THE FIBER TECHNOLOGY OF PLATES IN NICKEL CADMIUM BATTERIES (FNC)


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Resumen: De acuerdo con el requisito de las centrales eléctricas, siempre se necesitan sistemas de baterías confiables. Hay dos tipos principales de batería que se utilizan para esta aplicación: Baterías de plomo ácido y Baterías de níquel-cadmio. Las baterías de níquel-cadmio con sus propios beneficios son atractivas para muchas aplicaciones industriales, como plantas de energía, ferrocarriles, etc. Hoy en día, las baterías de plomo OPZS se usan en muchas plantas de energía, sin embargo, las características de las baterías de FNC lo convierten en un rival serio. Aplicación de plantas de energía. Por otro lado, las baterías convencionales de níquel-cadmio tienen una placa de bolsillo. Un nuevo tipo de placas para baterías de níquel-cadmio llamado estructura de fibra se propone en este documento.

Para aumentar la eficiencia, las baterías de níquel-cadmio pueden ser producidas por tecnología de fibra. En esta tecnología, las placas positivas y negativas están hechas en forma de partículas de níquel recubiertas. El uso de esta tecnología hace que las baterías FNC sean atractivas y útiles. Algunas de las propiedades importantes de este tipo de baterías son las siguientes: alta densidad de energía, larga vida útil, bajo factor de envejecimiento, baja resistencia interna, no requiere mantenimiento y no es necesario cambiar el electrolito. La tecnología de fibra ayuda a aumentar la pureza de la placa y la flexibilidad en la dimensión y proporciona una gran capacidad en la duración de la batería de FNC.

Palabras clave: Fibra, Batería de níquel-cadmio, Optimización de la sala de baterías, Aumento de la vida útil, Hoppecke, FNC

Abstract: According to power plants requirement, reliable battery systems are always needed. There is two main types of battery that are used for this application: Lead Acid Batteries and Nickel-Cadmium Batteries. Nickel-Cadmium batteries with their own benefits are attractive for many industrial applications such as power plants, railways, etc. Nowadays, OPZS lead acid batteries are used in lots of power plants, however, significant characteristics of FNC Batteries make it a serious rival for power plants application. On the other hand, conventional nickel cadmium batteries feature pocket plate. A new type of plates for nickel cadmium batteries called fiber-structure is proposed in this paper. In order to increase the efficiency, nickel-cadmium batteries can be produced by fiber technology. In this technology, positive and negative plates are made in the form of coated nickel particle. Using this technology makes the FNC batteries attractive and useful. Some of important properties of this type of batteries are as follows: high energy density, long service life, low aging factor, low internal resistance, maintenance free and no change of the electrolyte is necessary. Fiber technology helps to increase the purity of plate, and flexibility in dimension and provide high capacity in FNC battery life time.

Keywords: Fiber, Nickel-Cadmium Battery, Battery Room Optimizing, Increased life time, Hoppecke, FNC

1. INTRODUCTION

Nowadays, battery systems have an important role in power plants, and the absence of batteries in critical cases make lots of damages. Batteries are used for emergency conditions and DC pumps startup during power outages. The common choice in most power plants are OPZS batteries which are categorized in vented lead acid batteries feature liquid electrolyte, tubular plates and 2 V cells. However the disadvantageous of these batteries are lifetime and high maintenance cost. (IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, 2011)

2. THE MATERIAL OF BATTERY

Lead Acid Battery: positive pole is made of lead oxide (PbO2) and negative plate is made of lead, and the electrolyte of these battery types is sulfuric acid (H2SO4) and water (H2O). Pure sulfuric acid is usually about 25% to 40% of solution.

Nickel-Cadmium Battery: nickel hydrate (NiOOH) is the major part of positive plate, and sponge cadmium is the major part of negative plate. Potassium hydroxide solution (KOH) is the electrolyte of battery, and its density is usually about 20% to 35%. Nickel-Cadmium batteries are more expensive than similar types of lead acid batteries. Thus the needed investment is much higher, so the reasons which lead consumers to nickel cadmium batteries are as follows.

(IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations. 1994)

3. LIFETIME

There is a general rule about batteries lifetime which says the more discharge cycles the less lifetime. However, both lead acid and nickel cadmium batteries are sensitive to the depth of discharge (DOD) which means with 30% DOD batteries have longer lifetime against 80% DOD. Nickel Cadmium batteries are more expensive but their cycle life is much more than lead acid batteries. (Battery Sizing and prduct. 2014)

4. TEMPERATURE SENSITIVITY

Lead acid batteries are suitable for operation in the temperature range of 10 to 30 centigrade, because lead acid batteries are sensitive to temperature variations. Lead acid batteries capacity reduces fast against temperature reduction. On the other hand, temperature increment reduces lead acid batteries lifetime (for an increase of 10 degrees, the lifetime of lead acid batteries is halved). Nickel cadmium batteries are less sensitive to temperature variations. When the battery system should be used in low temperatures, the best choice is nickel cadmium batteries. The operating temperature range of nickel cadmium is about -20 to 60 centigrade degrees. However, the lifetime of nickel batteries reduces against temperature increment. (T.R.Crompton, 2000)

5. SELF DISCHARGE

If neither of these battery types is connected to the circuit, they will be discharged after a while. This is called self-discharge; this phenomenon in nickel batteries is faster than lead acid batteries. According to alloy is used in batteries structure and ambient temperature, during storage it is possible that nickel batteries lose 1% of their capacity a day. Thus, the batteries should be charged when they are going to be used. It should be noted that nickel batteries can be stored when they are completely discharged, though lead acid batteries should not be stored with low
charge level, because this decreases battery lifetime. (Dr.-Ing. Fischer W., 2014)

Figure. 1. Self discharge characteristic

6. VOLTAGE REDUCTION DURING THE CHARGE

The voltage of nickel cadmium batteries remains constant till the end. However, Terminal voltage of lead acid batteries decreases in the discharge process. (Afzali M., et al, 2016)

7. THE BATTERY SIZE AND WEIGHT

batteries can be discharged with a current 10 to 15 times larger than nominal current.

10. THE MEMORY EFFECT IN NICKEL CADMIUM BATTERIES

One of the most important disadvantages of nickel cadmium batteries against lead acid batteries is memory effect. For example, when nickel cadmium batteries discharge to 60% of its capacity several times and charge again, the battery system saves 60% in memory. So, another time battery system discharges more than 60%, the output voltage of battery will drop strongly. Due to memory effect, the battery capacity cannot be used completely specially in UPS applications where batteries are ready to use and do not charge and discharge regularly. Memory effect makes it impossible to use the batteries capacity completely.

11. NICKEL CADMIUM BATTERIES (Ni-Cd)

Nickel cadmium battery is a type of rechargeable battery that was made with metal nickel oxide as a electrode. also chemical reaction are as below:

\[
2 \text{NiOOH} + 2 \text{H}_2\text{O} + 2 \text{e}^- \rightarrow 2 \text{Ni(OH)}_2 + 2 \text{OH}^- \\
(1)
\]

\[
\text{Cd} + 2 \text{OH}^- \rightarrow \text{Cd(OH)}_2 + 2 \text{e}^- \\
(2)
\]

\[
\text{Cd} \rightarrow \text{Cd} + 2 \text{e}^- \\
(3)
\]

Lead acid batteries construction is simpler than nickel cadmium batteries. However, the proportion of battery stored energy to its weight is one of the least values among batteries (30-50 Wh/kg). Though, for nickel cadmium batteries this proportion is about 45-80 Wh/kg. This means the energy of nickel cadmium batteries is 30% more than lead acid batteries in the same weight. Thus, when batteries weight is important, nickel cadmium batteries will be suggested.

8. THE CHARGE SPEED

Nickel cadmium batteries can be charged in short periods like 1 hour, though the fastest charge of lead acid batteries cannot be less than 4 hours and its charge time is usually about 8 to 10 hours.

9. THE PEAK CURRENT OF DISCHARGE

Lead acid batteries discharge with a current of 5 times larger than nominal current is not suggested (for example a 9 Ah battery should not be discharged with a current larger than 45 A). However, nickel cadmium

\[
\text{Cd} + 2 \text{OH}^- \rightarrow \text{Cd(OH)}_2 + 2 \text{e}^- \\
(2)
\]

\[
\text{Cd} \rightarrow \text{Cd} + 2 \text{e}^- \\
(3)
\]

12. FIBER PLATES STRUCTURE

For increasing efficiency of plates and improve of current behavior of batteries Hoppecke produced plate with nano structurte of nickel material as Fiber structure plate. Fiber structure technology is used in positive plates and it provide more benefits for the plates for example long life time, low aging factor, low capacity losing and no need for changing electrolyte.

Figure. 2. different type of plates
Some characteristic of Fiber plates:

- no graphite
- high capacity over the life time
- high conductor density
- high porosity
- high elasticity of the fiber-structure

In comparison with conventional nickel cadmium batteries, FNC has the following advantages:

- electrochemical extremely robustness
- mechanical high robustness
- usable at low and high temperatures
- high number of lifetime cycles
- chargeable with high currents
- less capacity loss – longer life time
- high energy efficiency even at high currents
- good performance at low temperatures
- long lifetime at high temperatures
- high number of cycles
- electrolyte does not affect electrodes
- electrolyte is not corrosive to steel
- recharging with very high currents possible
- electrochemical robustness
- mechanical robustness

13. CONCLUSION

Though nickel cadmium batteries have low conductivity so other battery manufacture added some graphite to the plates for increasing conductivity but graphite in some charge and discharge react with hydrogen and produce carbonate so cause to lose capacity of battery but in FNC plate because of dense material no need to add graphite so it is pure plate and provide it long life for the cells.

✓ Thickness and size can easily be changed
✓ pure active material

Carbonate Formation (Pocket Plate Cells)
Carbonate Formation (K2CO3) and Influence on the Dischargeable Capacity versus Operating Time

Figure 3. Carbonate production in battery and battery capacity reduction

So capacity of the cell does not decrease and carbonate doesn’t produce therefore we no need to change electrolyte during life time of batteries, also aging factor that is most important characteristic of ni-cd batteries is very low and also improve life time of FNC batteries.

REFERENCES


IEEE, IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations. 1994, IEEE.