RESEARCH ALGORITHM FOR THE EFEICIENCY OF AN INDEPENDENT POWER SOURCE

АЛГОРИТЪМ ЗА ИЗСЛЕДВАНЕ НА РАБОТОСПОСОБНОСТТА НА НЕЗАВИСИМ ИЗТОЧНИК НА ЗАХРАНВАНЕ

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Annotation: *It has been created an algorithm that tracks the stages of constructing an independent chemical power source. It has been given consideration to the selection and design of the composite components, as well as the solving of construction tacks. Attention is paid to the mechanical-dynamic and climatic tests, which are carried out in order to prove the working capacity for both of the components and the whole unit as a final product.*

Keywords*: chemical power source, efficiency, working capacity*

1. Introduction

In the safety context, the process of construction of a stable, in terms of power and according to energy viewpoint, independent chemical power source has great meaning for the performance of the end product. The normal functioning of the energy source ensures stability of the implementation of the assigned tasks in the conditions of need for an independent power supply. The proposed algorithm aims to describe the steps, their designing and testing passes through – fig. 1. The main purpose is related to the need to confirm the correctness of the design solution and getting the requirements of the final product working.

2. Algorithm for evaluating the performance of a power source

The proposed algorithm examines the construction principle and the test sequence of a battery / power source /. A consistent reliability assessment is performed using the algorithm, from making the design decision about the type and sequence of the chemical elements / cells /, going through the building of physical samples and ending with their mechanical-dynamic test and exposure to environmental factors. The main task is to detect and eliminate the errors and drawbacks made in the development of the power supply in advance.

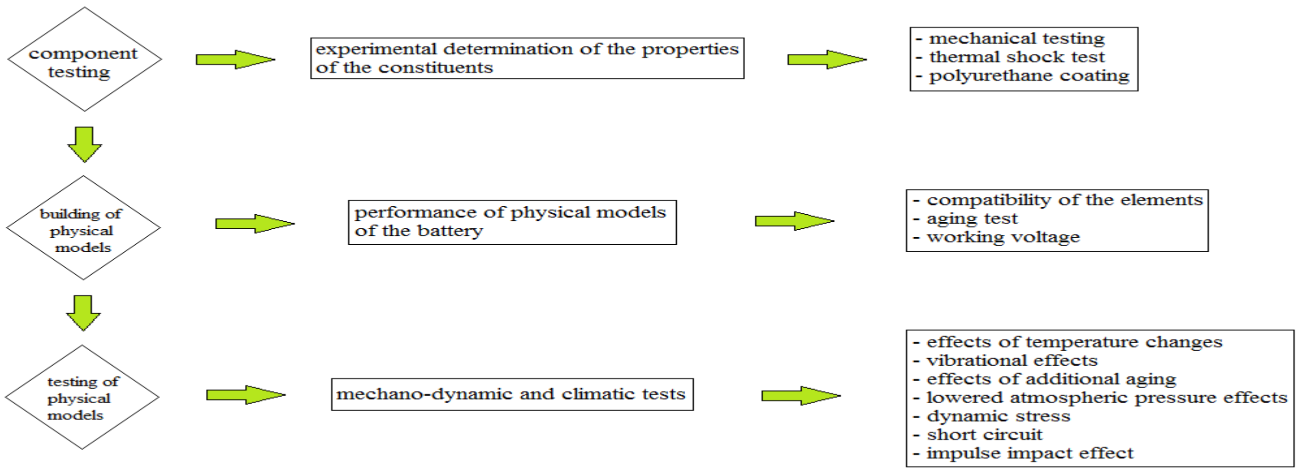

Fig. 1*. Algorithm for conducting a feasibility study of an independent power source*

The proposed algorithm is exemplary and the additional tests can be used to specify a particular feature of the developed battery or accumulator. The specificity of physical model testing /temperature range of operation, vibration effects, dynamic stress and others/ is determined by the application of the final product.

3. Determination of the constituents of the power source

The determination of the constituent elements of the power source is considered from two points of view: the first is related to solving a constructive task, regarding the gauges and power of the product and the second relates to the type of the electrochemical system that is used.

3.1. Solving a constructive task regarding the power source parameters

The produced and marketed chemical sources of electricity are characterized by a wide variety, different size, shape, voltage, capacity. Solving a question about choosing the right element begins with the design of the product, its purpose and the climatic conditions of use. The engineers and constructors of the final product, intended for use with an independent power source, determine: the available space in the shell; the requirements of the climate zone; the possibility of transportation and safe work. They make proposals that are being considered by a research team.

The starting point for solving the design task is related to the application of the final product and the power consumption requirements. When characterizing the operation of the chemical power sources the following parameters are used: power P and output power $P_{outp.}$

The power is equal to the product of the current and the voltage:

(1) **P =IU** [W or J/s]

The output power is determined by the formula:

(2) $P_{outp.} = \frac{UI}{m}$ [W/кg]

(3) or $P_{outp.} = \frac{UI}{m}$ [W/l]

where: m – amount of substance, obtained or consumed, of the electrodes, respectively in kg or l.

All stress-increasing factors lead to an increase in the power of the chemical power sources /CPS/.

When connecting the element to a voltage device, this is when it is subjected to voltage, an electric circuit is formed. The change in voltage is reflected to a large extent also by the current flowing through the element:

(4) $U = E - \Delta\varepsilon - Ir_{inner}$

where: U - element voltage, V;

$\Delta\varepsilon$ - element polarization, V;

I – size of the electrical current, A;

r_{inner} – the inner resistance of the cell, Ω.

In this way the working voltage of the chemical power source /CPS/ is always less than the electromotive forces /EMF/. In turn, the polarization $\Delta\varepsilon$ [V] can generally consist of electrochemical, chemical and concentration constituents:

(5) $\Delta\varepsilon = \Delta\varepsilon_{el} + \varepsilon_{chm} + \varepsilon_{conc}$

The ways of reducing the constituents of polarization and thus increasing the tensions of the CPS are associated with an increase in the surface of the electrodes, temperature increase and the concentration of the reagents or the use of catalytically active electrodes [3] [5].

3.2. Determination of the type of electrochemical system subjected to testing

The type of the electrochemical system that is used is determined on the basis of the manufacturer's data or the available markings on the packaging. Primary attention is paid to the features of the elements / cells / constituting the power source – electrodes, electrolytes, separators, and where possible the chemical reactions.

It is convenient to use three electrochemical systems when building physical models in relation to the determination of their working capacity and conducting a subsequent comparative analysis:

a/ Manganese-zinc currents with salt electrolytes **$Zn|NH_4Cl|MnO_2$**, the battery casing is an **anode** at the same time / built of Zn/, the active substance of the **cathode** is an electrolytic manganese dioxide /MnO_2/ or a chemical manganese dioxide; NH_4Cl, $ZnCl_2$, or a mixture of the two substances, are used for an **electrolyte**. The electrolyte is located in the thickened areas or in a microporous separator. Corrosion inhibitors are added in order to reduce the corrosion rate of the zinc in the electrolyte. The advantages of these batteries are related to the low price and the large number of type sizes, the relatively easy production technology and the readiness to be used immediately. The deficiencies are related to the descending discharge curve in operation, the relatively low specific separated energy and a significant drop in performance at high stress and low temperatures [1] [2] [4].

The Manganese-zinc power sources are also produced with an alkaline electrolyte **$Zn|KOH|MnO_2$.** Powdered Zn serves as an **anode** and MnO_2 as a **cathode**. The **electrolyte** is a gel solution of KOH or KOH in a matrix. Inhibitors of corrosion are included in the composition of the anode and electrolyte. Compared with the salt electrolyte power sources, those with alkaline have greater capacity and energy density during operation, especially at high stress and low temperatures, but have a higher price.

b/ In the silver-zinc primary cells **Zn/Ag_2O** or **$Zn|KOH|AgO,Ag^+$** powdered zinc is used for an **anode**, for **cathode** - silver oxide, and for **electrolyte** – a solution of KOH or NaOH. Silver is reduced over the cathode from Ag(I) to Ag(II), when operating the battery, in discharge mode, as the alkali electrolyte is used as a donor to hydroxyl groups and the following electrochemical processes occur:

- the oxidation reaction of the zinc metal is carried out on the anode:

$2Zn + 4OH^- = ZnO + HOH + Zn(OH)_2 + 4e^-$ /1/

- the following reaction runs over the cathode:

$2AgO + 2e^- + HOH = Ag_2O + 2OH^-$ /2/

a reduction reaction of the divalent silver ion to a monovalent ion and consequently to pure silver takes place following the scheme:

$Ag_2O + 2e^- + HOH = 2Ag + 2OH^-$ /3/

the equation is recorded cumulatively in the following form:

$2AgO + HOH + 2Zn = 2Ag + ZnO + Zn(OH)_2$ /4/

The silver batteries of this type have a horizontal discharge curve, high energy density and a low self-discharge. They can work under high stress, but the high cost of the building components is a disadvantage.

c/ The reducing agent in the primary lithium power sources **with a solid cathode and an aprotic electrolyte**, is lithium, and the oxidant - metal oxides, sulphides or fluorocarbons. **Electrolytes** are the solutions of lithium salts ($LiClO_4$, $LiBF_4$, LiBr) in aprotic solvents. In the lithium power sources **with a liquid or dissolved oxidant $Li|LiBr|SO_2$** and **$Li|LiAlCl_4,SOCl_2|SOCl_2$**., the **cathodes** in the power source are insoluble and are made of carbon materials, deposited on aluminum (for SO_2), based on nickel steel or stainless steel. The **electrolyte** in the lithium cells with sulfur dioxide is LiBr, dissolved in acetonitrile; in the elements with thionyl chloride and sulfuryl chloride - $LiAlCl_4$ $SOCl_2$ or SO_2Cl_2 with supplements [6].

The primary lithium power sources have greater capacity and energy density, a wider range of operating temperatures, better performance at lower temperatures and a lower self-discharge rate compared to the same parameters of manganese-zinc energy sources. A major disadvantage is the cost of this type of electrochemical systems. The primary lithium power sources are used in medicine, industrial and military electronics.

4. Functionality of the physical samples

The constructor of the final product must combine power source, power and functionality in a certain volume. Attention is drawn to the possibility of recharging the power supply when built by Secondary Cells and prolonging its life. Provided the final product is intended for single use, the power source should be built by Primary Cells. Each power source, depending on its type, is characterized by a particular operating mode of dilution at an average current and pulse current. They are key factors in determining its capacity and associated security circuits.

A neglected factor is the initial or shock current that occurs when the equipment first switches on. High currents run through it in a very short time until the chain reaches a steady state of operation. Avoiding this negative effect is achieved by programming a delay. The purpose is to stabilize the electrochemical discharge and resistance of the power supply system.

The working capacity of the power source depends on another two factors – dilution depth and self-discharge ability. Dilution depth mainly refers to power sources that are designed to store energy, obtained alternatively / from the sun or the wind / and it has to be given up by providing constant power, when the primary energy source is missing or uncontrolled and interrupted. These power sources must provide deep dilutions and multiple charge-discharge cycles.

Self-discharge is related to the loss of charge over time by the power source. In this connection, it is necessary to know how long the batteries or accumulators are stored before they are not used by the user. The primary batteries have a large self-discharge, so the downtime should be minimized after they are delivered to the user (including delivery time, installation time, stock inventory time and storage) or by selecting cells with poor self-discharge mode. The secondary batteries / accumulators / usually have a higher self-discharge mode, but they can also be recharged.

5. Mechanical-dynamic tests and environmental conditions

Mechanical-dynamic tests aim to establish the performance of chemical power sources after impacts, vibrations, mechanical-inertial impacts and others. Basically, these tests are related to the transportability of the final product and its operational safety.

Power sources have a limited range of operating temperature /from minus 30°C to plus 40°C/. Operating them beyond these limits will result in a permanent reduction of their working capacity or a complete refusal. In determining the technical characteristics these limits should therefore be taken into account. It should also be noted that the actual operating temperature of the power supply is higher than that of the environment. It is determined by the heat generated by the operation of the power supply itself and the heat removed from it by conduction and radiation. If the end-product temperature requirements foresee the exceeding of the operating range of the power supply, it is necessary to include a heating or cooling sub-system as required.

6. Conclusions

1. The algorithm, developed to determine the performance of the chemical power sources is used to track and describe the preparation steps, testing and systematizing the obtained results.

2. The power sources go through design solutions that are related to their power, capacity, mass and life cycle, which can be accomplished by a wide range, based on their different electrochemical structure.

3. The chemical power sources efficiency is also determined by their dilution depth, self-discharge and cyclic mode of operation, to which they are subjected, and the climatic conditions have an impact on the duration of operation.

4. Knowing the priorities of the end product is an important factor in determining the technology that should be used for the construction of chemical power sources.

7. Literature

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