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ENVELOPE-SEPARATOR TECHNOLOGY FOR LEAD/ACID AUTOMOTIVE BATTERIES

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Introduction

The necessity to adapt manufacturing technologies for lead/acid automotive batteries to the standard of modern mass-production resulted in increased efforts at the beginning of the 1970s and paved the way to the development of new manufacturing procedures and separator materials. For example, the usage of various types of separator in the U.S.A. in 1982 and in 1986 is shown in Table 1.

The initiative was taken by an American automobile manufacturer, who attempted to adapt modern manufacturing methods to battery production. In addition to applying state-of-the-art technologies, the company set out to develop a maintenance-free battery. This trend later spread to Europe, where, in response to the new manufacturing philosophy, the production of separator materials commenced in the early 1980s. The market distribution in Western Europe today is given in Table 2. It can be seen that the trend towards enveloping technologies is very strong. However, it is well known that separator materials alone are not responsible for this development. Enveloping itself is a complex process that involves materials, equipment, and support.

Separator materials

What effect has the new technology had on the development of battery separators? The familiar leaf-type separators have been replaced by highly

TABLE 1

North American battery separator market
(Separator consumption percent.)

Separator type	1982 (%)	1986 (%)
Polymeric	33.5	49.1
Glass	25.5	34.5
Cellulose	29.8	13.9
Other	11.2	2.5

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TABLE 2

Western European battery market
(Separator consumption percent.)

Separator type	1982	1986	1990
Polymeric (envelopes)	5.7	20.3	40.0
Leaf type	94.3	79.7	60.0

flexible materials, primarily polyethylene. The industry acquires the latter in roll form (Fig. 1), and the ready availability of this flexible material has led to the development of the envelope separator (Fig. 2). It is, in fact, the development of the envelope that has paved the way for new manufacturing technologies and battery designs while improving the efficiency of automotive battery manufacturing. This latter point is of particular importance, but is often difficult to substantiate.

Separator manufacturing equipment

Separator materials were first developed in isolation. Little, if any, attention was paid to problems involving processing of the materials in

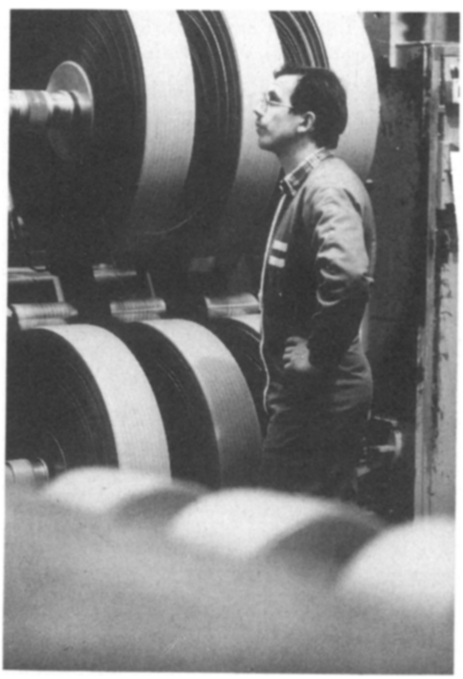
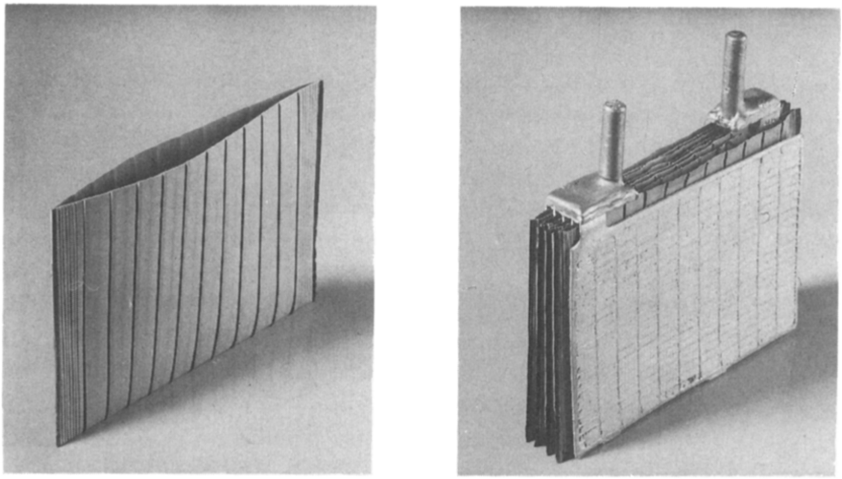


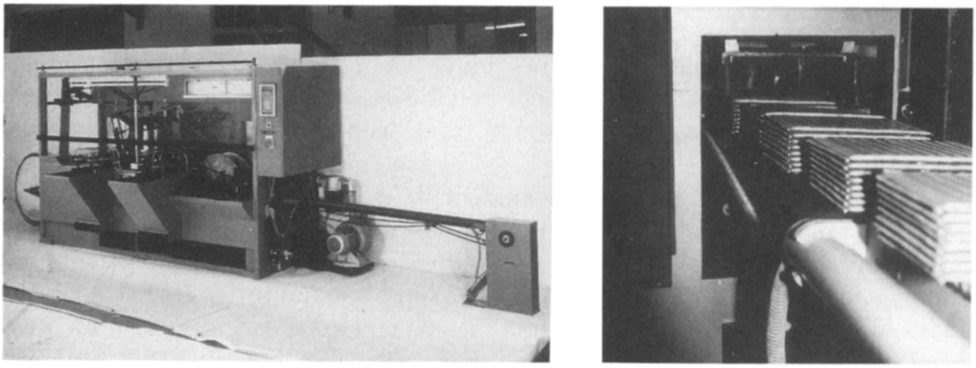
Fig. 1. Separator in roll form in a factory in Sélestat, France.



(a) (b)

Fig. 2. (a) Envelope separator; (b) envelope and plate.

battery assembly. Initially, this was not a major problem in the U.S.A. because battery manufacturers there, who were familiar with the new technology, took it upon themselves to develop the necessary enveloping equipment. However, the situation was different in Europe. There, it was necessary from the outset to develop materials and processing equipment simultaneously, as a total system, before approaching the battery industry. Thus, in the 1980s, the production of separator materials and the development of processing techniques followed a somewhat parallel course in order to meet the special needs and demands of the battery industry. Attention was particularly paid to making improvements in speed, reliability, and precision. The object was to produce enveloping/stacking machines that could match the speed and tempo of modern battery assembly lines. Even today, this objective has not been fully realized.



(a) (b)

Fig. 3. (a) 9-80CE Elbak enveloper; (b) enveloped plates leaving machine.

Present-day machines turn out around 60 envelopes per minute, of reliable quality and quantity, as stacked elements ready for further processing. While this is quite sufficient to keep up with conventional battery manufacturing practice, further streamlining in modern plants is making it difficult to keep pace with ongoing developments in assembly-line speed. In consequence, enveloping equipment has been developed to meet the more stringent requirements. New machines capable of turning out up to 80 envelopes per minute under manufacturing conditions will soon reach the marketplace (Fig. 3). With continued development, machines capable of producing 120, 150, or even 200 envelopes per minute are to be expected, since fully automated assembly-lines that turn out batteries at the rate of one every 8 - 10 s are also imminent. The manufacturers of modern separator materials must be ready to meet these new challenges. They must maintain adequate developmental potential, and be prepared to expand this potential when the need arises.

Technical support

The third major aspect of enveloping technology is the technical support that serves as the link between the battery industry and the separator manufacturing industry. The former industry must be kept up-to-date on major technological changes, such as those surrounding the enveloping process. In Europe, for example, there has been concern over the durability of the new envelopes. Questions have been raised concerning the reliability and life expectancy of a compact, high-voltage-discharge battery employing envelopes.

Table 3 summarizes data obtained in the author's laboratory from battery tests under two DIN specifications. It can be seen that cells with envelopes exhibit no irregularities under the DIN 43 539 life test (see row 7, Table 3). The results clearly demonstrate that enveloping does not have an adverse effect on battery life nor on reliability. On the contrary, there seems to be no risk in utilizing the definite advantages of technology to the manufacture of batteries.

The DIN tests proposed in October 1980, although not formally accepted, are useful in illustrating the quality of battery separators. These tests show that the life expectancy and reliability of batteries with enveloped plates are clearly superior to those built using conventional technology (see row 8, Table 3).

The elements also function extremely well during cold cranking (see row 6, Table 3). The excellent life expectancy is ultimately limited by the corrosion of the grids. Also, the problem of water loss (see row 9, Table 3) in connection with antimony alloys has been satisfactorily solved with the help of technical support efforts that have resulted in advances in polyethylene separators.

Ongoing support from separator manufacturers will ensure further progress throughout the battery industry.

TABLE 3

Technical comparison of automotive battery separators under DIN tests

Row	Parameter	DIN requirements	PVC	Cellulose	Glass	Polyethylene envelope
1	Backweb thickness (mm)		0.3	0.6	0.6	0.25
2	Pore size, average (μm)		15	25	30	0.1
3	Acid displacement (1.3 mm) (ml m^{-2})		200	180	100	150
4	Acid weight loss (%)		0.4	10	2	4
5	Electrical resistance (mΩ cm^2)		25	24	11	11
	(Ω cm^2)		0.16	0.15	0.07	0.07
Battery test results (DIN 43 539) with Pb–2.5 wt.% Sb grids						
6	Voltage (−18 °C, 30 s) (V)	>9.0	9.25	9.25	9.40	9.40
7	Life test (weeks)	$\geqslant 5$	>10	>10	>10	>10
8	Life test (DIN 43 539 E) (weeks)	$\geqslant 5$	5	6	6	>10
9	Water consumption (g $(A\ h)^{-1}$)	<6.0	6	3	6	4

Conclusions

In conclusion, it can be said that enveloping technologies have resulted in a new era in the manufacture of automotive batteries throughout the world. While observations here have been confined to the American and European markets, it should be pointed out that these technologies are also being widely accepted in Australia, Indonesia, Japan, and Korea.

Clearly, the role of the battery separator manufacturer is to continue to develop materials and equipment and to provide ongoing technical support to the battery industry. The technologies developed as a result of these efforts should ensure that the manufacturers of automotive batteries remain at the cutting edge of production technology.