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Research Article

TECHNIQUE OF BIT-BY-BIT RELIABILITY CALCULATION OF DUMP TRUCKS ELECTROTRANSMISSION

NURSULTAN B. ZHARKENOV[1*], SAPAR Z.H. KABIKENOV[1], SERGEI Y.U. KUTIENKO[1], KAIRATBEK T. ESBOSYNOV[1], AIDANA SUNGATOLLAKYZY[1] AND JAN VLNKA[2]

[1]Department of Transport Engineering and Logistic Systems, Karaganda State Technical University, 100027, 56 Mir Ave., Karaganda, Kazakhstan

[2]Department of Vehicles and Mobile Work Machines, Slovak University of Technology in Bratislava, 811 07, 5 Vazovova Str., Bratislava, Slovakia

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ABSTRACT

The development and updating of production advanced technology should be based on the use of the modern technique. Therefore, the subject of the research is urgent. The purpose of the work is the reliability calculation of dump trucks electrotransmission. With increasing number of the vehicles, the requirements of automobile reliability and reduction of specific metal intensity and labour intensity of maintenance and repair become stricter. Electric transmission of the heavy-load car represents the composite automated system. For the reasoned and precise calculation various methods, such as the analysis, model operation, systematization and others were used. As a result of the research, various failure rates on system were established.

INTRODUCTION

Electric transmission of the heavy-load car represents the composite automated system. It consists of the traction generator given to rotation by the heat engine, two traction electric motors connected in parallel which are built in in conducting the motor wheel, satellite electrical machines, electric management personnel and regulation, devices of monitoring connected by a circuitry.

Electric transmissions fall into number of the restored systems. For the purpose of obtaining criteria of reliability of the restored system by method of model operation it is necessary to make the statistical model of system considering structure, logical communications between elements and system duties (Soloviev, 1999).

Advantage of electric transmissions is that the widest range of automatic change of a torque and force of draft is provided, and also there is no rigid kinematic communication between electro-transmission units that allows creating various packaging schemes (Yogeswar, *et al.*, 2013).

Shortcomings of such transmissions are bound to larger dimensions, weight, cost, decrease in efficiency (Banatov, 1970; Adilakshmi, *et al.*, 2014).

These types of transmissions are applied in locomotives, dump trucks, some sea vessels, tractors, self-propelled mechanisms, military equipment and others (Stott, et al., 2009; Fernandez, et al., 2011).

MATERIALS AND METHODS

The application of a method on modular (bit-by-bit) calculation expediently when the estimated object in its most part can be collected from several compound standard or reference parts (Topchiyev, *et al.*, 1968).

For justification of scientific value of work and the

***Corresponding authors email: zhar_nursultan@mail.ru**

complex analysis of a technique of bit-by-bit reliability calculation of dump trucks electrotransmission different scientific methods, both empirical, and theoretical were used. During the research the scientific model operation which is based on use of formulas was used (Ashfaq and Sharma, 2011; Bindu, 2008).

In the course of the research, by drawing up model of system, the following initial positions were accepted:

1. The elements entering the structural flowchart of calculation of reliability are connected sequentially.

2. System failure or an element is an event casual and independent.

3. The failure of any element involving partial or complete violation of work of system is accepted to system failure.

4. Each element has the distribution law of time between refusals.

5. A system restoring time is terminating. As a first approximation for all elements to adopt the distribution law of a restoring time exponential.

6. The coefficient of prophylaxis (malfunction) characterizing the restoring time relation to operating time of system is accepted equal 0.01; 0.1; 0.5; 1.0; ∞.

$$\rho = \frac{T_r}{T_s} \quad (1)$$

7. Casual operating time of system decides on a series connection of elements on the basis of a stochastic algorithm.

$$Te = \min Ti. \quad (2)$$

where i=1, 2... n; n - number of elements of the structural flowchart accepted when calculating reliability.

The model of system and the structural flowchart of system reflect structural and logical communications between its separate elements, consider their appointment and a role in ensuring reliability (Sier and Monteith, 2016).

The carried-out analysis allows to draw a conclusion that the technique of the analysis of the quantitative characteristics of reliability is accepted on the following assumptions:

1. Only the main dependences of $\lambda(t)$ are considered, i.e. only casual refusals are considered.

2. For preliminary comparative calculations the exponential distribution law of casual refusals is adopted.

3. The reliabilities given about the intensity of refusals of separate elements are accepted according to literary data.

4. The restitutions given about intensity are absent as similar analysis it was not made so far.

5. Preventive repairs are not considered.

6. Only the first operation of the car (operation before overhauling) and each of the specified systems of transmission is considered.

It was established that the technique of the prior calculation of the quantitative characteristics of reliability of systems of the automated electric drive includes the following stages:

1. Definition of the block diagram of reliability of the considered system of the electric drive. We consider that connection of elements of reliability serial, failure of any element leads to an exit of their system of all system. We make the specification of all elements of reliability of system.

2. According to the provided literary data corresponding to each element of similarity of reliability of failure rate coefficients of similarity will be received in vitro at the continuous operation of an element. We accept failure rate at a silent state of an element

$$\lambda = 0.1 * \lambda_{i.} \quad (3)$$

3. For timing devices and the relay it is accepted the padding size of failure rate.

4. By operational analysis of system we install the most probable operating time for each element of reliability to and time of a non-working condition of t_s within a day.

5. We count a demand factor which is defined as:

$$K_d = \frac{I_o}{I} \quad (4)$$

6. We determine failure rate for actual working conditions taking into account the corresponding schedules by the following formulas:

a) for all elements of reliability, except timing devices:

$$\lambda_i = a_i * \lambda_{i0.} \quad (5)$$

b) for the switching equipment:

$$\lambda_i = \lambda_{i0} + q\lambda n. \quad (6)$$

where a_i – the correction factor considering influence of electric loading and surrounding medium;

q – Number of switching in an hour.

7. We define failure rate of all elements of reliability,

except timing devices, within a day taking into account work and idle time, we receive:

$$\lambda_k = \frac{\lambda_{io} * a_i * t_o \lambda * t_s}{24} \qquad (7)$$

8. We define failure rate for timing devices within a day taking into account number of switchings in days and idle time, we receive:

$$\lambda_k = \frac{\lambda_{io} * a_i * t_o \lambda * t_s}{24} = \frac{(\lambda * q\lambda_n)t_o + \lambda * t_o}{24} \qquad (8)$$

9. Knowing number of identical elements of calculation of reliability, we count failure rate for groups of elements like ($n_к$ * $\lambda_к$).

10. We define cooperative failure rate of system of the automated electric drive as the sum of failure rate of separate groups, we receive:

$$\lambda_s = \sum_{1}^{n} n_k * \lambda_k \qquad (9)$$

11. In view of that the above-stated calculation corresponds to the programmed working conditions, i.e. in actual practice, the system works at impact of vibration, jolting, blows, humidity, a cyclic change of environment temperature in other, we enter a correction factor K_s=25.

At the same time, we receive:

λ_s=25$\lambda'_{s.}$ (10)

12. We define a time between failures for each system of the automated electric drive, we receive:

$$T_o = \frac{I}{\lambda_s} \qquad (11)$$

13. We establish probability of no failure during the given time. We accept two calculated terms of 1000 hour and the 5000th hour. Term approximately corresponds the 5000th hour to work of system before overhauling. As we adopt the exponential distribution law, probability of no failure is determined by a formula:

P(t)=-expλ_s*t. (12)

14. We build schedules of dependence of P(t) for various periods of work of system.

15. We define a restoring time and we count availability quotient of K_a on the following formula:

$$K_a = \frac{T_o}{T_o + T_r} \qquad (13)$$

We make definition of failure rate for various equipment and the above-stated scheme of transmission. Considering at the same time that circumstance that the tabulated values of intensity of refusals are given for some maximal and minimum value, calculation is carried out for boundary values (Patarasuk, *et al.*, 2016; Chinwendu, *et al.*, 2017; Ying Xue, *et al.*, 2017; Pavlos, *et al.*, 2013).

RESULTS AND DISCUSSION

According to the above-stated technique calculation of the quantitative characteristics of reliability of system of electric transmission of a dump truck was

Table 1. Calculation of the quantitative characteristics of reliability of system of dump truck electric transmission

T_r. hour	$K_{a.}$
0	1.000
1	0.955
2	0.913
3	0.873
4	0.835
5	0.805
6	0.775
7	0.745
8	0.720
9	0.695
10	0.673
15	0.577
20	0.508

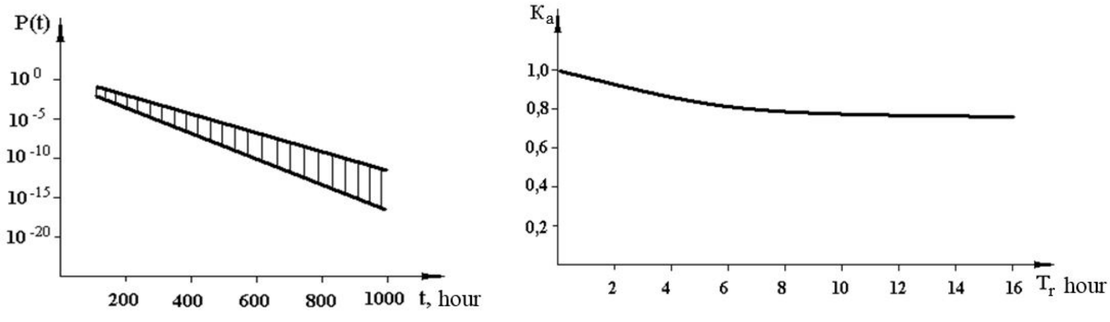

Fig. 1 Calculated dependences P(t)=-expλ_s*t and K_a=f(T_r) of transmission systems.

carried out. Results of these calculations are reduced in Table 1 and Fig. 1.

CONCLUSIONS

Having investigated a question of reliability of electrotransmission of dump trucks, it was developed approach to a technique of bit-by-bit calculation of reliability. Having analysed results from tables, it was selected the main characteristics on the calculated systems of transmission. As a result of the analysis it is established that the greatest failure rate on system in general, but without coefficient considering actual conditions was $\lambda'_{smax=}1952.63 \times 10^{-6}$ 1/hour, the least, in turn, – $\lambda'_{smin}=1910.28 \times 10^{-6}$ 1/hour.

Failure rate on system in general taking into account actual conditions has the following indicators: the greatest – $\lambda'_{smax}=1952.63 \times 25=48815.75 \times 10^{-6}$ 1/hour; the least – $\lambda'_{smin}=1910.28 \times 25=47757.0 \times 10^{-6}$ 1/hour.

From calculations mean time in clocks of an operating time on one refusal is visible, which is $T_{0max}=1/\lambda_{smin}=20.94$ hours for the greatest index and

$T_{0min}=1/_{smax}=20.4$ hours – for the least.

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