CURING PASTED PLATES FOR LEAD/ACID BATTERIES

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Practices and processes in plate curing

Manufacturers of lead/acid batteries originally cured battery plates by simply stacking the plates on pallets in the plant and allowing them to dry. Varying results were obtained using this method since there was no control of the ambient conditions. Four-to-eight days after pasting, a manufacturer was fortunate if the plates were cured at all, much less dried.

These undesirable conditions were partially overcome by setting aside an area in the manufacturing plant specifically for curing. A room was constructed away from outer walls to minimize the effects of external weather conditions. Wetting the plates during curing also provided better process control. Burlap or canvas was used for this purpose Many areas similar to this still exist in plants today and yield serviceable plates. Other manufacturers have expanded the isolated-room concept by building rooms with heaters, humidification controls, and even some ventilation These parameters are basic to oven design, namely, controlling the atmosphere within an enclosed chamber

Subsequent research has shown that the curing and the drying of lead/acid battery plates can be greatly enhanced and precisely controlled. The process is dependent upon several variables including time, temperature, humidity, energy, and the actual chemical processes taking place.

During curing, the plates of lead/acid batteries undergo a chemical process, involving free lead and oxygen, which is known as the hydroset process. The chemical combination is an exothermic type reaction that requires a water catalyst Studies have shown that the rate of reaction is dependent on the amount of water present in the plates. The data presented in Fig 1 indicate that the rate of reaction is fastest for water contents between 6 and 9 wt.%. If the water content of the paste is outside this range, the capability for the lead and oxygen to react is greatly diminished. The importance of the initial water content prior to curing is very evident if accelerated curing is desired Since the lead/oxygen reaction generates heat, it has a tendency to heat the entire plate, including the water. The water will actually vaporize and migrate to the plate surface and into the surrounding air. As the reaction continues, the water content drops until a point is reached at which the reaction may almost stop. If the atmosphere is humidified, migration of water in the plate to the surrounding air is inhibited, and the water content of the plate is maintained.

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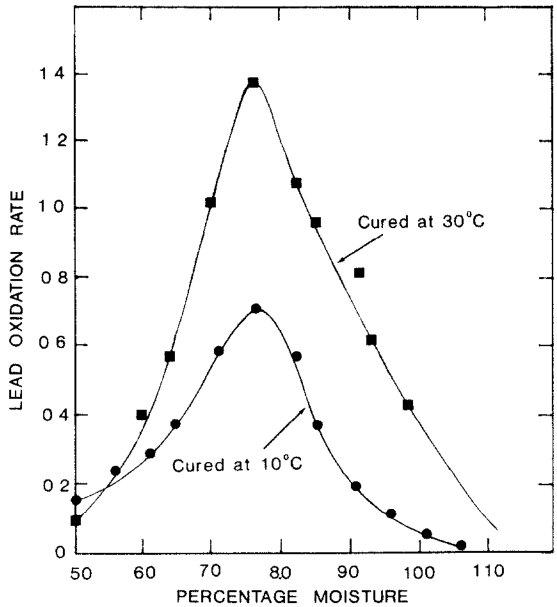

Fig 1 Rate of plate curing as a function of the water content of the plate [1]

A further consideration in the hydroset process is the type of basic lead sulphate compounds desired The specific formation of these compounds is temperature dependent Thus, if a temperature control is included in the curing chamber design, the operating conditions of the equipment can be fixed at their optimum level to achieve satisfactory results in the fastest time

During the curing process, the grid-alloy surface undergoes corrosive attack This results in a strong bond between the grid and the paste, thereby allowing plates to be readily handled without disintegration A further occurrence during curing is the formation of voids within the paste caused by the loss of water. These voids are important for the final porosity and the performance characteristics of the plates If the water is removed from the plates too quickly, then cracks can occur which will result in either rejects or poor performance All these features highlight the importance of controlled humidity and water content.

After the curing process, the plates will still contain about 4 - 6 wt % moisture This moisture can now be removed in the same oven, but again at a controlled rate Ambient air is mixed with recirculated oven air and the resulting moist air is exhausted Water pick-up occurs during air interchange The rate of pick-up depends on the temperature of the chamber and the rate of air interchange The advantages of drying the plates in the same oven are (i) good control, (ii) improved energy efficiency (the plates and the oven are already heated), (iii) one less material-handling step; (iv) better utilization of floor space

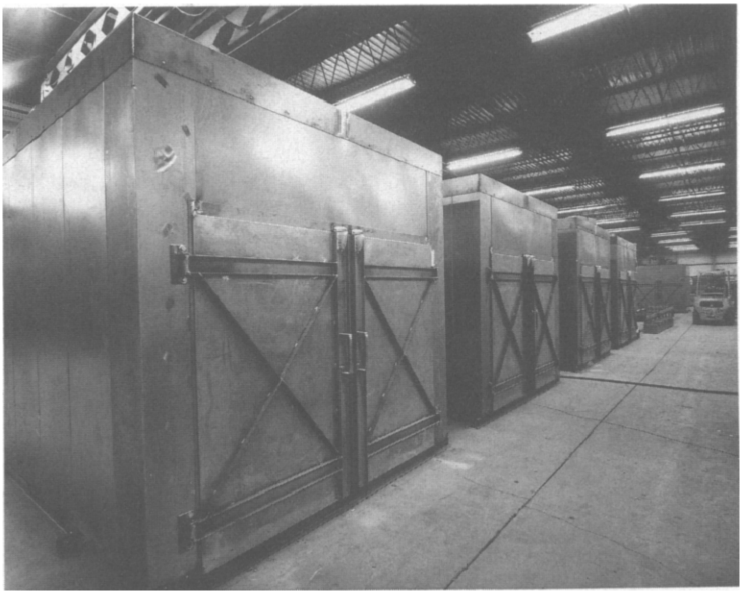

Fig 2 Plate curing chamber developed by Oven Systems Inc

Equipment for plate curing

Many factors must be taken into consideration when designing thermal processing equipment for curing lead/acid battery plates. They include. equipment size, space limitations, performance requirements; available energy inputs

Equipment layout

Equipment size is generally dictated by production requirements. At present, the hydroset process takes place in a batch-type system whereby a shift output of pasted plates is loaded into the oven, when the latter is full, the curing process is commenced, Fig. 2. The most common method of loading involves delivery of pallets to the oven using a fork-lift truck with the pallets stacked one above the other.

Sufficient space must be provided around the pallets to allow for proper circulation of the oven atmosphere. Normally, the stacks near the centre of each pallet will become hotter than those near the edges This results in non-uniform curing. Thus, pallets or racks in the oven should also be given adequate space to allow for proper circulation.

Another important aspect in loading is the protection of the equipment Since a fork-lift truck is not a very precise piece of equipment, occasionally collisions can occur with other racks, the interior walls of the oven, the oven door, etc Consideration should therefore be given to the provision of internal protection such as guard rails or very sturdy racks.

Air circulation

The method and amount of air used in recirculation is of prime importance since (a) the pallets will sometimes completely fill the oven, but at other times will only partially fill it, (b) it is essential that all the plates are processed in the same manner, irrespective of their location in the oven. If air is supplied at one location and picked up at another, then the air will tend to follow the path so defined. For example, if air is introduced at the top and drawn along each side at the bottom, then there will be no circulation near the bottom area If the plates are stacked on pallets, then air circulation will be poor because solid, horizontal dividers are generally used If the air is delivered along the full length and full height of one side of the oven, however, then a more definite flow pattern will develop that will provide more consistent conditions for all the plates, irrespective of their location in the chamber. Under these conditions, the plates can be stacked on pallets or hung in racks

The amount of air is also important since too little, even if properly distributed, may not provide uniformity. Approximately 225 - 280 m^3 min^{-1} is a good guideline for a chamber containing the plates resulting from an 8 h pasting shift

Correctly designed ductwork for even air distribution in equipment of this nature would have adjustable slots or outlets to provide a means of final balancing Sufficient outlet velocities will provide enough ducting back pressure for a balance to be achieved. There must be enough slots to enable the air streaming from them to travel a sufficient distance to average out before striking the first row of pallets If this is not done, this row of pallets could be adversely affected. The opposite wall would be designed similarly. The slots would be adjustable so that fine tuning could be obtained

Fan and heater

The next consideration is the fan location Since floor space is always an important consideration, the logical location for the fan is on the top of the oven

The best position for the heat source, whether it is electric or gas, is on the return side of the fan Measurement of the outlet temperature of the supply duct provides a signal to control the heater Heat is added on demand and the air is thoroughly mixed in the fan and delivered to the supply duct The heaters are now remote from the chamber and their radiant energy will not affect portions of the chamber itself

Humidification

A humidification system is needed As found for the fan and heater, the return-air duct is a good location for this system so that the water, the heat and the recirculation air can be mixed in the fan and delivered uniformly to the supply duct

Humidification can be obtained by using either atomized water or steam A side benefit of the use of atomized water is a flow of oxygen because of the compressed air used for atomization. The oxygen is used up in the chemical reaction taking place. The electric heater will provide heat to supplement the exothermic heat being generated to vaporize the atomized water. Later, in the drying cycle, the heaters are available to provide the heat input required for moisture removal When steam is used, the generator must be of a size sufficient to provide adequate amounts of moist heat. The chamber heater in this case may not be required.

Finally, independent control of both the wet and dry bulb temperatures must be available so that complete flexibility is available.

Other considerations

Curing ovens should be designed and constructed so that leakage does not occur To achieve this, the openings around the doors should be fitted with gaskets to ensure a tight seal. The oven should be matched and sealed to its foundation. The shell should be of unitized construction without holes or leak points Where holes are required, at shafts, for instance, they should be sealed tight using suitable gaskets. Finally, dampers should be tight sealing and yet operable.

Materials for construction are also important. Stainless steel should be considered for long-lasting and corrosion-resistant quality. Aluminum may prove to be a possible alternative depending on the process or plates under manufacture.

Even though the hydroset process is an extremely important step in the manufacture of a battery, steps taken prior to this process, namely, pasting and flash drying, are of equal importance and should not be underestimated.

Conclusions

This paper has covered various aspects of the hydroset process and final drying of battery plates in a controlled chamber Through the use of such chambers, battery makers are obtaining finished plates of consistent quality in 48 h or less, including final drying Added benefits include (i) reduced free-lead in plates, (ii) reduced floor space requirements, (iii) better knitting of paste to grid, (iv) reduced inventories, (v) reduced battery rejects.