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Short communication

Control of vital chemical processes in the preparation of lead-acid battery active materials

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Abstract

Chemical reactions occurring during the processing of positive and negative active material of lead-acid batteries have a significant impact on the performance and life of the product. Understanding and control of these chemical and electrochemical processes will result in batteries which consistently meet vehicle requirements.

Keywords: Batteries; Lead-acid; Process control; Chemical processes

1. Introduction

A casual visitor to a modern automotive lead-acid battery factory is understandably impressed by the multiple lines of high speed automated equipment turning out component parts and assembling and testing intermediate and final product. However, much of the science and technology involved in the manufacture of consistent high performance, long life vehicle batteries is chemical or electrochemical in nature and as such is invisible. In particular, the chemical reactions vital to preparation of positive and negative active material must be understood and controlled. Various process parameters have a profound impact on the composition and crystal structure of active material during oxide manufacturing, paste mixing, plate flash drying, curing and formation.

2. Lead oxide

The basic raw material used in the preparation of lead-acid battery positive and negative active material is lead monoxide—commonly known as “leady litharge”, “grey oxide”, “lead dust” or simply “battery oxide”. The material as produced by the two most common processes—ball mill and Barton pot processes consists of finely divided particles of two polymorphs of PbO (tetragonal and orthorhombic) and 20–30 wt.% metallic lead. The fine particles of unoxidized metallic lead are uniformly dispersed throughout the material and act as the fuel in the subsequent plate curing reactions.

Physical and chemical characteristics of the oxide as determined in the manufacturing process are among the earliest harbingers of the resulting battery’s performance and life.

Oxide produced by the ball mill and Barton pot processes while similar in some regards vary from each other in several key aspects. The origin of the differences can be explained by studying the reactors in which the material is produced.

Observation of the flow diagrams or visiting the actual factories in which ball mill and Barton oxide is produced can be overwhelming. The variety and size of the equipment and control panels as well as the noise and heat in the actual factory can be impressive. The majority of the equipment in such an installation however consists of preparation, classification, storage and transfer devices of a material handling nature. Focus from a process/material control standpoint should be on the reactor—Barton pot or ball mill.

Barton pot (Fig. 1): Ultrapure molten lead is carefully metered by pump or gravity feed valve into the Barton pot reactor. Inside the reactor is a rotating paddle near the reactor bottom. When the molten lead inventory in the pot reaches the level of the paddle, small droplets of lead are splashed up into an airstream which is drawn through the upper portion of the reactor. The airstream is trifunctional (source of oxygen, cooling, conveyance/separation) and therefore requires precise velocity control. The oxide produced is conveyed out of the reactor by the air stream into particle size classifying and separation devices such as upsweep ducts, settling tanks, cyclones and baghouses.

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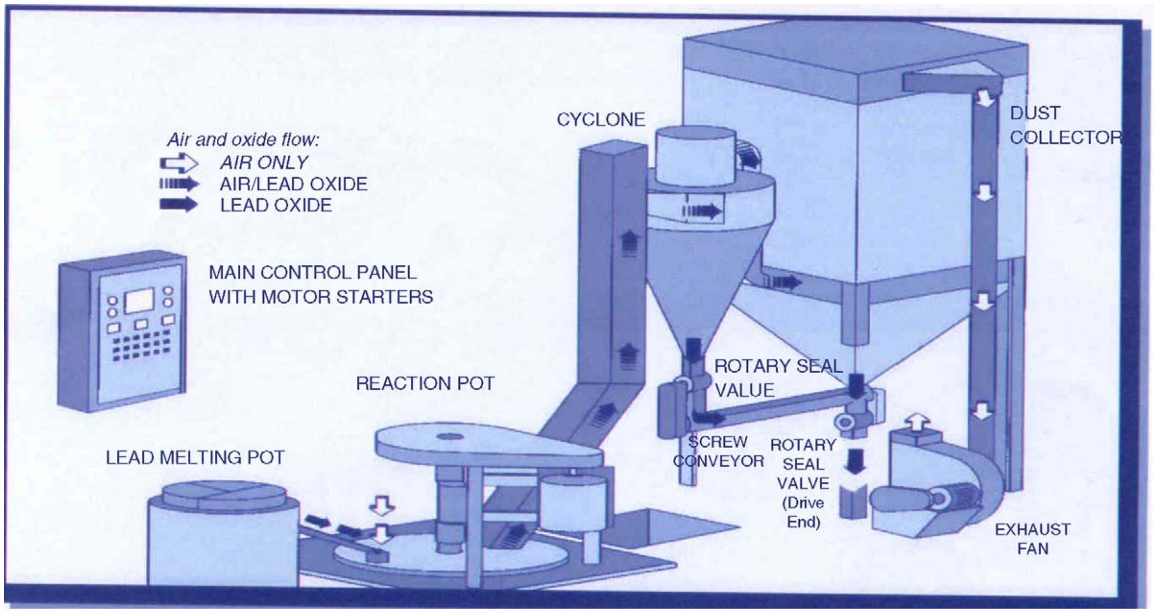

Fig. 1. Barton oxide system. *Source:* Eagle Oxide Services.

Coarse particles are returned to the Barton pot for further size reduction. A secondary grinding process such as a hammer mill is frequently used to enhance uniformly and break up oxide agglomerates. A small stream of water is frequently injected into the reactor to assist in controlling reaction temperature and to promote production of the tetragonal polymorph of PbO.

Ball mill (Fig. 2): Unlike the Barton process, the ball mill process is solid state—the feed stock consists of pieces of lead (pigs, shot, etc.) and the reactor is operated at temperatures below the melting point of lead. In the process, pieces of ultrapure lead are conveyed into a rotating ball mill. The lead pieces serve as both the feed stock for the reaction and the grinding media. Heat is generated by attrition and the exothermic oxidation of the surface of the lead pieces. An airstream, similar to that in the Barton process provides the oxygen, assists in cooling and conveys the appropriate size particles out of the reactor. Product

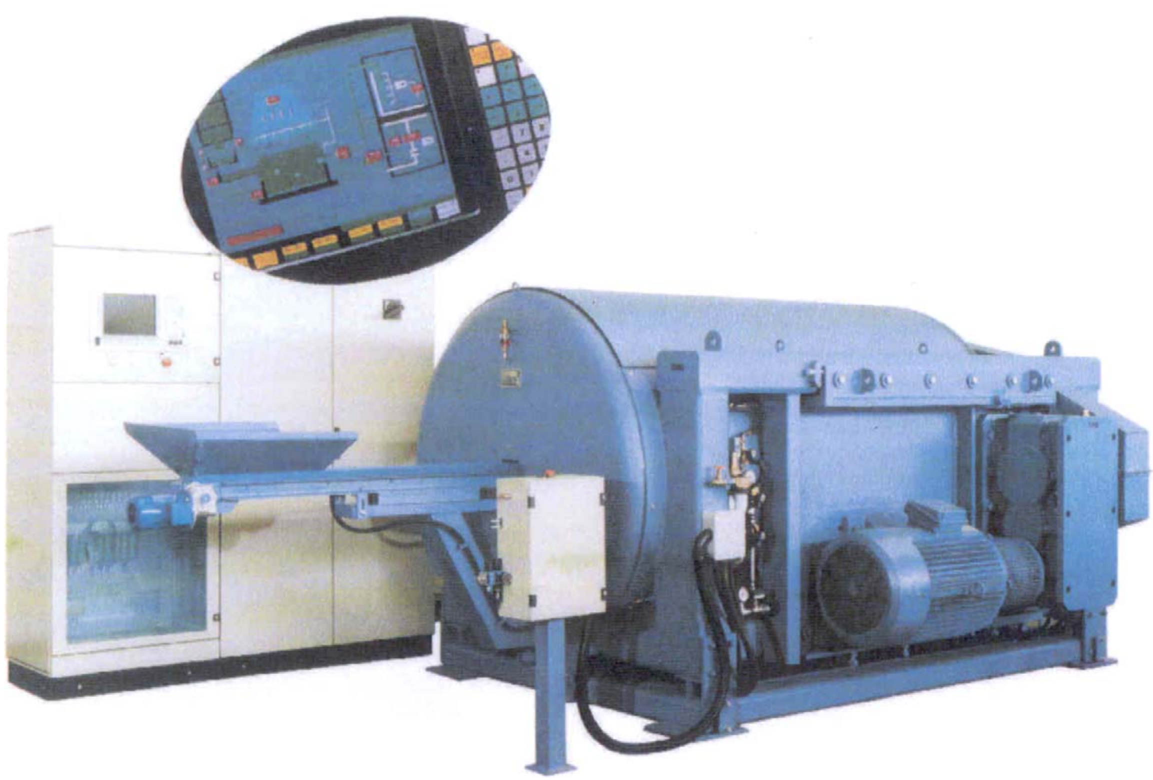

Fig. 2. Ball mill oxide system. *Source:* Sorema USA.