Investigations into Dry Cell Battery Discharge Rates Using TAM Air

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Lowest Resistances, Highest Resistances, Load Resistor

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INTRODUCTION

A dry cell baltery is an electrochemical cell in which the electron transfer of a chemical reaction is conducted outside the battery through an external circuit in a load. The reactions in the battery result in a decrease in the energy content of the substances in the battery, It is this energy decrease which can be used to power a device such as a flashlight. It is however not possible to utilise the entire energy because of internal energy losses within the battery. The energy that cannot be used outside the battery is converted to heat within the battery. By measuring this heat the efficiency of the battery may be investigated.

MATERIALS AND METHODS

Of the eight channels in TAM Air, four were charged with 1.5 V alkaline batteries, size AA A. Four resistors of different values were placed in the other four channels for connection to the batteries. The experiment was started when the circuit between each battery and its resitstor was completed. The experiment was performed twice using four batteries in each experiment. Each battery and each resistor was placed within a 20 ml glass ampoule with I ml of paraffin oil on the bottom of the ampoule to increase the thermal contact. Measurements were made at 22°C, with one sample taken every minute,

The resistors act as the load of the battery replacing an electrical lamp or motor The heal produced in a resistor may be considered as potentially useful energy. The battery voltage U (V) may be calculated from the measured heat production rate in the resistor P (W) by the following equation:

$$U = \sqrt{PR}$$

Here R (Ω) is the resistance of the load resistor.

The thermal power produced in the resistor can also be calculated by measuring the voltage and using Eq. 1. The setup used here has the advantage of clearly demonstrating how the energy output from the battery is divided into two parts, the useful energy in the resistor and the waste energy in the battery.

The two lowest resistances used, 1.35 Ω and 3.,85 Ω will give thermal powers high- er than TAM Air can measure. To overcome this in experiments #1 and #2, only part of the total resistances was contained in the ampoules. The additional resistors were placed outside the calorimeters, but connected in series with the resistors in the calorimeters. In the results of experiments #1 and #2, the calorimetric measurements have been corrected to include the thermal powers produced by the resistors outside the calorimeters.

Table 1 below shows an overview of the individual experiments. The lowest resistances cause a rapid drain of the battery (e.g. as in a flashlight) whereas the highest resistances cause a very low rate of discharge (e.g. as in an alarm clock). The right-hand column gives the thermal power produced in the resistors with the rated voltage of 1.5 V.

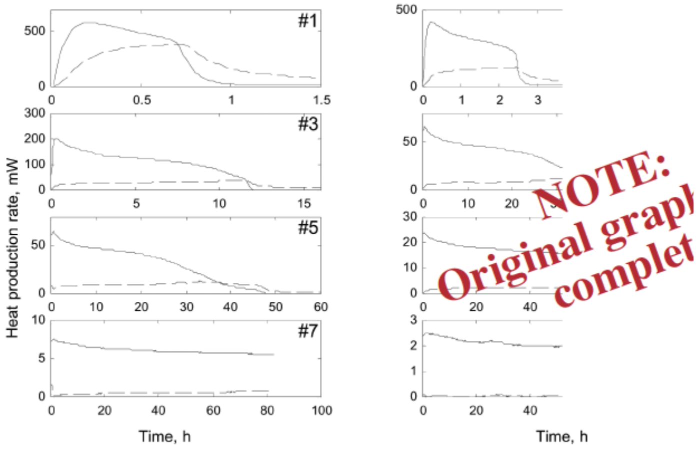
#	R / Ω	P(1.5 V)/mW
1	1.35	820
2	3.85	100
3	11.2	12
4	33.4	1.3
5	33.4	1.3
6	100.0	0.15
7	331	0.014
8	1006	0.015

Table 1.

RESULTS AND DISCUSSION

Results from battery experiments can be plotted in many different ways to give different types of information. Figure 1 shows the primary results from all eight experiments. Note that experiments 4 and 5, which were made using the same resistance value, produce similar results. In experiments 6 to 8 the batteries were not fully discharged during the course of experiment.

Figure 2 gives the battery voltage as a function of the integrated energy delivered to the loads (the resistors) for all eight experiments. It can be seen that these curves are similar except for the two highest rates of discharge. The final energy output of about 5000 J is approximately equal to the rated capacity for this type of battery. It is only with the two highest rates of discharge that the rated energy output from the batteries is not obtained. Figure 3 shows how the decrease in chemical energy in the battery may be divided into internal losses and useful energy in experiment #2. Note that the internal losses rise just before the useful energy production rate drops. These measurements were made to investigate the properties of batteries during discharge. It is also possible to assess the self-discharge rate of batteries and therefore their predicted shelf-life by measuring the very low heat production rates when they are not used. However these heat production rates are normally so low that it may be necessary to use a more sensitive calorimeter, such as the Thermometric 2277 TAM for this kind measurement.



NOTE:
Original graph
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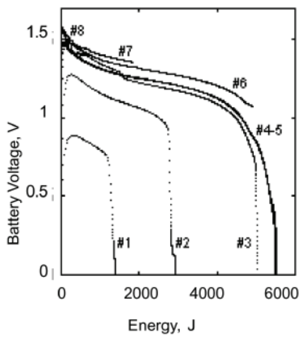

Figure 2. The voltage of each battery as a function of useful energy produced

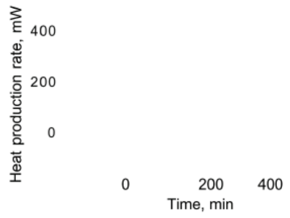

Figure 3. The division into useful energy and internal losses for battery #2. The front graph shows the heat production rate in the battery (internal losses), the middle graph shows the heat production rate in the resistor (useful energy), and the rear graph shows the sum of the two.

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