Advanced Battery Formation & Grading: Techniques & Issues

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1. Introduction

Over the past five years or so, the portable electronics industry has seen an incredible increase in demand for production to market, reliability of product, and an expanded feature set. All three of these items point directly toward a massive battery development effort around the world. The first companies that could develop or buy cell technology and get it into mass production to support this boon in original equipment sales would have a strong long term strategic position. Would the equipment suppliers be ready when the time came for mass production?

Of course, the Japanese manufacturers such as Sony and Sanyo answered the question internally by using its own engineering talent and designing an automated process from the very beginning. The initial downside was that it was a large financial cost to do so without a solid marketplace. Now, however, these companies are producing millions of cells per month while the rest of the world is trying to catch up. Today, the Sony sell price is nearly the same as the manufacture cost for most others.

It now becomes the job of the equipment suppliers to help companies narrow the gap, by providing proven technics, safety and reliability at a reasonable cost.

2. Formation Technics

When reviewing the capital expenditure requirements to move a pilot research and development effort to mass production, it becomes quickly obvious that the formation, grading and cell sorting portion of the process will be a significant portion of the overall budget. In fact, it has been stated that as much a 40% of the initial

capital could be invested in equipment such as the Bitrode Model SCF hardware.

It makes sense when considering the process. a hypothetical production line may be feeding the formation area with up to 20 or 30 batteries per minute, but each cell ends up charging or cycling for up to six or eight hours. To produce 35,000 batteries per day(1 million per month approximately) could require up to as many as 15,000 cells position of SCF formation/grading hardware. Depending on the production technique that can be used, the price per position could vary from well below $100.000 per position to nearly $200.00 not considering any automation. These prices can be more than 50% higher if the process is to be automated.

Because of the costs associated with the formation and grading process, it is wise to consider all the various techniques available. Techniques include simple series connected formation, individual cell control of series cells, and individual cell control. These applications are listed from least to most expensive.

With the series formation, there is no control over individual cells. Only the string of cells is monitored and control decisions are made on a group basis. Because of this simple process control, this method is also the most cost effective. For most production needs, it is also an adequate system for the majority of the formation time required when no data acquisition of grading needs to be done.

Once the cells would come off of the formation-only hardware, it might either go to the series or individual cell formation grading designed hardware. With the series control, each individual cell is being monitored with four point contact and can be bypassed when certain voltage limits are reached. This allows the balance of the cells to finish each stop appropriately, while all the time maintaining a high safety level. Because the cells are in series, it is still a less expensive alternative than individual cell control. This is a typical technique used for all types of NiMH production because the low nominal cell voltage

Likwise, the individual cell control is appropriate for lithium cell production, though there are exceptions when considering some lower voltage polymer injected lithium and lithium-metal cells. In any case, this technique does give maximum safety levels of each individual cell on charge over charge, over discharge, and high cell temperature conditions. Along with the increased control flexibility does also come a higher cost.

When discussing specific formation and grading techniques it is recommended that communication between the equipment manufacturer and cell manufacturer focus on safety issues with the battery because that will determine the techniques available. There will certainly be a trade between safety and cost and it will be in the specification process that will define to what level.

3. Grading

Unfortunately, there is no set criterion that advanced cell industry must adhere that defines standard tests and required results to prove a battery is gook of bad. In the lead-acid world, there are governing bodies that define rating systems and parameters that define a quality battery for use in an automobile. golf car, forklift and so forth. As of today, with a few exceptions, there is on test defining a cellular phone performance, camcorder of portable computer. This means that the grading requirements in production of cells vary between manufacturers and devices.

Capacity is always a graded characteristic. Does the process require impedance results? Current degradation times? Interval resistance? Open circuit voltage comparisons over extended periods? Some grading values gave been even more exotic. Make sure that the system chosen for production allows the user to program multiple variables and can correspond various results to a given grade. The system must be flexible of as product and requirements change a system may become obsolete fast. Likewise, make sure that the system gives useful report generation that can be modified used statistically, and archived in some form. With the production numbers needing to be achieved, there will a lot of data available to review and there must be mechanisms in place to sort of it will not be usable.

4. Other Issues

There are many other issues to discuss when considering specification of a formation and grading system for advance battery production. Technique and grading capability gave beenhighlighted as the most obvious and important, but do not discount several other areas of concern. Below are listed additional items that should

be discussed at length with the equipment supplier.

- What is the diversity of the product to be manufactured? If the system only needs to produce 18650 lithium round cells. than tooling is not an issue. However, if the facility is to be for aftermarket product, then tooling for eight of 10cell types could become an expensive proposition-both in time and exchangeable parts.
- What is the plant for product flow form assembly line to pack assembly(of shipping department)? Depending on volume of product, labor rate, numbers of sorted grades, the formation and grading process may require automation and several levels of integrated process control(IPC). There is the need for cost comparison.
- How is contact to the cell made? There are several methods of contact from cell holders, to coaxial pins to paralleled pogo pins. Depending on the target area of the cells, the cleanliness of the contact point and the amount of force requited to make solid contact. on design may be preferable over another. Certainly the coaxial pin design best handles all of the aforementioned situations best.
- How compatible is the software control with networking and multiple level control? Some supervisory personnel may want control or monitoring capability remote from the host PC. Engineers or sales people may want to look at specific details of production. This can be available over a network. In addition, systems can set up only low level control from remote terminals on the production floor, and give only supervisors high level interface.
- How does the equipment protect from cell failure modes? As has been noted with fires at Sony and Matsushita in the past, catastrophic failure is certainly possible but can be avoided. As the equipment manufacturers how each deals with certain situations--over temperature, over voltage, hardware measurement failure. Safely must be a concem and it will become obvious which companies design with this in mind, and which aim for the lowest cost of manufacture. Safety consideration does add cost.
- Lastly, what is ease of maintenance? Are the cell contacts easily accessible to replace, considering the pins will be the number one maintenance item? Was

maintenance considered in the design with sub-assemblies and accessability? Again, it will be obvious which companies understand the issues of high volume production.

To conclude, there are many issues involved is defining a formation and grading system for high volume production. Using a laboratory designed product for volume manufacture is not a solution and requires a specific hardware design that considers cost, safety, and control to fit the environment.

Know the issues, be open in discussions regarding cell performance, and chooses suppliers that have the capability of designing to need. There are the keys to building a volume manufacturing system, and specifically choosing a formation and grading operation.