

Footwear materials need to be tested for a variety of reasons; for instance soles need to grip the floor with sufficient friction.

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Selecting the correct materials

STEVE ROSE, SATRA

When designing new ranges of footwear, consideration needs to be given as to which types of upper and soling materials would be most suitable. But what factors need to be considered? Let us start with upper materials. The prime function of a footwear upper material is to protect, support and contain that which it surrounds. However, it must first be fashioned into the shape of the foot (normally in combination with a soling material) and be durable and stable. Desirable attributes include aesthetic appeal to the wearer as well as comfort and hygiene properties.

The essential properties of upper materials are:

Available in sheet form

Economical

Flexible and conformable

Resistant to manufacturing processes

Able to be cut, punched, stitched, roughed, adhered, cleaned and repaired

Resistant to ageing, damage and breakdown in wear

Other desirable properties are:

Available in a range of colours and textures

Sweat management for comfort

Water resistance

To be able to perform during shoemaking, it must be possible to cut the sheet material into the upper sections quickly and easily, with as little wear on the cutting tools as possible. The material should also preferably not suffer any unsightly edge effects after cutting. It must be able to be stitched, perforated and adhered to a range of other footwear

materials. These processes must also not cause any significant changes, damage or deterioration of the material itself. However, due to the wide range of stitching and cementing options available to shoemakers, it is unlikely that most sheet materials cannot be effectively stitched or adhered to other materials.

Many shoemaking operations involve heat, steam, stretching, pressure and other factors which can cause many problems including colour and dimensional change, weakening, cracking, melting, peeling, blistering and even complete breakdown (tearing, bursting or holing). While complete breakdown might not be common, minor damage can be and this can be most dangerous when undetected during shoemaking as the upper may break down when the shoe is in service and will then result in an unhappy or even injured customer.



Upper materials should be assessed for resistance to tearing.



Testing for grain crack can avoid problems at toe lasting.

New materials must therefore be thoroughly evaluated in advance (by laboratory testing and any other suitable means) to predict shoemaking behaviour and to identify any shoemaking vulnerabilities so that these can be highlighted on the making tickets. If possible, modified operations can be applied to the material to minimise, if not entirely prevent, the detrimental effects. However, it may not always be possible to prevent or reduce damage to the materials without compromising effective shoemaking operations. In these cases alternative operations may have to be considered (for example, by using different shoemaking constructions) if the material is to be used at all.

STRENGTH

One of the most common types of failure in shoemaking is due to lack of strength. Tearing, splitting and bursting may occur at many stages of shoemaking and in many instances these failures may be reduced or eliminated by reinforcing the material. However, it is critical that any reinforcements are correctly positioned and securely attached.

With respect to adhesive bonds, strengths both before and after ageing need to be tested as adhesives can initially perform well only to deteriorate in storage or in wear. The ageing treatments must correspond

both to the expected service environment (temperature and humidity) and also to the expected service lifetime.

The cost of the material needs to be considered both as regards the initial price and also with add-on costs (for example, if a backer needs to be applied). Having said that, the material and footwear must of course perform to customers' expectations or refunds and perhaps loss of future sales will be the true cost.

DURABILITY

Perhaps the most important functional requirement of an upper material is its ability to withstand service conditions over a reasonable time span. This time span will depend on the type of footwear, the wear environment, the market segment and the cost. Wearers will take these factors and others into account when determining whether the lifetime of their footwear is satisfactory or not. Shoe designers may concentrate on the visual appeal of the footwear at the point of sale, not after a period of wear, and this can cause significant problems for the manufacturer, even if processing shortcomings can be overcome.

Subject to adequate strength characteristics, the two most important factors when considering durability of uppers are resistance to flexing and abrasion damage.

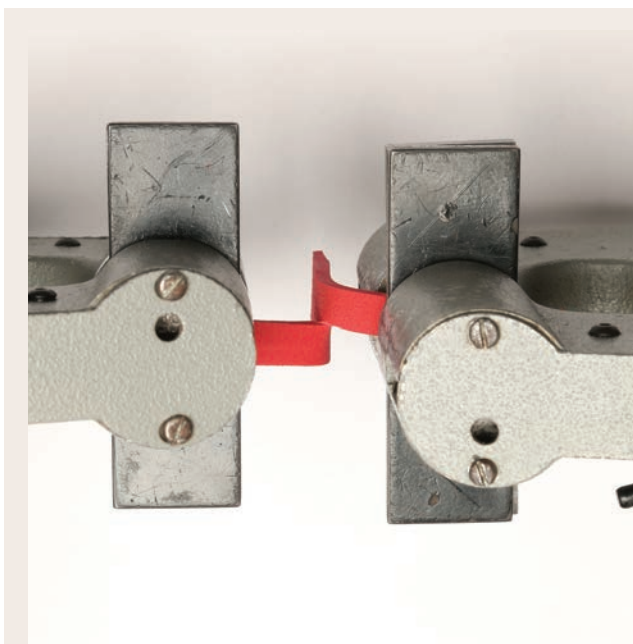
Although, it is within the shoemakers' ability to improve the strength of materials, it is much more difficult for them to improve these durability factors as these are controlled principally by the nature and construction of the materials themselves.

The durability of the aesthetics also needs to be considered. Is the upper prone to soiling and can it be easily cleaned should this occur? Many materials, particularly lighter-coloured absorbent materials, can be detrimentally affected by the soiling associated with everyday wear, particularly water-borne contaminants.

COMFORT

Many styles of footwear are constructed with more than just visual appeal in mind. Many brands extol the comfort properties of their products and the correct choice of upper material is essential in promoting these properties. This can apply to the look of the upper as much as the actual comfort properties; many consumers have preconceived ideas as to what the upper in a 'comfort' shoe should look like in terms of both styling and the materials themselves.

Of course the primary feature of any shoe affecting comfort is fit and this cannot be left to the upper material alone. However, given correct last sizes for the footwear range, the upper needs to have good shaping properties



Soling materials also need testing for tear strength.



A sole flex test will identify any risk of cracking in wear.

to closely match the last size and shape, and also be able to set permanently into the final shape.

After fit, the most important physical property pertaining to foot comfort that the upper can possess is that of moisture permeability and absorption. Good absorption will keep the foot and hose dry in the short to medium term and good permeability will ensure this continues into the longer term. A dry foot is normally a more comfortable foot. Sweat also removes excess heat from the feet and good permeability can help to regulate foot temperature. However, upper materials can also have increased or reduced thermal conductivity properties which can contribute more to keeping the feet warm in colder environments or cool in warmer conditions.

Even in footwear not sold principally for its comfort attributes, a higher level of perceived comfort than expected will enhance future sales of such footwear provided the more important properties demanded by the wearer are also satisfied. For instance, water resistance is another property which can enhance future sales, certainly in everyday and casual footwear where water resistance is not essential to its normal function.

SOLING MATERIALS

Soling materials must be safe and fit for purpose. But how to choose between those established types

available to the shoemaker and how to evaluate completely novel materials? There are around a dozen basic types of sole material in established use around the world.

Over the years, these materials have tended to occupy particular niches in the footwear market based on their form and attributes. Sometimes the main barrier to materials being used more widely is a psychological one, perhaps based on perceived customer expectations. These must be taken into account as well as technical suitability. Footwear design is arguably at least as much about aesthetic appeal as about technical function and these aesthetics come from appearance, feel, texture, weight, softness/hardness and even smell.

Most soles have to fulfil the same basic set of needs which are to insulate the foot from the ground, grip the floor with sufficient friction, be able to flex repeatedly without splitting or cracking, be durable and to maintain secure attachment to the upper. Then there are special or optional properties that may be required for particular purposes such as sports or industrial footwear. These attributes include shock absorption, electrical conductivity, washability, floor marking resistance and lightness in weight.

The footwear construction method chosen and the facilities or techniques available to the particular shoe factory

will be critical to the choice of sole. The main types of construction applicable to solings are direct moulding, stuck-on, stitched-on and autoclaved.

DIRECT MOULDING AND AUTOCLAVING

Direct moulding forms and attaches the sole in the same process. This requires the shoe factory to have the moulding machinery and suitable moulds, involving considerable capital investment. Vulcanised rubber is 'compression moulded' at high pressure into hot moulds. Using a different process, PVC and TR (thermoplastic rubber), having been melted with heat, are injection moulded into cool moulds. In the direct moulding process TR will not adhere well or easily to some upper materials such as leather. PU direct moulding also requires dedicated machinery, having to process two reactive liquids, metering and mixing them in precise quantities before pouring or injecting into a mould which is sealed to the upper.

Direct vulcanisation of rubber is successful to leather or textile but can tend to yield a rather heavy utilitarian type of product, although sponge rubber can be included as a midsole to save weight. PVC direct moulds well to a wider range of upper materials but again results in a heavy product. The process is nevertheless quite widely

practised and can produce low cost footwear. PU (reaction-moulded) is arguably the best sole material for direct moulded soles as it adheres very well to most uppers. It can be either an outsole on its own or a midsole in a dual density soling with a choice of outsole materials, to which it will also adhere well. It is lightweight, flexible and comfortable underfoot, features which are well understood by brands supplying to mature customers who value these attributes. The other main mouldable lightweight solings, EVA and microcellular rubber, cannot be direct moulded as they expand significantly as soon as the mould is opened.

Vulcanised rubber can also be employed in hand-built footwear where the sole components are assembled before the rubber is vulcanised, this being achieved in a large pressurised steam-heated 'autoclave' chamber. Prime examples are wellington boots and canvas shoes. The heat cures the rubber and fuses the various parts together, where they have been overlaid using vulcanising adhesives and consolidated by hand-roller. This process pre-dates injection moulded soles but is perpetuated to this day by many iconic brands and looks set to continue. It is perhaps a good example

of a traditional footwear product which is well-liked by the shoe and boot buying public and therefore endures in the face of more modern technologies.

STUCK ON UNITS

Virtually all sole materials may be pre-formed into units for adhesive attachment to the upper. Sheet materials will be die-cut to shape and size, mouldable materials will be individually formed. Caster units are moulded over-sized and subsequently trimmed to shape, perhaps after sole attachment. Advantages of using pre-formed sole units, apart from the shoe factory being able to buy them in from outside on demand, are that they have a good neat appearance and their insides can be cored out to save material (weight and cost) and to enhance flexibility. The sole bonding process is broadly similar regardless of the material combinations being united; the main differences lie in the preparation techniques used on the two surfaces and the adhesives and bonding conditions involved.

STITCHED-ON SOLES

Long before the above mentioned processes, soles were attached by stitching and many still are today, partly to provide a particular aesthetic and partly because stitching is the principal basis of some very popular shoe constructions. Firm materials such as sole leather and the harder grades of vulcanised rubber are very good at holding the stitching in place. These are the favoured sole materials for the Goodyear welted construction not only for their technical suitability; they are also seen as high grade soling materials fully appropriate to the type of footwear such as the gentleman's classic dress shoe which is most associated with this construction.

In the veldtschoen or stitchdown construction, again almost any type of sole material may be cemented to the runner after this has been stitched to the upper but most probably a moulded unit with an integral heel will be used. An important variation of the veldtschoen is the corner-stitched sole, incorporating a moulded lip so that it can be stitched on rather than cemented to a runner. Reaction

moulded PU is an excellent choice for this, being capable of being moulded with the necessary lip and even with the stitch holes already in place.

The machine sewn construction, as used for moccasins, puts a stitch through the outsole directly to the inside of the shoe, through any insole that is present, as well as the upper material. For moccasins and flat lasted shoes there is perhaps not so much customer expectation for leather or vulcanised rubber sole and so a wider choice of materials is available. In general, compact (solid) materials should be used as microcellular materials (which are softer) may not grip the stitching adequately and may also compress at the seam due to the thread tension. There is also more risk of tearing between adjacent stitch holes. In sidewall stitched soles the material is likely to be softer for reasons of sidewall flexibility. The solid mouldable sole materials are all suitable with TR being a well justified common choice, particularly in modestly-priced footwear.

The turnshoe construction, as used

for ballet shoes with soft leather soles, can also be used with polymeric sole materials provided these are flexible enough to allow the shoe (which is inside out when the sole is stitched on) to subsequently be turned right side out. Soft PVC is an excellent choice for this type of sole as it has both strength and flexibility in soft grades. It also has good mouldability for the thin stitching lip required. TR is similarly mouldable but is a less supple material.

COST

The cost of solings depends on processing and tooling costs as well as that of the raw material, its density, the necessary sole thickness and the labour and other machinery demands of the particular shoe construction. Leather is seen as an expensive material, as is TPU. Sheet materials other than leather (mainly resin rubber, microcellular rubber, EVA and vulcanised rubber) save cost by not needing individual sole moulds. Autoclaved vulcanised footwear yields many shoes per curing cycle. PVC and TR are mainly seen as economical

materials despite the mould tooling costs needed for unit sole production.

Vulcanised rubber and PU units are generally more expensive (a combination of material costs and tooling costs associated with moulding cycle times) but direct moulding (e.g. of PU) saves the adhesion operation once the tooling is paid for. Based on the number of low-cost court shoes carrying PVC soles rather than resin rubber or leather, PVC would seem to be very price competitive at present. Often, of course, the higher cost of superior materials is well worth paying and can be recouped in the higher selling price of premium products sold on quality, performance, aesthetics or brand.

Discerning customers willing to invest in durable quality will look at the sole so it is worth matching the quality of this to the upper and the general standard of shoe build. In the right market place there is nothing necessarily wrong with modest quality in the high-turnover single-season fashion market which is very price competitive. 🌀