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Research Article

CHANGING THE SELF-DISCHARGE OF ACID BATTERIES FROM TEMPERATURE AND WAYS TO REDUCE IT

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ABSTRACT

This paper discusses a method to reduce the self-discharge process of acid car batteries. The dependence of the self-discharge of storage batteries on the ambient temperature has been studied. At the same time, it was found that an increase in the storage temperature of storage batteries from + 15°C to + 45°C accelerates the self-discharge process up to 62% within 12 months. Replacing the alloy composition of the electrode, taking into account the electronegativity of the components, reduces the self-discharge process to 2% monthly. Batteries with electrodes, where antimony is replaced by calcium in the alloy, the self-discharge process is relatively low and the consumption of the working fluid is also relatively low. These parameters allow them to be manufactured as maintenance-free power sources.

KEYWORDS

Current source, rechargeable battery, electrode, self-discharge, lead-antimony alloy, replacement, fluid consumption.

INTRODUCTION

In a car, a current source, that is, the battery is an important element of electrical equipment - along with the generator, it acts as a current source. In them, the storage battery performs several functions: powering the starter when starting the engine, powering consumers with the engine off, powering consumers in addition to the generator when the engine is running.

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When working together with the generator, the storage battery provides transient processes that require a large current, and also smoothest the ripple of the current in the electrical network [1,2].

Lead-acid batteries are used as starter batteries in cars. The battery design is constantly being improved. Each battery consists of six batteries connected in series, united in one corpus. The housing is made of acid-resistant and non-conductive propylene. A separate accumulator combines alternating positive and negative electrodes covered with a layer of active mass. Insulation of opposite polarity plates is provided by a plastic separator.

Anode and cathode electrodes are made of lead alloy. In modern batteries, positive and negative electrodes are made of an alloy of lead and antimony with some electronegative metals added. Such batteries have a low self-discharge level and a minimum water consumption (1 g/Ah), due to evaporation during operation.

Among the alkaline earth metals, lithium (Li) is the ideal anode material for batteries due to its extremely high theoretical specific capacity (3880 mAh/g) and low density (0.59 g/cm3). Unfortunately, the uncontrolled dendritic growth of this metal has hampered their practical application over the past 40 years [3-7]. Due to the relative high cost in comparison with acid storage batteries, it is impractical to use them as car batteries.

According to the results of the research, the authors [8, 9] provide information on primary cells and batteries, backup chemical current sources, batteries and electrochemical capacitors of both Russian and foreign production. Analyze current-generating reactions, design features of various types of chemical current sources, their technical and operational characteristics, self-discharge reduction for lead and nickel - cadmium batteries. The rules of care, operation, storage and reduction of self-discharge are given in the work of the authors [10-11] in detail and with examples.

When using batteries, caring for them plays an important role and is simple, which is reduced only to regular checking of the electrolyte level. A low level may indicate overcharging, which is usually caused by a malfunctioning generator. During charging, the electrolyte level is slightly exceeded, so you should refill with this effect in mind. During operation, it is desirable to control the charge of batteries, which increases their service life.

Power sources lose part of the water from the electrolyte during operation. As a result, the reserve level of electrolyte above the plates decreases and the concentration of acid in the electrolyte increases (the density of the electrolyte increases), which negatively affects the battery life. The rate of water loss decisively depends on both the materials used for the production of the storage battery and the state of the vehicle's electrical equipment [12-13]. Depending on the combination of all these factors, it can differ by 10 or even 25 times. Therefore, a decrease in the electrolyte level to a critical one is possible in 1-3 months (with a faulty voltage regulator) and in 2-3 years. When using classic lead-acid batteries, the electrolyte level is checked at least 1-2 times a month and topping up with distilled water, as well as a relatively high self-discharge rate - up to 13% per month, which progresses during operation and after 1.5-2 years of operation increases 3-4 times. Therefore, if such rechargeable batteries are inactive for a long time, they must be recharged every 1-2 months.

The self-discharge process of a car battery is an unavoidable phenomenon, both internal and external. The speed of the process varies, in many respects it

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depends on the service. It is recommended to influence the speed of the self-discharge process to preserve the performance of batteries.

These power sources are designed for a certain capacity or the maximum amount of electricity received. When the external circuit is open, that is, the device is not in use and is outside the vehicle, this characteristic deteriorates. From the point of view of chemical reactions, self-discharge of a battery is the result of dissolution of lead of the positive electrode with the release of hydrogen, accompanied by a loss of electrical charge. At the cathode, the phenomenon is less pronounced and occurs due to the interaction of sulfuric acid with metal oxide, where the process is accompanied by the release of oxygen. The reasons for the self-discharge of the battery lie in its own design. This means that the self-discharge process cannot be avoided [14-16]. You can only change its flow time.

During their operation, the created ideal conditions also cannot stop the natural decrease in capacity. Minimal power loss is inevitable. It depends exclusively on the components of the elements of the device. An inactive battery naturally loses its capacity due to the reactions mentioned earlier. There are three more types of battery spontaneous discharge. First, during operation, the surface of the device becomes dirty. Under the influence of moisture or antifreeze, this layer connects the electrodes, becoming a conductor of currents. The value of the conducted current is quite small, but with prolonged inactivity, even under a weak influence, the battery is discharged quite significantly. Second, the anode and cathode wear out over time. As a result, a precipitate is formed from the active mass crumbled from them. In this case, the battery is discharged due to the accumulation of this substance, which can close the electrodes. This is a natural consequence of battery life and is therefore inevitable.

Third, faulty sources become the cause of self-discharge of a car battery. The presence of external consumers reduces the capacity, if they are constantly powered by the batteries of the machine, then they can cause significant damage, depending on how long the electricity will be used.

Even in ideal storage conditions for batteries, power loss cannot be avoided. But it can be controlled and reduced if you know what kind of measures and under what circumstances it is recommended to take. The latter include checking the voltage at least once a month. It should be within normal limits. If a fall is detected, then it is necessary to recharge the battery to maintain its performance.

As the ambient temperature decreases, the battery parameters deteriorate, but unlike other types of batteries, lead-acid batteries have a relatively low decrease, which is why they are widely used in transport in various regions of the world with large differences in weather conditions. It is theoretically believed that a lead-acid battery loses ~ 1% of its capacity for every 20 °C decrease in temperature. But self-discharge at low temperatures is slower, which is primarily due to a decrease in the rate of reverse chemical reactions.

Research methods and results obtained

In this study, experiments were carried out to reduce the self-discharge of storage batteries not only by minimizing adverse factors and observing the correct conditions but also by changing the composition of the lead electrode. The self-discharge rate depends on the service life of the device, as well as on its type - traditional or unattended. The norm is achieved if the ambient temperature is maintained within the range from +10 to + 15 °C and the absence of humidity. In this case, the battery must be clean and charged to the

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maximum. The amount of voltage drop will be different for used and new batteries. If the battery has been operated for a long time, then the minimum self-discharge of the car battery will be from 8 to 12% per month. The exact number depends on the life of the power supply. Very old batteries are also likely to lose capacity more quickly. In new batteries, the reduction should not exceed 6% per month. That is, in two weeks it will be within 3%, and in unattended devices - up to 1% per month. Under normal storage conditions, conventional batteries that last less than three years will lose their voltage completely after 3 or 5 months.

In the course of the work, studies were carried out to determine the degree of discharge of acid batteries depending on the temperature of their storage (Table 1). The discharge rate of new batteries in the first month is insignificant. Below are the degrees of self-discharge of lead-antimony batteries (12 V, 60 A/h) by months at a temperature of + 15°C; + 30°C and + 45°C.

Table 1

The degree of discharge of the lead-antimony battery depending on storage temperature

№ p/p	Storage at +15°C		Storage at +30°C		Storage at +45°C	
	Storagetime, month	Degreeofvacuum, %	Storagetime, month	Degreeofvacuum, %	Storagetime, month	Degreeofvacuum, %
1	1	96	1	96	1	94
2	2	94	2	90	2	84
3	4	92	4	81	4	73
4	6	88	6	75	6	64
5	8	85	8	71	8	55
6	10	81	10	64	10	43
7	12	77	12	56	12	34
8	14	73	14	47	14	27
9	16	71	16	41	16	23
10	18	70	18	35	18	16

As you can see from the table.1 the higher the storage temperature, the faster the self-relaxation process. As you know, when the degree of discharge of batteries is below 60%, they are recharged, so we can conclude that when storing new acid batteries at +15 °C, you can use it after 12 months, when storing +30 °C, you can use

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it after 7 months, at +45 °C can be used after only 4 months without recharging.

As you know, recently, antimony, traditionally used in battery plates, has been replaced with a more electronegative metal to reduce self-discharge. The lattices of the plates are made by plastic deformation of lead to obtain a lead strip, which is perforated and stretched. Such a plate is stronger than the traditional one, less prone to shattering and corrosion. This technology makes it possible to fully automate the process of obtaining plates, as well as to exclude the use of antimony in alloys - the most harmful factor in terms of emissions into the atmosphere in the production of storage batteries. In the production of conventional lead storage batteries, 1.7% of antimony is added to the lead electrodes consisting of perforated grids of lead alloy according to the existing technology. In this study, in order to reduce the self-discharge of batteries, instead of antimony, a more electronegative metal calcium was used (standard potential of antimony E = -0.14 V, standard potential of calcium E = -1.87 V). For this, in the manufacture of the lead alloy, instead of antimony, metallic calcium was added in an amount of 0.1%. The manufactured battery with lead and calcium electrodes should be of low self-discharge. The lower rate of reverse processes, that is, self-discharge in them, is due to the use of down conductors with the absence of antimony, its replacement with a more electronegative metal. Table 2 shows the consumption rates of the components for the preparation of 1 kg of lead-calcium alloy electrode.

Table 2

Consumption of components for the preparation of 1 kg of a lead-calcium alloy electrode

№ p/p	Components	GOST	Unitmeasurement	Norm	Technologicallosses, %	Norm taking into account losses
1	Roughlead	3778-77	g	1000	9-10	1090-1100
2	Metalliccalcium	1089-82	g	1,0 ÷ 1,1	2,0	1,02÷1,12
3	Metallicarsenic	48-16-607-77	g	1,0÷1,4	10,0	1,1÷1,54
4	Metallictin	860-76	g	2,3÷2,7	12,0	2,57÷3,02
5	Metalliccopper	859-2001	g	0,04÷0,06	4,0	0,041÷0,062
6	Metallicselenium	10298-79	g	0,2÷0,25	15,0	0,230÷0,287

Batteries with a lead-calcium alloy can be manufactured as maintenance-free, the results of the experiments showed that the self-discharge process in them is relatively low (Table 3) and the water

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consumption in the working fluid is insignificant. These batteries can be discharged without the electrolyte filling hole. But this type requires increased control over electrical equipment, since it is necessary to always maintain the required voltage.

Table3

Lead-calcium battery discharge rate depending on storage emperature

№ p/p	Storage at +15°C		Storage at +30°C		Storage at +45°C	
	Storagetime, month	Degreeofvacuum, %	Storagetime, month	Degreeof vacuum, %	Storagetime, month	Degreeof vacuum, %
1	1	99	1	98	0	97
2	2	98	2	96	2	94
3	4	97	4	94	4	92
4	6	96	6	93	6	89
5	8	95	8	91	8	86
6	10	94	10	89	10	84
7	12	93	12	88	12	81
8	14	92	14	86	14	79
9	16	90	16	84	16	75
10	18	89	18	81	18	71

In this work, the process of self-discharge of storage batteries is studied and research is carried out to reduce this process. Studies have shown that when storing acid batteries at + 10 °C, you can use it after a maximum of 12 months, when storing + 25 °C, you can use it after 7 months, at + 40 °C you can use it after only 4 months without recharging. And when replacing antimony in the alloy with a more electronegative metal calcium, the self-discharge of the battery decreased on average from 6% to 4% per month. Rates of consumption of components for the preparation of 1 kg of lead-calcium alloy electrode are given. Batteries with lead-calcium alloys, due to low self-discharge and low consumption of working fluid, make it possible to manufacture them as maintenance-free current sources.

REFERENCES

1. http://systemsauto.ru/electric/automotive-battery.html.
2. https://monolith.in.ua/structure-avto/akkumuljatornaja-batareja/.
3. Taganova A.A., Bubnov Yu. I., Orlov S. B. Sealed chemical current sources: cells and accumulators. Equipment for testing and

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Publisher: Oscar Publishing Services

operation: Handbook of St. Petersburg: Khimizdat, -L. -2005. 52 p.

4. Rykovanov A.S. Modern Li-ion accumulators. Types and design.Components and Technologies No. 11 for 2013. - P. 67–74.
5. Rykovanov A.S. Balance systems for Li-ion rechargeable batteries // Power Electronics. No. 1, -2009. -P.52–55.
6. Kolesnikov A.I. Methods for charging Li-ion batteries and batteries based on them. Components and technologies. -2012. -No. 11 – P.48–53.
7. Sadovnikov A.V., Makarchuk V.V.Lithium-ion batteries // Young scientist. -2016. - №23. - P. 84-89.
8. XuWu, JiulinWang, Fei Ding, Xilin Chen, Nasybulin E., Yaohui Zhang, Ji-Guang Zhang. Lithium metal anodes for rechargeable batteries // Energy & Environmental Science. -2014.Vol. 7.No. 2.Pp. 513-537.
9. Taganova A.A., BubnovYu.I., Orlov S.B. Sealed Chemical Power Sources: A Handbook. SPb.: Himizdat, -L. -2005. -262 p.
10. J. van Erkel C.L. Hidrometallurgical process for the treatment of used nickel-cadmium batteries / C.L. J. van Erkel, B.A. van Deelen, A.J. Kamphuis // Report on Conference. Geneva, Switzerland, September -1994. - P.133-139.
11. Mamatkulov A.K., Erkabaev F.I., Ruzmatov E.I., Zhumaeva G.J. Study of the process of measuring the self-discharge of acid batteries // International Scientific and Technical Journal "Chemical Technology. Control and management", 2020, No. 2 (92). - P. 21-23.
12. VarypaevV.N., DasoyanM.A., NikolskyV.A. M. Chemical current sources: Higher school, -M. -1990. - P. 207-211.
13. DasoyanM.A., NovoderezhkinV.V., TomashevskyF.F. Manufacture of electric batteries. 2nd ed., Rev. and add. -M.: Higher school, -1970. - P. 294-301.
14. Barkovsky V.I. et al. Influence of one-year storage on the parameters of maintenance-free lead-acid accumulators.Elektrotekhnika. -1988. - No. 8. - P.6-9.
15. Li V.V., Shipovalov D.A. The device of the automobile storage battery. Disadvantages and advantages of the car battery design // Young scientist. -2016. - №11. - P. 409-411.
16. 16. Beibulatova S.I., Seliverov D.I. Maintenance-free accumulators for railway automation and telemechanics // Young Scientist. -2012. -Number 3. -P.29-31.