Rechargeable Batteries

Given my editorial bemoaning the banning of steam on local boating lakes, I thought it timely to look at current rechargeable battery technology and whether it has any part in riding scale railways.

Those available to us are Lead Acid in its various packages, Nickel Cadmium (NiCad), Nickel Metal Hydride (NiMH) and Lithium Ion type.

Batteries are required for a range of purposes on our railways and not just as traction batteries. I don't include replaceable Alkaline Cells or other primary cells as used in taillights etc.

Even steamers need batteries to raise steam with a blower. We use lead acid; they are reliable and fuss free. The current draw required in use is small and they can be trickle charged after every use. The same goes for the compressor batteries in the ground level rolling stock. However, they will be discharged more in use, which makes it vital they are recharged immediately after use. Whilst one could use NiCad or NiMH batteries, they are more suitable for high current demand over a short period. They don't readily come as 12Volt units and their care in recharging is more demanding.

For IC locos the argument in favour of using lead acid is the same as in your car. They are extremely suitable to provide the high current demand required for starter motors. Car batteries don't like to be left discharged even for short periods, so its vital they are recharged soon after use or are hooked up to a DC generator or Alternator powered by the engine. If not, the so called leisure battery would be more suitable.

Finally we have Traction Batteries. Which are best is open to debate. I believe that deep cycle Gel Cells are the best and most appropriate. They will take deep discharge, deliver a sustainable high current, are spill proof and with the correct charger easy to care for. One major advantage for traction is that they are heavy.

It is in the area of traction that the various types have been developed, having being used initially in portable high tech appliances. The electronics industry has wanted high power, reasonable capacity, small size and light weight ever since the first 'Walkman'. The use of ever smaller personal electronics has driven this technology.

NiCads have powered RC Cars and boats for over 30 years (and cordless drills etc). More recently NiMH batteries have taken the lion's share of sales. The latter are more forgiving of poor charging regimes, give nearly as much current and are similarly priced. The main thing that favours NiMH is they don't suffer from the so called 'memory effect', where if NiCads are recharged without being fully discharged they 'forget' their total capacity.

The use of NiCads or NiMH in our scales would be prohibitively expensive. I've seen best price for power tool battery of 24 Volt 3 Amp Hr capacity NiMH at over £180.

With ever stricter restrictions on noisy Glow Plug and other IC engines in the RC hobby, there has been a move to battery power. The need for RC flight has

been lightweight power. This led the hobby to use Lithium Ion batteries. They are more likely to turn up in cordless power tools these days as well. Below is more detail on these batteries.
Are they suitable for us as traction batteries?
Whatever their benefits and disadvantages, they just aren't heavy enough to help with traction in ride on railways. They will be used in electric cars (full size). Recent research suggests their overall impact on the environment is much less than NiMH and they contain no rare earths. They will become safer and easier to manage, though I'm not sure some of the F1 drivers will agree, having experienced failures and fires in their KERS systems. They are expensive, though their price is getting closer to that of NiMH.
For us though, for the capacities we require they will remain exorbitant in cost, difficult to look after, have an ever present risk of fire and explosion and just aren't robust enough.
Even top quality deep cycle gel cell Sealed Lead Acid batteries are cheap and easy by comparison.

Lithium-ion polymer batteries, polymer lithium ion, or more commonly lithium polymer batteries (abbreviated Li-poly, Li-Pol, LiPo, LIP, PLI or LiP) are rechargeable batteries (secondary cell batteries). Normally batteries are composed of several identical secondary cells in parallel addition to increase the discharge current capability.
This type has technologically evolved from lithium-ion batteries. The primary difference is that the lithium-salt electrolyte is not held in an organic solvent but in a solid polymer composite such as polyethylene oxide or polyacrylonitrile. The advantages of Li-ion polymer over the lithium-ion design include potentially lower cost of manufacture, adaptability to a wide variety of packaging shapes, and ruggedness.
Cells sold today as polymer batteries are pouch cells. Unlike lithium-ion cylindrical cells, which have a rigid metal case, pouch cells have a flexible, foil-type (polymer laminate) case. In cylindrical cells, the rigid case presses the electrodes and the separator onto each other; whereas in polymer cells this external pressure is not required because the electrode sheets and the separator sheets are laminated onto each other.
Since individual pouch cells have no strong metal casing, by themselves they are over 20% lighter than equivalent cylindrical cells. However, all Li-Ion cells expand at high levels of state of charge (SOC); if uncontained, this may result in delamination, and reduction of reliability and cycle life; the case of cylindrical cells provides that containment, while pouch cells, by themselves, are not contained. Therefore, to achieve the rated performance, a battery composed of pouch cells must include an overall, strong, external casing to retain its shape.

The voltage of a Li-poly cell varies from about 2.7 V (discharged) to about 4.23 V (fully charged), and Li-poly cells have to be protected from overcharge by limiting the applied voltage to no more than 4.235 V per cell used in a series combination.

Overcharging a Li-poly battery can cause an explosion or fire. During discharge on load, the load has to be removed as soon as the voltage drops below approximately 3.0 V per cell (used in a series combination), or else the battery will subsequently no longer accept a full charge and may experience problems holding voltage under load. This can be achieved, as with other lithium-ion batteries, also harmed by under- and over-voltage, by circuitry that prevents overcharge and deep discharge.
Li-poly batteries typically require more than an hour for a full charge. Recent design improvements have increased maximum discharge currents from two times to 15 or even 30 times the cell capacity (discharge rate in amperes, cell capacity in ampere-hours). In December 2007 Toshiba announced a new design offering a much faster rate of charge (about 5 minutes to reach 90%).
When compared to the lithium-ion battery, Li-poly has a greater life cycle degradation rate. However, in recent years, manufacturers have been declaring upwards of 500 charge-discharge cycles before the capacity drops to 80%. Another variant of Li-poly cells, the "thin film rechargeable lithium battery", has been shown to provide more than 10,000 cycles.

Applications

A compelling advantage of Li-poly cells is that manufacturers can shape the battery almost however they please, which can be important to mobile phone manufacturers constantly working on smaller, thinner, and lighter phones.
Li-poly batteries are also gaining favour in the world of radio-controlled aircraft and cars, where the advantages of both lower weight and greatly increased run times can be sufficient justification for the price.
However, lithium polymer-specific chargers are required to avoid fire and explosion. Explosions can also occur if the battery is short-circuited, as tremendous current passes through the cell in an instant. Radio-control enthusiasts take special precautions to ensure their battery leads are properly connected and insulated. Furthermore fires can occur if the cell or pack is punctured. Radio-controlled car batteries are often protected by durable plastic cases to prevent puncture. Specially designed electronic motor speed controls are used to prevent excessive discharge and subsequent battery damage. This is achieved using a low voltage cutoff (LVC) setting that is adjusted to maintain cell voltage greater than (typically) 3 V per cell.
Li-poly batteries are also gaining ground in PDAs and laptop computers.

Charging

LiPoly batteries must be charged carefully. The basic process is to charge at constant current until each cell reaches 4.2 V; the charger must then gradually reduce the charge current while holding the cell voltage at 4.2 V until the charge current has dropped to a small percentage of the initial charge rate, at which point the battery is considered 100% charged. Some manufacturers specify 2%, others 3%, but other values are also possible. The difference in achieved capacity is minute.

Balance charging simply means that the charger monitors the voltage of each cell in a pack and varies the charge on a per-cell basis so that all cells are brought to the same voltage.

It is important to note that trickle charging is not acceptable for lithium batteries; Li-ion chemistry cannot accept an overcharge without causing damage to the cell, possibly plating out lithium metal and becoming hazardous. Most manufacturers claim a maximum and minimum voltage of 4.23 and 3.0 volts per cell. Taking any cell outside these limits can reduce the cell's capacity and ability to deliver full rated current.

Most dedicated lithium polymer chargers use a charge timer for safety; this cuts the charge after a predefined time (typically 90 minutes).

Disadvantages

When lithium polymer batteries first emerged in the market, they were expensive. Now that the prices are lower, they are used in a variety of devices from R/C cars to mobile devices. The major risk factor is the volatility. When punctured, Li-Po batteries react quickly by smoking and causing large fires.

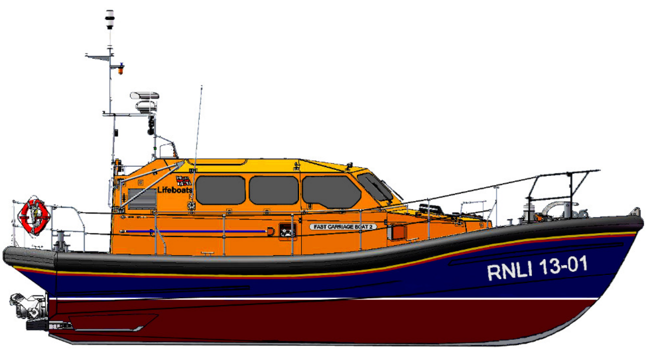
Storage

Unlike certain other types of batteries, lithium polymer batteries can be stored for one or two months without significantly losing charge. However, if storing for long periods, manufacturers recommend discharging the battery to 40% of full charge. In addition, other sources recommend refrigerating (but not freezing) the cell.

News & Letters

From the RNLI

The Royal National Lifeboat Institution (RNLI) has announced that its latest all-weather class of lifeboat will be called the Shannon. It follows in a 45-year tradition of naming the charity’s lifeboats after rivers or stretches of water, but it will be the first time that the name of an Irish river has been used.



Paul Boissier, RNLI Chief Executive, said: ‘I’m delighted to announce that our latest class of lifeboat will be called the Shannon. Current and previous classes of lifeboat carry, or have carried, the names of rivers from Wales, Scotland and