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Lead market trends—technology and economics

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Abstract

This paper presents an overview of the lead supply–demand balance in the Western World as well as price forecasts. It is expected that growth in both primary and secondary lead production will initially outstrip the corresponding growth in consumption, and will result in some surplus metal over the next 4 years. This surplus will cause a decline in the lead price. After this period, as the market moves into deficit, it is anticipated that prices will again move upward. In subsequent discussion, the importance of the lead/acid battery to the lead industry is demonstrated as are the significant future opportunities provided by this end-use sector for lead. Finally, a number of issues critical to the continued success of both the battery and the lead industries are canvassed: first, the decline in primary lead metal as a proportion of total Western World lead production and its potential impact on changing battery technologies; second, the need to develop lead specifications which meet the needs of contemporary and future battery technologies to ensure that battery quality and performance objectives are met in full. © 1998 Published by Elsevier Science S.A. All rights reserved.

Keywords: Primary lead; Secondary lead; Lead/acid battery; Supply–demand

1. Introduction

As the fourth most widely used non-ferrous metal, lead has been a part of civilization for thousands of years. Its high level of use in both developed and developing nations persists, despite the environmental pressure that has been imposed on the lead-producing and various lead-consuming industries. This is strong testament to the willingness of the industry at large to respond responsibly to environmental demands. It also reflects the manner in which modern society depends upon this often maligned metal.

The continued dependence on lead is due largely to society's growing need for portable energy. Whether it is starting a car, or powering a notebook computer or mobile phone, the demand is for power 'on-the-run', and while lead/acid has always enjoyed a monopoly in automotive applications, recent developments in the technology are growing its share of the portable power market. Thus, it is the lead/acid battery which underpins the continued growth in lead consumption.

In this paper, an overview of the lead supply–demand balance in the Western World for the period 1986 to 2006 is provided. As alluded to previously, growth in both consumption and production is expected. It will be demonstrated that Asia figures prominently in both the actual and the forecast growth in consumption and that it is indeed this battery industry which is driving the growth.

The rise in production level is expected to be driven mainly by growth in secondary (recycled) lead output. Little growth in primary output is forecast. This comes at a time when demand for 'primary' grade metal is growing rapidly due jointly to the growing battery sector and the greater demands of new battery technologies and applications. This situation will have several implications for the lead industry, two of which will be considered.

First, however, it is necessary to clarify the definitions of a number of regional references made in the course of this paper. The lead/supply situation is analysed in the context of both the 'Western World' and 'Asia'. In the present context, the 'Western World' encompasses all countries except for the former Eastern Bloc, China and North Korea. 'Asia' is defined as all Asian nations included in the Western World, excluding Japan. Japan has not been included in the present analysis of Asian lead consumption due to the fact that consumption has actually been in decline over recent years and is forecast to continue declining. This is in direct contrast with the balance of the Asian world. The data supporting the analysis of the

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lead-supply balance has been sourced from both the Lead Metal Service of Brook Hunt [1], and the Pasminco's internal marketing information databases.

2. Lead supply and demand

2.1. Trends in lead supply in the Western World

Four key components make up the lead supply in the Western World, namely:

- primary lead production, for which the predominant feed is mined concentrate,
- secondary, or recycled, lead production,
- net imports from the former Eastern Bloc, China and North Korea and
- refined lead supplied from strategic stocks held by the U.S. Defence Logistics Agency (DLA).

Each of these four components of supply are discussed below.

2.1.1. Lead mine production

Fig. 1 summarises mine production that is forecast to occur in the Western World up to the year 2006. Over the next 2 to 4 years, annual mine output is expected to rise markedly. This is due predominantly to start-up at the Cannington mine in North Queensland (Australia), the re-opening of the Faro mine in Canada, and expansions at various existing mines that include McArthur River and Elura in Australia and Red Dog in Canada. After year 2000, some contraction in mine output is expected, with closures at Polaris and Sullivan (Canada), and Hellyer (Australia).

2.1.2. Refined lead production

2.1.2.1. Primary lead production. Despite the surplus of concentrate expected in the next several years and the fact that, collectively, primary smelters are currently operating below their design capacities, many analysts predict that smelters will experience difficulty in having to treat additional concentrate. Therefore, the increase in primary lead production, in the longer term, will be marginal.

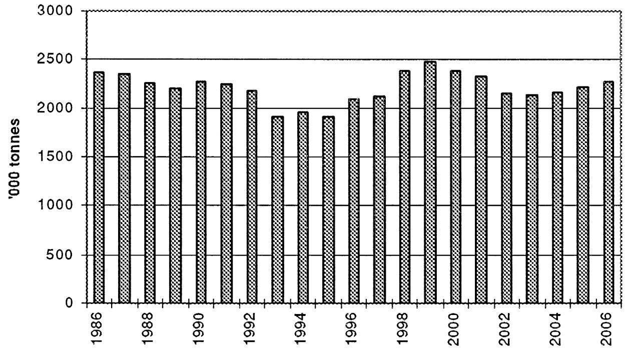

Fig. 1. The Western World lead mine output (1986–2006).

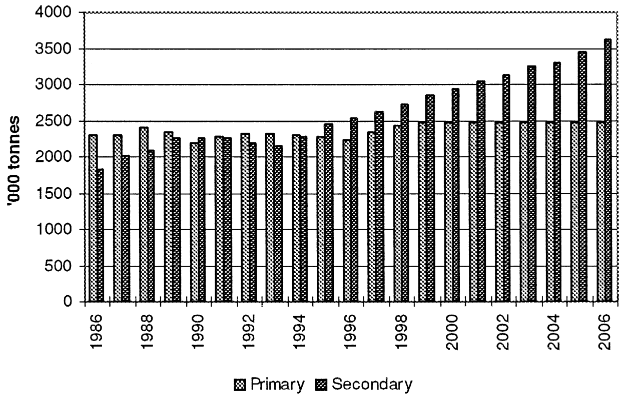

Fig. 2. The Western World refined lead output (1986–2006).

Fig. 2 illustrates this forecast. For 3 consecutive years from 1994 to 1996, output fell in the Western World. Over the next 3 years, production is predicted to rise from 2.24 to 2.46 million tonnes/annum, an average increase of just under 2% a year. Of this rise, some 30 000 tonnes per annum will stem from increased effective capacity, such as at Pasminco's Port Piric smelter. The remaining 220 000 tonnes/annum will be largely due to improved plant utilization. Beyond year 2000, primary lead production is predicted to remain stable at around 2.5 million tonnes/annum.

2.1.2.2. Secondary lead production. In the Western World, secondary lead output overtook primary lead output in 1990 (Fig. 2). The secondary lead industry went into a recession for the next 5 years, as the lead price languished at historically low prices. Spurred by rising lead prices, the situation reversed in 1995. Since then, secondary output has continued to outperform primary. By the year 2000, it is forecast that secondary production will exceed primary by 500 000 tonnes/annum.

The growth surge in secondary production over the past 3 years has probably been driven as much by improved recycling rates as by higher lead prices.

Improved recycling rates have arisen largely as the result of legislation such as Italy's COBAT scheme, the Compulsory Consortium for Spent Lead Containing Waste, which requires that all spent lead/acid batteries be recycled by COBAT members. In both Japan and Taiwan, manufacturers are now obliged to use secondary lead in the production of batteries. Despite such legislative changes, trend analysis indicates that secondary lead production growth will flatten toward the year 2000, as shown in Fig. 3. Because industrialized nations have limited scope to increase recycling rates further, future increases in secondary output will be linked to the growth in battery demand, together with improved recycling rates in the developing nations.

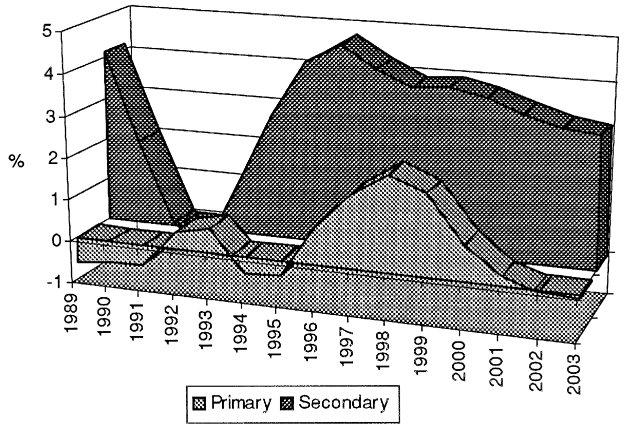

Fig. 3. The Western World refined lead production—trend growth rate (1989–2003).

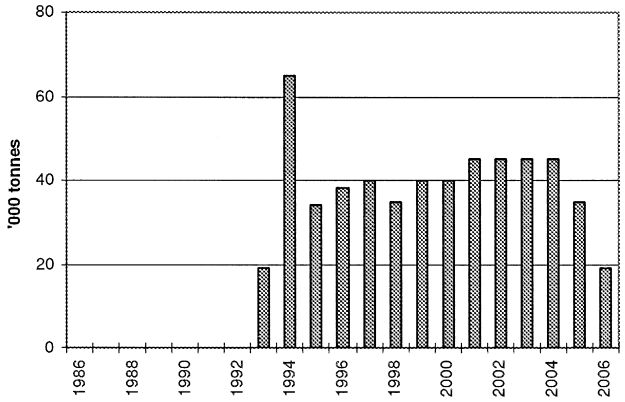

Fig. 5. DLA refined lead sales (1986–2006).

2.1.3. Net Eastern Bloc exports

After hitting a high of nearly 300 000 tonnes during 1996, the level of exports from the Eastern Bloc is expected to fall to around 80 000 tonnes/annum by 2006. As shown in Fig. 4, China has been the major Eastern Bloc exporter since 1994 and will continue as such. During 1996, China exported around 250 000 tonnes net to the Western World. By contrast, annual exports from China are expected to fall to around 180 000 and 50 000 tonnes by the year 2000 and 2006, respectively.

2.1.4. Drawdown of DLA stocks

The U.S. DLA is responsible for acquiring and disposing of goods deemed to be strategically important. Metals are included in the list of strategically important goods. Before the fall of communism in Eastern Europe and the USSR at the beginning of the decade, the DLA built a substantial stockpile of lead, among other metals. Since then, the DLA has been releasing lead to the market in a manner aimed at minimizing disruption to the supply/demand balance. This is a difficult task to achieve as even an 1% variation in the supply/demand balance can exert a significant impact on price, as will be discussed below. Fig. 5 illustrates the rate at which metal has been, and is forecast to be, released. The DLA will always present problems for supply, demand and price forecasts because its current policy of not 'disrupting' markets can change overnight depending on US economic and foreign policy.

An overview of total Western World lead supply is provided in Fig. 6.

2.2. Trends in lead consumption

2.2.1. Western World

In the 10-year period up to 1996, annual consumption of lead in the Western World increased at about 2% per year. As can be seen from the data given in Fig. 7, the period was dominated by a recession between 1989 and 1993 when there was no increase at all in annual consumption.

In the 10-year period up to 2006, consumption is forecast to continue to grow at just under 2% and will rise to 6.1 million tonnes.

2.2.2. Asia

The growth powerhouse in Western World lead consumption over the past 10 years has been Asia. Excluding

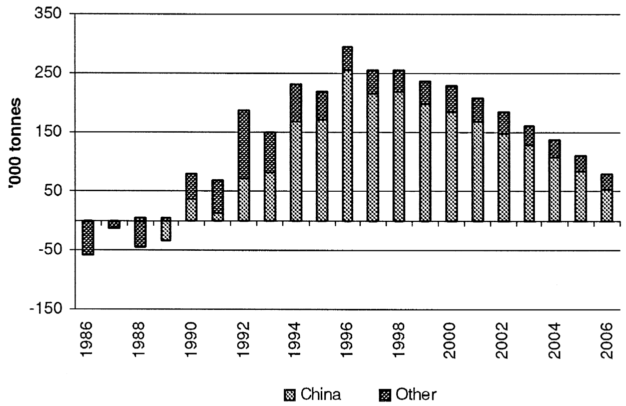

Fig. 4. Net imports from the former Eastern Bloc, China and North Korea (1986–2006).

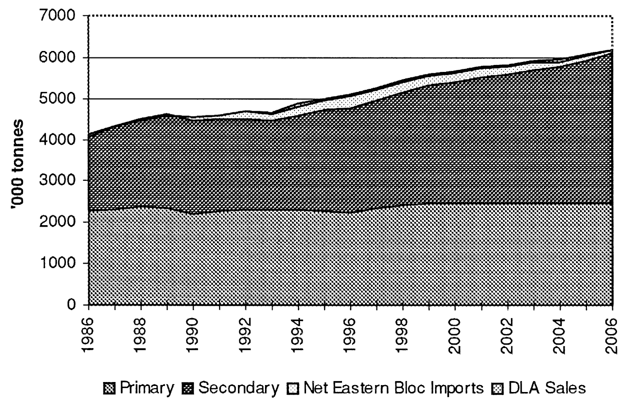

Fig. 6. The Western World refined lead supply (1986–2006).

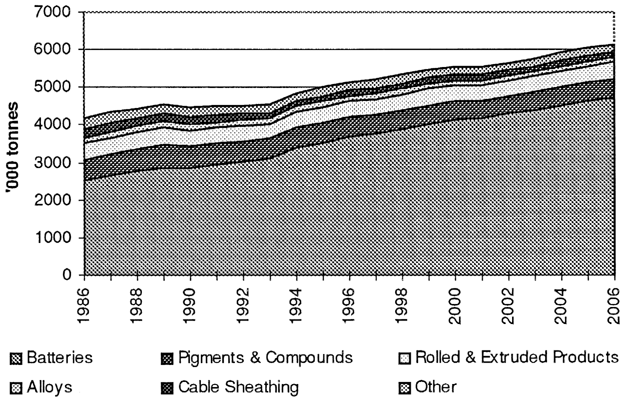

Fig. 7. The Western World lead consumption—by end-use (1986–2006).

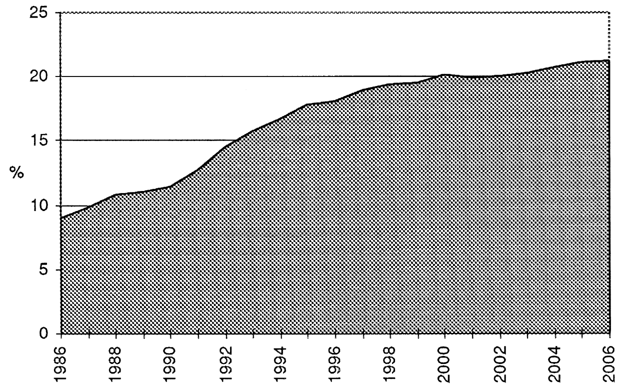

Fig. 9. Asian lead consumption as a proportion of that of the Western World (1986–2006).

Japan, Asian lead consumption has risen by about 10% annually, i.e., from 0.4 million tonnes in 1986 to more than 0.9 million tonnes in 1996, as seen in Fig. 8.

During the next 10 years, however, a more mature average growth rate of 3.4% per annum is expected. By the year 2006, annual consumption will be around 1.3 million tonnes.

The increasing importance of Asia as a lead-consuming region is demonstrated in Fig. 9. In 1986, Asia accounted for less than 10% of total Western World lead consumption. By 1996, the amount was 18%. By 2006, it is expected to exceed 20%.

Put another way, Asia accounted for 57% of the total Western World lead consumption growth between the years 1986 and 1996. After the year 2000, it will continue to dominate Western World growth rates, but less so.

2.3. The supply–demand balance

The Western World lead market remained in deficit in 1996—the third successive year of shortage (Fig. 10). A fourth successive deficit is forecast for 1997, then 4 years of surplus production of up to 70 000 tonnes/annum. The market is expected to move into deficit again in 2002.

Obviously, there is a strong inverse relationship between supply–demand and lead prices. Supply surpluses or deficits as low as 1–2% of consumption can result in significant price swings in very short time-frames. Speculative actions notwithstanding, given the forecast surplus over the next 4 years, the lead price is expected to fall and bottom out at US$500 in 2001. The price will rebound as the market again moves into deficit after 2001.

3. The importance of the lead/acid battery industry

3.1. Western World battery sector

The lead industry has become increasingly dependent on the battery industry. At present, more than 70% of lead is consumed in the Western World by this sector (Fig. 11), compared with some 60% in 1986. By the year 2006, the battery industry is forecast to account for 77% of Western World lead supply.

Significantly, between 1989 and 1993, when there was no growth in overall lead consumption (refer to Fig. 7), the battery sector managed almost 2% annual growth while all

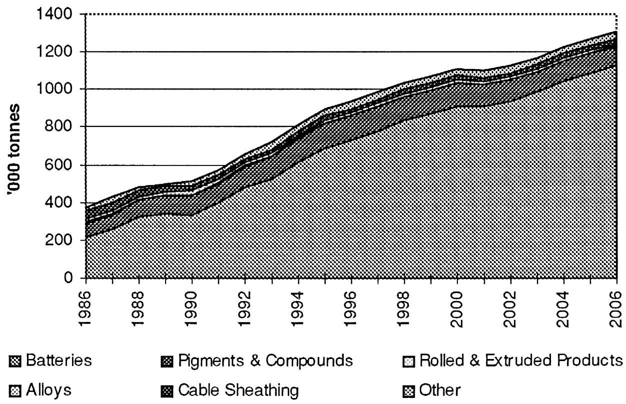

Fig. 8. Asian lead consumption excluding Japan—by end-use (1986–2006).

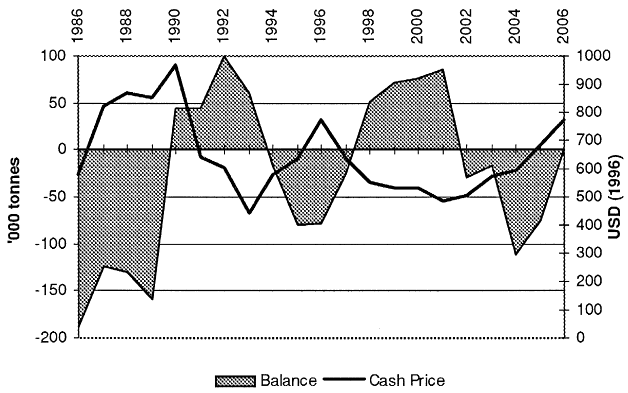

Fig. 10. Western World lead supply balance and prices (1996 US$ equivalent) (1986–2006).

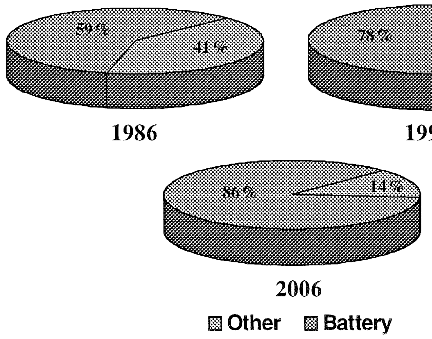

Fig. 11. Consumption of lead in the Western World battery sector (1986–2006).

other end-uses contracted by more than 3% per annum on average.

With non-battery end-uses expected to continue contracting over the next 10 years, the fortunes of the lead and battery industries will become increasingly intertwined.

3.2. The Asian battery sector

In Asia, the interdependence between the lead and battery industries is even more pronounced. Fig. 12 illustrates the rapid rise in the battery sector's importance—from about 60% of overall lead consumption in 1986, to 78% in 1996, and a forecast 86% by 2006.

In Asia, lead consumption in the battery sector has increased by more than 230% during the past 10 years, compared with around 30% in the rest of the Western World. In the next 10 years, the contrast will remain significant, for example, the sector's lead consumption will grow by 54% in Asia, compared with 22% elsewhere in the Western World, and will represent 40% of the total increase in demand in the Western World.

Therefore, by any measure, it is clear that the Asian battery industry has been, and will continue to be, pivotal to the success of the world lead industry. As indicated earlier, however, growth in lead consumption by the Asian battery sector is gradually diminishing (Fig. 13). The reasons include: (i) a gradual reduction in the average lead content of each battery; (ii) extended battery life due to

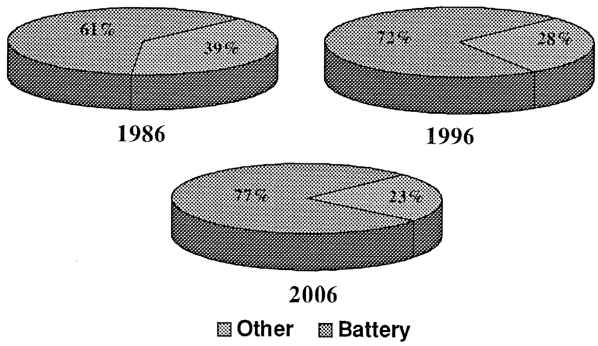

Fig. 12. Consumption of lead in the Asian battery sector (1986–2006).

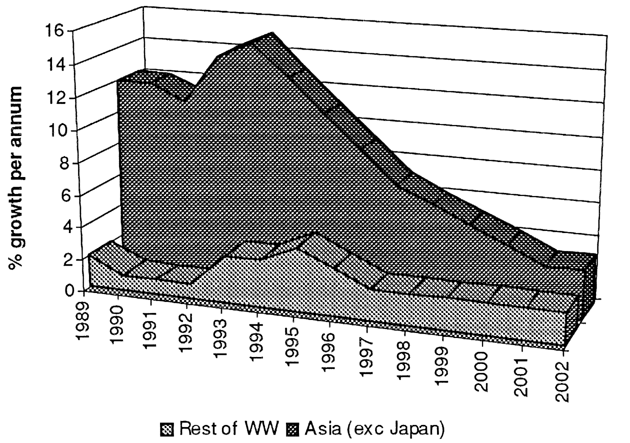

Fig. 13. Trend growth rates in lead consumption—Asian battery sector vs. rest of Western World battery sector (1986–2006).

improved technology, roads and vehicle charging systems; (iii) the establishment of battery production facilities in Asian manufacturers' traditional markets (such as the Middle East and Africa) and in countries with low labour costs (such as China).

4. Current and future drivers of lead/acid battery growth

Given that future growth in lead consumption is underpinned by expansion in the battery industry, it is important to examine briefly what has been generating and what is expected to sustain this growth.

4.1. Automotive applications

The mainstay of the continued expansion in lead acid battery production is, of course, the demand for automotive units, that the world's automobile fleet will grow to around 600 million by year 2006 and that this is no cost-effective competing technology on the horizon, the future of lead/acid is secure. Moreover, the automotive industry's wish to increase the voltage of car electrical systems from 12 to 24 or even 36 V presents additional opportunities. There is a strong likelihood that whichever voltage is chosen, it will be necessary to split the electricity supply into two sources. One of these sources would serve the high-rate discharge loads, i.e., engine starting, most likely to be a conventional flooded maintenance-free (MF) battery. The other source would provide energy for low rate deep cycling, a perfect duty for a valve-regulated lead/acid (VRLA) battery.

4.2. Stationary and portable power

Further improvements to the cost and performance of VRLA batteries will lead to a broadening in the range of applications where the technology will be considered preferable to existing dry cells and other electrochemical systems. Specific examples might include portable power tools, laptop computers and mobile phones. With the gathering pace of development in high-tech portable electronic applications, a relatively high growth rate for VRLA batteries can be expected.

Other factors driving growth in VRLA battery production include: (i) an increasing need for emergency uninterruptible power supplies for computer networks; (ii) the shift from flooded to VRLA technology in telecommunications facilities; and (iii) the high growth of telecommunications installations in Asia.

4.3. Electric vehicles

With government regulations and legislation driving the development of viable electric vehicles (EVs), it is likely that demand for lead/acid batteries in this sector will grow significantly. The EV market can be divided into three sub-segments.

4.3.1. Set-route vehicles

The battery market presented by vehicles designed for 'set-route' duty, such as buses and delivery vans, is largely shared between lead/acid, nickel/cadmium, and nickel/metal hydride.

4.3.2. Commuter vehicles

As yet, no battery system has been discovered that will provide the distance capability demanded by the market for commuter vehicles. For this reason, it is generally expected that the first generation of marketable EVs to be considered acceptable for this market will be powered by heat engine–battery hybrid systems. The second generation is expected to incorporate a fuel cell in place of the heat engine. In both cases, it is most probable that the battery will be lead/acid, due to its low cost and peak power performance.

4.3.3. Motorcycles

More key potential markets for electric motorcycles exist in Asia where most of the technology's development has taken place. This application represents the most promising new market for lead/acid batteries due to the suitability of the system to a duty which excludes air-conditioning and heating. A great advantage of the electric motorcycle from a marketing perspective is its capital cost, which is similar to a petrol equivalent.

5. Implications of growth and technological development in batteries for the lead industry

Given the importance of the lead/acid battery, it is important to review that the sector's strong growth and technological development will have on the lead industry in the short- to medium-term.

5.1. Primary lead supply–demand balance

The first issue to be explored centres on the convention within the battery industry to specify primary 'soft' lead for the production of battery oxide for positive and negative active materials.

As illustrated earlier, only marginal growth in primary lead production is forecast over the next 10 years. At the same time, consumption of lead in the battery sector is anticipated to grow at around 2% per annum. Given these two conflicting trends, it would seem reasonable to assume that at some stage there will be insufficient primary lead produced to satisfy demand. In order to provide some insight into just when this time will occur, a simple model has been constructed. Broad assumptions made in the development of this model are as follows: (i) all battery manufacturers specify primary lead for active material production; (ii) on average, the amount of lead used in battery active material as a proportion of the total lead used in the battery has risen evenly from 50% in 1986, to 55% in 1996, it is expected to rise further to 58% by 2006; (iii) 100% of all lead consumed in the production of lead chemicals is of primary origin; (iv) 100% of lead imported from the Eastern Bloc and released by the DLA is of primary origin.

Applying these assumptions to actual and forecast consumption data provides a model for determining primary lead demand. Subtraction of this calculated demand for primary lead from the forecast production reveals that a shortage of primary lead will first occur and then quickly worsen at around the turn of the century. The results of this analysis are presented in Fig. 14. Exacerbating this apparent shortage will be the continuing shift toward lead–calcium alloys in the production of batteries, due to the requirements of both MF and VRLA batteries and the development of high productivity continuous grid manufacturing techniques. Given that the supply of these alloys

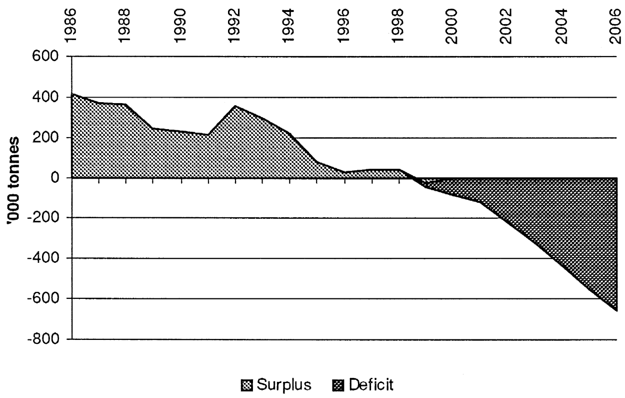

Fig. 14. Balance of primary refined lead supply in the Western World (1986–2006).

is generally from primary sources, in accordance with the high-quality requirements of battery manufacturers, this trend will accentuate the shortage of primary material. Clearly, therefore, it will be necessary for some battery manufacturers to source soft lead from the secondary lead industry.

Secondaries can produce lead at a high level of purity, it is a question of how much effort and technical resource, and therefore cost, is required to produce a suitable product. In fact, a number of secondary plants have already commenced soft lead production, but at increased cost. Conversely some primary plants have commenced complementing concentrate supply with scrap batteries. This is the case with some producers in Japan and Europe. As these practices grow, it will become increasingly difficult to distinguish between primary lead producers, secondary producers and those who mix feed sources.

In the future it is proposed that lead will be supplied by five key smelter types:

(i) vertically integrated primary producers—with their own mines and smelters;
(ii) custom primary smelters—who purchase concentrates and/or bullion from the open market;
(iii) mixed smelters—primary smelters using lead scrap as partial feed,
(iv) improved secondary producers—for whom enhanced refining will result in increased costs;
(v) generic secondaries—supplying predominantly antimonial alloys.

Thus, the source of supply will no longer guarantee either quality or purity suitable to a particular end-use. Instead, consumers will need to focus greater attention on specifications which are relevant to their own specific end-use.

5.2. Suitability of present generic lead specifications

The changes occurring in the various sources of refined lead, as detailed above, is resulting in an increased focus on the quality and purity of lead for battery production. This focus is being accentuated by the trend toward MF batteries for automotive applications and VRLA batteries for the consumer and the industrial end-use sectors, where high quality raw material inputs are critical.

This is because the main purpose of MF and VRLA technology is to remove the need for maintenance during the life of the battery, i.e., to eliminate the need for water addition. Certain elements, even in trace quantities, can accelerate the rate at which water is lost from the battery via electrochemical dissociation. Thus, in order to minimize the maintenance required during service life or, in the case of VRLA, to insure against failure by dry-out, it is important that the raw materials used to construct the battery minimize the extent of water loss.

Current practice, with regard to soft lead supply, usually involves battery producers taking what they perceive to be the safe step of specifying a generic 99.99% purity primary lead for MP and VRLA technologies. The fact that present 99.99% lead specifications were developed at a time when antimonial grid alloys dominated the performance of the battery in terms of water loss is rarely considered. Furthermore, rather than truly reflecting the needs of the battery, the elements and levels listed in these generic specifications were more a reflection of the refining and analytical capabilities of the lead producers. Generally, the specifications do not reflect the specific needs of the contemporary consumer.

For batteries which employ antimonial alloy grids, the use of soft lead in compliance with such present specifications results in adequate performance. In the context of the greater demands of both MF and VRLA batteries where lead–calcium grid alloys are employed, research has demonstrated that generic specifications such as 99.99% are inappropriate [2–7].

This is due primarily to the fact that generic specifications do not include many elements which have been demonstrated to be harmful to the performance of both MF and VRLA batteries. Additionally, other harmful elements which are included are often specified at inappropriately high levels.

Alternatively, elements which are routinely specified at low levels, such as bismuth, tin, cadmium and zinc, can actually have a positive impact on battery performance at levels higher than those stipulated.

In summary, therefore, there is a clear need for lead producers to address the mismatch between current generic lead specifications and the requirements of the various sectors of the battery industry, particularly at the high-technology end.

6. Conclusions

An analysis of the lead supply–demand balance for the Western World reveals that future growth in lead supply is expected to initially outstrip consumption growth and, thereby, will result in some surplus metal over the next 4 years. This surplus will cause a decline in the lead price. After this period, it is forecast that, as the market moves into deficit, prices will again trend upward.

It has also been demonstrated that the rise in consumption is becoming increasingly dependent upon growth in the battery industry, much of which is occurring in Asia. Significant opportunities for future growth in this sector are provided by the automotive industry, high-tech portable electronic applications, telecommunications, and electric vehicles.

A potential challenge is beginning to present itself in the form of an apparent shortage in ‘primary’ grade metal. Traditionally, most battery producers have specified primary lead for the production of battery active-material. Thus, significant growth in battery production is translating into strong growth in demand for ‘primary’ grade lead.

Accentuating this demand is the trend to MF and VRLA batteries, the concomitant trend to lead–calcium alloys, and the increasing ratio of lead in active material to total lead in the battery. This comes at a time when forecast growth in primary lead output over the next 10 years is, at best, marginal.

This situation has two major implications for the lead industry. First, it will be necessary for a proportion of the secondary industry to produce ‘primary’ grade metal. Second, in order for the suitability of lead to be guaranteed, new lead specifications based upon the needs of contemporary and future battery technology rather than historical smelter capabilities will need to be developed.

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