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Factors affecting electrolytic level maintenance in acid batteries

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Abstract. The aim of this study is to increase the utilization factor of the active masses by ensuring that the electrolyte in the batteries is evenly distributed over the separator height and kept constant at the desired height.

1 Introduction

Lead-acid batteries, as well as other chemical current sources are divided into hermetically sealed, electrolyte gel-type disposable and reusable batteries, depending on the structure, field of application and conditions. The various types of chemical current sources are widely used in various sectors of the economy and extensive research is being conducted to improve them [1-7].

The capacity of hermetically sealed batteries is relatively small, and such batteries are mainly produced in enterprises established on the basis of foreign technologies. Most of the enterprises produce lead-acid liquid electrode, reusable batteries.

In liquid electrolyte batteries, the electrolyte occupies the electrode block and fills the pores of the separator. The pores of the separators are varied and consist of small pores filled with electrolyte, which allow the passage of ions, and relatively large pores, which allow the passage of oxygen.The use of the principle of immobilization of the electrolyte requires a high degree of accuracy of the ratio of the pores of the battery block elements: the ratio of the pores must ensure the pores of the positive electrodes operating in liquid conditions, and the pores of the negative electrodes operating in the form of gas diffusion electrode [8-14]. Hermetic lead accumulators use microfiber fiber separators (AGM type). The separator, which consists of glass fibers with 100% wetting properties, holds the electrolyte well and is resistant to acid.

One of the main reasons limiting the use of these types of microfiber glass separators in large-capacity batteries is their inability to keep the electrolyte constant at the height of the separator. Downstream of the electrode from the separator leads to an uneven flow of processes, as well as a decrease in the utilization factor of active masses [15, 16]. In the process of returning oxygen, uneven distribution is created, which leads to additional heating of the upper part of the battery. For these reasons, all large-capacity batteries need to be operated in a horizontal position, which is sometimes inconvenient in practice [17].

In batteries with a gel electrolyte, the formation of gas channels in the gap between the

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electrodes occurs due to the expansion of the released oxygen gases as a result of the action of the gel electrolyte on the solidification process. The presence of such channels allows the flow of oxygen from the positive electrode to the negative electrode through the gap between the electrodes, rather than through the electrode to the cavity under the cover of the battery.Gel electrolytes are more resistant to the effects of the gravitational field and provide good contact between the electrode and the electrolyte of any design. However, the stability of these electrolytes is low, they are destroyed by mechanical action, the resistance is 5-10% higher than that of ordinary liquid electrolytes [20]. In addition, the presence of gas channels is random and does not guarantee optimal distribution of oxygen flow along the electrode height.

The aim of this study is to increase the utilization factor of the active masses by ensuring that the electrolyte in the accumulators is evenly distributed over the separator height and kept constant at the desired height.

2 Methods

The process of studying this connection in the battery separator to determine its expansion when the electrolyte is soaked in the separator, a rectangular bath of organic glass AXM-280 with dimensions of 5x10 cm, a 10-layer microfiber separator was placed.

In the middle of the top of the bath was a slit, and we put a lid made of ascending organic glass, designed to pour a certain amount of electrolyte with a density of 1.27 g / cm3. This device is designed to measure the expansion of a separator when it is compressed under a certain load and immersed in an electrolyte.

We calculated the porosity of the separator by the volume of electrolyte added using the following formula:

$$\gamma_p = V_{poro}/V_{size} = (V_{dimen} - V_{cage})/ V_{dimen} = 1-(1- \gamma_0)*d_0/d_p$$

here γ_0, d_0 – porosity of the separator ва P_0 thickness at pressure;
γ_p, d_p - porosity and thickness of the separator at P pressure;
V_{poro} - the size of the pores of the separator;
V_{dimen}– the overall dimensions of the separator.

Putting the values $\gamma_0 = 0.91$; $d_0 = 2.0$ mm (according to the certificate of the separator) in the above formula, we calculated the porosity of the separator at different pressures.The measurement results are presented in Table 1. We then placed a 10-plate separator block in a device that detects its expansion during the process of soaking with electrolyte and gave static pressures of different values given in the table. In this case, we recorded the values when the indicator showing the thickness of the separator was balanced.

Table 1. Variation of separator porosity under different pressures

P, kPa	10	20	30	40	50	60	70	80	90	100
γ_p, %	91	90.6	90.1	89.5	88.8	88.4	87.1	87.5	87.9	86.3

Then each time the separator was immersed by adding 10% of the porosity of the electrolyte, and when the indicator showing the change in the thickness of the separator reached equilibrium, we recorded its value and determined its change in thickness under the influence of the electrolyte. Based on the data obtained, the change in porosity of the separator at different pressures was calculated.

3 Results and Discussion

When the separator was soaked with an electrolyte with a density of 1.27 g/ cm^3, its thickness was set to depend on different pressures (Fig. 2). As can be seen from the dependence graph, an expansion is observed depending on the degree of soaking of the separator with the electrolyte. Because the microfiber glass is very well wetted (the application angle is 0), its myrotoles are quickly covered with electrolyte and the system tries to transfer its energy (surface energy of the electrolyte) to neighboring fibers, causing them to shrink and expand.

The average values obtained from experiments to determine the dependence of the separator thickness on the degree of soaking with the electrolyte at different pressures show that when the electrolyte is soaked to 70% in the separator, the pressure expansion in the range of 15-25 kPa has a normal value (Fig. 2).

As the pressure exceeds 20-25 kPa, the expansion of the separator is accelerated due to the ingress of electrolyte between the microfibers.

In this case, the penetration of the electrolyte between the microfibers may have a ponasimon effect. Once the maximum is reached, the thickness changes little until the absorption is 100%.

Based on the results obtained, the elongation levels at different pressures were determined when the separator was completely immersed in the electrolyte: 4.6% at 10 kPa, 6.9% at 20 kPa, 7.2% at 50 kPa, 7.5% at 70 kPa, 7 at 90 kPa, 8%.

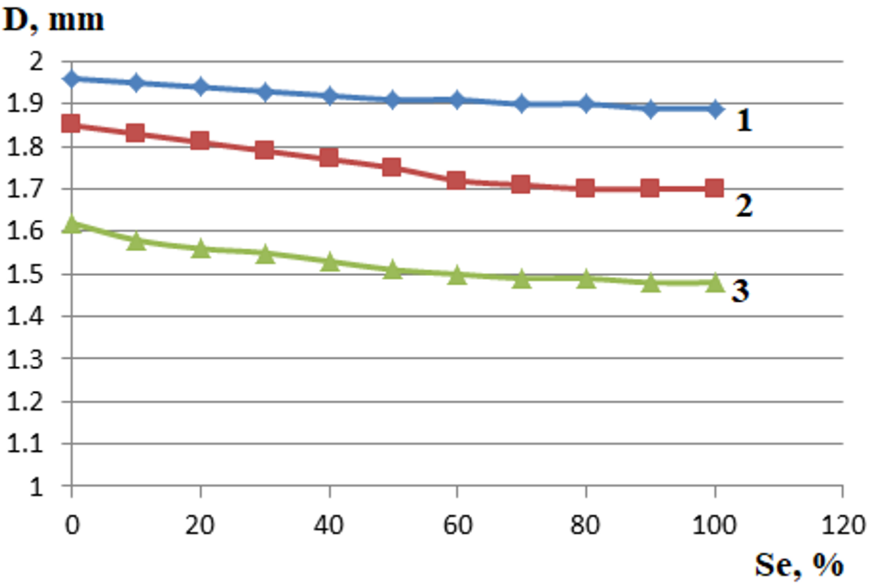

Fig. 2. Dependence of separator thickness (d) on electrolyte impregnation rate (V) at different pressures (1-20 kPa; 2-50 kPa; 3-70 kPa)

It can be seen that the expansion of the separator from electrolyte absorption was found to be mainly in the pressure range of 15–25 kPa (Fig. 3).

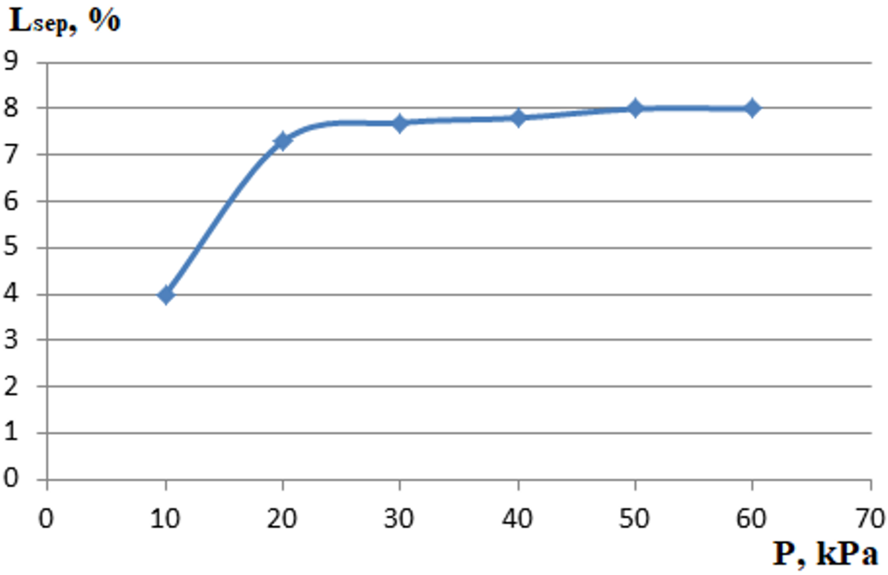

Fig. 3. The elongation of the separator depends on the level of load applied when it is filled with electrolyte

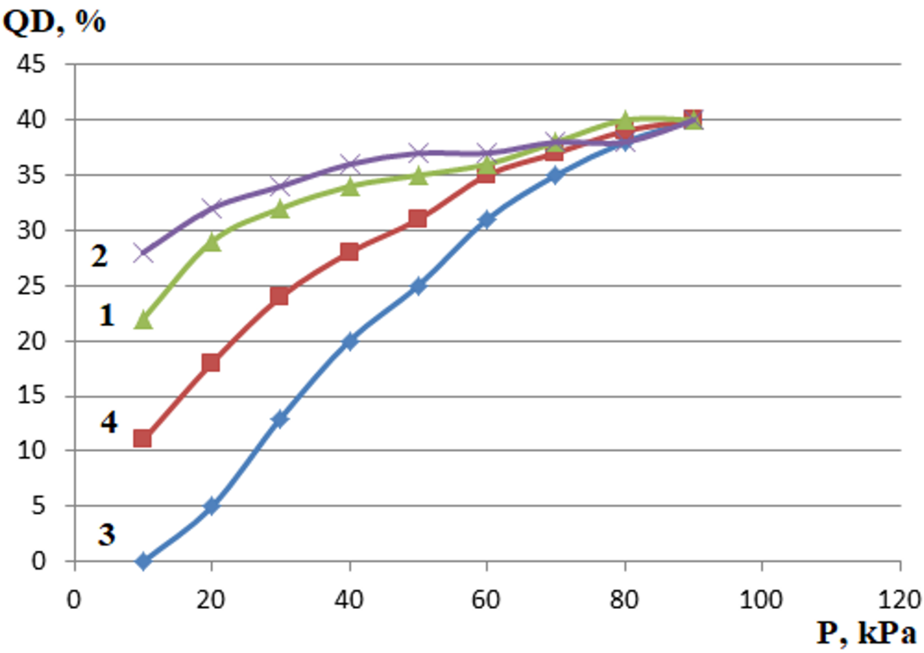

Fig. 4. Residual deformations of dry (1,2) and electrolyte-soaked (3,4) separators

The results of experiments on the dependence of residual deformations on the effect of load on dry and electrolyte-impregnated separators showed that the difference between residual deformations in dry separators is relatively small when the load is successively increased and decreased. When the loads on the electrolyte-soaked separators are applied successively and reduced, the difference in residual deformations is almost 2 times larger (Fig. 4). This data allows the pressure on the electrodes when compressing the separators to be optimized.

4 Conclusions

Thus, based on the results of an experiment conducted to study the dependence of the degree of compression of the separator on the height distribution of the electrolyte in acid batteries, it can be concluded that:

-based on the results obtained to determine the degree of compression of the separator depending on the size of the load, the compression speed of the separator should be kept as low as possible to maintain the maximum uprugost of the separator.

- according to the results obtained on determining that the thickness of the separator depends on the degree of soaking with the electrolyte at different pressures, when the electrolyte is soaked in the separator up to 70%, the expansion of the separator in the pressure range of 15-25 kPa has the lowest value.

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