Manufacturing technology

Waterproof shoes the Sympatex way

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Some five years ago, developments and applications of the air-permeable but waterproof Sympatex membrane – previously used only in garments – were increasingly focused on footwear. Since then, the membrane has found its way into the complete range of footwear, from children's, trekking and city shoes, to boots and safety footwear. Besides, a wide variety of raw materials such as leather, textile uppers, natural linings and synthetics, are now in use. If these variables are combined with the present different types of footwear manufacturing techniques, it can be seen that the quality requirements for an ideal shoe are complex and exacting. This article looks at some of the recent technological developments and the related quality criteria.

Technological developments

Membranes have an ideal range of properties for incorporation in footwear. Of prime importance is the extremely high stretchability (> 300 percent), combined with very high strength and a relatively high melting point (220 °C), which facilitates manufacture by lasting without any risk of damage, and making it unnecessary to fit the membrane as a sock. Another advantage of the membrane is that it has no pores to become clogged during use or cause leaks. Another not unimportant feature is the raw polyester material from which it is made, which has a sound ecological reputation.

So what does a consumer expect when buying Sympatex shoes? Market surveys have shown that, leaving aside such criteria as fashion appeal and price, consumers now attach distinctly greater importance to waterproofing than to respiration. However, the latter two criteria are right at the top of the list of priorities. Here, we will look in particular at waterproofing, which is closely linked with respiration and the following factors influencing the transmission of moisture vapour:

- specification of the membrane laminate properties (bonding of Sympatex membrane to textile lining or upper material)
- distribution of glue dots
- moisture transmission by textile or leather component
- nature of open pore
- water repellent finishing treatment applied to upper material (using fluorinated resin)
- secondary constructional elements – use of perforated caps, shoe shape, use of comfort lining fabrics, etc.

The development of waterproof footwear requires the following steps:

1. designing the shoe,
2. selecting the materials and
3. the appropriate processing technology

During these processes quality must be kept constantly in mind, seeking to minimise water transmission through the upper material. Any residual water transmitted (still not ac-

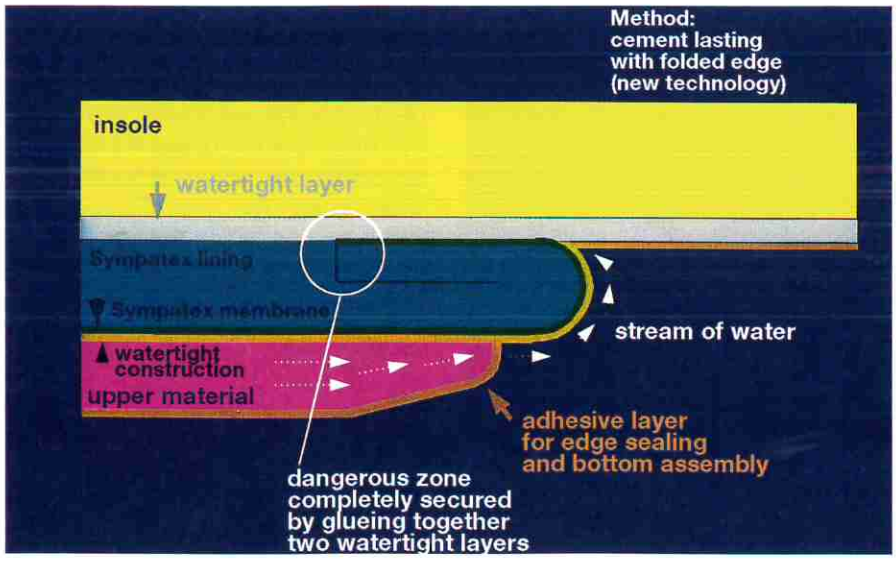

Fig. 1: Construction for cement-lasted shoes

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ceptable from the consumer's point of view) must be eliminated by the design of the sole area.

1.Designing the shoe

There are both advantages and disadvantages in the use of laminate sock membranes. The disadvantages include:
1. creasing, impairing both quality and appearance
2. problems associated with sealing complex lining seams
3. higher material costs (laminate, sealing tape, adhesive)
4. higher manufacturing costs
5. problems in fixing the sock to the shoe or fastening it to the upper; this may lead to abrasion and reduce comfort

As mentioned earlier, an open membrane can be incorporated into the shoe with perfectly sealed bottom edges, and clearly this is the best way to overcome the problems. In addition, seams should always be plain and straight. It is clear that irrespective of whether the design uses a sock, or open incorporation into the bottom, seam sealing will always be a critical quality aspect. The design must maximise certainty when tape sealing the lining seams. In principle, the Sympatex design concept is also used for moccasins and styles incorporating sole seams.

Material requirements

A major criterion is that the material selected must minimise water permeation. Upper leather material, for instance, must take up not more than 35 percent of water during seven hours in the Bally Penetrometer. On the other hand, the open pore leather respiration characteristics must be preserved. This can be achieved by means of a water repellent vat finishing process using special fluorinated resins such as are available from 3M. Foam interlinings must be reticular (i.e. have open pores). The water repellent properties must also be supported to the maximum extent by the choice of other components such as sewing yarn, interlining, decorative elements and insoles.

Processing technologies

Specific Sympatex requirements must be met for processing the upper and the bottom parts. When processing the upper it is first necessary to gain experience in the difficult operation of seam sealing. As mentioned above, proper materials processing and the right design concept are closely linked. Optimum lining seams are narrower than 5 mm, the minimum stitch spaces being 4 mm. The remaining yarn ends must be cut off to avoid any capillary effect. These seam requirements have been established to ensure perfect watertightness after sealing with tape. Tape sealing is done with seam sealing tapes specially approved for Sympatex.

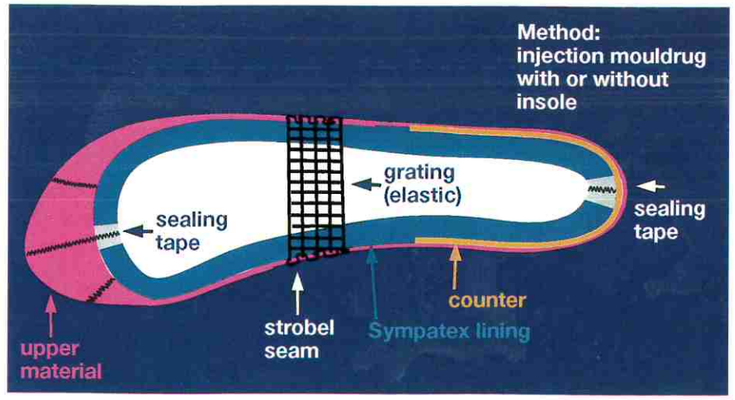

Fig. 2: Construction for shoes with injection-moulded shoes

When sealing the tape, it is important to avoid creasing (also in the sealing tape), and ensure optimum energy transfer from the hot air to the place to be sealed, without burning or fusing the material. Interlinings (e.g. foam) are incorporated in such a way that they are broken off where the prefabricated sole starts. Fitting places for eyelets and hooks are covered by a material protecting the membrane from damage, which improves waterproofing.

For obvious reasons, only the inturned portion of the upper material may be completely covered with adhesive, since otherwise the respiration would be affected. When processing the sole, we make use of the high strechability of the membrane during the lasting process, but space does not allow for a full description here. A qualitative breakthrough has been achieved with the new sole processing technologies described below (Patents applied for).

Cemented sole process

This cement lasting method involves bevelling the edges of the inturned portion of upper material for approx. 12 -15 mm and folding them back to eliminate the capillary effect of the water (Diag. 1). Folding back is not necessary in the toe and heel areas because the loads occurring at these places are only of a static nature. This technology is also used in the Flex and Goodyear designs.

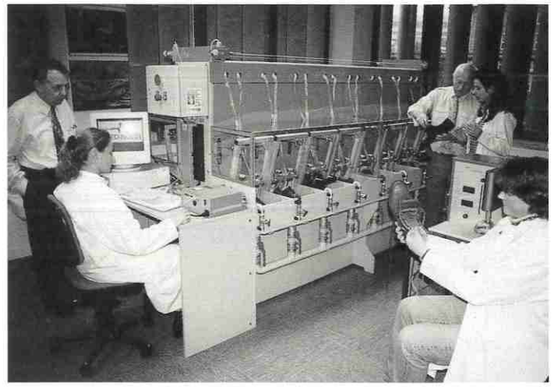

Fig. 3: This walking simulator simultaneously tests 32 pairs of shoes, arranged in parallel. Any water leaks in the sole area are identified using electronic moisture sensors, and plotted against time on the monitor indicating their exact location

Injected sole process

The partially pre-shaped Sympatex lining upper is joined directly to the sole material, with or without an insole, by injection to form a perfect fit (Diag. 2). Further aspects of this technology depend upon the precise injection conditions. It is self-evident that when insoles are used with this technology – in contrast with the 'material requirements' general specifications – there must be good form fit adhesion to the injection compound.

Conclusions

There are a number of important quality aspects influencing the manufacture of Sympatex footwear, which necessitated the development of specially optimised technologies. Obviously, high quality shoes cannot be made without the appropriate manufacturing technology, but of itself, this is insufficient; the QA system is of equal importance. New prototypes (laminates and shoes) are approved in principle by the technical marketing department. We also make regular retail purchases samples for testing. We have also developed a walking simulator (Diag. 3) which can simultaneously test 32 pairs of shoes.

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