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Reliability of Collector (Bottle) Set in ACS

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Annotation. DC motors are widely used in industry due to their deep, smooth and economical speed control. However, the reliability of DC machines is lower than that of asynchronous machines due to the presence of a sliding contact collector-brush combination. Statistical analysis shows that in terms of reliability in AC machines, it is necessary to distinguish four "weak sets": collector-brush set, bearing ring, armature ring, drive throwing pot we pay attention to the collector-brush set, taking into account the above.

Objective: To ensure the reliability of AC collectors.

Methods: Ensuring the reliability of the collectors of AC machines Ensuring the reliability of the design of the collector parts in detail. Keywords: Reliability, Collector-brush, the possibility of continuous operation, in AC machines, rectangular deviation, constant current (OT)

Introduction:

The efficiency and durability of a collector unit is determined by the influence of three main factors related to electromagnetic processes, mechanical effects, and the physicochemical nature of the sliding contact.

Electromagnetic influencing factors are determined by electromagnetic loads, voltage between adjacent plates, reactive EYUK, current overload, and so on.

Mechanical impact factors are determined by the technological and design characteristics of the machine: weakening of compression, eccentricity and ellipticity of the collector, vibration level of the whole machine or unit and rotor speed.

Factors of the physicochemical nature of the sliding contact are determined between the current collection conditions and the surrounding condition: brush and collector coupling, brushing, collector material, ambient temperature, humidity, acidity, and dust.

It should be noted that a contact film (polish) is formed on the surface of the collector. the presence of a film reduces the wear of the collector, slows down the speed, and facilitates a more comfortable distribution of flow under the brushes. Humidity, the presence of active gases in the environment, and especially dust have a detrimental effect on the collector material.

In addition, a large amount of damage to the collectors is caused by the friction of the brushes against the collector and the high flow density under the brushes when the brushes are not firmly attached to the collector, which is accompanied by a significant increase in temperature, ie. thermal ionization of the brush contacts occurs as a result of local heating of individual areas.

Opening and closing the contact points with the formation of a small electric arc on the collector surface leads to the destruction of the collector surface.

The most effective means of reducing collector wear are:

Improving the switching conditions of the machine by properly adjusting the additional poles, selecting the brand and size, the brushes for the power and voltage of the machine, reduce the rotation speed of the collector and select the appropriate pressure brush to the collector.

Careful balancing of the armature is also important to reduce vibrations in the collector. Practical and experimental data show that the leakage of the collectors during continuous operation of the machine is 0.03-2 mm per year in copper containing 99.9% of the base metal (taking into account the presence of silver). The amount of other compounds in the chemical composition does not exceed one hundred percent.

Figure 1.8. M1 copper used for collector fabrication

Total other elements should not exceed 0.1%.

- iron - 0.005%;
- nickel - 0.002%;
- sulfur - 0.004%;
- arsenic - 0.002%;
- lead - 0.005%;
- rux - 0.004%;
- oxygen - 0.05%;
- driving - 0.002%;
- bismuth - 0.001%;
- tin - 0.002%.

Copper alloy M1 has excellent physical properties: high electrical conductivity and low (0.018 μOm) electrical resistance, which is further reduced by 2.8% after heat treatment. The plastic properties of the alloy allow it to be used for the production of parts used in solid joints with an operating temperature of up to 250 ° C.

Due to its very low content, the price of M1 copper is 20% higher than that of other popular brand M2. Various copper rolled products made of M1 alloy are widely used in cryogenic industry. Due to its thermal stability, its hardness, strength and plastic properties do not change under extremely dangerous temperature conditions.

Copper with a chemical composition similar to the local M1 class is produced in many countries with developed metallurgical industries:

- Japan (JIS standard), USA - S1100, S1220.
- European Union (EN standard) - Cu-ETP.
- UK (BS standard) - S106.
- France (AFNOR standard) - Cu-B.
- Italy (UNI standard) - Cu-DHP.

As a national product, analogues of the M1 brand are undoubtedly the leading metallurgical industry in Germany in the production of various alloys of oxygen-free copper. Non-ferrous metallurgical plants produce three types of alloys in accordance with DIN and WNR standards - Ecu57, ECu58, SF-Cu.

The coefficient of friction of lubricated metal is 0.011, without lubrication - 0.043. There are two categories of alloys according to GOST 1173-2006 on Brinell hardness: during the test it should be remembered that the linear shrinkage of M1 is 2.1%. Copper melts at a temperature of 1083 ° C, casting is carried out in the temperature range of 1150-1250 ° C.

For example, for collectors made of copper M l, it is 0.36 and 0.22 mm per 10,000 hours when using 611M and EG-74K, respectively.

In most cases, the leakage of the collector depends on the normal state, or a shortened normal distribution. Figure 1.9 shows the curvature of the integral function (curve 2) of the GP-311B generators (curve I) and the flow rate distribution of the GP-311 collectors.

Due to its deep, smooth and economical speed control, DC motors are widely used in industry. However, the reliability of DC motors is lower than that of asynchronous motors due to the presence of a sliding contact collector-brush connection. Statistical analysis shows that in terms of reliability in AC machines, it is necessary to distinguish four "weak sets": collector-brush set, bearing ring, anchor ring, drive throwing pot. Faults in the commutator-brush assembly are governed by normal law, bearing faults by Weibull's law, armature faults by logarithmic-normal law or superposition of laws, and drive windings by exponential law. The above regarding the distribution laws of node faults is of a generalized nature, but does not exclude other distribution laws. The number of DC machines produced is less than the number of asynchronous machines, so the data are less statistically significant. However, the amount of available statistics on the reliability of AC machines and their individual units allows us to get a complete picture.

The largest proportion of faults occur in the collector-brush and the bearing ring. According to operational statistics, on average, about 25% of machine failures are caused by collector failures. In some cases, for example in transport, this figure reaches 44-66%. One of the main causes of failure in traction engines of electric locomotives is the occurrence of all-round fires.The share of collector failures due to all-round fires is on average 70%.

A study of DC motors found that faults in the collector assembly were 56%, due to mechanical damage - 34%, and faults in the armature and poles - 10%. Analysis of statistical data on failures of DC-717A heavy-duty DC motors revealed that the armature and collector-brush assembly are the least reliable units. The failure of electric machines due to the failure of the collector-brush set varies from 21.6% (ferrous metallurgy enterprises) to 37.8%. (enterprises producing mineral fertilizers) and an average of 26.5% for all industries; for anchors - from 19.6% (non-ferrous metallurgy) to 42% (coal industry) and on average - 27.7%.

The fault distribution law of DK-717A traction engines is presented as a superposition of two Vaibul laws with corresponding weights. Figure 1.5 shows that the failure rate of electric motors depends on the walking distance of the vehicle.

If you imagine the level of failure of electric machines in the form of a function λдв = кр *f(x) (where kp is the coefficient taken into account working conditions for groups of enterprises in different industries, xt is another factor), then the coefficient according to statistics kr as follows:

For engines of the mining industry and ferrous metallurgy - 0.837, for non-ferrous metallurgy - 0.919, for the coal industry - 1.166, for the chemical industry - 1.137.

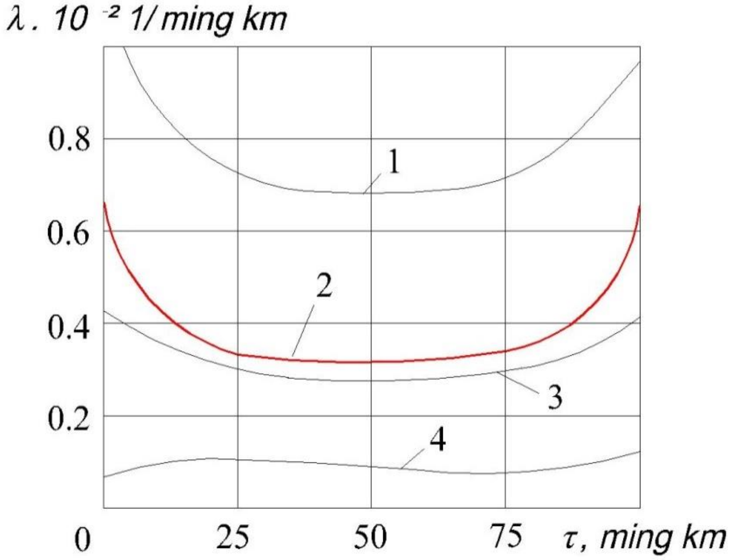

Figure 1.5. Rapid breakdown of electric machines (1). chulg'am (2). Collector-brush (3) mechanical. The graph above shows the indicators for the transport sector.

Let's take a look at the damage to the main parts of AC machines. Typically, collector damage includes surface abrasions, scratches on the surfaces due to its shape, burning and melting of surfaces, uncomfortable switching and all-round fire. If one of the listed damages occurs, the machine must be stopped to make appropriate repairs. The collector must be sanded to eliminate the fault. Some types of AC machines use plastic collectors. In most cases, the failure of such collectors is due to the breakdown of the insulating part of the work or the covering of the arc.

Damage to the anchor bolts occurs due to the following reasons: damage to the body insulation between the bolts. set of steel coils, alternating connections (with polygonal sections in coils) with anchors, collector plates with connecting petushk cleaning cleaning (on high-powered machines), tire removal, anchor coils amine retention (on high-speed machines) and so on.

Injuries to the exciter, the auxiliary pole, and the compensating coil are rare. They usually cause a breakdown of the body insulation between the coils and the car's magnetic system.

The most common mechanical parts of DC machines are sliding or oscillating bearings and the shoulder of the shaft. Typical signs of damage to these units are oil leakage, malfunction of the lubrication rings, breakage of the ball or rollers, breakage of the separator, sticking of the balls, wear of the shoulder part of the shaft, and so on.

Damage to the traverse of the brush can be manifested in the form of a fracture of the traverse ring, which can be caused by it in the bearing or other device, adjusting the position of the brush holders on the fingers or bracket traverse, traverse holding the bracket holders and so on.

The occurrence of any of these damages will result in the machine malfunctioning, which must be stopped to make appropriate repairs.

For example, we consider the reliability of traction machines The most time-consuming and frequent failures of electric vehicles include recirculation and combustion of the collector, and the brush holder, armature belt, spool insulation failure, co. breakage of the cable outlet of the shaft, rotation of the drive mechanism. These faults are the result of electrical and mechanical factors.

Mechanical factors can lead to bearing failure, breakage and loosening of connections, rings and bolts, destruction of the electrical collector surface layer, and damage to the insulation. Due to the low reliability of the switching, the collector plates are burned chaotically or in a certain order. During the operation of the machine, if the necessary precautions are not taken, a fire will develop on all collector surfaces. The formation of burns is caused by poor switching and overheating of the collector-brush connection elements, due to the intensive accumulation of the collector-brush brushes, which contributes to the overheating of the arc and the appearance of circular flashes [8].

The most severe type of malfunction is the formation of a circulating fire in the collector, which accounts for 24% of all faults, as well as a violation of the insulation of the armature between the windings and the body.

Typically, insulation failure leads to the opening of the belts, especially if the protection of the electrical circuits does not work in a timely manner. When analyzing the failures of 1,800 ED-170A electric machines, the ED-118A, GP-311B reported 58% of the failures of the electric equipment of electric locomotives, according to five-year operational monitoring data with an average operating time of 32,400 hours. forms.

It is interesting to analyze the statistics of the technological process (technological reliability) of the production of DC machines.

Below are the results of the GP-311B direct current generator control and fault detection at the manufacturer’s test station [7].

1. Rotation of the collector due to heat - 24.1%.
2. Deformation of the collector in the cold state - 3.5%.
3. Darkening of collector plates - 2.5%.
4. Other defects of the collector (contact surface retention, melting of pads, insulation damage) - 1.47%.
5. Damage to the anchor insulation in the case - 3.66%.
6. Sequential closure of anchor insulation - 3.77%.
7. Removal of varnish from the anchor - 32.75%.
8. Bearing failure - 8.05%.
9. Other defects (belt loosening, rotor overheating, switching failure) - 20.2%.

For example, we calculate the probability of continuous operation P (τ) and the failure rate a(τ) of high-load machines. Figure 1.5 Fault Level Curve. The formulas **$\lambda(t) = \frac{a(t)}{P(t)}$ and $P(t)=\exp[\int_0^t \lambda(t)\,dt]$** are used for the calculation..

The following values are determined according to Figure 1.5:

λ (0) – $0.66*10^{-2}$ 1/ thousand. km, P(0)=1, a(0)=$1•0.66•10^{-2}=0.66•10^{-2}$ 1/ thousand. km.

for τ=25,000 km λ (25,000) = 0,36 * 10^{-2} 1/ thousand. km. Integral value 2, τ.e. the area under the curve. **$\int_0^{25000} \lambda(\tau)\,d\tau=0.1105$** Therefore, according to the above, error-free operation **P (25000) = 0.4005** Furthermore, proceed to the formula, $\lambda(t) = \frac{a(t)}{P(t)}$ as a result of failure **a(25000)= 0.4005 • 0.36 • 10^{-2} = 0.1442•10^{-2} 1/ thousand. km. At a distance of 25,000 to 50,000 km, l = const = 0.36 * 102 1/thousand km.**

Then the value of $\int_0^{50000} \lambda(\tau)\,d\tau = 0.1105 + 0,36*10^{-2}*25=0.2005$ is the probability of continuous operation

P = (50,000) = 0.3348. Error rate a (50,000) = 0.3348 • 0.36 * 102 = 0.1205 • 102 1/thousand. km.

For the same **τ =75,000 km λ (75,000) = 0,36 • 10^{-2} 1/ thousand. km.** Value **$\int_0^{75000} \lambda(\tau)\,d\tau = 0.2005 + 0,36*10^{-2}*25= 0.2905$** Hence, the probability of error-free operation is P (75 000) = 0.2796. Error rate a (75,000) = 0.1007 • 10^2 1/ thousand. km.**km. for τ=100,000 km λ (100,000) = 0.5 * 10^{-2} 1 / ming. km.** Value **$\int_0^{100\,000} \lambda(\tau)\,d\tau = 0.4155$**

Probability of trouble-free operation P (100,000) = 0.2244. The failure rate is a (100,000) = 0.1481 * 10^2 1 / thousand. km.

Conclusion

In conclusion, it should be noted that reliability is a complex feature that includes failure, permanence, serviceability, stability, safety, manageability, viability and safety. The normal operation often depends on the condition of the collectors and coils, and it is recommended to consider the reliability of each part in their design. It requires reliable maintenance.

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