of service delivery).

The modern technological world offers a number of solutions to optimize the business of transport services.

However, they are usually expensive and therefore unacceptable for most small and medium-sized transport organizations, which make up the majority of a company number providing passenger transport services.

The strategy of building a business involves identifying and accounting for factors that will contribute (or categorically hinder!) to profit from business activities. The category of the most important circumstances that directly affect the success of vehicle transport companies include such as: competitiveness; costs associated with the operation of transport; options for business registration in state tax authorities and the amount of tax payments, etc.

The increase in operating costs for individual transport and taxis reduces the mobility of the population in relation to the use of public passenger vehicle transport (PPVT). Improving the quality of service, comfort in the vehicle stock, speed, validity of the fare on PPVT lead to increased mobility.

Given the current requirements for admission to the market of transport services PPVT, the requirements of the customer services are becoming more stringent. In order to improve passenger traffic in c. Kyiv, tenders have been launched for a number of profitable routes with more stringent requirements, namely buses with a capacity of 60 seats, equipped with sensors for counting passenger traffic of at least four high-definition video surveillance cameras, environmental standard 5-th EU etc. [8].Therefore, truckers need not only to meet these requirements of tenders, but also to have the technical and methodological tools to process statistical information on passenger traffic. When implementing technical means of passenger traffic control, carriers must optimize the work of passenger vehicles using intelligent automated systems (eg., DynaPCN 10-20 systems, PTV Visum software products, automatic control system, "Intranso" from Gemicle etc.).

Analysis of recent research results

Effective provision of transport services for passenger transportation is to determine the level of their satisfaction by providing services with the expected level of quality [4].

To achieve this goal in the work performed an analysis of recent research by scientists and implemented developments in practice. A significant contribution to the modern understanding and development of the organization and management of transport activities belongs to scientists: V.P. Alferiev, I.D. Afanasenko, N.V. Afanasieva, G.L. Bahiiv, A.M. Gadzhinsky, M.P. Gordon, W.A. Gudkov, M.E. Zalmanova, K.V. Inutyiniy, E.A. Kravchenko, O.A. Crawley, L.B. Miritin and others. Note that a crucial role is played by sound methods and technologies of passenger transportation and methods of improving the level of transport services directly taking into account the management of technological and operational processes that need to be investigated and improved [2, 3].

The issue of rational vehicle organization taking into accounts the interests of not only carriers but also passengers, which will ensure the proper quality of transportation and the ability to control and influence it's insufficiently studied and is a priority area of research [4, 6]. The researchers are devoted to optimization of work of passenger motor transport on quality criteria in the article [1-6].

Purpose of research

However, not only must the transport operator meet the requirements of transport customers, he must also take care to optimize the work of vehicle stock and qualified personnel in order to reduce the overall cost of providing services. That is, to find such optimization methods for which the cost of transportation will be the lowest.

In this regard, the author substantiates the algorithm for optimizing the technical, operational and economic performance of the vehicle stock of passenger transport in order to reduce fixed and variable transportation costs.

Research results

The general level of public passenger transport services in Ukraine is currently insufficient for the majority of the population to be able to prefer public rather than individual transport to meet their transportation needs. It is known that the main part of the movement of citizens is related to professional and business activities [7]. Depending on the employment of the population in certain territorial entities (cities, suburbs, settlements, communities, etc.), the share of professional and business transport activity may differ significantly. But it always prevails over social and domestic transport mobility. According to the results of population surveys (potential passengers of public transport [1]) professional and business transport activity is in the range of 57-77% (Fig. 1).

Fig. 1. Social structure of transport mobility by public transport in cities and suburbs (sociological survey)

Unfortunately, this share of passengers using public transport is due to the need caused by the low income of citizens who use it forcibly.

In the structure of the use of different types of transport within the territorial associations there is a pattern [2], presented in Fig. 2.

As can be seen in the graph, on average 25% of citizens use personal cars and 3% use taxi services. According to the results of the survey of these citizen's categories, more than 60% of them are ready to use public transport, but subject to the quality of this service. Thus, the number of potential passengers may increase from the existing 62 to 78-80%. That is, as a result, passenger traffic can increase by 16-18%, which is a significant indicator for carriers in terms of motivation to improve the quality of service.

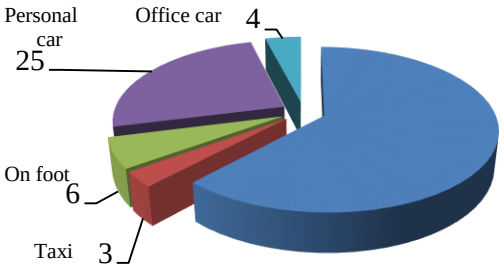


Fig. 2. Percentage distribution of the population's use of various modes of transport for professional and business needs.

In June and October 2021, we conducted our own research - a survey of passengers in c. Kyiv to determine the quality of public transport from the point of view of users.

As a result of the survey, the following qualitative indicators with the level of weight were established (Fig. 3).

The most important of the quality indicators were the exact schedule and optimal filling of the cabin, which was expected, but the indicator "tariff" was in last place. And this indicates that passengers are consciously willing to pay for quality services.

Thus, we have statistics on the undoubted motivation for carriers to improve the quality of services, which in turn will provide additional revenue in the range of 16-18%.

Customers of public passenger transport (self-government bodies) often set intervals for the movement of vehicles stock on routes in a small range of time (mostly 5-10 minutes for urban, 15-20 for suburban). This approach is not rational or justified. Therefore, business carriers need to convince customers of the facts (statistics) in the adoption of rational intervals of movement depending on the time of day, working or weekends, seasons and so on.

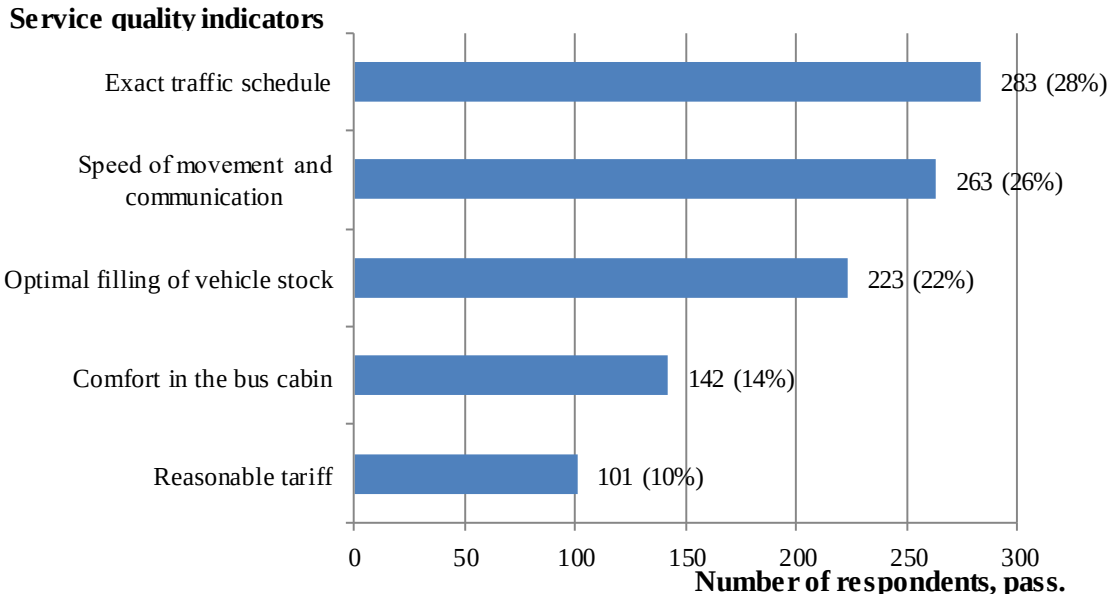


Fig. 3. Results of passenger surveys on the quality of public transport.

The author's view on the way out of the above problems is as follows.

The ideal transport process for passenger traffic would be to continuously adjust the distribution of vehicle stock on routes over time according to the variable supply of passenger traffic, so that in any race of any route to constantly maintain equality between transportation requests and their provision of vehicle stock.

Currently, such a technical possibility exists, but there is no unambiguous model for transport networks of different territorial entities and we have to develop individual projects for specific networks, directions, routes, which requires the involvement of specialists from outside. The author proposes an adapted algorithm to solve this problem. Consider the scheme (Fig. 4).

The generalized project is that the vehicle stock must be equipped with an accurate system for calculating passenger traffic online and GPS trackers. Information on changes in passenger traffic must be processed on its own server.

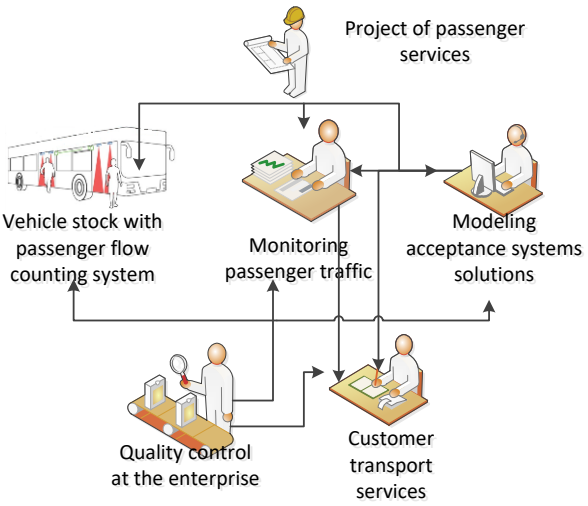
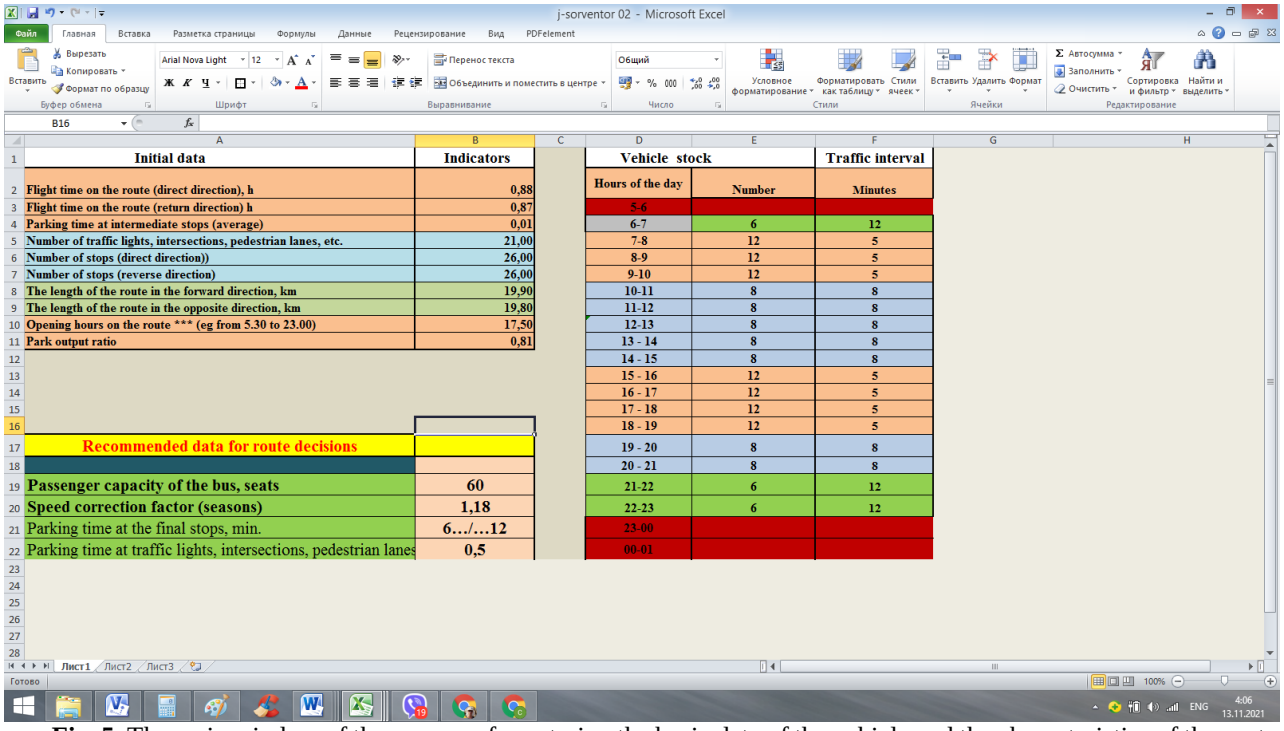


Fig. 4. The scheme of interrelations between operations of process of monitoring and rendering of services on quality criteria

The simulated system under specific conditions is a complex control system of the vehicle stock. The last element should be the operational department for quality control – compliance of the quantitative vehicle stock and intervals of movement to the passenger flow, monitoring of customer feedback, reporting to the Customer of transport services.

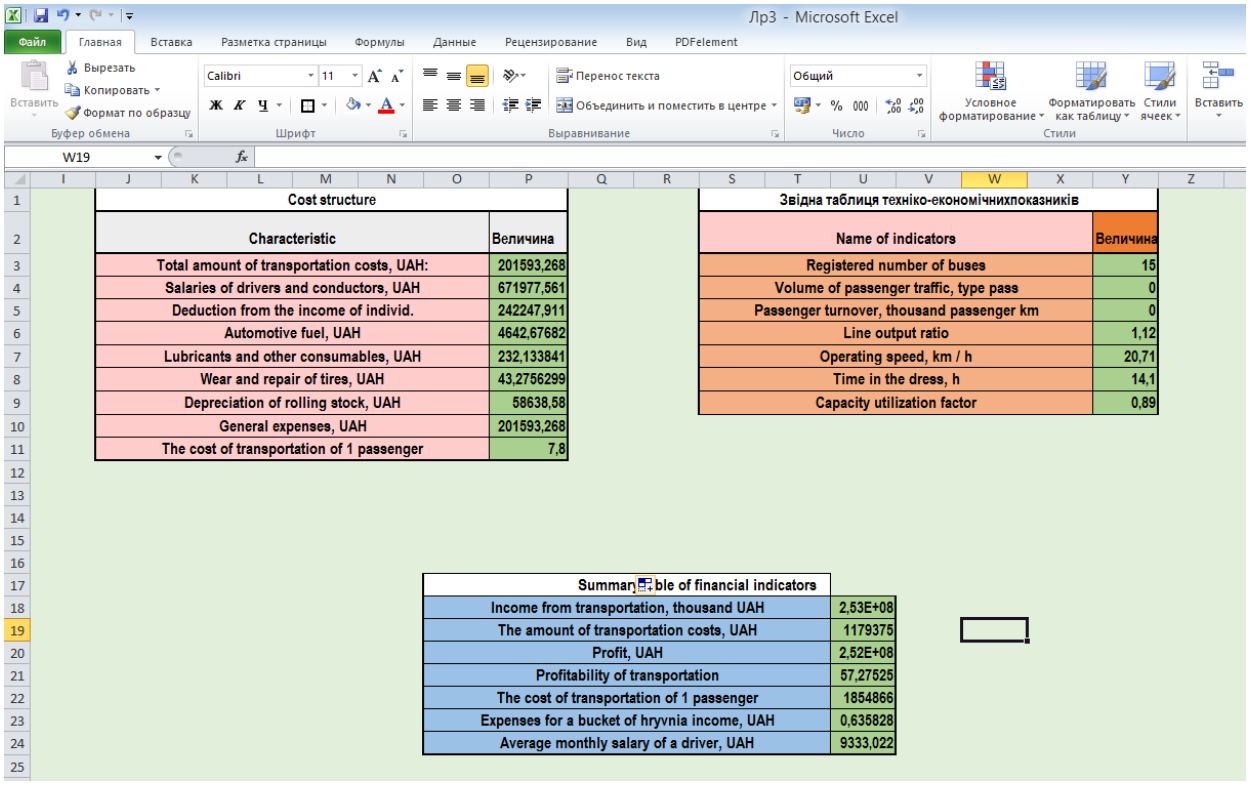
To calculate the technical, operational and economic performance of passenger vehicles in order to minimize total costs, the author developed an algorithm for optimizing the operation of the quantitative vehicle stock depending on the capacity of passenger flows and the range of intervals.



Initial data	Indicators
Flight time on the route (direct direction), h	0,88
Flight time on the route (return direction) h	0,87
Parking time at intermediate stops (average)	0,01
Number of traffic lights, intersections, pedestrian lanes, etc.	21,00
Number of stops (direct direction))	26,00
Number of stops (reverse direction)	26,00
The length of the route in the forward direction, km	19,90
The length of the route in the opposite direction, km	19,80
Opening hours on the route *** (eg from 5.30 to 23.00)	17,50
Park output ratio	0,81
Recommended data for route decisions	
Passenger capacity of the bus, seats	60
Speed correction factor (seasons)	1,18
Parking time at the final stops, min.	6…/…12
Parking time at traffic lights, intersections, pedestrian lanes	0,5

Vehicle stock		Traffic interval
Hours of the day	Number	Minutes
5-6		
6-7	6	12
7-8	12	5
8-9	12	5
9-10	12	5
10-11	8	8
11-12	8	8
12-13	8	8
13 - 14	8	8
14 - 15	8	8
15 - 16	12	5
16 - 17	12	5
17 - 18	12	5
18 - 19	12	5
19 - 20	8	8
20 - 21	8	8
21-22	6	12
22-23	6	12
23-00		
00-01		

Fig. 5. The main window of the program for entering the basic data of the vehicle and the characteristics of the route.



Cost structure	
Characteristic	Величина
Total amount of transportation costs, UAH:	201593,268
Salaries of drivers and conductors, UAH	671977,561
Deduction from the income of individ.	242247,911
Automotive fuel, UAH	4642,67682
Lubricants and other consumables, UAH	232,133841
Wear and repair of tires, UAH	43,2756299
Depreciation of rolling stock, UAH	58638,58
General expenses, UAH	201593,268
The cost of transportation of 1 passenger	7,8

Звідна таблиця техніко-економічнихпоказників	
Name of indicators	Величина
Registered number of buses	15
Volume of passenger traffic, type pass	0
Passenger turnover, thousand passenger km	0
Line output ratio	1,12
Operating speed, km / h	20,71
Time in the dress, h	14,1
Capacity utilization factor	0,89

Summary table of financial indicators	
Income from transportation, thousand UAH	2,53E+08
The amount of transportation costs, UAH	1179375
Profit, UAH	2,52E+08
Profitability of transportation	57,27525
The cost of transportation of 1 passenger	1854866
Expenses for a bucket of hryvnia income, UAH	0,635828
Average monthly salary of a driver, UAH	9333,022

Fig. 6. Window of technical, operational and economic indicators.

The main criterion for the work of the vehicle stock is the amount of cabin filling, which will not exceed 80% of occupied passenger seats. Calculations of the corresponding technique are automated in the table processor of the

Microsoft Excel program. The initial parameters are all technical and operational performance of the vehicle stock, route characteristics, as well as passenger traffic data, which is calculated by the hour of the day and integrated into an external database, located in the module of the passenger traffic monitoring system (GRT-DM 02).

Of course, there are various intelligent automated systems that allow not only to provide statistics of passenger traffic, but also to calculate the number, passenger capacity of the vehicle stock, traffic intervals at different times of the day.

However, they are too expensive for the carrier firstly, and secondly, to work with these systems you need to be trained and most importantly, for these systems you need to regularly pay the developer for support and other services. So, we have an additional fixed cost item.

The author's development is more attractive, namely - the algorithm will be available for testing for 30 days for free, and at the end of this period can be purchased for a nominal fee. For the user, development does not require any skills or training.

All you need for the carrier is to have a passenger traffic calculation system installed on the buses (regardless of the manufacturer), an adaptive module for integrating statistics into Excel, and a personal computer with Microsoft Office.

Also have all the necessary characteristics of the route - distance, number of stops, downtime at stops and more (specified in the instructions). The data are entered in the response of the table cell and the result is formed automatically (Fig. 5).

The program also calculates a number of technical and operational indicators that can operate the head of the convoy and economic and financial calculations for the accountant and the head of the car company (Fig. 6).

Thus, the heads of car companies with the help of this program have the opportunity to optimize the work of the vehicle stock, reduce the cost of passenger transportation, cost and increase their profits.

Conclusions

1. Studies substantiate and confirm the effectiveness of the proposed algorithm for optimizing the work of vehicle stock on the route and allow to calculate the fixed and variable costs of the workflow of services.

2. Analytically substantiated and tested in practice algorithm for determining the optimal amount of vehicle stock and passenger capacity from the power of passenger traffic and the recommended interval of movement.

3. The introduction of the proposed method will not only improve the quality of services and increase the profits of truckers, but over time to establish a clear production business process, namely: to optimize the number of qualified personnel; reduce the total cost of providing the service; to improve the work schedule of driving crews in accordance with the requirements of the legislation; upgrade vehicle stock by increasing revenues due to increased passenger traffic and reduced variable and fixed costs; to ensure the environmental friendliness of the project (reduction of emissions of combustion products) due to the optimization of traffic intervals and reasonable passenger capacity of vehicle stock; reducing the load of routes and the intensity of traffic on them.

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АЛГОРИТМ З ОПТИМІЗАЦІЇ ВИРОБНИЧИХ ПРОЦЕСІВ І ОПЕРАЦІЙ ПАСАЖИРСЬКИХ АВТОПЕРЕВЕЗЕНЬ

С. І. Бондарєв

Анотація. Дослідження транспортних процесів тісно пов'язані з економічними й експлуатаційними показниками роботи автомобільного транспорту. При плануванні автоперевезень найбільш важливим фактором є вартість транспортної послуги. Відомо, що неправильно виконана організація роботи автотранспорту враховуючи тип, розмірність, режими роботи РС, кількісний склад, кваліфікацію та межі відповідальності персоналу, а також інші організаційні заходи призводить до невиправданих витрат. Загалом, це призводить до зменшення привабливості бізнесу його власнику, також зменшенню мотивації для виконавчого персоналу.

Тому дослідження, які пов'язані з підвищенням ефективності роботи автотранспорту за рахунок скорочення витрат є доцільним і актуальним. У статті наведені результати досліджень з планування транспортних процесів при виконанні пасажирських автоперевезень загального користування на міських та приміських маршрутах. Запропонований метод спрямований оптимізувати кількість РС і його пасажиромісткість від потужності пасажиропотоку і рекомендованого інтервалу руху, а також дозволяє розрахувати економічних і фінансових показників на основі оптимізаційної моделі.

В статті представлені результати досліджень з визначення транспортної рухливості громадським транспортом мешканців міст і передмість. На основі дослідних даних опитування населення, встановлені ряд якісних показників роботи пасажирського транспорту з точки зору його користувачів. А також, з аналізу досліджень, встановлена вірогідність збільшення пасажиропотоку за рахунок перерозподілу населення (потенційного користувача громадським транспортом), яке користуються індивідуальним транспортом і таксі.

Отже головною метою проведених досліджень є багатокритеріальна задача, що полягає у забезпеченні адекватного прогнозування постійних та змінних витрат при виконання пасажирських автоперевезень на громадському автотранспорті загального користування. А також отримання постійного і прогнозованого прибутку за рахунок методу оптимізації роботи рухомого складу, роботи водійських бригад в плаваючому графіку, усунення непродуктивних витрат.

Ключові слова: пасажирські автомобільні перевезення, громадський транспорт загального користування, оптимізація бізнес процесів на автотранспорті, раціональні рішення в сфері пасажирських перевезень, оптимізація транспортного процесу.

АЛГОРИТМ ПО ОПТИМИЗАЦИИ ПРОИЗВОДСТВЕННЫХ ПРОЦЕССОВ И ОПЕРАЦИЙ ПАССАЖИРСКИХ АВТОПЕРЕВОЗОК

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Аннотация. Исследование транспортных процессов тесно связано с экономическими и эксплуатационными показателями работы автомобильного транспорта. При планировании автоперевозок наиболее важным фактором является стоимость транспортных услуг. Известно, что неправильно выполненная организация работы автотранспорта, учитывая тип, размерность, режимы работы подвижного состава, количественный состав, квалификация и пределы ответственности персонала вместе с другими организационными мероприятиями приводит к неоправданным затратам. Как правило, это приводит к уменьшению привлекательности бизнеса его владельцу, а также уменьшению мотивации для персонала.

Поэтому исследования, связанные с повышением эффективности работы автотранспорта за счет сокращения расходов целесообразно и актуально. В статье приведены результаты исследований планирования транспортных процессов при выполнении пассажирских автоперевозок общего пользования на городских и пригородных маршрутах. Предлагаемый метод направлен оптимизировать количество подвижного состава и его пассажировместимость от мощности пассажиропотока и рекомендуемого интервала движения, а также позволяет рассчитать экономические и финансовые показатели на основе оптимизационной модели.

В статье представлены результаты исследований по определению транспортной подвижности жителей городов и пригородов. На основе опытных данных опроса населения установлен ряд качественных пока-

зателей работы пассажирского транспорта с точки зрения его пользователей. А также, на основании полученных результатов исследований, установлена вероятность увеличения пассажиропотока за счет перераспределения населения (потенциального пользователя общественным транспортом), пользующегося индивидуальным транспортом и такси.

Следовательно, главной целью проведенных исследований является многокритериальная задача, заключающаяся в обеспечении адекватного прогнозирования постоянных и переменных расходов при выполнении пассажирских автоперевозок на общественном автотранспорте общего пользования. А также получение постоянной и прогнозируемой прибыли за счет алгоритма оптимизации работы подвижного состава, работы водительских бригад, устранение непроизводительных затрат.

Ключевые слова: пассажирские автомобильные перевозки, общественный транспорт общего пользования, оптимизация бизнес-процессов на автотранспорте, рациональные решения в сфере пассажирских перевозок, оптимизация транспортного процесса.

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