Power pack

TAKING STOCK

Richard Stocker, one of Horiba MIRA's advanced energy research scientists answers our questions about where we are now with EVs and where we are going

The Motor Industry Research Association has been providing the automotive world with a broad range of facilities since its inception in 1946. In keeping with the trend toward electrification, the organisation has recently benefitted from a massive investment in an advanced battery development suite (ABDS) that features a host of development and testing tools.

Entitled Horiba MIRA since a 2015 buy-out, the scope of the company makes it uniquely positioned to ponder the current state of the EV market. Over to you, Richard:

WHAT'S HAPPENING WITH BATTERY PACK DESIGN?

It is moving towards higher voltage and higher capacity to meet demands with range and fast charging. In terms of cell configuration, there are two distinct options that get preferred: a very large amount of small 18650 cells, connected with multiple strings in parallel, or large format, high-capacity prismatic/pouch cells largely constructed with only one or two strings in parallel. Both designs have their advantages/disadvantages and depend on the vehicle application.

Battery chemistry-wise, most manufacturers (with the exception of Tesla) are moving towards high-energy NMC cathode chemistries, maximising the nickel content and increasingly, silicon doped anodes.

HOW IMPORTANT IS TEMPERATURE CONTROL BECOMING?

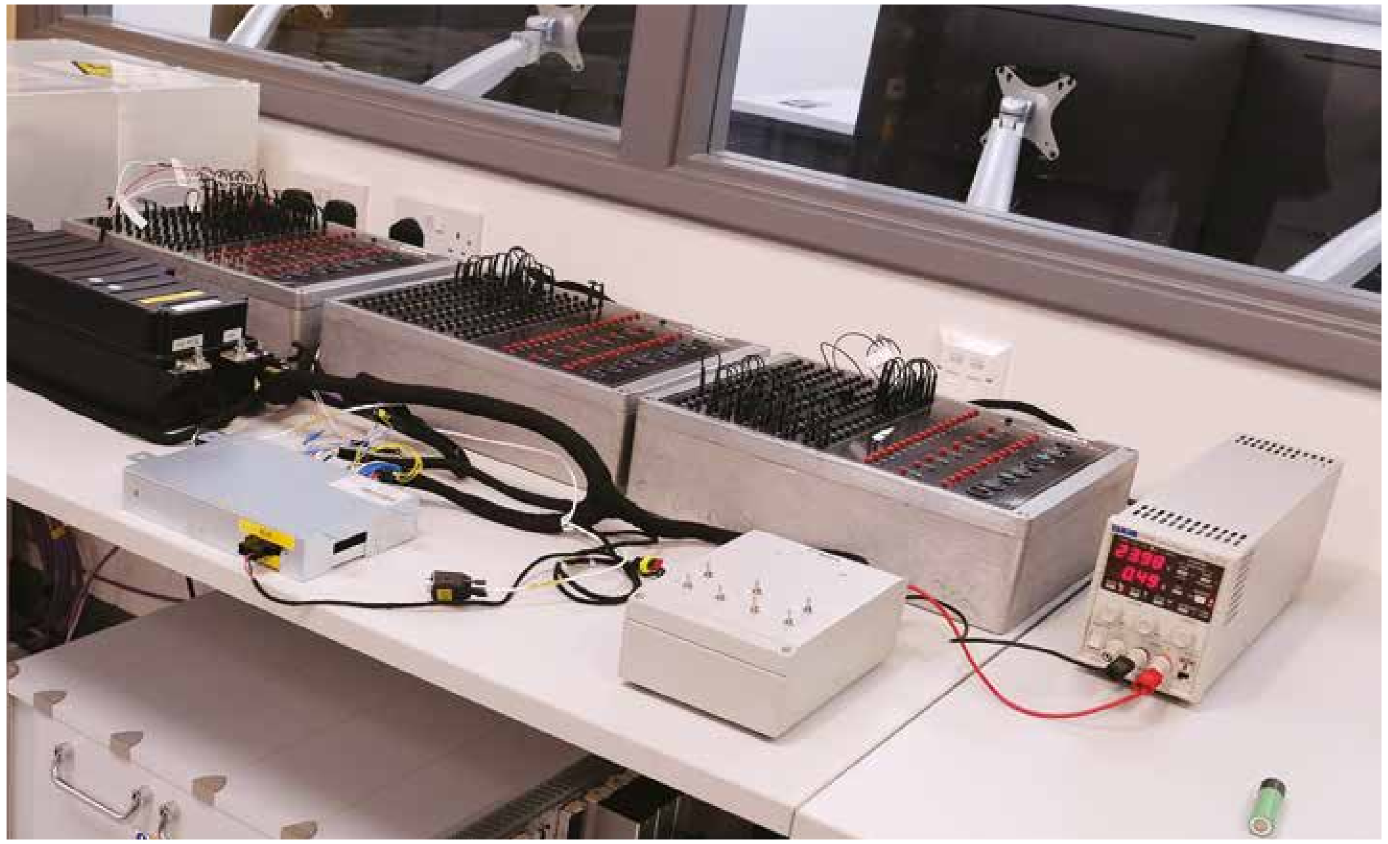
It's very important, and it depends on cost. For lower cost EVs passive or active air cooling is the most used approach. This is only applicable however if the battery pack is not required for high power outputs. For more high performance vehicles liquid cooling is the preferred approach, based on its superior cooling capability, and because it has less reliance on ambient conditions. However, it is likely that liquid cooling will become more prevalent as faster charge rates and higher overall pack capacities become more common.

Battery pack design is improving, particularly knowledge around optimum cell thermal management, which will have a large effect on lifetime. The most significant challenge however, could lie in the battery management system, which needs to allow the required performance while delivering the maximum possible lifetime for a given cell.

Progress has been made in this area, with tailored charging profiles to avoid lithium plating, intelligent charge timing to reduce state of charge (SoC), and temperature compensation in operational strategies.

The environmental conditions of each market play an important consideration, and making an electric vehicle suitable to all is indeed a challenge. High temperature regions can cause considerable problems with accelerated battery pack degradation, and low temperature regions can come with reduced performance, and in particular, inability to charge without battery pack damage.

Therefore, we are now seeing more focus for OEMs to increase the AER at the temperature extremes (both hot and cold) through battery thermal



Part of the ABDS suite

management, including the ability to pre-condition the packs to an optimised temperature.

ARE THERE ENOUGH RAW MATERIALS?

Market studies have suggested that quantity of lithium and other battery cell components (particularly cobalt) is a problem, and this could lead to a price increase of these materials with demand. Overall quantity, however, should be sufficient to make lithium-based cells for the medium term, and battery pack chemistries are moving to be less cobalt-based. For the longer term, there are chemistries being developed without lithium (sodium-ion and magnesium-ion).

HOW CAN RANGE BE IMPROVED?

There are obstacles we face when we look at range – driving style, traffic and additional weight produce both positive and negative outputs on battery life. The emphasis on range does present many challenges, one of which is understanding the actual performance and characteristics of the battery cells. Horiba MIRA's new advanced battery development suite (ABDS) allows us to carry out such activities at extremely high resolution and accuracy. With the ability to characterise cell performance, the technical boundaries continue to be pushed and result in more useable energy and consequently EV range. We are also using the ABDS facility to investigate the details of cell ageing mechanisms and how to keep cells within the 'sweet spot' to lower the degradation and increase the durability of these cells. The facility gives us the capacity to exercise modules and packs with up to 1,000V, 1,200A and charge at 600kW.

These capabilities allow us to future-proof the facility for the next five years and verify pack performance and the design of future EVs. As we look at increasing performance and range, other components of a battery, most noticeably cooling, must be developed to ensure that everything runs at the most efficient level. The ABDS facility, climatic wind tunnels and thermal testing equipment provides detailed analysis of battery, powertrain and cabin cooling to ensure maximum gains are made.

WHAT ARE CUSTOMERS ASKING FOR?

What the original equipment manufacturers (OEMs) want is to increase the energy available within EVs. This results in the need for increased battery capacity and energy optimisation.To achieve this, OEMs rely heavily on cell chemistry improvements to aid the energy density or power density of their battery packs. Another option to gain energy is to look at how efficiently the system operates. Our efforts will be to focus on this newer approach by offering OEMs total energy management (TEM) analysis and development.

As the cell chemistry becomes more energy dense, the requirement for greater levels of safety and state-of-the-art cooling systems grow. Furthermore, long term issues such as material sustainability, packaging and recyclability must take centre stage as the industry manages the transition from ICE to hybrid and EV.

Faster charging is also an important demand, and people are moving towards very quick charging, high-voltage packs. The important consideration here is how to do this

A little BMW under test

without causing reduced lifetime through charging specific ageing mechanisms (i.e lithium plating, electrode oxidisation and excessive heat generation).

IS A PERMANENT ONBOARD BATTERY DEFINITELY THE BEST SOLUTION?

The swappable battery pack idea has some benefits, but also has some downsides that would need to be resolved. One issue is that battery packs are far from being standardised across different vehicles, and therefore it could be difficult to find a battery pack of the same design when a replacement is required. There is also the issue of degradation, which could lead to inconsistent performance of a vehicle dependent on the current lifetime stage of the pack being swapped in, and this would be difficult to keep consistent without early retirement of battery packs, and the associated environmental aspects and cost.

Battery packs are also increasingly being incorporated into the physical structure of the vehicle, which makes removing them a difficult task, and it may not be quicker than fast charging.

DO YOU SENSE MORE PLUG-IN EVS OR MORE HYBRIDS IN THE FUTURE?

The industry is moving more heavily to emphasise the battery pack and reduce the influence of the engine, and therefore will gradually move from hybrids to plug-in hybrids and eventually will prioritise full EVs. The reason for this is the movements to make cities zero emission zones, and the trends for emissions decrease, which will eventually lead to emission regulations below what even hybrids can meet. This will be a gradual process however, and in the short to medium term there will still be a place for hybrid vehicles.

Legislation and incentives are really helping push EV vehicles. Particularly around the world with the zero emission zones in cities, and the implementation of much stricter emissions laws, is making EVs (and fuel cells) far more appealing. In addition to this, many countries have openly discussed banning diesels and sometimes all ICE engines in the long-term future, which is also facilitating the development of electrified powertrains.

HOW DO FUEL CELLS FIT INTO ALL THIS?

Fuel cells appear in a lot of automotive roadmaps in the long-term future (post 2030) as part of fuel cell/EV hybrids. The advantage they give is that they help solve the range issues that pure EVs have, and the emissions problems that hybrids have.

They do still however require a lot of development before they can be considered in this way, not least cost. There is also still a fundamental issue of how hydrogen is created, which if from reformed methane is not environmentally sustainable.

It is likely that the use of fuel cells will be on larger, long distance vehicles, with smaller city vehicles remaining electrified due to the shorter-range requirements. •

They can analyse power packs up to 1,000V