**Maximizing Lifespan and Efficiency:**

**The Regeneration Revolution for Lead-Acid Batteries**

**A Case Study in the Kurdistan Region of Iraq**

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# Contents

**Abstract**

Lead-acid batteries have long served as a reliable and cost-effective power source within the telecom industry. However, with time, these batteries experience capacity decline and sulfation, potentially disrupting telecom operations. This study investigates the viability of lead battery regeneration as a solution to restore battery capacity and prolong their operational life. We conducted a comprehensive analysis of 112 lead-acid batteries utilized by telecom operators in the Kurdistan region of Iraq, with a focus on the effectiveness of the regeneration process. The outcomes of this research carry substantial implications for the maintenance of telecom infrastructure, cost reduction, and environmental sustainability.

Additionally, the scope of battery regeneration extends beyond telecommunications and encompasses various lead-acid-based battery types, such as gel batteries, (semi-)traction batteries, and starter batteries. Its potential applications span across diverse sectors, including Uninterruptible Power Supply (UPS) Batteries, forklift and material handling equipment batteries, solar energy storage batteries, and other similar domains, promising enhanced sustainability and economic benefits.

**Lead Battery Description**

A lead battery consists of cells, typically with a 2.1 V nominal voltage. A 12 V battery contains six connected cells with lead bridges. The cells are housed in a casing, often made of polypropylene or ABS, with a sealed top. Each cell has positive and negative electrode pairs separated by specialized separators:

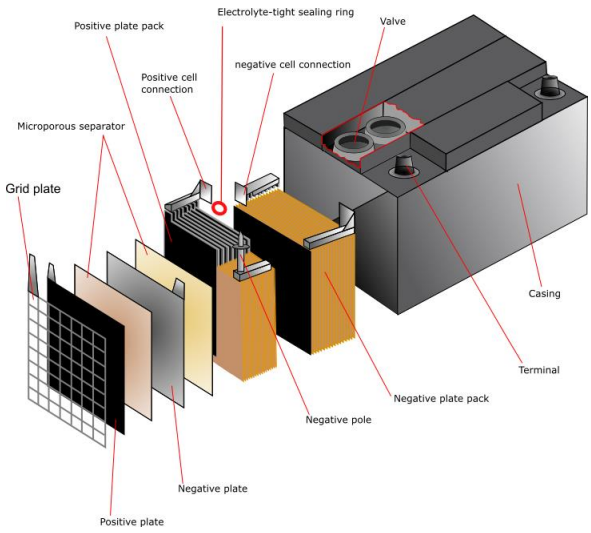
**Positive Pole:** Contains lead grids with alloying components (e.g., Pb-Sb, Pb-Sn, Pb-Ca, Pb-Sb-As) and lead peroxide paste (PbO2) in cavities as active components.

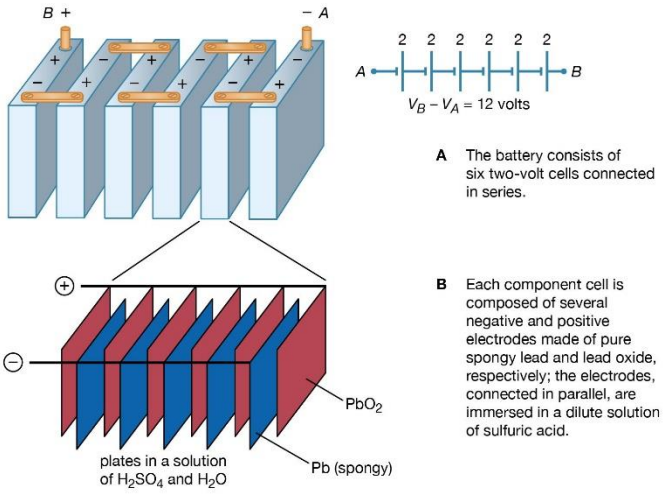
**Negative Pole:** Similar to the positive pole grids but filled with porous lead, acting as a lead sponge.

**Microporous Separator:** Prevents short circuits and is usually made of materials like celluloid fibers, glass fibers, or polyvinyl chloride. It offers electrical insulation, ion transport, debris filtration, sponge-like characteristics, and resistance to sulfuric acid.

**Electrolyte:** It's a substance containing free ions that enable electrical conductivity, often in the form of an ionic solution.

**Expander:** In older batteries, wood was used as separators to maintain chemical flow. Modern batteries use lignosulfonates, organic macromolecules, as expanders for long-term performance.



**What is sulphation?**

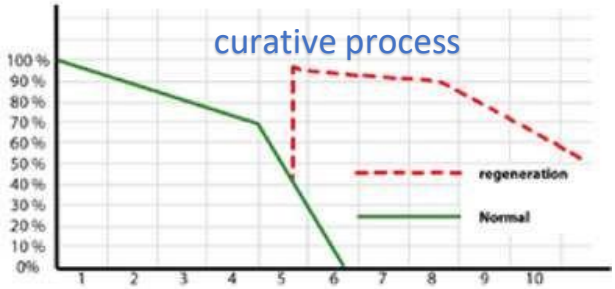
During use, small sulfate crystals can be formed. This is completely normal and not harmful. After a certain period, however, this unshaped lead sulfate converts to a crystalline form that. deposits on the negative plates. This leads to the development of large crystals, which reduce. the battery's active material that is responsible for high capacity and low resistance. Sulfation also lowers the charge acceptance.

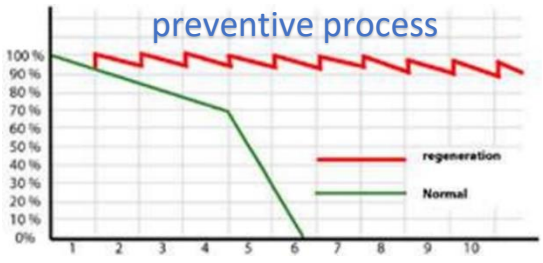

**Regeneration concept**

The regeneration process with the Replus consists of transforming the lead crystal sulfate accumulated on the electrodes back into active matter.

A used battery treated with the Replus will then have greater capacity than a new battery not treated.

Regeneration can be done as a curative process for batteries over 5 years old, or as a preventive process




**Reconditioning regeneration** allows you to restore old (5, 6, 7 … years), medium to well-maintained batteries that have 'silted up' as a result of natural sulphation, to a 90%-100% productivity

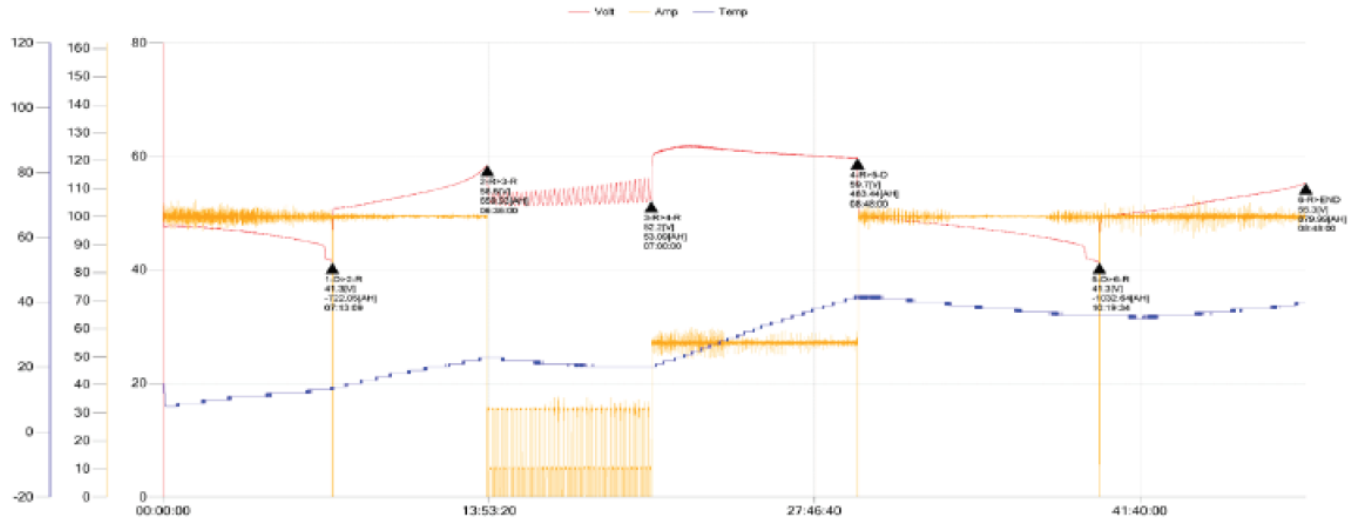
**Maintenance regeneration** allows you to keep your battery in optimal, sulphate-free condition, by means of a yearly short regeneration.

**Battery reconditioning: reports**

The Replus software allows you to create fully detailed reports in PDF, WORD or Excel that give you an excellent idea of the condition of the battery before and after the process.

## Load Test Result (MCS)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site Name | Energic Pus HQ | | | | | | | | | | | Test Date | 3/04/2015 14:06:11 | | |
| Site Code | Waregem | | | | | | | | | | | Test Time | 48:44:43 / 57:36:00 | | |
| Province | West - Vlaanderen | | | | | | | | | | | MCS NO. | | | |
| Brand | | Volt. | 48V | Ah | 1100 | Cells | 24 | Standby Volt. | 49.2V | Type | | Year/Manuf. | 2013 | Ambient Temp. | 27°c |

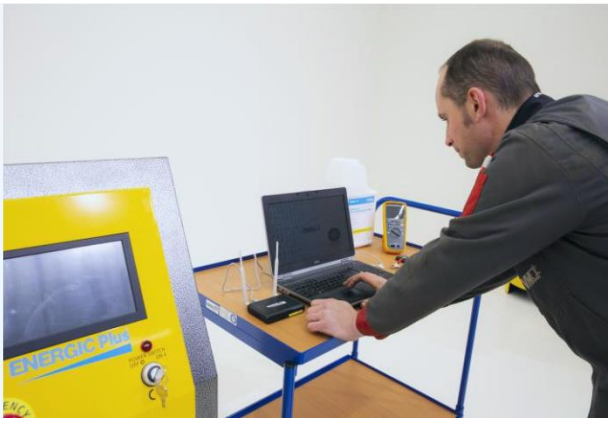



| Index | Method | Pulse | Setup Time | Elapsed Time | Setup Volt | Max Volt | Min Volt | Setup Amp | AH | Temperature | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Discharge | 1 | 13:12:00 | 07:13:09 | 41.3 | 51.4 | 41.3 | 100.0 | -722.0 | +013 | (66) |
| 2 | Restoration | 1 | 06:36:00 | 06:36:00 | 60.4 | 58.5 | 43.5 | 100.0 | 659.9 | +023 | 60 |
| 3 | Restoration | 4 | 07:00:00 | 07:00:00 | 62.4 | 56.3 | 51.4 | 31.4 | 53.1 | +020 | 5 |
| 4 | Restoration | 2 | 08:48:00 | 08:48:00 | 62.4 | 62.1 | 52.4 | 55.0 | 483.4 | +042 | 44 |
| 5 | Discharge | 1 | 13:12:00 | 10:19:34 | 41.3 | 57.4 | 41.3 | 100.0 | -1032.6 | +036 | (94) |
| 6 | Restoration | 2 | 08:48:00 | 08:48:00 | 62.4 | 55.3 | 43.3 | 100.0 | 880.0 | +040 | 80 |
| | | | | 48:44:43 | | | | | | | |

This is how you should interpret the report: when you compare 1 and 4, you notice that the time needed to discharge the battery is much longer in step 4. This is a direct result of the restoration in mode 2 and 3. When comparing step 5 to step 2, you can see that the set battery voltage is reached much later than in step 2. This means that your battery lasts longer and has been restored to a good condition.

**Battery monitoring System (BMS) : Wireless detection of bad cells**

- Wireless detection of bad cells 2-80 V + free analysing software
- The voltage is measured every 3 minutes during the discharge process
- The condition of each cell receives a colour indication
- When using the BMS system in combination with the REPLUS/BDX, you'll get a Full overview of the condition of your battery down to every cell.




BMS-1211204001

| Cell No | 00:00 | 00:03 | 00:06 | 00:09 | 00:12 | 00:15 | 00:18 | 00:21 | 00:24 | 00:27 | 00:30 | 00:33 | 00:36 | 00:39 | 00:42 | 00:45 | 00:48 | →3min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #1 | 2,11 | 2,11 | 2,04 | 2,03 | 2,02 | 2,01 | 2,01 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 1,99 | 1,99 | 1,98 | 1,98 | 1,98 | |
| #2 | 2,13 | 2,13 | 2,05 | 2,05 | 2,03 | 2,03 | 2,03 | 2,02 | 2,02 | 2,01 | 2,01 | 2,01 | 2,01 | 2,01 | 2,01 | 2,01 | 2,00 | |
| #3 | 2,14 | 2,14 | 2,06 | 2,06 | 2,04 | 2,04 | 2,04 | 2,03 | 2,02 | 2,02 | 2,02 | 2,02 | 2,02 | 2,01 | 2,02 | 2,01 | 2,01 | |
| #4 | 2,14 | 2,14 | 2,03 | 2,02 | 1,99 | 1,99 | 1,98 | 1,97 | 1,96 | 1,95 | 1,96 | 1,95 | 1,94 | 1,94 | 1,94 | 1,93 | 1,93 | |
| #5 | 2,16 | 2,15 | 2,03 | 2,02 | 1,98 | 1,98 | 1,98 | 1,96 | 1,95 | 1,95 | 1,94 | 1,93 | 1,93 | 1,92 | 1,92 | 1,91 | 1,90 | |
| #6 | 2,13 | 2,13 | 2,01 | 2,00 | 1,97 | 1,96 | 1,96 | 1,95 | 1,94 | 1,94 | 1,93 | 1,93 | 1,93 | 1,92 | 1,92 | 1,91 | 1,91 | |
| #7 | 2,13 | 2,13 | 2,02 | 2,01 | 1,99 | 1,99 | 1,99 | 1,98 | 1,97 | 1,97 | 1,97 | 1,96 | 1,96 | 1,96 | 1,96 | 1,95 | 1,95 | |
| #8 | 2,10 | 2,10 | 2,02 | 2,01 | 2,00 | 2,00 | 1,99 | 1,98 | 1,98 | 1,97 | 1,97 | 1,97 | 1,96 | 1,96 | 1,96 | 1,96 | 1,96 | |
| #9 | 2,15 | 2,15 | 2,01 | 2,00 | 1,97 | 1,96 | 1,96 | 1,95 | 1,95 | 1,94 | 1,94 | 1,93 | 1,93 | 1,92 | 1,92 | 1,92 | 1,91 | |
| #10 | 2,15 | 2,15 | 1,98 | 1,96 | 1,92 | 1,92 | 1,91 | 1,89 | 1,89 | 1,88 | 1,87 | 1,86 | 1,86 | 1,85 | 1,84 | 1,83 | 1,83 | |
| #11 | 2,10 | 2,10 | 1,91 | 1,89 | 1,84 | 1,83 | 1,82 | 1,80 | 1,78 | 1,77 | 1,75 | 1,73 | 1,71 | 1,68 | 1,65 | 1,61 | 1,56 | |
| #12 | 2,14 | 2,15 | 1,98 | 1,96 | 1,92 | 1,92 | 1,91 | 1,89 | 1,88 | 1,87 | 1,86 | 1,85 | 1,84 | 1,83 | 1,82 | 1,81 | 1,80 | |
| Sum | 25,58 | 25,59 | 24,14 | 24,01 | 23,67 | 23,63 | 23,58 | 23,42 | 23,34 | 23,28 | 23,22 | 23,14 | 23,08 | 22,99 | 22,94 | 22,83 | 22,74 | |
| Avg | 2,13 | 2,13 | 2,01 | 2,00 | 1,97 | 1,97 | 1,97 | 1,95 | 1,95 | 1,94 | 1,94 | 1,93 | 1,92 | 1,92 | 1,91 | 1,90 | 1,90 | |

The software checks the actual voltage of each sender every 3 minutes and stores this value in a table. Colour codes indicate the charge condition of each cell (empty to full) continuously, as a result of which the performance curves are very detailed.

**Applications of Lead-Acid Battery Regeneration:**

Lead-acid battery regeneration techniques can be applied to various types of lead-acid-based batteries, including gel batteries, (semi-)traction batteries, and starter batteries. Here are some examples of applications where regeneration can be beneficial:

1. **UPS (Uninterruptible Power Supply) Batteries**: UPS systems often use valve-regulated lead-acid (VRLA) batteries, which can benefit from regeneration to extend their service life and maintain reliable backup power for critical equipment.
2. **Forklift and Material Handling Equipment Batteries**: Lead-acid batteries used in forklifts and other industrial equipment, often categorized as (semi-)traction batteries, can be regenerated to improve their performance and reduce replacement costs.
3. **Solar Energy Storage Batteries**: In solar power systems, lead-acid batteries are used for energy storage. Regeneration can help enhance their performance and increase their lifespan, which is crucial for off-grid or backup power applications.
4. **Telecommunications Backup Batteries**: Lead-acid batteries are commonly used in telecommunication infrastructure for backup power. Regenerating these batteries can help maintain network reliability during power outages.

It's important to note that while regeneration techniques can be applied to various lead-acid battery types, the effectiveness of the regeneration process may vary depending on the battery's age, condition, and chemistry. Additionally, specific regeneration methods and equipment may be tailored to different types of lead-acid batteries to achieve the best results. Therefore, it's advisable to consult with professionals or manufacturers who specialize in battery regeneration for guidance on the most suitable approach for your specific application.

**Conclusion:**

The results of the battery regeneration study, which involved "Shoto 6-FMX-100B" and "Northstar Red NSB100FT Red" 12V, 100AH, and 150AH lead-acid batteries used in the telecom industry, reveal several significant findings. These batteries, manufactured between July 2015 and October 2016, had 3 to 4 years of operational history. Notably, 96% of the tested batteries were successfully regenerated, with a majority experiencing improved electrical resistance and increased capacity post-regeneration, indicating the effectiveness of the process. This success underscores the potential for battery regeneration to extend the lifespan and enhance the performance of various types of lead-acid-based batteries, including gel batteries, (semi-)traction batteries, and starter batteries.

Battery regeneration offers a sustainable and cost-effective solution for maintaining reliable power sources in a wide range of applications, such as telecommunications, UPS (Uninterruptible Power Supply) Batteries, forklift and material handling equipment batteries, solar energy storage batteries, and similar scenarios. Encouraging further research and testing on a larger scale will provide valuable insights into the long-term benefits of this method while actively promoting its adoption. This not only contributes to cost savings but also minimizes waste and reduces the environmental impact across diverse industries.

## Tables

**Table 1 :**

*Instruments Utilized in this Study.*

| NO | Description /Specification | Qty |
|---|---|---|
| 1 | TVH/139TA1918 BATTERY REGEN1-100V 300Ah | 1 |
| 2 | TVH/165TA2362 BATTERY DISCHARGER MPD-1007E | 1 |
| 3 | TVH/33837974 BMS SYSTEM 120V (10 X 12V) | 1 |
| 4 | TVH/100BA5069 BMS SYSTEM 48V (9 X 6V) # optional | 1 |
| 5 | TVH/47978151 DIGITAL HYDROMETER # optional | 1 |
| 6 | TVH/21840974 BATTERY IMPEDANCE METER | 1 |

# Figures

***Figure 1.***

*Following the battery regeneration process, this figure clearly shows the difference between the pre-regeneration and post-regeneration states, highlighting the remarkable success in enhancing battery capacity Out of the 112 batteries that were tested.*

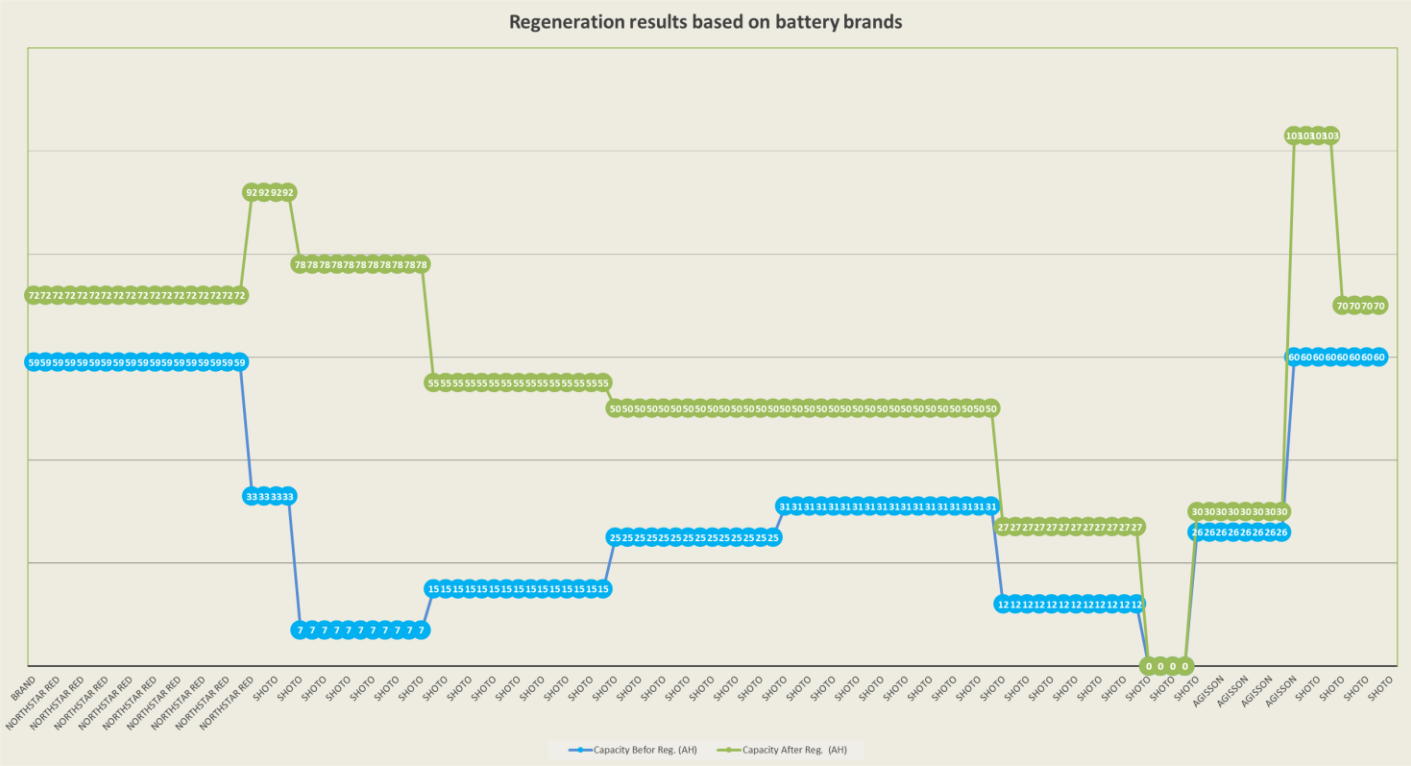
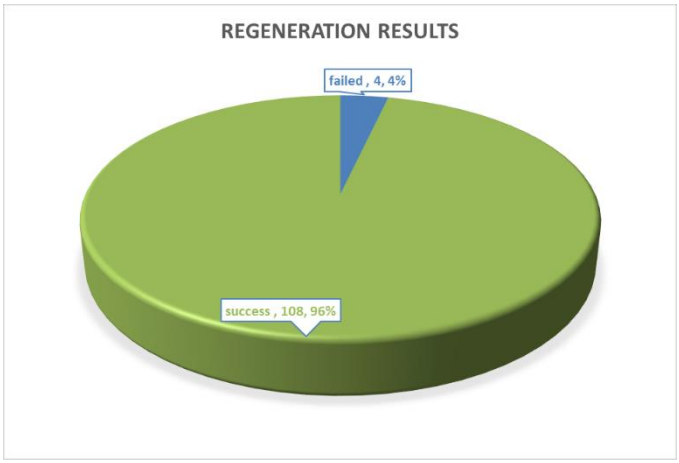
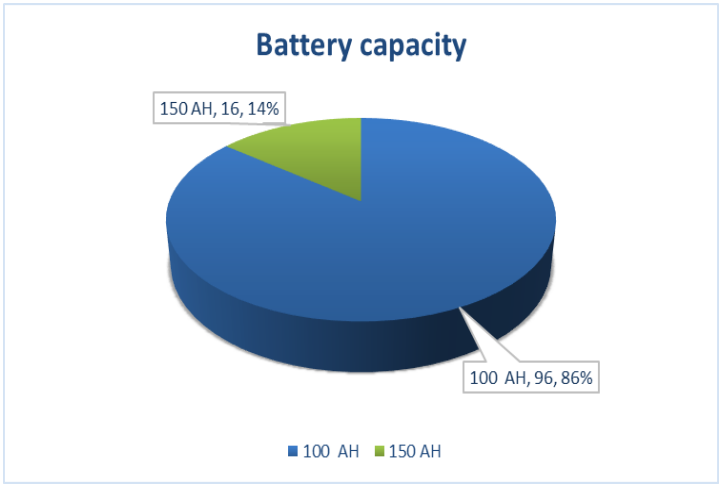
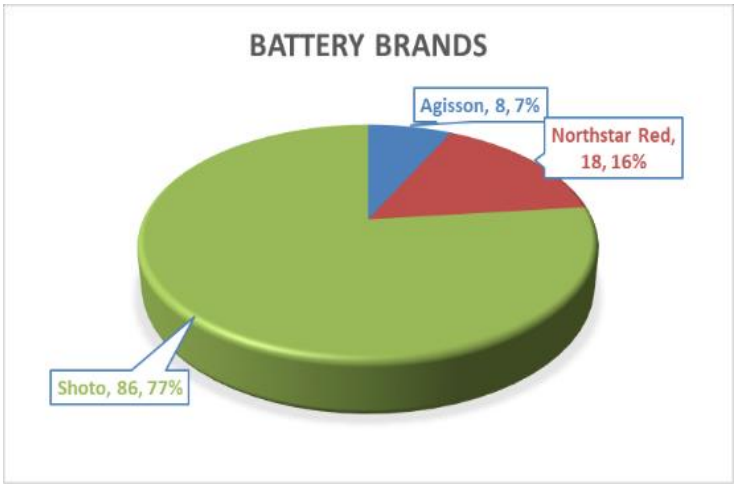


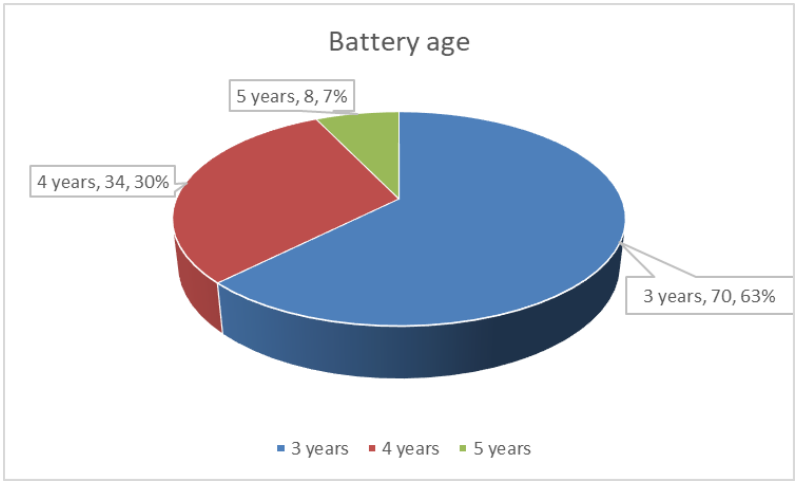
***Figure 2.***

*the success rate of 96% among the tested batteries.*



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