Journal of Power Sources, *31* (1990) 359 - 362

TOTALLY AUTOMATIC ELEMENT MANUFACTURING PROCESS FOR LEAD/ACID BATTERY FACTORIES

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Introduction

Total automation in the production of lead/acid battery elements requires the following general process steps and the transfer mechanisms that are needed in connection with these steps:

- stacking of plates and separators: enveloping and stacking will become more common in the future
- checking the quality of stacked elements, *i.e.*, number and quality of individual components
- process forming the lead connections: normally cast-on-strap (COS)
- quality checking of assembled elements with lead components and connections, *e.g.*, examine for possible short-circuits
- inserting the accepted elements into battery containers

The need to check the process is, of course, very much dependent on the component quality and the manufacturers' performance requirements. Because the automatic lines tend to be very efficient and highly utilized, the need for good quality control is obvious.

At present, there are efficient stacking and enveloping/stacking machines on the market. These machines, *e.g.*, the enveloping ELBAK machine, which has been described in the preceding paper at this Conference [1], are already adaptable to automatic battery-production lines. The quality of individual battery components, especially the plates, can still cause many problems that can only be handled by proper inspection methods. Depending on the situation, the resulting action could be either stopping the process completely, or transferring the faulty elements automatically to a side line and allowing the process to continue.

The need for inspection after the COS procedure is dependent upon the nature of the process itself and the design of the batteries being produced. Occasional manual monitoring is sufficient if the process and the products are well designed.

Lead/acid battery manufacture has witnessed various developments during recent years. These, and the complicated nature of some of the processes, have inhibited the development of automated strategies so that there are only a few partly-automated machines on the market, and even

0378-7753/90/$3.50

fewer fully automated processes that are tailored to meet the specific needs of a given battery manufacturer.

Cast-on-strap process

Technical description of process

The COS process includes:

- wrap-stacking machine
- conveyor between stacking and COS process
- COS process, complete
- robot for feeding elements into containers
- conveyer for containers

An automatic conveyor connects the wrap-stacking machine and the COS process. During transportation, the element thickness is measured. The allowable tolerances are adjustable, *e.g.*, ± 0.5 to ± 3 mm. If the tolerance requirement is not met, a signal is given and, if required, the process is stopped. Another approach is to use a special conveyor that collects rejected elements from all checking points; this can be delivered as an option. If a properly adjusted ELBAK machine is used with reasonable plates, problems are so rare that it is judicious to stop the machine. If the plate quality varies, or very thin plates are used, this option could be useful.

The COS machine consists of specially made cassettes that convey the elements through the process, the cassette conveyor, and the functional stations. Between the stations, there is room for the accumulation of cassettes. This levels the production flow and leads to a high degree of efficiency. The following sequence of operations takes place:

- feeding and aligning of components
- checking element quality
- feeding the element into the cassette
- aligning the elements and closing the cassette
- inverting the cassette
- bending of outer, and brushing of all lugs
- applying the flux
- preheating the lugs, if thick
- casting of all lead components
- element testing, if required
- inverting the cassette
- opening the cassette
- unloading the cassette and inserting elements into container
- perforating the containers (optional)

Feeding the elements into the cassettes is done automatically; during the feeding action all the element components are aligned. After aligning, the element is checked for different envelope folding errors. If the dimensions of the folded separator pockets differ by more than is allowed, the element is rejected and the following procedure is similar to that described earlier for thick elements. The allowed tolerances are adjustable between +1 and +10 mm.

When all the elements are in place, the plate lugs are aligned to ensure that their location corresponds with the mould cavities. After this, the cassette is closed using an adjustable torque. The cassette is then inverted and the plate lugs brushed to give a clean soldering surface. Both the pressure and time of brushing are adjustable to suit even the processing of calcium plates that have been stored for months.

If there are problems in guiding the outer lugs into the tight mould cavities, the lugs may be bent inwards to achieve a proper fit. The application of flux is carried out automatically. Dripping of flux liquid is eliminated by a proper dosing procedure. If cell construction is critical, either because of restricted use of excess lead or the use of very thick lugs, the lugs may be preheated to assure good quality soldering.

The casting of lead components is activated using a very efficient mould design that results in a cycle of 21 s and high quality soldering. The temperatures of the mould and the lead to be fed are kept constant to within ±5 °C.

Elements may be tested if so required, *e.g.*, for short circuits, polarity, and bad connections. Normally, the process is problem-free so this is not a necessity. If some cells are fed manually from intermediate storage, a polarity check may be required.

Next, the cassette is opened to a dimension that is adjustable and a robot picks up the elements and places them into the container. The robot is specially designed for this purpose and utilizes the best proven technology. Guiding the elements during insertion is so efficient that elements fitting tightly into the container are processed automatically. The robot can operate on a 21 s cycle.

The containers are loaded either automatically or manually onto a special conveyor. This feeds the containers to the robots' handling point. After filling with the elements, the containers are transferred to the assembly line. If the battery design is suitable and the process is controlled, there is minimum requirement for intermediate monitoring of single batteries at this stage. This means that automatic assembly can be achieved. The conveyor is designed so that automatic hole punching in the container partitions can be easily accomplished; the universal punching equipment is optional.

Production capacity and rate

Actual production for the COS process is, of course, dependent upon the total process, the battery design, and the labour force. The material handling and the COS process guarantee a cycle time of 21 s per battery; this performance can be reached easily, even in continuous production up to battery sizes of 88 A h. A cycle time of 17 s is possible if the material handling is modified and the mould design is made to match this requirement. Larger batteries can also be produced: the cycle time for batteries in the range 95 - 125 A h is about 25 s. Still larger batteries are produced at three cells per casting, with a cycle time of about 50 s per battery.

The process is designed to function without problems in an automatic and continuous manner. In spite of the fast cycle, all component and cassette movements in the process are smooth and accurately controlled. This feature leads to a long and trouble-free life with minimum delays in production. More than 95% of production time can be utilized effectively.

Battery type can be changed very rapidly. Any change in element dimensions can be accomplished in less than 5 min. The mould change will take abut 30 min of efficient production time. This could be shortened, if necessary, by using automation in mould handling and preheating.

Safety of process

Because of the high level of automation of the COS process all critical processing parts have been totally enclosed. This design results in less than 0.05 mg m^{-3} lead-in-air values by using only moderate amounts of air. The process is equipped with windows made from laminated glass; these can be opened to allow access to any part of the process. To assure negative air flow when one of these windows is open, a flow volume of about 3000 $m^3 h^{-1}$ is required. This ventilation is sufficient, even when manual insertion of elements under abnormal situations is being undertaken.

The risks due to mechanical movement are avoided by a safety system that stops all critical movements when the windows are opened; this enables manual work to be carried out in the robot area.

Conclusions

The COS process described above solves the following problems commonly associated with battery-element manufacture:

- low productivity
- stoppages due to process failures
- poor quality of lug-to-strap fusion
- slow and difficult changeover from battery type to type
- poor alignment of cell components
- lead in air
- monotonous work
- need for intermediate storage
- component tolerances

Reference

1 A. Schwetz, *J. Power Sources, 31* (1990) 355.