UDC 311.313:629.33(477.64)

MODEL OF TRANSITION FROM MACHINE TO WORKING TIME OF FLEET OF TECHNICAL OPERATION OF ROAD TRANSPORT

Ivan Rogovskii, DS., Professor,
National University of Life and Environmental Sciences of Ukraine,
e-mail: rogovskii@nibip.edu.ua

Let us consider the question of the transition from machine to working time of the park [1]. Let the requirement for service arise at the moment of computer time $\bar{}_i$. In the system of counting the working time of the machine park, this will correspond to the moment in time:

$$\frac{\bar{}}{}, \qquad (1)$$

where $k_{ri}, k_{\alpha i}$ – the coefficients of technical readiness of the system of serviced elements and the use of serviceable elements for the time from the beginning of the countdown to the moment the i-th requirement arises.

The value k_B of the utilization rate of serviceable machines in the fleet can be obtained by analyzing the annual and shift modes of operation. In addition, the results obtained can be refined by comparison with the expected load of machines, based on the planned amount of work, as well as with statistics on the actual use of serviceable machines in the past [2].

With a constant intensity of use of machines throughout the year, we get . However, if the operation of the machine park is seasonal, then the value k_{Bi} will change over time. Let the distribution of the annual consumption of machine resources by months be given. The specific weight of the consumption of machine resources for each month as a percentage of the annual is known

.

For simplicity, we assume that during each month the intensity of use of machines does not change. Then the utilization rate of serviceable machines k_{Bi} in time from the beginning of the countdown to the moment the i-th requirement arises can be determined with sufficient accuracy by the formulas:

$$\frac{}{}\left(d_1 + d_1 + \cdots + d_j\right); j = 1 + \left[\frac{}{}\right]$$

where $k_и$ – the average annual coefficient of use of machines;

– moment of working time when the -th requirement arises;$(i-1)$

– average monthly working time of the park;

[x] – a function of the integer part ofx.

The coefficient of technical readiness of serviced elements k_{ri} cannot be set in advance at all, since its value depends not only on the intensity of the flow of requirements, but also on the unknown, determined only in the process of solving the task, the efficiency of the service system.

Therefore, the flow of requirements for closed queuing systems in the working time reference system cannot be predetermined at all, but must be formed in the very process of solving the problem on the basis of a predetermined flow in the machine time reference system. Hence it follows that the computer time reference system proposed for describing the incoming flow of requirements is the key to solving the problems of queuing requirements in closed systems using the Monte Carlo method.

Let us assume that the mathematical model for servicing requirements has already been compiled and is being implemented on the computer, as a result of which the working time moments $(i-1)$ of the return of the serviced requirements to an external source become known, of which only the values $T''_{pr} = 1,2,3,\dots,i-1$ bare contained in the memory of the machine $T''_{pr} > T_{i-1}$. The moment of occurrence of the next th requirement can be determined by the formula:

$$k_{ri} = k_{\Gamma,i-1} - \frac{k_{\Gamma.э}}{zT_{pi}}(T_{pi} - T_{\text{p}.i-1}) + \frac{k_{\Gamma.э}}{zT_{pi}}\sum_{(r)}(T_{pi} - T''_{pr})_{+}, \qquad (2)$$

where $(x)_{+} = \max(x;0)$ or cannot take negative values;

$k_{\Gamma.э}$ – coefficient of technical readiness of the machine park, which could take place if the machines required maintenance only by their crews.

Coefficient $k_{\Gamma.э}$.is determined analytically by formula (1), into which the corresponding values of λ' and μ' are substituted. If there is no system for servicing vehicles by their crews in the network, the value $k_{\Gamma.э} = 1$ is substituted into formula (2). On the right side of this formula, the second term determines the decrease in the technical readiness factor for the period $T_{pi} - T_{\text{p}.i-1}$, due to the occurrence of the $(i-1)$-th requirement, and the third term – its increase due to the serviced requirements returning to the external source for the same period of time, which corresponds to the physical meaning of phenomena in a closed network of mass service [3].

The formation of the moment of working time of the occurrence of the i-th requirement is carried out by the iterative method in the following sequence. In the first approximation $k_{ri1} = k_{r,i-1}$, it is assumed that. Then, according to the formula (1), also in the first approximation, the value is determined which is used in order to find a more accurate value T_{pi1} of the technical readiness factor k_{ri} using the formula (2).

At this, the first cycle of the process of successive approximation ends and the transition to the second cycle is carried out, which is carried out similarly, starting with the definition T_{pis} by formula (1), etc. Each time, the values of the moments of occurrence of the i -th requirement obtained in this and the previous cycles are compared T_{pi}. The formation can be considered complete if the condition T_{pi}:

$$T_{pis} - T_{pi,s-1} \leq \pm\beta, \qquad (3)$$

where s – the serial number of the cycle of re-formation of the moment of occurrence of the i-th requirement;

β – predetermined calculation accuracy.

If condition (3) is satisfied T_{pi}, it is taken equal to T_{pis}, all values are excluded $T''_{pr} < T_{pi}$ from the computer memory and service simulation is carried out i-th requirement in the queuing network, as a result of which the memory of the machine is replenished by the time of its return to an external source T''_{pr}.

From the analysis of formula (2) it follows that k_{ri} less and less differs in value from $k_{r,i-1}$ with an increase T_{pi} in when $T_{pi} \to \infty$ the value of the coefficient of technical readiness stabilizes. However, the formation of the moments of occurrence of service requirements by the proposed iterative method showed that even in the initial period of modeling, in order to achieve a calculation accuracy of up to one thousandth, it is usually sufficient to perform no more than 3–4 repeated cycles of formation of the moment of occurrence i-th applications.

The moment of occurrence T_{pi} of each request in an external source in the reference system of the working time of serviced elements is obtained. If we accept the same working time counting system for service devices, then the described transition from machine to working time is sufficient for solving practical problems of mass service. However, more complex situations often occur in practice. For example, a machine park can work in one shift, and the workshops servicing it in two shifts, or vice versa. The machine park can work in two shifts and be serviced by several workshops with one-, two- and three-shift operation modes. In this case, for an external source of requirements and for each queuing system connected to a common network, different working time reference systems are adopted.

So, for an external source of requirements and all queuing systems operating in different modes, one could adopt a single calendar time reference system. But then the flow of working time of serviced elements and devices with different interruptions in each system would be discrete, which would undoubtedly lead to significant difficulties in modeling and especially in optimizing queuing systems by changing their operating modes. Therefore, while maintaining for the source of requirements and each queuing system the reference of working hours corresponding to their specific modes of operation, it is proposed to use calendar time only for the transition from one of the accepted systems of reference of working hours to another. To do this, the time is conditionally taken as a calendar time minus weekends and holidays, common requirements for the source and all queuing systems.

To change from working hours T_p in one system through calendar time T to working time in another system, taking into account the discrete nature of the flow of working time, as well as the fact that requirements arise at the source or leave the queuing system only during working hours, the following logically obvious formulas can be proposed:

$$T = \left[\frac{T_p}{n_c t_c}\right] t_ц + \left\{\frac{T_p}{n_c t_c}\right\} n_c t_c; \qquad (4)$$

$$T_p = T - \left[\frac{T}{t_ц}\right]\left(t_ц - n_c t_c\right) - \left(T - \left[\frac{T}{t_ц}\right] t_ц - n_c t_c\right)_+ \qquad (5)$$

where n_c – the number of work shifts per day; t_c – the duration of the shift; $t_ц$ – calendar cycle time (days) (24 h and 1440 $min,$ depending on which unit of time measurement is adopted); *[x],* $\{x\}$ – integer and fractional part functions *x;* $(x)_+ = \max(x; 0)$.

With different operating modes of the source of requirements and the service system, there are periods of time when the service devices are working, but the requirements are not received (for example, during the second shift of the workshops during one-shift operation of the fleet), and vice versa. In the first case, the devices can be busy servicing earlier received requests that were in the process of servicing or were waiting for servicing at the beginning of the considered period of time. In the second case, a queue may form even if the attendants are free, but do not work according to the mode set for them. Then, at the end of the break, the devices immediately receive several requests at the same moment of their working time. In this case, the ordinariness of the flow of requirements disappears, which, obviously, like stationarity, is a relative concept, it may or may not manifest itself depending on the accepted time reference system.

All these complex situations are described by the above formulas (4) and (5). Let the park work in one shift (7 *h),* and the service workshop – in two (14 *h).*The same moment of park working time $T_{\text{р.п}} = \Delta\ h$at according to formula (4) corresponds to two moments of calendar time $\Delta \to 0$, $T_1 = 31\ h$ and $T_2 = 48\ h$ and two moments of the working time of the workshop -$T_{\text{р.м1}} = 21\ h$ and $T_{\text{р.м2}} = 28\ h$. The workshop works without receiving new applications for one hour $T_{\text{р.м2}} - T_{\text{р.м1}} = 7$ h. Suppose now that the park works two shifts during the day, and the workshop one seven-hour shift. In the park, demands arise at the moments of working time and hours $T_{\text{р.п1}} = 50; T_{\text{р.п2}} = 54; T_{\text{р.п}s} = 56$. Then, according to formulas (4) and (5) and hours $T_1 = 80; T_2 = 84;\ T_3 = 96\ h\ T_{\text{р.м1}} = T_{\text{р.м2}} = T_{\text{р.м}s} = 28$, the workshop receives three demands at the same time at the same moment of its working time.

However, formulas (4) and (5) are valid under the condition of the same operating modes of service systems every day, for example, with a five-day working week. With a six-day working week, seven-hour shifts and a working day reduced by 1 hour on weekends, for practical calculations, an average shift duration equal to 6.83 working hours can be taken. At the same time, errors in determining the moments of working time should not exceed 2.5% even in the initial period of simulation. Consequently, the possibility of determining the moments of occurrence of applications in different reference systems of working time has been obtained, which will be repeatedly used in the future when modeling queuing processes occurring in complex stochastic networks.

References

1. Rogovskii I. L., Titova L. L., Voinash S. A., Sokolova V. A., Tarandin G. S., Polyanskaya O. A. Modeling the weight of criteria for determining the technical level of agricultural machines. IOP Conference Series: Earth and Environmental Science. 2021. Vol. 677. P. 022100. doi:10.1088/1755-1315/677/2/022100.

2. Hrynkiv A., Rogovskii I., Aulin V., Lysenko S., Titova L., Zagurskiy O., Kolosok I. Development of a system for determining the informativeness of the diagnosing parameters of the cylinder-piston group of the diesel engines in operation.

Eastern-European Journal of Enterprise Technologies. 2020. Vol. 3 (5(105)). P. 19-29. doi:10. 15587/1729-4061.2020.206073.

3. Voinalovych O., Hnatiuk O., Rogovskii I., Pokutnii O. Probability of traumatic situations in mechanized processes in agriculture using mathematical apparatus of Markov chain method. Engineering for Rural Development. 2019. Vol. 18. P. 563-269. doi:10.22616/ERDev2019.18. N245.

Міністерство освіти і науки України

Національний університет біоресурсів і природокористування України
Механіко-технологічний факультет
Кафедра транспортних технологій та засобів у АПК

Академія прикладних наук Університету управління та адміністрування в Ополе

Академія інженерних наук України
Українська асоціація аграрних інженерів

ЗБІРНИК ТЕЗ
доповідей
VI Міжнародної
науково-практичної конференції
«Автомобільний транспорт та інфраструктура»

AutoTransport and Infrastructure

19-21 квітня 2023 року
м. Київ

ББК 40.7
УДК 631.17+62-52-631.3

Рекомендовано до друку рішенням наукової ради механіко-технологічного факультету Національного університету біоресурсів і природокористування України від 18 квітня 2023 р., протокол № 8 .

Збірник тез доповідей VI Міжнародної науково-практичної конференції «Автомобільний транспорт та інфраструктура» (19–21 квітня 2023 року). Національний університет біоресурсів і природокористування України. Київ. 2023. 250 с.

ISBN 978-617-8102-96-8

В збірнику представлені тези доповідей науково-педагогічних працівників, наукових співробітників, аспірантів і докторантів, студентів, фахівців транспортної галузі, учасників VI Міжнародної науково-практичної конференції «Автомобільний транспорт та інфраструктура», в яких розглядаються нинішній стан та шляхи розвитку автотраспортної галузі.

ISBN 978-617-8102-96-8

ОРГАНІЗАЦІЙНИЙ КОМІТЕТ:

Отченашко В. В., начальник науково-дослідної частини – голова організаційного комітету;

Братішко В. В., декан механіко-технологічного факультету – заступник голови організаційного комітету;

Тадеуш Покуса, проректор Академії прикладних наук Університету управління та адміністрування в Ополе, Польща – заступник голови організаційного комітету;

Киричок П.О., президент Академії інженерних наук України – заступник голови організаційного комітету;

Загурський О.М., професор кафедри транспортних технологій та засобів у АПК – секретар організаційного комітету.

Войтюк В. Д., професор кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка;

Дьомін О.А., доцент кафедри транспортних технологій та засобів у АПК;

Калінін Є. І., завідувач кафедри тракторів, автомобілів та біоенергоресурсів;

Новицький А. В., завідувач кафедри надійності техніки;

Мацюк В. І., заступник декана з наукової роботи механіко-технологічного факультету, професор кафедри транспортних технологій та засобів у АПК;

Михайлович Я. М., професор кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка;

Роговський І. Л., завідувач кафедри технічного сервісу та інженерного менеджменту імені М. П. Момотенка.

Савченко Л.А., завідувачка кафедри транспортних технологій та засобів у АПК.