METHODS AND TECHNICAL MEASURES OF INCREASING THE OPERATIONAL RELIABILITY OF ELECTRICAL VEHICLES

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ABSTRACT

This article presents the results of the analysis of the methods, technical means, factors such as temperature, humidity and vibration to increase the operational reliability of electrical systems, especially electrical systems in agriculture.

Keywords: electrical conductivity, temperature, humidity, vibration, reliability.

Electrical failure can cause significant downtime, loss of productivity and increased maintenance costs. Factors such as temperature, humidity and vibration contribute to the failure of electrical equipment, especially in agriculture.

Agriculture is an important sector of the world economy, contributing to food security, job creation and economic growth. In recent years, the use of electric drives replacing traditional mechanical and hydraulic systems in agriculture is becoming more and more widespread. The proposed strategies can be implemented at different stages of electrical engineering design, development and maintenance.

The most technical branch of agricultural production with electric motors is animal husbandry, which includes about 50% of electric motors in agriculture. One of the main indicators of the reliability of electric motors is the failure rate λ_0, which in turn depends on the period of operation. It is usually accepted that there are three periods of operation. The Weybull distribution curve shape parameter and breakdown depend on the lifetime of electric motors. Thus, an exponential distribution with α=1 is obtained, which is characterized by λ_0 = const, which corresponds to the normal operating period. For the exponential law, the failure probability density f(t) and the integral function F(t) are defined by Eqs:

$$f(t) = \lambda_0 e^{-\lambda_0 t} \quad (1)$$

$$F(t)=1-e^{-\lambda_0 t} \quad (2)$$

With an exponential distribution, the probability of failure of an electric motor at time **t** can be written in the form of the formula (2.10), where the total failure rate is the sum of elementary failure rates for specific reasons:

$$P(t)=1-F(t)=1-Q(t)= e^{-\lambda_0 t}=e^{-\sum_{i=1}^{n}\lambda_i t} \quad (3)$$

According to the expression (3), each value of the elementary failure rate corresponds to its probability of failure due to a certain reason. Based on the above, the following expression was obtained:

$$P(t)= \prod_{i=1}^{n} P_i(t_i) = P_1(t_1) * P_2(t_2) * P_3(t_3) * \ldots .* P_n(t_n) = \prod_{t_u 1}^{n}[1 - Q_i(t)] \quad (4)$$

Since the expressions (3) and (4) describe the same value of the probability of failure of the electric motor, they can be equated. In this case, the value corresponds to the time interval for observing the sample:

$$P(t)=\prod_{i=1}^{n} P_i(t_i) = e^{-\lambda_0 t} \quad (5)$$

(5) by taking the logarithm of the expression, an equation related to the probability of failures due to specific reasons determined on the basis of the results of troubleshooting of non-working electric motors is created:

$$\lambda_0 t = -\ln(\prod_{i=1}^{n} P_i(t_i)) = -\ln\left(\prod_{i=1}^{n}\left(1 - Q_i(t_i)\right)\right) \quad (6)$$

The solution of equation (6) with respect to the value of the current time of observation of sample i is the following expression:

$$t=\left(\frac{-\ln\left(\prod_{i=1}^{n} P_i(t_i)\right)}{\lambda_0}\right) = \left(\frac{-\sum_{i=1}^{n} \ln P_i(t_i)}{\lambda_0}\lambda_0\right) \quad (7)$$

According to the formula (7), the sample observation time depends on the rate of failure of its elements, which are electric motors, and the logarithm of the product of the probability of partial failure-free operation related to certain failure causes.

The logarithm of the product of partial running time probabilities can be expressed as a sum of logarithms. Thus, in order to determine the coefficient Ki, which describes the degree of influence of each individual failure cause on the reliability of their operation, in order to eliminate the failure of electric motors, it is necessary to take the derivative of time with respect to the probability of failure associated with a certain failure cause.

$$K_i = \frac{\partial t}{\partial P_i(t_i)}\left(\frac{\frac{\partial}{\partial P_i(t_i)}\sum_{i=1}^{n} \ln P_i(t_i)}{\lambda_0}\right) \quad (8)$$

From (8) comes the final formula for calculating the influence coefficient of each individual exploitation factor.

$$K_t = -\frac{1}{\lambda_0 P_i(t_i)} = -\frac{1}{\lambda_0[(1-Q_i(t_i))]} \quad (9)$$

According to the expression (9) for the exponential distribution of failures, the coefficient K_i, which describes the level of influence of each individual work factor, depends on the probability of failure during work for a certain reason and the average life of electric motors. The next most important operational factor is the impact of an aggressive environment. The use of high-quality protection against emergency overloads associated with asymmetric mode increases the projected resource by an average of 50% for all studied technological processes.

Mathematical models for determining the predictive value of electrical performance failure	
$f(t) = \lambda_0 e^{-\lambda_0 t}$	failure probability density
F(t)=1-$e^{-\lambda_0 t}$	integral function
P(t)=1-F(t)=1-Q(t)= $e^{-\lambda_0 t}$=$e^{-\sum_{i=1}^{n}\lambda_i t}$	possibility of failure
P(t)=$\prod_{i=1}^{n} P_i(t_i) = P_1(t_1) * P_2(t_2) * P_3(t_3) * \dots * P_n(t_n) = \prod_{t_u 1}^{n}[1 - Q_i(t)]$	probability of failure due to causes from i to n
t=$(\frac{-\ln(\prod_{i=1}^{n} P_i(t_i))}{\lambda_0}) = (\frac{-\sum_{i=1}^{n}\ln P_i(t_i)}{\lambda_0}\lambda_0)$	with respect to the value of its current time
$K_t = -\frac{1}{\lambda_0 P_i(t_i)} = -\frac{1}{\lambda_0[(1-Q_i(t_i))]}$	impact factor of the exploitation factor

CONCLUSIONS

In order to increase the operational reliability of electric motors of agricultural electric vehicles, measures are taken to eliminate the main causes of failures for the highest efficiency. For a submersible pump, the predicted life increases from 3,480 hours to 5,340 hours when overloads are eliminated, to 10,150 hours when asymmetric modes and overloads are eliminated, and to 25,000 hours when all dominant factors are eliminated.

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