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Original Research Article

COMPARATIVE PERFORMANCE EVALUATION OF A SINGLE 200AH BATTERY AND EQUIVALENT TWO – 100AH BATTERIES CONNECTED IN PARALLEL

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ABSTRACT

Deep cycle batteries are in practice, either used as single batteries at desired amp-hour (Ah) ratings or a parallel connection of a number of lower amp-hour rated ones to achieve the desired amp-hour rating. This works presents an experimental determination of the runtime performance of a single 12V, 200Ah deep cycle battery and two (2) 12V, 100Ah batteries connected in parallel to achieve 12V, 200Ah rating. The single 12V, 200Ah deep cycle battery and two (2) 12V, 100Ah batteries connected in parallel were loaded separately using the same inverter and the same load and the rate at which they discharged was tracked. Analysis of the performance showed that the single 12V, 200Ah battery exhibited a longer runtime under the same load condition, than the parallel connection of two 12V, 100Ah batteries.

1. INTRODUCTION

Cells or batteries are designated by the nominal capacity in ampere hours (Ah) and by the nominal voltage, which has been standardized at 2.0V/cell for the lead acid battery. This value applies at the nominal electrolyte temperature and density (Peng, 2011). Each cell consists of an electrolyte with positive and negative electrodes. Electrochemical reactions occur at the electrodes to generate free electrons, which generate electrical energy and the amount of energy that can be stored depends on the mass/volume of electrodes while the power capacity is determined by the contact area of electrodes with the electrolyte (Fathima and Palanisamy, 2015). Cells in a battery pack may be electrically connected in parallel in order to increase the pack capacity and meet requirements for power and energy (Zhang and

Mi, 2011; Gong et al., 2014; Bruen and Marco, 2016). Internal resistance imbalance between parallel-connected cells because of differences in internal resistance can lead to uneven current distribution within the cells and this can be detrimental to the battery life (Gogoana et al., 2014). Parallel battery connections can increase current rating but the voltage remains the same while connecting batteries in series will combine the voltage but keep the original amp capacity (Gonderman and Gonderman, 2014). The size of the battery bank required, for a particular application, will depend on the storage capacity required, the maximum discharge rate, the maximum charge rate, and the minimum temperature at which the batteries will be used (Nupur et al, 2013).

The voltage across the terminals of a battery is related to the battery's state-of-charge (SOC), which in turn is related inversely to the depth-of-discharge (DOD). The relationship between voltage across battery terminals and SOC or DOD was reviewed extensively by Perez (1993). The state of charge of a discharging deep cycle battery can be determined by using a voltmeter (Digital multimeter) to read the voltage across the battery terminals (Perez, 1993).

Batteries on discharge will generate heat, which affects internal resistance and accelerate electrochemical reactions within the battery. Also high discharge rates quickly drain the battery. The combination of high ambient temperatures and high discharges rates can cause serious battery damage. These high discharge rates can be avoided by using a larger capacity battery. Larger capacity batteries can be obtained by connecting lower capacity batteries in series or in parallel as required by an application using appropriate Ah capacities. In any given case, there may be multiple solutions with the choices limited by battery availability and budget.

Experimental and simulation studies on the performance of batteries have been carried out and are well documented in literature. However, search has turned up no experimental study on the comparative performance of multiple solutions of battery configurations to obtain larger capacity for a particular problem. The result from such a work will offer ready solution option when faced with multiple solutions of battery configurations to achieve larger capacity. This work investigates the comparative performance of using a single deep cycle battery (DCB) at desired rated amp-hour and connecting two lower amp-hour rated DCBs to achieve the same desired amp-hour rating.

2. MATERIALS AND METHODS

In this work, the performance of a single 12V deep cycle battery unit of 200Ah was compared with two 12V, 100Ah batteries connected in parallel to obtain 12V, 200Ah capacity of the single unit. The performance of both batteries was investigated and compared.

2.1. Materials

The materials used in this study include the following:

1. 3 deep cycle batteries (one 200Ah and two 100Ah rating) each of 12V.
2. Mercury 1200VA, 12V inverter

3. Battery load tester (BLT)
4. Digital multimeter
5. Plier/Screw driver
6. 60 and 100 watts bulb to serve as load
7. DCB connecting cables

2.2. Assumptions

The following assumptions were made during the study:

1. Both battery units were charged to full capacity with the inverter, tested with the BLT and then allowed to float to about 13.22V.
2. The voltage taken across the battery terminals immediately a load was applied was taken as its 100% charge state.
3. Voltage readings were taken every 60mins i.e 1hr, until the battery completely discharged to about 10.50V (100%DOD).

2.3. Methodology

The following procedure was adopted for the single unit of 200Ah battery

1. At a float voltage of 13.22V, the positive and negative wires of the inverter were connected to the corresponding positive and negative terminals of the battery.
2. The 20A inverter mode was selected.
3. A load of 200 Watts was applied to the battery as shown in Figure 1
4. With the applied load, the inverter was put on and the immediate voltage of the battery was read at its 100% state-of-charge (SOC) or 0% Depth-of-discharge (DOD).
5. The voltage of the battery was read at every 60mins interval until it was completely drained.

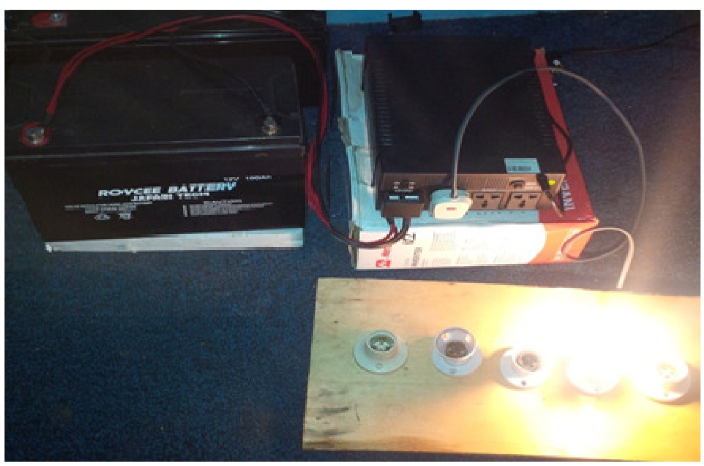

Figure1: Single unit of 200Ah Battery with about 200watts load applied, (black cable -negative, red cable-positive)

The following procedure was adopted for the double unit of two 100Ah batteries.

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1. The two 100Ah batteries were connected in parallel so as to yield 200Ah.
2. The corresponding terminals (black-black and red-red) of the batteries were also connected together with red and black cables, as shown in Figure 2.
3. The corresponding cables (red and black) from the inverter were connected to battery terminals and it was ensured that they were tightly fastened.
4. The 20A inverter mode was selected.
5. With the 200watts load applied, the voltage across the battery terminals was measured using a multimeter at an interval of 60 minutes and recorded.

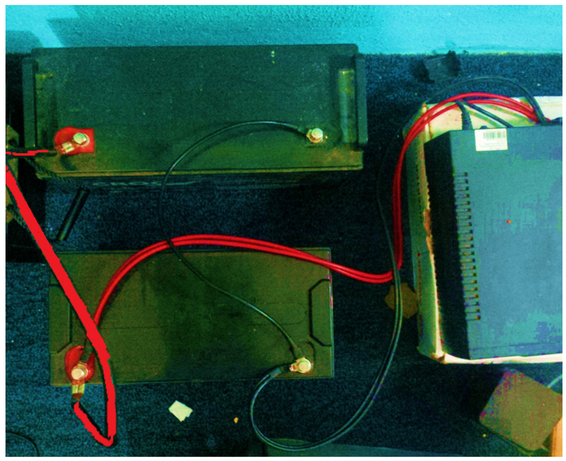

Figure 2: Two 100Ah batteries connected in parallel

2.3.1. Precautions

The following precautions were taken in the course of the investigation

1. The inverter was disconnected from the AC source after it attained full charge.
2. The battery was allowed to float to 13.22V after charging before the commencement of the battery analysis so that the heat generated during the recharge cycle could dissipate. If this is not done, the heat could accumulate and accelerate grid corrosion, which is one of the major causes of battery failure.
3. Without the cooling time the heat grows, accelerating grid corrosion, which is one of the major causes of battery failure.
4. With the negative cable connected first, it was ensured that the battery terminal screws and cables to the inverter were tight in order to avoid sparks and unnecessary charge leakage.

In addition, the two batteries connected in parallel were of the same voltage and amp hour ratings (12V, 100Ah) so as to keep their voltages and rates of discharge as even as possible.

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3. RESULTS AND DISCUSSION

The results obtained are presented in Figures 3 and 4. From the values obtained as shown in Figures 3 and 4 it was observed that the single 200Ah battery performed better and lasted longer than the two 100Ah batteries connected in parallel. The rate of discharge was higher for the two batteries connected in parallel than for the single battery (Fengky et al., 2017). It was observed from Figures 3 and 4 that whereas the single 12 V, 200 Ah battery delivered power for over 500 minutes, the 12 V, 200 Ah battery, obtained by connecting two 12V, 100 Ah batteries in parallel delivered power for less than 500 minutes. This implies that it is more economical to buy and use a single 200 Ah battery than buying two (2) 12V, 100Ah batteries and connecting them in parallel to serve as a 12 V, 200 Ah battery.

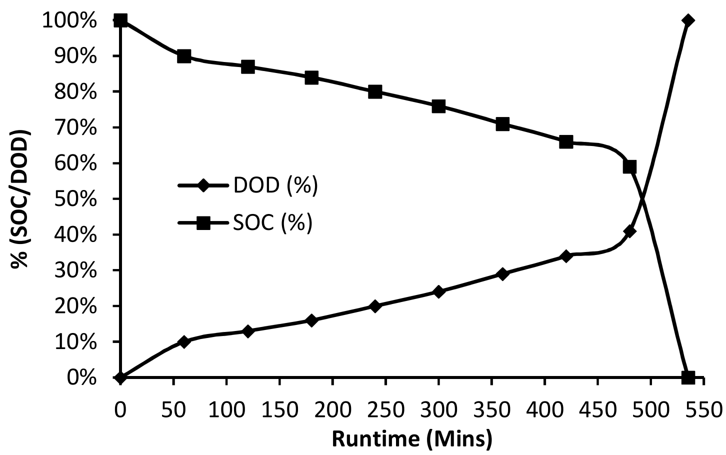

Figure 3: Plot of SOC/DOD vs runtime for single 12V, 200Ah battery

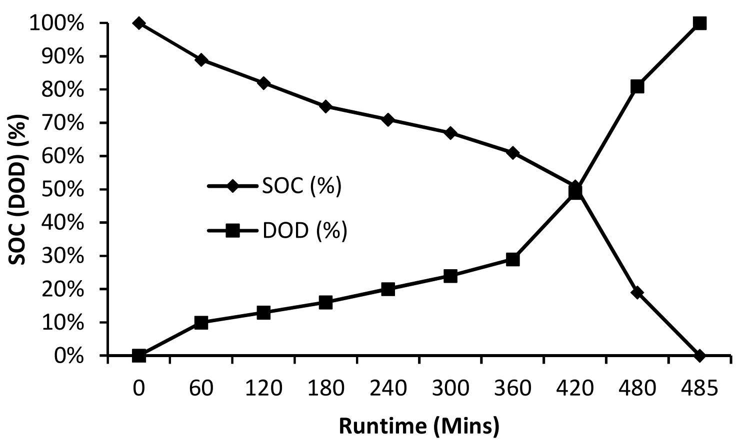

Figure 4: Plot of SOC/DOD vs runtime for two 12V, 100Ah batteries connected in parallel

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4. CONCLUSION

This work compared the performance of a single 12V, 200Ah deep cycle battery with another 12V, 200Ah option obtained by connecting two 12V, 100Ah batteries in parallel. The results of their runtime performance indicated that it is more economical to use a single 12V, 200Ah deep cycle battery than buying two 12V, 100Ah deep cycle batteries and connecting them in parallel to obtain 12V, 200Ah. Therefore, it is better to use single deep cycle batteries at required amp-hour rating than connecting lower amp-hour-rated batteries in parallel to achieve desired amp-hours requirement for a particular application.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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