Regeneration of Deteriorated Chinese E-bike Batteries with ITE Super-K Activator

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Abstract

Chinese E-bike batteries are 36 volt (10 or 12Ah) connecting three 10 or 12Ah batteries in series. The battery life is 6-12 months when used its 70 to 80% capacity each cycle of the each use is only 30% of the capacity, the cycle life will be over 1,000 cycles. In this paper, outline of the bicycle and the batteries are described. Also, the authors attempted to regenerate deteriorated or abandoned batteries. The regeneration treatment produced useful batteries with ITE's Super-K Activator. The regeneration rate was 50 to 70% of the total batteries. The capacity maintenance test for the new 10Ah E-bike batteries with or without ITE Activator. We confirmed that ITE Activator is useful for extending the battery life and reduce the waste battery, contributing greatly to our environment.

Keywords

battery life, activator, lead-acid battery, discharge voltage, cycle life, battery charger, battery capacity

1. INTRODUCTION

In Shanghai, China, 6,000,000 electric bicycles are now in practical use. A representative electric bicycle is shown in Figure 1. An electric bicycle is commonly called an "E-bike". The retail price is 1,500 yuan, which is equal to 20,000 Japanese yen. However, the price per bike is reduced to around 10,000 yen when purchased in a mass of between 20-50 E-bikes. The main characteristics of E-bike are shown in Table 1. In this report, the period of availability, the price of battery, the causes of deterioration and the reproduction process are tested.

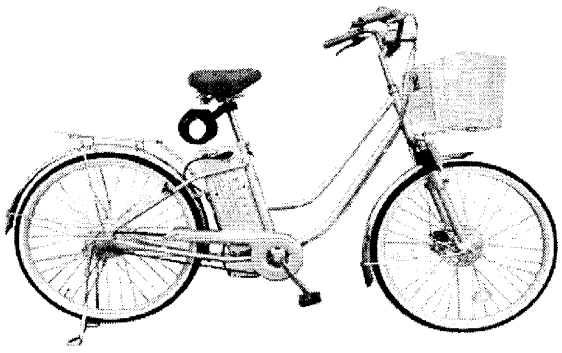

Fig. 1 E-bike in China

Table 1 Specifics of E-bike

1. Size	1160×620×1070mm
2. Running distance	Over 40km (one charge for about 30km running distance)
3. Weight	40kg
4. Battery	Lead-acid battery (36V, 10-12Ah)
5. Charging time	4-8 hours

2. LIFE OF LEAD-ACID BATTERY, SECURITY PERIOD AND BATTERY CHARGES

In order to start the engine, it is either necessary to use a high current (100-300A) lead storage battery for several seconds, or to use a deep charge and discharge (as for golf cart, forklift, and motor car). The battery life of the latter varies greatly with the electric discharge profundity of the battery. The discharge depth and relations of life are shown in Figure 2.

In every case of a 100% discharge, the battery life is between 200-250 cycles (the capacity is reduced to 60% compared to a new battery). However, in the case of a 50% discharge and repeated recharging, the battery life is between 400-500 cycles. In the case of a 30% discharge, the battery life is lengthened to 1,200 cycles. When the consumption time limit of an E-bike battery is decided, the guaranteed life for daily use depending on distance can be determined. According to Figure 2, for

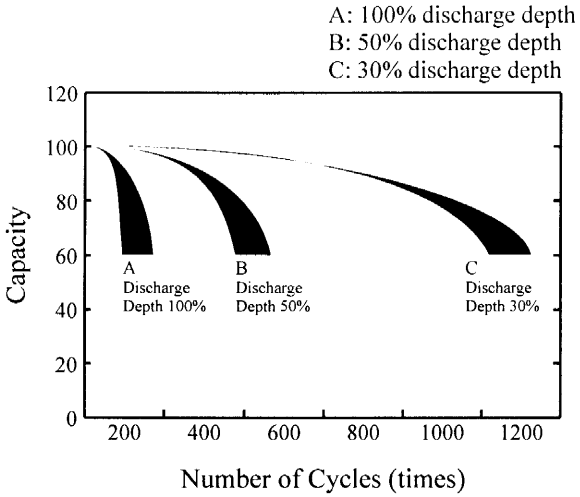

Fig. 2 Life of lead-acid battery and depth of discharge

2-passengers and complete discharge, 200 cycles can be guaranteed for daily to use.

The battery life is about 3 years if used for a distance less than 10km every day. Therefore, the battery guarantee is measured by mileage because it is a rational decision. Usually, a battery is 36V, 10-12Ah, and it is sold for 350 yuan (5,000 yen) as new. For a Japanese salary level, 5,000 yen is not high to change batteries once a year. However, it is considerably high for a Chinese person with an average salary of 15,000-20,000 yen. In Japan, a four-wheeled motor car of COMS uses a battery of 48V 40Ah at 200,000 yen. It becomes a considerable burden to change the battery once a year. At such a high cost, even if the motor car is environmentally-friendly, it is difficult to use. Extending the battery life by double or triple and reducing the cost of the battery a necessary to increase the use of electric vehicles which is an important contribution to the environment.

3. ELECTRIC CURRENT AND CHARGE TIME

Table 2 shows the electric current value which is necessary for a 36V battery. The charge was overnight and performed with an attached battery charger. Table 3 shows the increase in voltage for 22 hours charging of 3 separate batteries of 12V each and 1 battery was charged by an SL-3 battery charger (2 amperes). When the charge begins using the SL-3 battery charger for lead storage

Table 2 Electric current and charge time

The case of 36Volt, 10Ah	
(1) Start time (one rider)	18-20A
(2) 30-40km at consistent speed	5-6A
(3) 50-60km at consistent speed	7-10A

Table 3 Voltage at charge

Charge	Voltage of each battery				
time	VA(V)	VB(V)	VC(V)		
0V	11.36	11.37	11.45	Current (A)	Total (V)
0h	11.69	11.73	11.80	1.80	35.4
1h	12.25	12.27	12.33	1.86	36.5
2h	12.60	12.65	12.69	1.86	37.9
3h	13.01	12.85	12.88	1.89	38.52
4h	13.39	13.06	13.21	1.94	39.1
6h	14.72	14.49	14.93	1.87	43.8
7h	14.89	14.62	15.17	1.29	44.4
22h	13.86	13.86	14.18	0.02	41.8

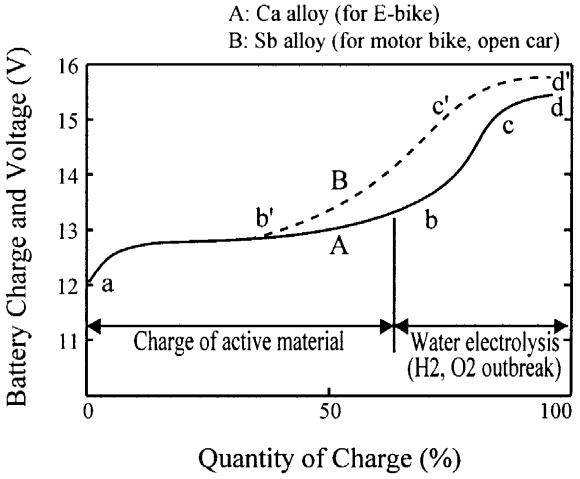

Fig. 3 Charge curve chart

Table 4 Discharge voltage (measurement of 3 batteries)

5A discharge	VA(A)	VB(V)	VC(V)
0 min	13.86	13.86	14.18
90 min	12.06	12.05	12.05
142 min	10.85	10.85	10.81
144 min	10.60	10.59	10.47

batteries at maximum of 2 amperes 12V, the battery voltage increases and the electric current value fell to 1.8-0.02A. Figure 3 shows the change of the battery voltage. It shows the decrease in voltage of 3 batteries when discharged by the electric current of 5 amperes. A charge of less than 11V required from 142-144 minutes and so it can be understood that a complete discharge of electricity requires about 140 minutes for these 12V batteries. Table 4 shows the voltage at the time of a discharge during 0-144 minutes.

Table 5 shows a voltage change at the time of charge.

Table 5 Voltage at charge

Charge	Voltage of each battery				
time	VA(V)	VB(V)	VC(V)		
0V	11.36	11.37	11.45	Current (A)	Total (V)
0h	12.01	12.05	12.12	1.85	35.4
1h	12.48	12.50	12.55	1.84	37.1
2h	12.78	12.82	12.93	1.85	37.7
3h	13.09	13.73	13.18	1.86	39.0
4h	13.54	13.56	13.60	1.84	40.0
7h	15.04	14.85	15.15	1.08	44.6
8h	13.94	13.93	13.99	0.05	42.1
9h	13.95	13.83	14.10	0.04	41.9

The charge is completed in about 7 hours and achieves about 44V by a 3 serial battery. This battery requires 144 minutes to achieve 10.5V per each 5 amperes electric discharge.

4. DIFFERENCE OF BATTERY CAPACITY WITH BATTERY CHARGER

Table 6 shows the results of a comparison of three kinds of battery chargers. Battery chargers (1) and (2) are for 36V, and (3) is for 12V. Battery charger (3) was used because the final voltage was 15.5V and when compared with a 36V charger it achieved triple, 15.5 x 3, which equals 46V and is a considerably high voltage. Almost all batteries for E-bike require 15V or less. Each battery is charged to 14.8V, therefore, in order to charge to 36V (3 serials), the final voltage of many chargers is set to 44.4V. SL-3 of (3) has the characteristic of being able to charge to a high voltage. The charger of (1) and (2) for E-bike requires an average discharge time of 98-108 minutes. However, the battery which is charged by SL-3 of (3) requires 117-118 minutes and the discharge volume is larger.

As for the charger of the seal type battery which uses are Ca alloy grid, the current and voltage is usually constant. Figure 4 shows the charge method.

1. t0-t1 is charged by current (1.5-2.0 amperes)
2. t1-t2 is charged by voltage (14.8V or another voltage setting)
3. t2-t3 is charged by constant low current (0.05-0.01A)

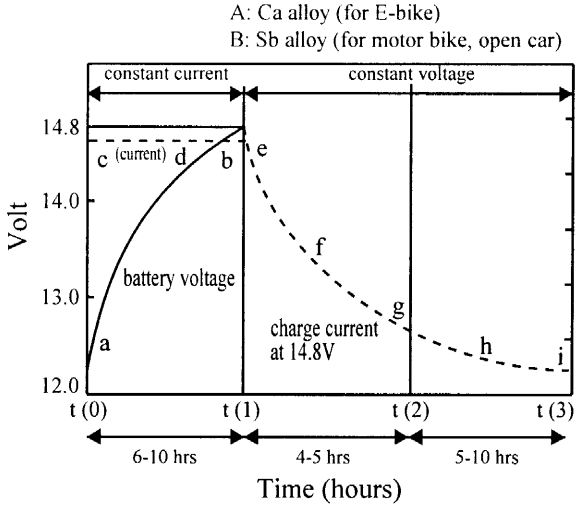

Fig. 4 Change of electric current charge

4.1 Cycle test

At every stop in t1 and discharge by cycle test, the quantity of electric discharge tends to become considerably small and to gradually decrease. At the stop of charge in t2 and repeated discharge, a considerably large Ah appears. It can be said that the charge efficiency is around 90%. In many cases, the quantity of electric discharge does not increase even if the charge is by a low electric current to t3.

5. EFFECT OF ACTIVATOR, INFLUENCE ON SULFURIC ACID DENSITY

An E-bike battery (a seal battery of Ca alloy) from Zhanjiang Battery Co. of 12V/10Ah, dissolved by an activator (0g/l, 1.0g/l, 3.0g/l) in sulfuric acid (specific gravity 1.32) was tested. The results are shown in Table 7.

5.1 Test up to 300 cycles

Figure 5 shows a test to 350 cycles of a battery for E-bike. When more than 100 cycles were achieved, the effect of the activator was given clearly. It can be understood that low sulfuric acid density increases both capacity and cycle life.

Table 6 Comparison of 3 kinds of battery chargers

charge type	charge current (A)		charge voltage	Battery discharge average time (min)		
	initial	final	final (max)	group 1	group 2	group 3
(1) Sino-America	1.90	0.01	41.5(44)	98	105	106
(2) Guangzhou	1.80	0.02	42.0(44)	100	101	105
(3) SL-3	1.85	0.05	15.5(16)	117	118	118

Table 7 Effectiveness of activator

No.	Activator (A) 0.0g/l	Activator (B) 1.5g/l	Activator (C) 3.0g/l
1	104	103	105
2	108	105	108
3	107	106	109
4	108	107	109
5	107	108	110
6	108	109	110
7	107	109	111
8	108	110	112
9	106	111	112
10	107	110	111
11	108	112	113
12	109	112	114
13	110	112	115
14	109	111	114
15	108	112	114
16	109	113	115

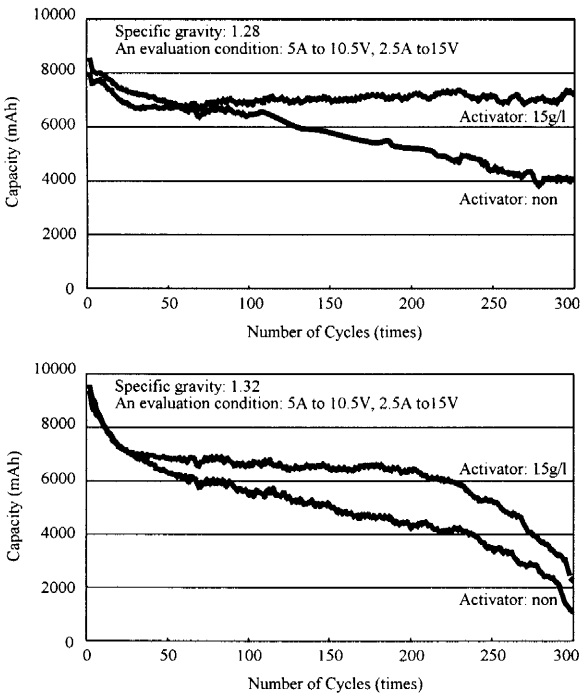

Fig. 5 Cycle test of sealed battery for E-bike

6. REPRODUCTION OF DETERIATED BATTERY

Concerning the disposal of six batteries for E-bike, the time of charging was measured for charge and discharge. The results are shown in Table 8. (A) shows the battery voltage, the change of the voltage after 7.5 hours when charged by 1A, and the time of discharge for 5A. The discharge time of some batteries was 55, 76, and 90 minutes which is less than half of a new battery, however, almost all batteries were greater than 10-120 minutes. When the charge is enough, it is possible to use the battery. The charge (A) was the maximum charging voltage of 16V with SL-3. Therefore, it can be thought that the disposed battery recovered greatly.

6.1 Reproduction processing

After each cell of 10cc including 5% activator was left unattended for 2 days, the activator invaded the inside of the electrode. After 2 days of overnight charging by SL-3, the discharge was consecutively 5A. The results of this charge/discharge No. 1-8 is shown in Table 9. There are many cases where the electric discharge time increases from 149.9 to 154.1, 141.4 to 144.4, 95.12 to 145.6 minutes. However, the 8th time of B is restored greatly when compared with a value of A before reproduction. Table 9 shows the recovery. About 60% are restored to mint condition. However, areas which did not recover and areas which further deteriorated were observed.

7. CONCLUSION

(1) A deteriorated battery for E-bike has a recovery rate of around 50%.
(2) Use of an activator on a new battery prolongs the battery life greatly.
(3) Depending on the charge method, deterioration of the battery was reduced and the life lengthened.
(4) A cause of battery deterioration was a decrease of water, therefore, an addition of water extends the life beyond 2 years.
(5) As for the sulfuric acid density, specific gravity 1.28, it is possible to confirm that there was little deterioration and a long life with a specific gravity of 1.32 is currently used widely. A similar thing can be said about a large-sized battery. Battery life can be lengthened to 5-10 years and a reduction in battery disposal can be achieved through the use of a lead-acid battery system and making a considerable contribution to the environment and humanity.

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Table 9 Recovery processing and result of disposed battery

	Brand	Brand (1)			Brand (2)			(3)	(4)	(5)	(6)	Data
	Number	A1	B1	C1	A2	B2	C2	A3	B3	C3	D3	
(A)	0V(V)	12.92	12.90	12.91	12.13	11.04	12.04	12.65	12.96	11.72	12.85	2005-6-23
	1A charge				12.54	12.20	12.47	16.43	16.61	12.97		
	1.0h				12.62	12.28	12.55	17.19	17.20	13.14	13.72	
	1.5h				12.69	12.34	12.62	14.48	15.94	13.78	14.40	
	2.0h				12.80	12.44	12.73	14.40	14.76	14.95	14.45	
	2.5h				13.08	12.57	12.85	14.97	14.70	15.83	14.47	
	3.0h				13.18	12.67	12.96	14.34	14.59	15.85	14.48	
	3.5h				13.29	12.79	13.07	14.38	14.64	15.90	14.61	
	4.5h				13.39	12.87	13.15	14.44	14.51	15.95	14.78	
	5.0h				13.44	12.93	13.20	14.50	14.54	15.96	14.97	
	5.5h				13.54	13.00	13.30	14.60	14.90	15.95	15.15	
	6.0h				13.71	13.10	13.43	14.84	14.76	15.92	15.85	
	6.5h				14.05	13.17	13.63	14.72	14.78	15.95	15.95	
	7.0h				15.81	13.32	15.35	14.75	14.77			
	7.5h				16.11	15.10	15.77	14.74	14.75			
	0V(V)					15.54	16.11	14.76	14.78			
	5A DCH time	132.1	76.13	101.2	128.2	120.0	145.3	55.0	0.0	90.5	157.0	2005-6-24
	filling 10cc/cell water with 5% activator after 2 days then charge											
(B)	5A DCH time				121.1	124.1	127.3	95.1	3.0	109.7	151.6	2005-6-28
	(1)	149.9	141.8	156.8	120.0	112.5	125.6	Leakage		117.5	151.6	2005-6-29
	(2)				115.9	108.4	124.6	148.9		117.8	143.6	2005-6-30
	(3)	149.5	136.5	131.1				135.3		99.3	149.3	2005-7-1
	(4)				117.3	116.3	125.3				150.8	2005-7-2
	(5)	156.0	141.4	154.8	117.5	112.7	127.1	123.6		67.1	148.6	2005-7-4
	(6)	153.6	143.3	150.7				125.3		75.0	148.8	2005-7-5
	(7)	153.3	143.3	152.1	115.2	112.2	125.3	142.6		60.3		2005-7-6
	(8)	154.1	144.4	155.1	93.0		123.4	145.6			151.5	2005-7-7

DCH = Discharge