Performance and Regeneration of Lead-acid Batteries and the Use of Battery Activator for Electric Wheel Chairs

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Abstract

The driving and charge-discharge tests were carried out on the used lead-acid batteries for electric wheel chair. When the used batteries were repeatedly subjected to driving test on road after full charge, the electricity delivered from the battery during driving was gradually decreased. This battery was discharged at 90A after full charge, the driving time was increased because of the improvement of sulfation by the discharge at higher current. The batteries with/without activator were tested to confirm the effect of activators under the similar charge-discharge conditions as that in driving on road.

Keywords

electric wheel chair, lead-acid battery, used batteries, activator

1. INTRODUCTION

Most of the electric wheel chairs are powered by lead-acid batteries. It is required that the batteries as power sources are high power and long life. The lead-acid batteries are well suitable for the power requirement, and being used for every wheel chair. In practice, however, the battery life is insufficient to drive.

On the other hand, some of used and deteriorated batteries are disposed as land fill especially in the developing countries. Our research group has reported that deteriorated batteries may be regenerated by high rate discharge and activators [Tachibana et al., 2003; Sugawara et al., 2003; Nakagawa et al., 2006].

In the present paper the authors describe the results of driving test on road using a electric wheel chair. The charge-discharge test in laboratory is also discussed to confirm the effect of activator on battery performance.

2. EXPERIMENTAL

2.1 Wheel chair and batteries used

A MyShattle (brand name of Sanyo Co.,Ltd.) as electric wheel chair with the mortar of 24V was used with three steps of gearbox (high, medium and low). The two batteries (GS EB 35; GS-Yuasa Co.,Ltd., 12V, 35Ah) were used, and charged by a SL-3 charger (Daiji Kogyo Co.,Ltd) for 20h before each driving test. The initial current was 1-2A, and the current decreased to 0.2-0.3A after 20h.

2.2 Battery performance tests

(1) Outdoor-driving test
The driving tests on road were carried out under the following conditions. The same person drove the wheel chair by high speed on the same road in every test. The atmospheric temperature and the wind velocity were recorded with the values of voltage and current during driving.

(2) Discharge test at 90A
After driving test for several times the batteries charged by SL-3 charger were discharged at constant resistance of 0.12Ω (referred to as the discharge at 90A) to 9V. The batteries were recharged to be subjected to driving test once again.

(3) Charge-discharge test by ITE's activator
After driving test, the charge-discharge cycle tests were carried out under the similar discharge current to that in the driving test. In this experiment, one of the ITE's activator (PNH2) was added to one of two batteries. The conditions were as follows. The batteries were charged by SL-3 charger for 20h, and then discharged at 5A until the each battery voltage went to 9V. This charge-discharge was repeated.

3. RESULTS AND DISCUSSION

Figure 1 shows a typical result of the values of voltage and current during the driving on road. The continuous and stable driving was maintained at about 5A, and the voltage is gradually decreased. When the voltage dropped to 18V, the rotation of the driving motor stopped. The average driving time and electricity discharged from the battery were 200-300min and 20-25Ah, respectively.

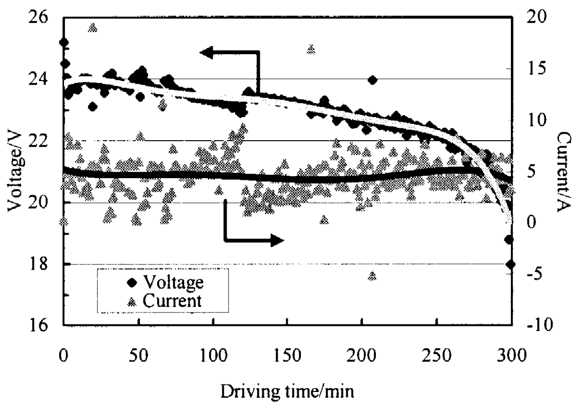

Fig. 1 The change in voltage and current during the continuous driving on road.

Figure 2 shows the driving time and electricity discharged during driving for the run numbers. The driving tests were performed once a day. The runs 1-10 show the results after charging the used battery every driving test. Since the driving time depended on the wind velocity, the battery performance was compared with the electricity discharged. These results indicate that the battery deterioration proceeds slowly to decrease the electricity discharged by the repeat of run. The results in the runs 10 and 11 will be explained in the later section.

Since one of the factors in the deterioration would be presumed to be due to the so-called sulfation, the following test was carried out. The two batteries were charged by SL-3 charger for 20h, and then discharged to 9V at about 90A. This charge and discharge process was repeated two times. The discharged batteries were recharged by SL-3 charger for 20h and then subjected to driving test on road. The results are shown in the run 11and 12 of Figure 2.

The electricity discharged and driving time increased after the treatment of the discharge at 90A. This suggests that the deterioration is due to the sulfation formed during the repeats of driving. The sulfation is removed by high rate discharge at 90A [Tachibana et al., 2003], and the battery performance is recovered to extend the driving time of the wheel chair.

Figure 3 shows the discharge curve of two batteries at

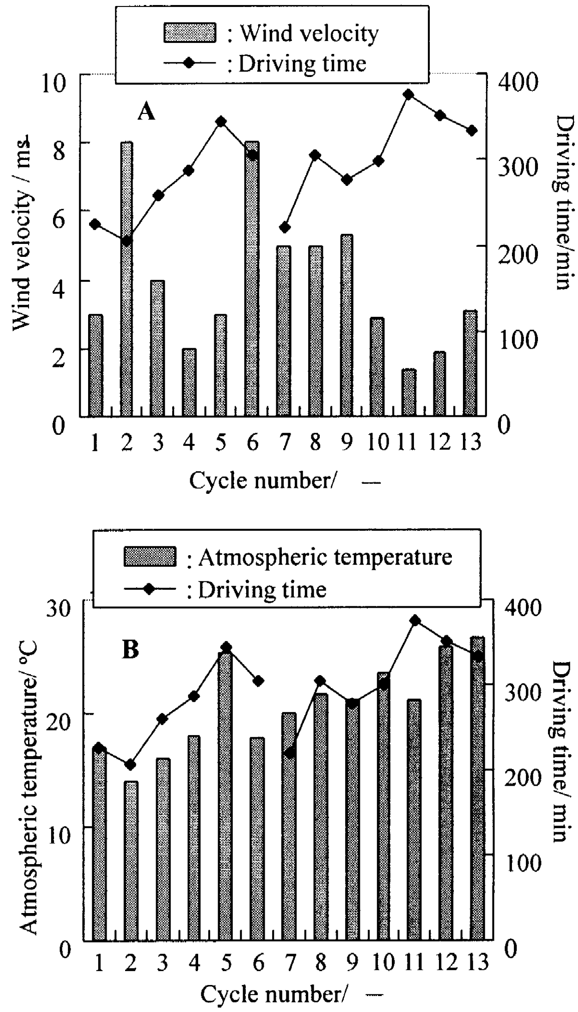

Fig. 2 Effects of wind velocity and atmospheric temperature on electricity used during the continuous driving.

about 90A. There was no significant difference in the discharge capacity between two batteries. The discharge capacity was about 15-20Ah. We have reported that deteriorated lead-acid batteries were regenerated by the addition of organic polymer as activators. The effect of activator was tested for the batteries used in this experi-

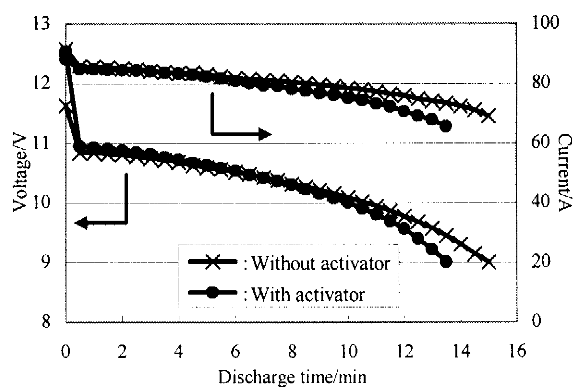

Fig. 3 Change in voltage and current in discharge test at 90A

ment. Since the two batteries showed similar performance each other in the charge-discharge, the ITE's activator (PNH_2: polyvinyl alcohol based activator) was added to one of two batteries to confirm the effect of activator on charge-discharge performance. Another one without activator was subjected to the charge-discharge test in a similar manner as above. The charge and discharge currents were selected as close as possible to the ones in SL-3 charger (1.5A) and driving test (5A), respectively.

There was no significant difference between the discharge capacity of two batteries with and without the activator.

Next, the discharge test at 90A was carried out as shown in Figure 4. The discharge capacity gradually increased with the cycle numbers, and approaches constant. The capacity of the battery with activator is smaller than that without activator. This shows that the activator molecules are adsorbed on the electrode surface to result in the voltage drop in the discharge process. This increase in the discharge capacity with cycle numbers shows the batteries used for the driving and discharge test at 5A deteriorate by the sulfation. Consequently, during the repeat of the discharge test at 90A, the sulfation may be gradually recovered by such a high rate discharge.

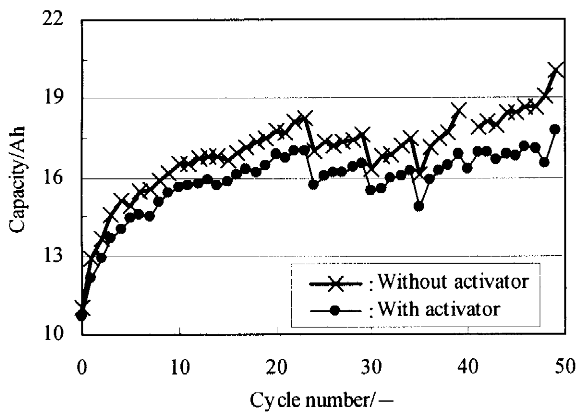

Fig. 4 Discharge test of the batteries with and without activator at 90A.

Figure 5 shows the effect of activator on cycle performance in the discharge at 5A after the charge at 1.5A. There was no significant difference between two batteries in the initial cycles, because of the cycle test for the batteries without the sulfation after the high rate discharge at 90A. With the progress of the cycle tests, the battery performance is obviously improved by the addition of activator. As reported by the authors [Tachibana et al. and Sugawara et al., 2003], the main reason of battery deterioration is attributable to the sulfation, which may be depressed by activator. Since the discharge was performed under the practical driving conditions, this

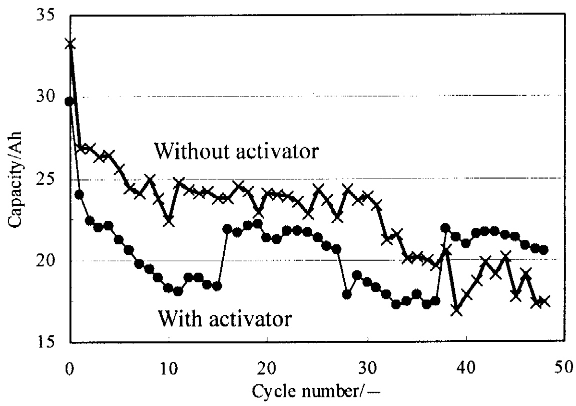

Fig. 5 Cycle performance of charge-discharge with and without activator.

result suggests that the activator may enable the deteriorated batteries to be subjected to reuse without waste disposal treatment.

4. CONCLUSION

The driving and charge-discharge tests were carried out by the used lead-acid batteries for electric wheel chair. The obtained results are as follows.

(1) When the used batteries were repeatedly subjected to the driving test on road after the full charge, the electricity delivered from the battery during driving was gradually decreased.

(2) This battery was discharged at 90A after the full charge, the driving time was increased because of the resolution of sulfation.

(3) The addition of activator was effective for the extension of battery life.

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