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OVERVIEW OF THE AG/ZN BATTERIES ACCORDING TO THE TECHNICAL LITERATURE

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Abstract
The silver-zinc battery has become an integral part of every major aircraft and satellite project and of every major military program. For this reason we want to use this battery type in our project for electrical airplane. The Ag-Zn battery has some advantageous properties against Li battery.
Aircraft system have to be a foolproof construction. This paper gives an overview according to the technical literature.

1 Introduction

Silver-zinc batteries are capable of providing high voltage and currents, is equivalent in watt-hour capacity to more (4-6) lead-acid batteries.
We can use silver-zinc batteries as the little silver buttons in hearing aids and because of its high energy density, silver-zinc batteries are used in military applications for example torpedoes.
Electronics of satellites and missiles use this type of batteries. It can be used in a low-temperature condition, it can provide high energy with a small mass, and encompasses a sufficient shelf life but it is expensive. The silver-zinc battery is used when space and weight are the most important.

It is not inflammable as Li-ion battery. This fact is very important for aircraft. Thus silver-zinc battery can be advantageously used in aviation.

2 Background of aircraft battery system

Gerald Halpert et al. wrote a history about batteries in space [1]. They paper shows the development of batteries in space research. Earlier the Ag-Zn battery was the first choice in space missions. The Ni-Cd battery became the major energy storage device over the next 20 years because of its long cycle life. The Ni-H_2 battery started to play a role in the 80s. Recently, there has been considerable interest in the use of lithium-ion batteries because of their high specific energy and energy density.

The earliest use of a battery in an orbital spacecraft was the primary Ag-Zn battery used in the Russian spacecraft, Sputnik, launched October 4, 1956. This primary battery was used to provide power for communication and spacecraft operation. There were no solar cells available for charging, and thus when the energy was depleted, communication was terminated. The Ag-Zn primary was intended to provide power to the 84 kG spacecraft for three weeks. The spacecraft actually remained in orbit for three months. The second Sputnik, launched a month later, carried the dog known as Laika. The second Sputnik was six times larger than first one and lasted five months. It also utilized a much larger Ag-Zn battery.

Silver-zinc batteries have been used in several U.S. spacecraft. Ranger 3 (1961 launch), utilized two, 14 cell 50 Ah, Ag-Zn batteries for its main power, and two, 50 Ah, 22 cell batteries for its TV camera power. Ranger 3 was placed into solar orbit and took moon photos. Mariner 2, containing one battery of 18, 40 Ah, Ag-Zn cells, was launched August 27, 1962, and was the first successful interplanetary mission to Venus [1].

The general purpose batteries have to have high energy density (more than 100 Wh/kg), high charge/discharge cycles (more than 1000) and low cost.

Much research has been done to increase the energy density, but these efforts typically expensive. Batteries are rated in terms of their ampere hour capacity (Ah) and their nominal voltage.

Some batteries used in space [2]:

- Silver-Zinc (Ag-Zn)
- Nickel-Cadmium (Ni-Cd)
- Nickel-Metal Hydride (Ni MH)
- Nickel-Hydrogen (Ni –H2)
- Lithium-ion

Many factors limit the ability to approach theoretical values – both electrochemically and practically. For example:

- Concentration gradients
- conductivity
- kinetics
- side reactions
- temperature, etc

Table 1 shows some data of battery types for aircrafts

Table 1. Comparison of different types of battery chemistries [2]

Chemistry	*Theoretical V*	*Theoritical Ah/kg*	*Theoretical Specify energy Wh/kg*	*Practical nominal voltage*	*Practical specific energy*	*Practical Energy density Wh/dm^3*
Silver-Zinc	1.85	283	524	1.5	105	180
Nickel-Cadmium	1.35	181	244	1.2	35	100
Nickel-Metal Hydride	1.35	178	240	1.2	75	240
Lithium-ion	4.1	100	410	4.1	150	400

Requirements: Batteries must be designed to mitigate against a catastrophic fault in one cell

- Thermal runaway conditions
- Short circuits
- Open circuits

According to Dr. Ross Dueber, President and CEO "To provide further insight on just how "clean" silver zinc batteries are when compared with lithium-ion technology, the difference is dramatic.

The primary materials of silver zinc batteries (i.e. silver and zinc) are fully recyclable. That means that the materials derived from recycling process are of the same quality as the materials that went into the initial creation of the battery. Recycling the raw materials results in using a fraction of the energy required to mine for new materials [3]."

Fig. 1 shows a lithium battery after fault.

Figure 1. Fire of the Li-ion battery [3]

3 Future of Silver - Zinc Battery

According to t. R. Crompton the silver - zinc results according to the size and construction of each individual cell the storable energy amounts to 70 to 120 Wh/kg or 150 to 250 Wh/dm^3. This value is considerably above the values of all battery systems currently on the market [4].

We have to exam in the case of batteries:

- High Performance
- Clean Technology
- Safe

Up to 30-50 % more run time than conventional lithium-ion batteries. With recent improvements in battery cycle life, silver zinc batteries achieve 200+ cycles at 100 percent discharge to 80 percent of rated capacity and thousands of cycles at intermediate discharge [5].

More than 95 percent of key battery elements can be recycled and reused. The raw materials recovered in the recycling process of silver-zinc batteries are the same quality as those that went into the creation of the battery. new materials is minimized. Also, there will be financial incentives for consumers to recycle their silver-zinc batteries [5].

Silver zinc batteries contain no lithium and are inherently safe. They are not subject to the recent FAA air travel restrictions now placed on lithium-ion batteries. Silver zinc batteries feature a water-based chemistry that is not flammable. The battery is therefore free from the problems of thermal run away and fire [5]. Silver zinc has significantly higher volumetric energy density than conventional technologies such as lithium-ion. In the case of silver - zinc battery has 40 percent more energy density than conventional lithium-ion batteries.

Nowadays there are not serious obstacles the in the development of silver-zinc rechargeable battery chemistry. Literature data in the database SciFinder [6] mentions the keyword “silver zinc battery” (1952-2015) in 235 article.

The formation of AgO and Ag_2O was observed by variation of the oxidation potential. Pound et al. [7,8] investigated the electrochemical processes on polycrystalline silver at different temperatures between 295 K and 478 K. The authors could show that the surface-processes are diffusion-controlled.

4 Conclusion

This paper helps to choose the battery for an aircraft. In our work we would like to develop a stable battery operating. Our task has a purpose: Battery without fire in the airplane.
For this reason we want to use silver – zinc battery instead of lithium battery. Our short circuit protection will be for silver – zinc battery.

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