Journal of Power Sources 78 (1999) 65–67

Synthetic fibre reinforcement of absorptive glass-mat separators for valve-regulated lead–acid batteries

R. Simarro

Bernard Dumas, P.O. Box 3, Creysse, 24100 Bergerac, France

Abstract

The contribution of synthetic fibres to the puncture resistance of absorptive glass-mat (AGM) battery separators when they are combined with glass microfibres is presented. Other mechanical characteristics necessary for the automated manufacture of batteries are also improved by the addition of well-chosen synthetic fibres. The selection of these synthetic fibres is of paramount importance given that specific physical parameters such as wicking, porosity or wettability have to be taken into account to design a useful and long-life AGM battery separator.

Keywords: AGM battery separators; Puncture resistance; Synthetic fibres for AGM; Wicking

1. Introduction

When published work on the performance of glass microfibre separators is reviewed, it is noted that four major issues account for the bulk of the discussions and research:

Wicking
Porosity
Compression
Strength

The choice of fibres decides the best balance between the four desired goals.

There is an interrelationship among these characteristics for a given selection of fibres. Thus, a fibre investing an absorptive glass-mat (AGM) with good porosity, with high surface area, a consistent pore distribution and fibre length will also show good wicking. A consistent fibre length will give good compression characteristics, and a good resilience, leading to good overall strength of the separator, both for puncture resistance, and for strain–stress resistance.

This paper covers the process of fibre selection to obtain a strong AGM, but considers at the same time other characteristics necessary for the good performance of the recombination VRLA battery.

2. Choice of glass microfibres

After more than twenty years experience, we have learnt to correlate the diameter of fibres with good performance, and gained knowledge in blending coarse fibres (2–4 μm diameter) with fine fibres (less than 1 μm) to obtain the desired puncture resistance, resilience, wicking and bulk porosity.

Our recent experience is that if we use one 'mono' glass microfibre (coming from a single fiberizing source, with no mixing) showing the appropriate porosity and diameter distribution necessary for good wicking, better results can be obtained in compression–relaxation of the AGM. The fibres are more bulky (less weight per volume) and are easier to compress. For instance, normal blends of fine and coarse fibres can be dry-compressed by 20% when a pressure of 40 kPa is applied, whereas a 30% compression can be obtained for a mono fibre with the same average pore size under the same pressure (Fig. 1).

This difference in compressibility helps the assembly of batteries, for less stress is transmitted to the stack of plates and separators, avoiding the crushing of the AGM prematurely.

The puncture resistance of a mixture of coarse and fine fibres can be improved by adding fine fibre to the blend, but this is an expensive process, and in addition, fine fibres give poor compressibility and more difficult battery filling with acid. It has also been observed that the puncture resistance of an AGM obtained from mono glass microfibres is higher than the one obtained by mixtures of fibres having the same average pore size (Fig. 2).

Apparently, the strength of a matt of fibres coming from a single source derives from the fact that the whole array of fibres, with different diameters, is arranged ran-

0378-7753/99/$ - see front matter
PII: S0378-7753(99)00012-9

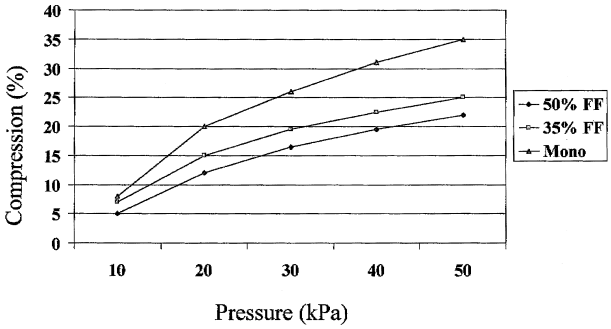

Fig. 1. Compression of AGM as a function of pressure applied and fibre composition.

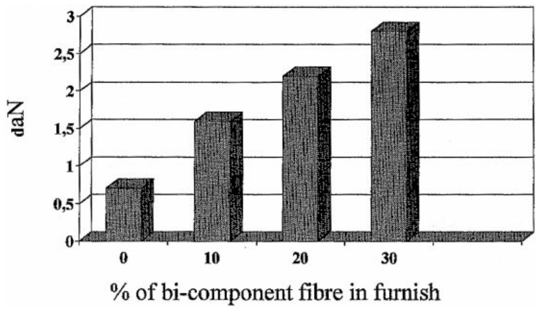

Fig. 3. Improvement of puncture resistance with the addition of bicomponent synthetic fibres.

domly, using to the maximum the number of interconnections of fibres to give maximum tenacity and resilience.

These 'mono' fibres require further development, but they appear to be promising for AGM use.

3. Improvement of strength by synthetic fibres

The characteristic matt strength of AGM can be improved by adding well-selected synthetic fibres that contribute to the interlocking of the glass microfibres, without being detrimental to the porosity, compression or wicking necessary for good performance inside the battery.

The puncture resistance of an AGM separator can be doubled by adding 10% of a selected synthetic fibre, increased threefold by adding 20% of synthetic fibre and fourfold with 30% synthetic. These improvements are significant, and are related to the function of the synthetic fibres used (see Fig. 3).

Bicomponent synthetic fibres composed of a sheath and a core have been developed to give more strength to fibre matts. The chemical nature of the core and the sheath can be different, and in the case where we choose a temperature-resistant core wrapped with a thermoplastic sheath, we can obtain the adhesion of many glass microfibres to these long softened synthetic fibres.

Modern bicomponent fibres tend to comprise a polyester or polypropylene core, with melting temperatures ranging from 140° to 170°C, and a polyester copolymer sheath that melts between 110° and 130°C. These fibres can be mixed easily with glass microfibres to obtain the matts for use as separators.

Attention has to be paid to the selection of the nature of the synthetic fibre in order not to impair the performance of the separator. The wicking capacity of an AGM separator is very sensitive to the amount of synthetic fibre used: for a height of 30 cm, a 100% glass microfibre AGM can wick double the amount of acid after 72 h when filled from the bottom, compared to a 30% synthetic-fibre-containing AGM (see Fig. 4). For reduced separators heights (up to 15 cm) the difference in wicking is about 10%.

In most automated battery-assembly lines, the strength required to be handled in zigzag folding and mounting can be obtained by the use of binding bicomponent fibres, without having a deleterious effect on operations being conducted afterwards.

The integrity of the fibre matt is enhanced, given that the chemical resistance of bicomponent synthetic fibres is better than that of glass microfibres. For glass a maximum loss of 3% in weight following the BCI methods is accepted, whereas for well-selected synthetic fibres the weight loss is under 1%. This means that compression, and integrity of the AGM separator survive longer time with fibres than without.

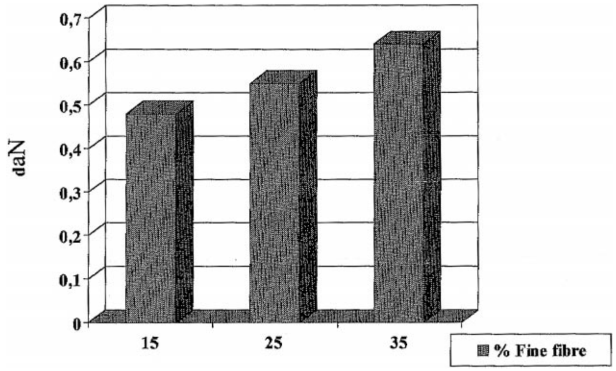

Fig. 2. Puncture resistance for different fibre blends (100% glass microfibres).

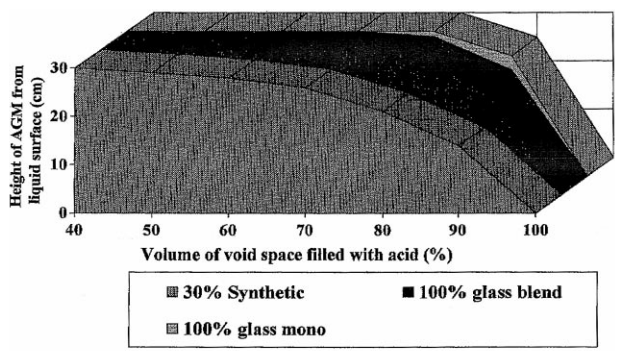

Fig. 4. Wicking profile: effect of synthetic fibre on the pattern of acid absorption.

The resilience of AGM-containing bicomponent synthetic fibres is better than one with 100% glass. When we substitute 30% of coarse fibre by synthetic, the matt can be compressed some 20% more for a given compression pressure (50 kPa), and both are recovered in the same way.

4. Conclusion

One ‘mono’ glass microfibre has proven to give better characteristics than mixtures of glass microfibres, both in strength and the functionality required inside the battery. This type of fibre requires further development, involving both AGM and glass microfibre producers in the development process.

The strength required nowadays for an AGM can be achieved by using bicomponent synthetic fibres mixed with glass microfibres. These find application in typical VRLA batteries or in new designs requiring a given porosity, wicking, compression and strength beyond what can be obtained from glass microfibres, but retaining their favourable features.