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Status of the lead/acid battery industry in India

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Abstract

The lead/acid battery industry in India, including the present technology status, is described. Outlined are the technologies adopted by large-scale manufacturers and small-scale makers. Prices of Indian batteries, production quantity, names of major manufacturers and their yearly turnover, estimated future demand, and the available range of batteries are discussed. The quantity of lead and recycled antimonial alloy used, pollution control status, and the nature of supporting industries are given. Details of the Indian Standards pertaining to the lead/acid industry are also included. The various processes starting from lead recycling to grid casting, paste preparation and pasting, curing, formation, dry charging and assembly adopted by both well-established makers and small-scalers are outlined.

Introduction

The development of the lead/acid battery industry in India until 1985 has been reported previously [1]. A further update of certain features was given by Raychaudhuri [2] in 1987. The paper presented here describes the current situation, particularly the technology status.

Background

In 1988, India accounted for 1.7% of the estimated 6-billion-dollar* world production of automotive batteries. By contrast, in the industrial battery sector, India's share was 3.8%, i.e., a 69-million-dollar production of the 1.80-billion-dollar world market.

The constraints under which the battery industry operates within the Indian Government's industrial policy, have undergone noticeable changes. Nowadays, there is more freedom to choose collaborators, more scope in the nature and extent of such collaboration, and more planning to absorb the latest manufacturing technologies. Nevertheless, the regulated market still continues, together with harsh duties on the import of raw materials and stiff taxation all along the line. As a result, the cost of a battery to an Indian user is almost twice that experienced by neighbours in the East or in the Gulf. For exports, therefore, the Indian Government grants heavy subsidies by way of duty-drawback and lightening the tax burden down the line.

Notwithstanding the above, the lead/acid battery industry in India has dug in and is well entrenched at a turnover of US$ 265 million per annum. This market is estimated to increase per annum at the rate of 5% in the automotive sector, 2 to 3% in the motive power and railway sectors, and 12 to 15% in the rapidly growing power sector.

*Note: the value of the US$ is taken as Rs 20.00 at June 1991.

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The industry mix

There are two distinct groups of battery makers in India, namely, the well-established with a turnover of US$ 200 million during 1990 and the medium- and small-sector units producing batteries worth US$ 64 million. The technologies adopted by these two groups, however, are as diverse in nature as they are distinct in culture. The established manufacturers have adopted the latest technological practices from western countries or Japan for the production of batteries (in polypropylene boxes) for two-wheeler vehicles and automobiles. For other applications, mostly using batteries with capacities >70 A h, the latest processes are used up to the formation stage. Following this, the assembly is carried out with over-the-lid 'proud' connectors or 'sunk-in' types. The medium- and small-scale producers still employ the age-old practices of previous generations. There are emerging, however, some exceptions.

It is estimated that the medium- and small-scale producers command 59% (in numbers) of automotive battery manufacture. By contrast, the cash value of such batteries is only 46% of the total. This is because the sector sells automotive batteries at around 60% of the price charged by the major companies. Thus, small manufacturers can take advantage of tax benefits, excise revenue benefits, and very low subsistence wages for their work force. The quality of their product varies from excellent to mediocre.

Prices

The production in terms of market value of Indian batteries in the large sector, including all taxes, is given in Table 1. The unit price ranges from US$ 0.11 per W h for automotive batteries to US$ 0.30 per W h for stationary batteries of 10 000 A h (Table 2). This irrational increase results from monopolies rather than from material content.

TABLE 1

Estimated battery production in India between 1988 and 1991

Battery type	Turnover in millions of US$		
	1988–1989	1989–1990	1990–1991 (estimate)[a]
Automotive batteries[b] including two-wheeler batteries	102	122.5	160
Industrial batteries	69	76	100
Miscellaneous consumer batteries	5	5.2	5.3
Total	176	204	265

[a]Turnover expected to grow at 5 and 12% per year for automobile and two-wheeler batteries, respectively.

[b]Total number of automotive and two-wheeler batteries manufactured at present is 2.89 and ~5 million, respectively.

TABLE 2

Prices of Indian batteries

Category of battery	Price (per W h) including all duties and taxes (US$)
Automotive battery in hard-rubber box and over-the-lid connector	0.11–0.125
Automotive battery in PP box	0.13–0.14
Motive-power battery	0.14
Stationary battery (up to 300 A h)	0.15
Stationary battery (up to 2000 A h)	0.20
Stationary battery (from 5000 to 10000 A h)	0.25–0.30
Automotive battery made in small-scale sector	0.07–0.08
Automotive battery made in medium-scale sector	0.095–0.10

TABLE 3

Estimated vehicle demand during 1990–1991

Battery type	Demand (millions)
Passenger cars	0.175
Tractors	0.11
'Jeeps'	0.033
Heavy goods vehicles	0.143
Three-wheelers	0.044
Two-wheelers	0.75

Vehicle demand

Table 3 shows the estimated vehicle demand for the period 1990–1991. To this should be added 4.63 million vehicles already in existence (for the first four categories) and 7.70 million two- and three-wheelers.

Battery demand

The estimated demand for batteries in 1994–1995, in numbers of units is given in Table 4. In terms of value, this total demand is calculated to be US$ 335 million at the prevailing factory lead price of US$ 1750 per tonne.

Exports

During 1989–1990, India exported 18% of its lead/acid battery production in value. Of this, 5.5% comprised automotive batteries and 12.5% industrial. The latter were

TABLE 4

Estimated demand of batteries during 1994–1995

Battery type	Demand (millions)
Automobiles	3.5
Two- and three-wheelers	8.0
Motive power	0.65
Railcoach lighting, air-conditioning, electrical multiple units, diesel starting	0.21
Telecommunication	0.42
Power sector and UPS systems	0.20
Railway signalling	0.35
Non-conventional energy sources	0.04

mostly motive-power types. It is interesting to note that the small-scale sector gave a good account of itself by exporting 57% of the industrial batteries and 39% of the total number of units. Part of the latter export of industrial batteries consisted of importing ready-made plates from abroad and re-exporting them in the assembled condition. The Indian Government has been allowing this practice.

Raw material and wage component

Salary and wage expenses (including fringe benefits to employees) are between 7.5 and 12% for the established sector of the battery industry. The small-scale sector gets away with paying only 2 to 2.5% of their sales as wages. The raw material (mostly lead) to turnover ratio lies between 47 and 51% for the established sector. For the small-scale sector, this ratio would be not less than 55%. The high raw-material content accounts partly for the high cost of Indian batteries in the local market, not taking into account the stiff imposts and duties.

Range of batteries manufactured in India

The typical ranges of lead/acid batteries for various applications made in India are listed in Table 5. In addition to these battery types, India also manufactures batteries for submarines, using both traditional technology and the newer CSM grid technology. The latter is, however, only at the trial stage.

There are seven large-scale batteries manufacturers in India (Table 6) and one of these has recently entered into the production of sealed 'maintenance-free' units.

Lead used

In 1989, the Indian storage battery industry used about 60 000 tonnes of primary lead. Of this, 12 000 tonnes were used for adjusting the composition of manufacturers'

TABLE 5

Typical ranges of lead/acid batteries made in India

Battery category	Voltage range (V)	Capacity range (A h)	Battery container
Two-wheelers	6	4	polypropylene (PP)
	12	2.5 and 5	polypropylene
Automobiles	6	100–150	hard rubber
Automobiles	12	45–200	hard rubber
Automobiles	12	32–70	polypropylene
Motive power	18–80	78–720	hard rubber or talc filled PP single cells assembled in steel crates
Stationary	2	20–10000	hard rubber up to 2000 A h FRP up to 10000 A h
Railway coach	2	200–800	hard rubber
Electrical multiple units	10	75 and 90	hard rubber
Diesel starting	8	290 and 450	hard rubber
Submarine	2	C[a]	C[a]

[a]C = classified information

alloys and 48 000 tonnes for making lead oxides (both ball-mill and Barton-pot types). India produces 30 000 tonnes of primary lead from mines owned by the Government-sponsored Hindustan Zinc Ltd. This company operates eight mines in the states of Rajasthan, Andhra Pradesh, Bihar and Orissa. The output comprises only 1.2% of the total world production of lead [3]. It is estimated that India will produce 65 000 tonnes of lead during 1991–1992 when its Chandereya lead–zinc complex goes on stream. This would still be a very small proportion (2.64%) of the total world production. It is estimated that the demand for primary lead in India will be 115 000 and 154 000 tonnes during 1994–1995 and 1999–2000, respectively. If it is assumed that 64% of the primary lead will be used in India for batteries in 2000 AD, [3], then the required quantity amounts to 99 000 tonnes. About 35 to 40% of this would have to be imported.

Recycled lead

The lead/acid battery industry in India consumed 36 000 tonnes of antimonial lead for their grids and top lead during 1989. There are three major and six minor plants for recycling battery lead (Table 7) apart from scores of mini plants and backyard smelters.

Major smelters make made-to-order alloys and supply these to established manufacturers and small-scale operations. They also supply basic antimonial lead alloys from which the major units produce their own in-house alloys by adding proprietary constituents such as arsenic and other grain-refiners. Generally, major manufacturers employ a low antimony–selenium nucleated alloy for batteries that are intended for automobiles and some stationary and railway applications. For motive power, a high antimony alloy without arsenic is preferred. By contrast, small-scale plants invariably use a 4.5 wt.% antimony alloy, or a 4 wt.% antimony alloy with arsenic and nucleated

TABLE 6

Lead/acid battery manufacturers in the established sector

Manufacturer	No. of factories	Collaboration with	Annual turnover (US$ million)	Year
Chloride India Ltd. (Calcutta)	4	Chloride, UK	90	1990
Standard Batteries Ltd. (Bombay)	3	Furukawa (for automotive) Oldham SA (for industrial) Hagen Batteries (for submarine)	38.5	1990
Amco Batteries Ltd. (Bangalore)	2	Yuasa	32.5	1989/90
Willard India Ltd. (New Delhi)	1	Japan Storage Battery Co.	34	1990/91
UB Mec Batteries Ltd. (Bangalore)	1		8.5	1989/90
Nicco Batteries Ltd. (Surajpur)	1	Globe International	4.0	1990
Bharat Batteries Manufacturing Co. Pvt. Ltd. (Calcutta)	1		3.0	1989
Amara Raja Batteries (Tirupati)	1	GNB Inc. (for sealed batteries)	[a]	[a]

[a]Just started.

TABLE 7

Battery component manufacturers (supporting industries)

Nature of component	Number of plants		
	Major	Medium	Small and mini
Battery grid alloy	3	6	44
Lead oxides	4	10	42
Hard-rubber boxes and lids	4	7	40
Sintered PVC separators	3	7	34

with copper and sulfur. These alloys are supplied in a ready-made form by the smelters. For top lead, small-scale operations use 'home made' 3.5 wt.% antimony alloy.

A minuscule quantity of lead–calcium–tin–aluminium alloy is used by some small-scale plants for making maintenance-free batteries for emergency lighting, computers, photoflashes and UPS systems. A large-scale unit, just started, also uses this alloy. To date, calcium-based grids are not manufactured for automotive batteries.

Technology status

Grid and component casting

All major manufacturers employ automatic gravity-casting machines of various western makes for their automobile battery grids. The temperature of the melting pot and of the top and bottom parts of the moulds are controlled closely. For small parts and top lead, rotating automatic casters are used, except in some cases (especially for making batteries with polypropylene (PP) containers) where cast-on-strap (COS) is used.

The thickness of the positive and negative grids is generally 2 mm and 1.7 to 1.8 mm, respectively. In some applications, however, a thickness of 1.3 mm is employed for both positive and negative grids. The small-scale sector still uses up to 2.4 mm for positive grids and 2 mm for negative grids. Major makers use around 5.9 g per A h of grid material for positives; in small operations the amount is greater than 8.0 g per A h!

Tubular battery grids are manufactured in large plants with pressure-casting machines of both western and local make. By contrast, the small plants employ only 'semi-automatic' gravity casters for grid lengths up to 310 mm maximum. For the casting of automotive-battery grids, the small-scale sector uses semi-automatic pneumatic casters or ancient hand-casting machines. The semi-automatic machines can cast up to 7 double panels per min. Carbon is applied mostly to the moulds, although a few small operations also employ cork.

The common problems experienced by the small-scale sector are the usual ones; namely, hot tearing or cracking due to an arsenic alloy without proper nucleants, uncontrolled mould and pot temperatures, or high dross interference.

Paste preparation and pasting

Major manufacturers are tending towards the use of remote controlled paste mixing, with oxide silos and dosing tanks for acid, water and slurry. At the same time, they also make do with older paste mixers of around one-tonne capacity, with zigma blades, cooling coils and tilting arrangements. In such cases, the addition of oxides and other additives, together with the removal of paste, is carried out manually.

The medium- and small-scale sector employs zigma mixers or edge runners with direction and scraping blades. The batch sizes vary from as low as 30 kg to half a tonne. All the equipment is fitted with water-cooling facilities. The large-scale manufacturers invariably use leady oxide for both the positive and negative pastes. Some makers, however, add a small amount of red lead to the positive mix in order to modify the formation time and to achieve the high initial battery capacities demanded by the testing authorities. The leady oxide is made either by the ball-mill or by the Barton-pot process. The former method is about three times more popular. This is mainly due to the traditional use and familiarity with the ball-mill product and the preference shown towards this material for positive pastes.

The small- and medium-scale sectors generally prefer to employ a blend of red lead and litharge in paste making; but some opt for leady oxide. Most manufacturers add a dilute solution of acid directly to the oxide, while others prepare a water paste first and then add a stronger acid solution. The tendency is to restrict bulking the paste and, therefore, the density is seldom less than 4.5 g l^{-1}. By contrast, well-established manufacturers keep the density below 4.0 g l^{-1}.

Since the market for battery assemblers demands formed positives of weight 26 kg (for 100 plates) and negatives of 22 kg, there is apparently a national waste in the management of lead content. Education of the assemblers is a hopeless task. Nevertheless, the use of thinner grids and optimum paste is becoming accepted by some technically qualified entrepreneurs.

All the major manufacturers employ modern pasting machines with accompanying flash driers and curing ovens. Along with these, a small 'correction bay' may exist in which retrievable imperfect pasted plates (as noticed by the line inspector) are manually repasted to the required standards.

The small-scale plants have adopted manual pasting. This has arisen because of the plentiful supply of willing workers who work for very low wages. A good 'paster' can complete 600 to 800 double panels in an 8-h shift; this equates to the output achieved in 5 min from a pasting system of the type in operation at major battery plants. The small-scale producers cover the pasted plates with moist jute cloth. The stack remains covered (and hence is kept moist) for 2 or 3 days and is then air- or oven-dried. Alternatively, some manufacturers dip the pasted plates momentarily in a vey dilute solution of acid and then allow the plates to 'pickle' in a closed box for 2 days before air drying. As would be expected the quality of such plates is variable.

Paste density measurements using cube weight containers are undertaken by some small-scale manufacturers, while others use more empirical methods. The quantity and fineness of the expanders used in the negative paste also varies from one plant to another. In general, barium sulfate, carbon and lignin comprise the expander, and are supplied either individually or in a ready-mixed form. Very few plants use slurries of expanders. It is common for small- and medium-scale manufacturers to add dynel fibre to the positive-paste mix.

Plate formation

Established manufacturers have not installed extensive 'casette' formation procedures. Some manufacturers, however produce automotive batteries with pasted plates assembled in battery boxes and then conduct initial charging with great care and thus bypass formation. For medium- and small-scale manufacturers, the use of formation tanks (where both the positive and negative plates are lead-burned to the outside lead 'stick') is still a way of life.

It is normal to pass up to 0.4 A h per g of positive active material. The formation is generally completed within 24 h in the case of automotive plates. Some manufacturers include an idle period. The formation period for tubular plates is much longer, with one to three idle periods. For special stationary batteries, a couple of discharge/charge cycles are undertaken in order to stabilize the battery output.

Dry charge

The major manufacturers have both normal extended-charged and dry-charged batteries; for automotive types the proportion is roughly 80:20. For exports, however, dry-charged negatives are generally employed. The traditional method of drying by 'kerosene fumes' has given way to inert-gas drying or electrical vacuum drying in ovens. Platen drying is not used. In general, small-scale plants do not produce dry-charged negatives.

Cell/battery assembly

For both two-wheeler PP batteries (6 V, 4 A h to 12 V, 2.5 and 5 A h) and automotive batteries up to 12 V, 70 A h, the process of assembly in the case of large manufacturers is by the COS, through the partition, squeeze welding box to lid heat-sealing route.

The separators are invariably of the sintered PVC type for both automotive- and motive-power batteries. There are three major manufacturers of such separators in India and a number of minor ones (see Table 7). In addition, most of the large-scale manufacturers have in-house separator plants. One manufacturer uses microporous rubber separators and another microporous 'plastic' separators for batteries designed for stationary applications.

For batteries over 12 V, 70 A h, and also for a few 6 V batteries that are made in hard-rubber boxes, the technology of assembly is by the traditional 'comb-and-dam' method, manual insertion of separators and the groups into the boxes, and welding of intercell connectors of the over-the-lid 'proud' or 'sunk-in' variety, followed by bitumenous sealing. Small-scale plants, of course, follow the above procedure for batteries made only in hard-rubber boxes. A few of the compaines have developed ingenious intercell connection and adhesive sealing techniques.

Battery test facilities

All the major manufacturers have their own raw material and component testing laboratories and a final battery 'test house'. They also have R&D divisions, and also draw upon the results obtained by their collaborators. There is also a Central Electrochemical Research Institute in India, one of a chain of Government Laboratories. The Institute conducts basic research on storage batteries and holds training courses for battery personnel. Their expertise and research findings are available to the industry on a know-how fee basis.

Indian standards for the battery industry

The Bureau of Indian Standards (BIS) has published a number of Indian Standards covering almost the entire range of lead/acid batteries and their components. These are given in Table 8. There is also a Certification Scheme by the BIS whereby the Bureau issues a BIS MARK to a product based on a elaborate test scheme on products picked at random from the market.

Testing apparatus

Most of the apparatus for evaluating batteries under the above Standards is manufactured in India. Large-scale manufacturers also import some sophisticated test rigs for specialized and computer-controlled automatic testing procedures.

Atomic absorption spectrometers, polarographs, etc., for the testing of impurities in the components and raw materials are mostly imported, as locally-made units have not been fully tried and tested. For research needs and for totally accurate analysis of lead products for impurities, the Babha Atomic Research Centre, Bombay, can also lend assistance.

There are also other central laboratories to test batteries and their components, e.g., the National Test House and regional laboratories run by the Small Industries Service Institute; the latter, as the name implies, caters for the small-scale sector.

Pollution control status

The Indian Government and the various State Governments have specified the upper limits for lead in factory premises, i.e., near the emission stack, tap water and

TABLE 8

Indian Standards for the battery industry

Subject	Specification No. IS
Lead/acid storage batteries for motor vehicles	7372
Lead/acid storage batteries for motor cycles, etc.	1145
Lead/acid traction batteries	5154
Stationary cells and batteries, lead/acid type (Planté)	1652
Stationary cells and batteries, lead/acid type with tubular positive plates	1651
Stationary cells and batteries, lead/acid type with pasted plates	6304
Lead/acid batteries for train lighting and air-conditioning services	6848
Lead/acid batteries for diesel locomotives and rail cars	7624
Lead/acid batteries for electric locomotives and electrical multiple units	7660
Miner's cap lamp batteries (lead/acid type)	2512
Lead/acid storage batteries for aircraft	1846
General requirements and methods of tests for lead/acid batteries	8320
Rubber and plastic containers for lead/acid storage batteries	1146
Synthetic separators for lead/acid batteries	6071
Specification for sulfuric acid	266
Specification for water for storage batteries	1069
Specification for sealing compound for batteries	3116
Specification for lead	27
Specification for antimony	211
Specification for refined secondary lead	3717
Specification for lead sub-oxide for batteries	12292

effluents. These values are given in Table 9. It should be noted that the above values are more than those required by NIOSH (USA) or ACGIS (USA), but some of the values match the limits imposed by certain other countries. It would be a lengthy business for the Indian industries in the lead/acid sector to implement totally the requirements of the Government as awareness of the need for pollution control has still to take firm root. Nevertheless, there is an enormous fund of skill and technical ability for solving the engineering problems associated with such pollution.

Supporting industries

The lead/acid battery industry in India is well served by component makers. The list of such supporting industries is given in Table 7. The above facilities (e.g., leady oxide, box and separator production) are in addition to those already in place in the major battery plants. The present trend among large-scale plants is to have small vendors undertake component manufacture under strict supervision of quality.

TABLE 9

Pollution control limits for lead

Pollution area	Duration of exposure	Specified upper limit	Controlling authority
Workplace	TLV for 8 h	0.15 mg m^{-3}	State Chief Inspector of Factories
Workplace	TLV for 15 min (instant exposure)	0.45 mg m^{-3}	State Chief Inspector of Factories
At factory stack	anytime	50 mg m^{-3}[a]	State Chief Inspector of Factories
Drinking water	anytime	0.1 mg l^{-1}	Public Health Department
Inland effluents		0.1 mg l^{-1}	State Pollution Control Board
Industrial effluents to public sewers and marine waters		1.0 mg l^{-1}	State Pollution Control Board

[a]For particulate matter.

TABLE 10

Service life of batteries in the established sector

Category of battery	Service life (years)
Automotive batteries	2–3
Motive-power batteries	3–4
Railcoach batteries for lights and fans	3–4
Stationary batteries for float service (tubular)	10–15
Stationary batteries for cycling service	6–8

Battery service life

The service life of batteries made in India by the established large-scale sector is given in Table 10. It should be remembered, however, that the prevailing ambient temperatures are much higher than those in Europe and most Western countries. Hence, the service life attained can be taken as quite good. Further, the service life of automotive batteries should be considered against the background of unsatisfactory road conditions.

Conclusions

The lead/acid battery industry in India has matured. It is well entrenched and poised for very rapid growth in all sectors during the next few years. Implementation of state-of-the-art manufacturing processes is proceeding at a rapid pace.

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