Present and future of lead/acid battery manufacture in the Commonwealth of Independent States (formerly the USSR)

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Abstract

The production of lead/acid batteries in the former USSR, and now in the CIS, is concentrated in eight manufacturing plants (seven in Russia, one in Kazakhstan). The batteries that are manufactured include: automotive, aircraft, stationary, traction, diesel locomotive, railway car, boat, motorcycle, low-capacity sealed, and submersible designs. These activities involve the annual processing of 230 000 tonnes of lead. A brief review is given of the technology used in each of the battery designs.

Automotive batteries

The basic electrical characteristics, dimensions and weight of the various types of automotive batteries, manufactured in the CIS, are given in Table 1. These batteries are produced mainly in the dry-charged state and possess the following discharge characteristic during the first cycle after filling the electrolyte and without boost charge: discharge current $3C_{20}$ during 3 min to a final voltage of 1.0 V per cell. The self-discharge rate does not exceed 10% after a stand period of 14 days. The batteries withstand overdischarge with a direct current of $0.1C_{20}$ during 4 cycles; each cycle is uninterrupted for 100 h.

The minimum life of maintenance-free automotive batteries is 3 years, or not more than 100 000 km of vehicle travel. Polyethylene, polypropylene, and ethylene and propylene copolymer monoblocks are used.

Stationary batteries

Stationary batteries are usually of the 'surface-box' type. The battery capacity varies from 36 to 5328 A h. The batteries are all produced on the basis of three sizes of plates. The electrical characteristics of stationary batteries are listed in Table 2. The average daily self-discharge after 30, 15 and 3 days of storage is 1.0, 1.4 and 1.8%, respectively.

Aircraft batteries

Along with nickel/cadmium and silver/zinc batteries, lead/acid aircraft batteries are also manufactured in Russia. They are used for independent aircraft-engine starting,

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TABLE 1

Specifications of automotive batteries

Battery type	Capacity, (A h)	Voltage, (V)	Dimensions (mm)			Weight (kg)	
			length	width	height	Without electrolyte	With electrolyte
(a) Batteries with element lids ('over-the-top' connections)							
6ST-45EM	45	12	238	178	221	14.8	18.8
6ST-50EM	50	12	258	174	234	15.9	20.8
6ST-55EM	55	12	260	172	223	17.4	21.0
6ST-60EM	60	12	280	180	237	19.0	24.5
6ST-75EM	75	12	356	176	236	23.3	30.0
6ST-75TM	75	12	356	176	233	21.7	28.1
6ST-90EM	90	12	419	185	236	27.6	35.0
6ST-105EM	105	12	473	185	236	30.9	39.1
6ST-132EM	132	12	510	209	241	39.2	49.2
6ST-182EM	182	12	520	280	240	54.9	69.6
6ST-190TN	190	12	582	237	236	55.4	69.9
3ST-150EM	150	6	324	175	236	21.1	27.2
3ST-150TM	150	6	324	175	234	19.8	26.0
3ST-155EM	155	6	324	175	236	22.7	29.2
3ST-155TM	155	6	324	175	234	21.4	27.9
3ST-215EM	215	6	426	194	240	31.8	40.8
3ST-225EM	225	6	426	194	240	33.6	41.3
(b) Single-lid batteries ('through-the-wall' connections)							
6ST-44A	44	12	206	175	210	9.1	13.5
6ST-50A	50	12	242	168.5	224	12.2	16.7
6ST-55A	55	12	242	175	210	11.2	16.0
6ST-65A	65	12	304	162	213	16.0	21.3
6ST-66A	66	12	301	175	210	13.2	19.0
6ST-75A	75	12	340	168	232	19.4	25.2
6ST-77A	77	12	339.1	175	210	15.1	22.0
6ST-88A	88	12	376.9	175	210	17.0	25.0
6ST-110A	110	12	330	239	230	22.8	32.0
6ST-110AN	110	12	364	239	240	25.2	34.4
6ST-132A	132	12	511	182	241	35.2	43.0
6ST-190A	190	12	524	239	243	44.0	59.2
3ST-215A	215	6	425	170	240	23.6	32.6
(c) Maintenance-free batteries							
6ST-55A3	55	12					

cockpit and instrument lighting, position lights, etc. Aircraft batteries are operable at temperatures that range from +40 to −5 °C. The basic electrical parameters of aircraft batteries are given in Table 3. The cycle life varies from 65 to 100 over a general calendar life of 2 to 2.5 years. The batteries can be stored for 5 to 7.5 years.

Diesel-locomotive batteries

Diesel-locomotive batteries are used to start locomotive engines, to power the control circuits, and for lighting when the engine is idle. The battery capacity ranges

TABLE 2

Electrical characteristics of S-type stationary batteries

Battery type	Discharge mode						Charge rate (A)
	10 h		3 h		1 h		
	capacity (A h)	current (A)	capacity (A h)	current (A)	capacity (A h)	current (A)	
S-1	36	3.6	27	9	18.5	18.5	9
S-2	72	7.2	54	18	37.0	37.0	18
S-3	108	10.8	81	27	55.5	55.5	27
S-4	144	14.4	108	36	74.0	74.0	36
S-5	180	18.0	135	45	92.5	92.5	45
S-6	216	21.6	162	54	111.0	111.0	54
S-8	288	28.8	216	72	148.0	148.0	72
S-10	360	36.0	270	90	185.0	185.0	90
S-12	432	43.2	324	108	222.0	222.0	108
S-16	576	57.6	432	144	296.0	296.0	144
S-20	720	72.0	540	180	370.0	370.0	180
S-28	1008	100.8	756	252	518.0	518.0	252
S-36	1246	129.6	972	324	666.0	666.0	324
S-44	1584	158.4	1188	396	814.0	814.0	396
S-52	1872	187.2	1404	468	962.0	962.0	468
S-60	2160	216.0	1620	540	1110	1110	540
S-64	2304	230.4	1728	576	1184	1184	576
S-68	2448	244.8	1836	612	1258	1258	612
S-72	2592	259.2	1944	648	1332	1332	648
S-80	2880	288.0	2160	720	1480	1480	720
S-88	3168	316.8	2376	792	1628	1628	792
S-92	3312	331.2	2484	825	1702	1702	825
S-100	3600	360.0	2700	900	1850	1850	900
S-108	3888	388.8	2816	972	1998	1998	972
S-116	4176	417.6	3132	1044	2145	2145	1044
S-124	4464	446.4	3348	1116	2294	2294	1116
S-132	4752	475.2	3564	1188	2442	2442	1188
S-140	5040	504.0	3784	1260	2590	2590	1260
S-148	5328	532.8	3996	1332	2738	2738	1332

from 350 to 450 A h. The battery monoblock is made from either ebonite or plastic. The electrical characteristics of the batteries are presented in Table 4. After 15 days storage, the self-discharge does not exceed 1% per day. The life is 3 to 4 years, or 170 to 300 cycles.

Railway-car batteries

The capacity of railway-car batteries is 440 A h. They are used for supplying the passengers with electric power.

TABLE 3

Electrical characteristics of aircraft batteries

Battery	Discharge rate					Maximum discharge current (A)
	10 h		5 min			
	Capacity (A h)	Current (A)	Current (A)	Capacity (A h)	Final voltage (V)	
12A-5	5	0.5	15	1.25	16.8	30
12A-10	10	1.0	30	2.5	16.8	60
12A-30	26	3.0	107	8.92	14.4	210
12SAM-28	28	5.6[a]				
12SAM-55	55	11.0[b]				
12ASA-150	125	25[a]				

[a]5-h discharge rate.

TABLE 4

Electrical characteristics of diesel-locomotive batteries

Battery type	Discharge rate							
	10 h		5 h		5 min		Interrupted	
	Current (A)	Capacity (A h)	Current (A)	Capacity (A h)	Current (A)	Capacity (A h)	Current (A)	Capacity (A h)
32TN-450-U2	45	450	68	340	900	75	1700	1015
48TN-350-U2	17.5	350	54	280	800	66.6	1350	1015
48TN-410-U2	41[a]	410	60	300	900	75	1500	1015

[a]20-h discharge rate.

Traction batteries

The production of traction batteries is limited in Russia. This is because nickel/iron batteries are used mainly for the power supply of electric carts, loaders and other floor vehicles. Lead/acid batteries with capacities of 80 and 400 A h are manufactured with pasted plates.

Motorcycle batteries

Motorcycle batteries are used for sustaining the ignition systems of motorcycles and scooters. The batteries are manufactured with a nominal voltage of 6 or 12 V. The battery capacity is 8 to 18 A h. A discharge current of $3C_{20}$ can be maintained for 3 min down to the final voltage of 1.0 V per cell. The self-discharge after an idle period of 14 h does not exceed 10%. The batteries can endure overcharge with a direct current of $0.1C_{20}$ during four cycles; each cycle is uninterrupted for 100 h. The minimum battery life, if operated, is 18 months provided the vehicle service does not exceed 20 000 km.

Submersible batteries

Basic achievements in the manufacture of submarine lead/acid batteries have been reported previously [1].

In Russia, lead/acid batteries are widely used in submersibles that are used for study of the oceans of the world. The battery capacity is 200, 680 and 2650 A h. The hydrostatic pressure is compensated either by elastic compensators or by electric insulating fluid that separates the electrolyte from the ambient water.

Sealed Batteries

The manufacture of low-capacity (up to 5 A h) sealed batteries has commenced in recent years.

Battery development

The development of new types of lead/acid batteries is conducted in two scientific research institutes: (i) the Institute of Starter Batteries in Podolsk (Moscow region), and (ii) All Union Scientific Accumulator Institute in St Petersburg.

In these Institutes, as well as in a number of other organizations, research is performed in the theory, technology, design and operation of lead/acid storage batteries. The most recent results are as follows:

- Effective methods has been developed for protecting copper from attack by sulfuric acid. This has allowed the use of copper grids in the negative electrodes that, in turn, increase the specific energy of various types of batteries
- Research into the corrosion of lead and its alloys has made it possible to use low-antimony and antimony-free alloys that are characterized by increased corrosion resistance. These alloys include: Pb–Sb–Ag, Pb–Sb–As–Ag, Pb–Sb–As, Pb–Sb–Se–As, Pb–Ca, and Pb–Ca–Sn–Al
- Studies of the electrochemistry of surface-active materials has led to the discovery of a number of effective expanders and self-discharge inhibitors. These improve the electric characteristics of batteries both at increased starter discharges and at low temperatures. The additives also reduce the self-discharge and gassing rates by a factor of 2 to 3. New foam generators have also been developed for the plate-formation electrolyte, as well as additives that can restore completely sulfated batteries
- Effective binding agents for the positive active material have been developed and used. These agents comprise a combination of polymeric fibres and suspensions that create a space frame and prevent shedding of the active material
- New thermodiffusion processes have been devised for leading and aluminium tinning. These permit aluminium and its alloys to be used in the manufacture of current-conducting tabs for batteries

Research in the field of plastics metallization has given rise to the development of a technology for the manufacture of lead/acid batteries. Most important is the technology for the manufacture of dry-charged batteries. In these batteries, production of the negative electrodes is based upon the use of lead oxidation inhibitors during the air drying of the formed electrodes. The process can now be conveyorized. Tank and container formation of automobile and other batteries is also being undertaken. In addition, there is now technology for the production of dry-discharged stationary batteries, as well as a combined procedure for the manufacture of dry batteries with nonformed negatives and with formed, but partially discharged, positive plates.

Along with the use of locally-made machinery, battery plants are now purchasing equipment that is manufactured by the leading foreign companies. For a long time, we have been cooperating with the Chloride Company. Casting and milling equipment supplied by this Company has been used for many years and has given trouble-free service. We also cooperate with the Jungfer Company (Austria) and with a number of US and German companies. The Scientific Research Institute is successfully conducting joint research projects with scientific centres in Eastern Europe, these include SLEHIT (Bulgaria), IXIX (Yugoslavia).

The future of the industry

As for the future of the lead/acid battery industry, first, it is necessary to increase the production rate, especially the share of maintenance-free batteries. It is also essential to expand the range of the batteries available. It is planned to eliminate the deficit in battery production by the following strategy. The primary step is to re-equip present battery plants. It is also intended to create a chain of small production facilities (e.g., 50 to 100 thousand batteries per annum) that would use battery scrap. A decision has also been taken to commence battery production at plants that produce lead metal. The shortfall in battery manufacture will also be ameliorated by the establishment of centres for the maintenance, repair and restoration of batteries. The raw materials resource will be expanded by the intensive use of secondary lead. For this purpose, an appropriate technology has been developed as well as specialist equipment for the electrothermal recycling of production waste and battery scrap.

New technologies are being developed for the introduction of continuous grid-casting and plate manufacture. Close to completion are studies aimed at the production of leady oxide on the basis of a totally new method that combines the Barton-pot process and grinding treatment.

Research will also be continued in the fields of plastics metallization, titanium protection against sulfuric acid, and the search for new additives that will include electrically-conducting polymers.

The above measures will make it possible to increase the volume of battery production, to improve the electrical characteristics, to prolong battery life, and to reduce self-discharge. In order to realize this programme, we also hope to collaborate with foreign partners in both scientific and commercial fields.