An article published in
MetalBulletin Magazine
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The power of lead

A recent series of reports have shown that demand for lead in its main applications is assured for the foreseeable future, writes Dr Andy Bush of the International Lead Association

In recent months, the conclusions of a series of reports have given a clear message that the future demand for lead looks good and that it will be needed more than ever to support the growing market for energy storage solutions.

Lead metal itself has seen year-on-year increases in production to reach record levels – an increase of 5.5% per year in 2001-2011, to more than 10 million tonnes annually, according to the International Lead and Zinc Study Group (ILZSG). That demand has been principally driven by lead batteries, which now represent more than 80% of lead use.

Lead-based batteries are an essential component in the world's one billion vehicles, in particular SLI batteries (Starting, Lighting, Ignition) for commercial and passenger vehicles, either as original equipment in new vehicles or as replacement batteries – this represents about three-quarters ($22.8 billion in value) of the total lead battery market. Indeed the "aftermarket" for replacement batteries is by far the most significant part of the business – for SLIs it is estimated to be at least four times larger than the original equipment market.

Contrary to common belief, the need for greater energy efficiency and reductions in carbon emissions for vehicles is not having an adverse effect on the lead-based battery market – and 600 million lead batteries were produced worldwide in 2012 – as lead battery technologies are often at the forefront of innovation.

The importance of lead batteries for the automotive industry, plus lead's guaranteed availability as a sustainable resource with low environmental life-cycle impacts, has now been confirmed in a series of reports produced by a group consisting of Europe's automotive and industrial battery producers, plus the vehicle manufacturer associations of Europe, Japan and South Korea, with the International Lead Association (ILA) also representing the lead industry.

ILA

The LC Super Hybrid is an example of an advanced car with a bigger 48 volt lead battery

No alternative

In its recent study *A Review of Battery Technologies for Automotive Applications* (published by Eurobat this year), the group examined the likely future for battery technologies in the automotive sector. At present lead-based batteries are the technology of choice for almost all SLI battery applications and the study concluded that these batteries will by necessity remain the most widespread energy storage system in automotive applications for the foreseeable future, with no alternative technology currently available to challenge this position.

With the global car fleet predicted to grow to 1.6 billion vehicles by 2030, according to a UN Economic Commission for Europe report, a step change in technology is needed to ensure that sustainable mobility can reduce carbon dioxide emissions in the long-term. In response to this challenge, vehicle manufacturers in Europe have striven to meet targets for reduced CO_2 emissions with a subsequent rise in alternatives to the conventional car engine. These alternatives include fully electric vehicles and a variety of hybrid vehicles where the energy stored from braking is used to boost a car's acceleration, or in some cases for some electric driving. This has seen greater use made of lithium-ion and nickel-metal-hydride batteries, but one constant has remained – all these vehicles in addition still need a 12V SLI lead-based battery.

Among the advantages of lead-based batteries are their low cost and unparalleled ability to start an engine at cold temperatures in conventional and micro-hybrid vehicles. In hybrid vehicles, which have a limited amount of electric driving, and full electric vehicles, several battery chemistries are available for vehicle propulsion. However lead-based 12V batteries are also essential in providing the power for features such as air-conditioning, entertainment systems and safety features working alongside other battery technologies.

Innovations in battery technology in the automotive sector will help reduce carbon dioxide emissions further. A good example of this is the LC Super Hybrid vehicle, developed and demonstrated with support from the Advanced Lead-Acid Battery Consortium. Advanced lead-batteries also now provide start-stop functionality and other micro-hybrid features in a significant proportion of the new vehicles marketed in Europe. These types of battery require more lead as they are bigger than those found in conventional cars due to the need to restart the vehicle more frequently and operate in a partial state of charge.

The findings of the group show that lead-based batteries remain a reliable, cost-effective, safe and fully recyclable energy storage solution – important attributes as the battery industry aims to maintain the exemption for lead-based batteries within the EU End-of-Life Vehicle Directive's wider ban on lead in light-duty vehicles, which is due for review in 2015.

Commenting on the report, Johann-Friedrich Dempwolff, chairman of Eurobat, which represents Europe's automotive battery industry, said: "This report demonstrates the necessity of maintaining the exemption for lead-based batteries within the EU End-of-Life Vehicle Directive. We believe that the EU's legislative and regulatory framework should therefore guarantee a fair and technology-neutral competition between battery technologies."

Batteries play a number of other key roles in everyday life, which are also expected to add to future demand for lead. These applications include stationary batteries acting as a back-up power source (uninterruptible power supply) in telecommunications, public transportation and medical facilities. They can also help reduce greenhouse gas emissions by efficiently storing electricity generated from both conventional and renewable energy sources, such as solar and wind power.

A plentiful and safe supply

With predictions that future demand for lead from the automotive industry will increase, the group also examined the future availability of the metal and other substances critical for alternative battery chemistries. The report *Resource Availability of Metals used in Batteries for Automotive Applications* revealed that there are currently no concerns about the availability of lead or the security of its supply for the foreseeable future. Moreover, resource availability of materials such as copper, calcium, selenium and tin, which can be used as alloying elements in lead-based batteries, is also unlikely to be an issue.

The plentiful supply of lead is supported by the efficient collection and recycling infrastructure for lead-based batteries, with more than half of the 10 million tonnes of refined lead metal produced worldwide in 2012 coming from recycled sources. Lead is one of only three metals to have a global production rate of more than 50% from secondary production, with close to 100% of US lead production and 75% in Europe from recycled material.

In its analysis of the resource availability of substances used in other battery technologies, the study identified a number of challenges. For example, increasing use of lithium-ion batteries in portable electronics, coupled with their use in new applications, is expected to result in a substantial increase in demand for lithium.

Increased demand for lithium would need to be met predominantly from lithium reserves via primary production as at present lithium-ion battery recycling is in its infancy with less than 1% of lithium recycled, and only a few companies able to recycle lithium-ion batteries at the end of their life. Part of the reason for the lack of commercial recycling operations is that lithium-ion battery recycling is complex and not currently economically viable, with recycled lithium potentially costing up to five times more to produce than primary metal. With lithium having a low economic value, any recycling would probably be driven by other metals contained in the battery such as nickel and cobalt.

The report concludes that the use of lead-based batteries should continue to be encouraged for a number of reasons, including the fact that this technology is the most competitive option from technical and economic perspectives and the fact that the existing market for automotive and industrial lead-based batteries can predominantly be met with recycled material.

Environmental impacts

Attention is increasingly being paid to the environmental impact of products through their entire life cycle, including factors such as extraction, fabrication, recycling and the use of energy and transportation. Europe's vehicle and industrial battery manufacturers have also carried out a life-cycle assessment (LCA) for lead-based batteries (soon to be published) and came to several significant conclusions.

From an end-of-life perspective, the LCA study has found that the high recycling rates of lead-based batteries dramatically reduces their environmental impact. In the US alone, lead battery recycling keeps 2.4 million tons of batteries out of landfills and it is estimated that 97% of a lead battery can be recycled, including the casing and acid.

In this "closed loop system" there is limited opportunity for lead to be released into the environment or to present a risk to human health. These factors contributed to the study finding that lead-based battery production has a minimal environmental impact in relation to the overall lifecycle impact of vehicle production.


ILA

Fully electric and hybrid vehicles still need lead SLI batteries

Moreover, the advanced lead-based batteries used in start-stop and micro-hybrid engine systems offset any environmental impact caused through their production by the considerable savings that they enable in global warming potential. Over the lifetime of a vehicle that uses these systems there are likely to be significant emission savings of carbon dioxide equivalent due to a reduction in fuel consumption of 5-10% compared with a conventional vehicle.

In a separate LCA study published in 2010 by the Argonne National Laboratory, USA, it was concluded that lead-based batteries had the lowest cradle-to-gate environmental impact of all battery technologies considered. The study compared life-cycle data from manufacturing lead, nickel, sodium and lithium-based batteries, and it reported that lead-based batteries had the lowest production energy, and lowest emissions of carbon dioxide, particulate matter, nitrogen oxides, sulphur oxides and volatile organic carbons.

ILA technical manager Dr Alistair Davidson, who worked on these studies, observed: "Lead-based batteries effectively operate in a closed loop in which commercial considerations drive the collection and efficient recycling of used batteries and the majority of their components at the end of their life. As such, lead use in batteries is a fantastic example of the circular economy in action – something that policy makers around the world increasingly recognise as being necessary to address negative environmental and social impacts associated with raw material extraction and production."

Rather than predicting an uncertain future for lead, these new studies have supported the conclusions that the demand for lead will continue to be driven by society's need for cost effective, reliable, safe and environmentally responsible energy storage solutions.