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Static and Dynamic Characteristic Lead Acid Redox Flow Battery

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Abstract. Proper use of electrolytes and sufficient quantities will increase the energy capacity and efficiency of a battery. Redox Flow Battery (RFB) is a new type battery with electrolyte flow through the battery unit cell. This study uses two electrodes (Pb and PbO) each with a size of 22.5 x 7.5 cm^2 and sulfuric acid solution as electrolyte. Two battery systems have been created with the same cell dimensions to provide an ideal comparison analysis. There is a static electrolyte single cell system (static battery) and a flowing electrolyte single cell system (dynamic battery) called lead acid RFB. The experimental results show that RFBs have a discharge time 1.5 hours longer than static batteries. RFB generates a battery capacity and average energy efficiency of 6821 mAh and 83%, respectively, meanwhile the static battery generates 6207 mAh and 77%.

Keywords: dynamic, electrolyte, redox flow battery, single cell system, static.

INTRODUCTION

Electric energy saving is the main issue of building electrical conservation so that alternative energy such as wind and solar is combined as a source of building electricity.[1] However, the output of electric power from alternative energy depends on a nature that is uncertain.[2] Storage of electrical energy is one of the solutions in this problem. RFB (Redox Flow Battery) is an excellent candidate for the storage of electrical energy at a large scale.[3] RFB consists of two types of RFB two electrolyte flow and one single electrolyte flow. RFB single electrolyte has very simple coating construction and low cost manufacture.[4] In previous research, the uniqueness of RFB single electrolyte has been investigated from static electrolyte treatment and dynamic electrolyte treatment to constant current variations of charging and discharging.[5] However, it has not yet identified the battery's capacity to change the number of cycles and electrical characteristics of each cycle. In this research, we have compared the characteristics of voltage, battery capacity, and efficiency of static and dynamic RFB lead acid to the number of cycles.

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EKSPERIMENTAL DETAILS

Figure 1 is a single electrolyte RFB lead acid consisting of three parts: electrochemical cell system, battery management system, and PC unit that is monitored in real time. An electrochemical cell made with only one single cell consists of a Pb and PbO_2 electrode material of 22.54 x 7.5 cm^2 which is separated by a separator in an acrylic box. 30% sulfuric acid electrolyte of 450 mL placed in separate tank flows at a rate of 9 mL/min using a pump. Turnigy accucell 6 50W is used as battery management system (BMS) and is equipped with a charge/discharge cycle test with constant current method up to 2 A. The software interface in this research is ChargeMaster 2.02.

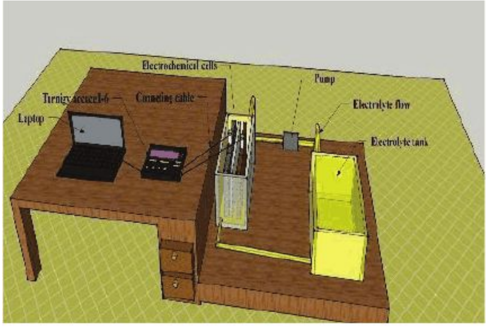


FIGURE 1. Design of the system flow cell and battery real time monitoring system.

Two lead acid battery systems are made with the same cell dimensions to provide ideal comparison analysis. One system cell is used in static electrolyte conditions and one cell is used in flowing (dynamic) electrolyte conditions called lead acid RFB. This variation in static and dynamic electrolyte flow treatment is expected to provide information on the performance difference of the battery. Both systems are discharged early to determine the initial characteristics of the battery before the test charge/discharge test cycle with a constant current of 1 A, then a cyclical test of 3 cycles was performed for each battery system. Software will record, in real time, data voltages, capacities, and currents over time during the charging and discharging processes that take place. The results of this cycle test are used as a reference to determine the performance of energy efficiency values of both battery systems that have been made using the equation as follows.

Coulomb efficiency:

$$E_c = \frac{\int I_d dt}{\int I_c dt} \quad (1)$$

Energy efficiency

$$E_E = \frac{\int P_d dt}{\int P_c dt} \quad (2)$$

Voltage efficiency

$$E_V = \frac{V_{md}}{V_{mc}} \quad (3)$$

Where I denotes current, P is power, V is voltage, c is charge, d is discharge, md middle point of discharge and mc is middle point of charge.[6,7,8]

RESULT AND DISCUSSION

Characteristics of Electrochemical Cells

Figure 2 shows a lead acid RFB system tested with a standard multimeter yielding a potential cell value of 2.05 volts. This result is appropriate as in the previous study,[9] in which the use of a combination of Pb and PbO_2 electrode materials and sulfuric acid electrolyte solutions can produce the ideal RFB system. So, it can be ensured that the RFB system made can be tested with the cycle charge/discharge test with constant current method.

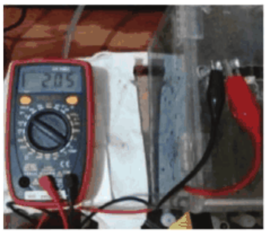
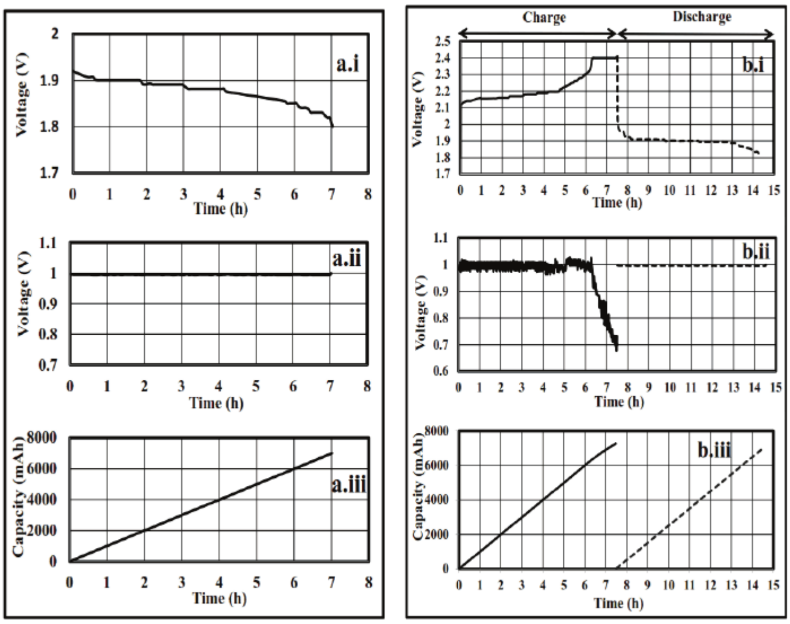


FIGURE 2. The initial testing of lead acid RFB system.

Furthermore, the lead acid RFB is tested for initial discharge characteristics with a constant current method of 1 A until the battery charge is indicated as being depleted. Based on the results of the test, we have obtained the graph of discharge characteristics as shown in Figure 3.



(a) (b)

FIGURE 3. a) Initial Characteristics of lead acid RFB during discharge time a.i) Cell Voltage, a.ii) 1 A Constant Current treatment a.iii) Battery capacity. b) One cycle charge/discharge test b.i) voltage vs time b.ii) constan current vs time b.iii) battery capacity vs time.

Figure 3 (a.i) shows how lead acid RFB produces an initial discharge voltage of 1.93 V with a constant current of 1 A for 7 hours Figure 3 (a.ii), until it drops at a voltage of 1.8 V Figure 3 (a.i) reaching a capacity of 7000 mAh Figure 3 (a.iii). These initial discharge results indicate that lead acid RFB already has a high capacity. The BMS turnigy Accucell 6 50 W automatically detects 1.8 V as the cut off voltage identified as lead acid RFB load has started to run out. The battery is then filled to full and disarmed. So, the lead acid RFB can be tested with charging and discharging.

The results of this activity can be seen in Figure 3 (b) with the RFB charging and discharging test results which have the same graphic pattern in other research [10], so RFB models are a kind of secondary battery. In the initial RFB charging Figure 3 (b.i), the voltage rises from 2.05 V slowly for 4.8 hours and then the voltage rises exponentially to 2.4 V until saturation and remains in this state until the battery is full at 7.3 hours. This condition causes the charge around the electrode to be placed to produce a potential difference between the two electrodes. Therefore, the saturation voltage at the filling process of Figure 3 (b.i) is assumed to know the amount of energy already stored maximally so that the charging current slowly decreases, as in Figure 3 (b.ii). This trend of electric current decreases as an indication of slow electron flow rejection at the time of charging, but the value of capacity increases in the process of charging lead acid RFB, as in Figure 3 (b.iii).

Comparation of Static and Dynamic Battery for Three Cycles

Based on the three cycle test (Figure. 4), the performance of a dynamic battery (lead acid RFB) is better than a static battery. This is shown by the length of the discharge time range, this indicates that the electrolyte tank system and electrolyte flow in the dynamic battery can increase the battery life cycle.

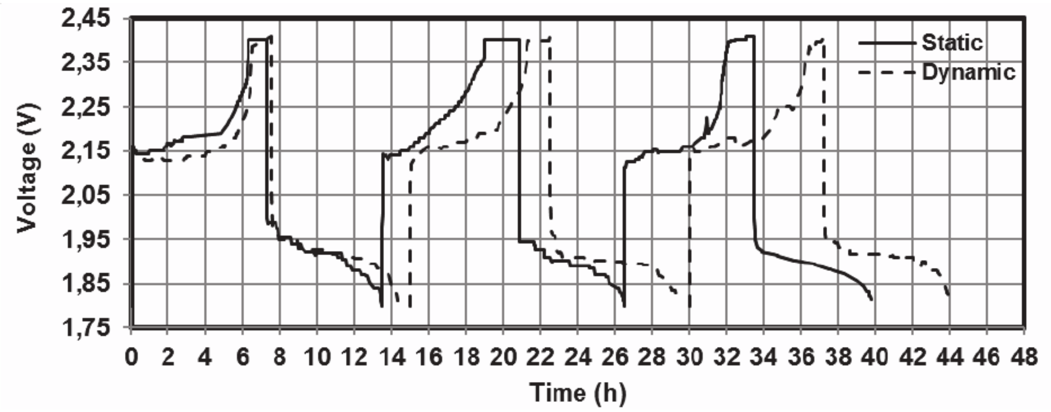


FIGURE 4. Comparison three cycle test of dynamic battery system (lead acid RFB) and static battery system.

Figure 4 shows that both static and dynamic batteries have the same peak charging voltage during the charging process, but have different performance voltage ranges when the static battery charging process is larger than the dynamic battery. In contrast, the dynamic battery performance voltage range of the release process is greater than the static battery. These results indicate the energy required when charging from a static battery larger than a dynamic battery. In addition, Figure 4 also shows that the life cycle of a dynamic battery system is longer than a static battery system. Some electrical parameters based on the results of the cycle test comparison of both static and dynamic batteries are shown in Table 1.

TABLE 1. Comparation Electricity Characteristic Static Lead Acid Battery and Dynamic Lead Acid Battery (RFB).

Feature	Static Lead Acid Battery			Dynamic Lead Acid Battery (RFB)		
$V_{(middle\ point\ of\ charge)}$ V	2,19	2,21	2,16	2,14	2,19	2,17
$V_{(middle\ point\ of\ discharge)}$ V	1,90	1,89	1,89	1,88	1,89	1,89
$I_{(charge)}$ A	0,99	0,99	0,99	0,99	0,99	0,99
$I_{(discharge)}$ A	1	1	0,99	1	1	1
$t_{(charge)}$ sekon	26256	26446	25256	27128	27069	26064
$t_{(discharge)}$ sekon	22326	21776	22515	24555	24554	24224
Number of Cycle	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3

Table 1 shows the electrical characteristics of a static battery and a dynamic battery. This is very important to learn because it has a close relationship with the energy efficiency of a battery. As expressed in equation 2 that the value of the energy efficiency depends on the median voltage, current, and time range of the charge/discharge process. Based on the results of the cycle test of three cycles, the comparative efficiency of each battery has been obtained, as shown in Table 2.

TABLE 2. Comparation E_v, E_c and E_E from static and dynamic battery systems.

Cycle Number	Static Lead Acid Battery			Dynamic Lead Acid Battery (RFB)		
	E_v%	E_c%	E_E%	E_v%	E_c%	E_E%
1	86.8	85.8	74.5	87.8	91.4	80.3
2	85.5	91.4	78.2	86.3	91.6	79
3	87.5	89.1	78	87	93.8	81.8

Table 2 shows each efficiency value of three cycles obtained from equations 1, 2, and 3. Dynamic batteries tend to have an efficiency value greater than static batteries. These results suggest that dynamic batteries can reduce the amount of energy needed to achieve the same results. This study has also studied the change in battery capacity value of the three capture cycles shown in Figure 5.

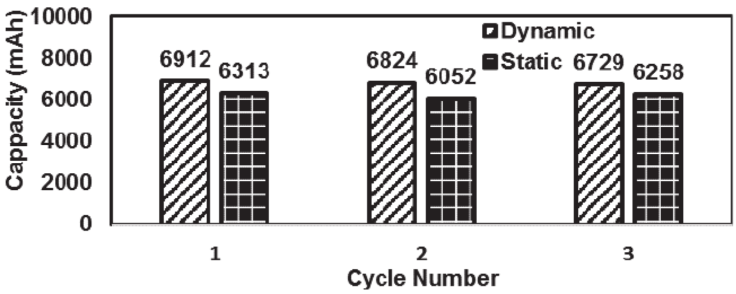


FIGURE 5. Capacity versus cycle number of static and dynamic battery.

Figure 5 shows the dynamic battery having a greater capacity value than a static battery with an average difference of 614 mAh from the test results of three cycles. The use of electrolyte tanks and electrolyte flows can increase the capacity of the secondary battery system.

SUMMARY

This research resulted in characteristic curves of two modified lead acid batteries: static battery and dynamic batteries (RFB) models. Based on all the parameters, the conclusions are:

1. The single cell of RFB system generates a potential cell value of 2.05 volts.
2. Dynamic batteries have a lower charging voltage than static batteries, but on the contrary they have higher discharging voltages than static batteries.
3. RFB system can add a battery life cycle of about 1.5 hours and increase battery capacity by about 614 mAh.
4. RFB battery model has better performance than the static lead acid battery model in that it has an average energy efficiency rating of 83% for RFB and 77% for the static battery.

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REFERENCES

1. M. P. T. Sulistyanto, K. B. Pranata and Solikhan, *Proceedings of 4th International Conference on Computer Applications and Information Processing Technology (CAIPT) 2017*, (IEEE Xplore, Kuta Bali, 2017), pp. 1-7.
2. L. Baumann and E. Boggasch, Int. J. Hydrogen Energ. **41**, 740-751 (2016).
3. M. H. Chakrabarti, E. P. L. Robert, C. Bae and M. Saleem, Energ. Convers. Manag. **52**, 2501–2508 (2011).
4. J. Collins, G. Kear, X. Li, C. T. J. Low, D. Pletcher, R. Tangirala, D. Stratton-Campbell, F. C. Walsh and C. Zhang, J. Power Sources **195**,1731–1738 (2010).
5. C. P. Zhang, S. M. Sharkh, X. Li, F. C. Walsh, C.N. Zhang, and J.C. Jiang, Energ. Convers. Manag. **52**, 3391–3398 (2011).
6. D. Reed, E. Thomsen, B. Li, W. Wang, Z. Nie, B. Koeppel, and V. Sprenkel, J. Power Sources **306**, 24-31 (2016).
7. X. Teng, C. Sun, J. Dai, H. Liu, J. Su, and F. Li, Electrochem. Acta **88**, 725–734 (2013).
8. M. Xiao, P. Liao, S. Yao, J. Cheng, and W. Cai, J. Renew. Sustain. Energ. **9**, 054102 (2017).
9. D. Pletcher, and R.G.A. Wills, J. Power Sources **149**, 96–102 (2005).
10. M. Ghufron, K. B. Pranata, *Proceeding of The 7th Annual Basic Science International Conference 2017*, (Brawijaya University, Malang, 2017), pp 44-47.