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(54) Title: DEFORMABLE MATERIALS AND STRUCTURES COMPRISING THE SAME (57) Abstract A mixture of visco-elastic polymeric material having a viscosity in the range of 1×10^5 to 1×10^7 Poise and a particulate filler is used, in particular, in shoe structures to conform to the shape of the underfoot and provide increased comfort.		

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DEFORMABLE MATERIALS AND STRUCTURES COMPRISING THE SAME
Field of the Invention

The present invention relates to deformable materials, and in particular to structures comprising such materials which are for insertion into shoes to provide increased comfort for the wearer.

Background of the Invention

It is known in the art of shoe manufacture that appreciable moulding of underfoot shoe structures in contact with the forefoot to the shape of the forefoot leads to increased comfort during shoe wear. Traditionally a 6 to 10 mm deep layer comprising cork particles in a solvent-loaded rubber has been deposited during shoe manufacture between a leather-based insole and the outsole of a shoe. However underfoot structures comprising such cork/rubber layers take from days to weeks of wear of the shoe to conform to the underfoot contours of the forefoot and thereby give increased comfort.

Further disadvantages of these cork/rubber layers include the possibility of their attacking adhesive bonds within the shoe structure, and also that the combined depth of the leather insole and cork/rubber layer restricts the latter's application to shoes of a traditional welted construction.

GB-A-2058545 discloses a shoe insert to support the toes and prevent the foot sliding forward when wearing, for instance, ladies' court shoes. The insert comprises a sandwich having an intermediate layer of a rubber or a foamed plastics material in the form of a wedge. The wedge is positioned to fit under the metatarsal region of the foot.

A deforming insole is described in US-A-4977691 for athletics shoes. The insole comprises a visco-elastic material which deforms on the application of force, but that has sufficient elasticity to resume its original shape upon removal of the force. The disclosure is concerned

with shock absorption by an elastic deformation of the insole.

It would be desirable to provide a material which will undergo a progressive, non-returnable, or plastic, deformation, in particular to match the underfoot shape, in a period of time to provide the wearer with increased comfort throughout the maximum life of a shoe. It would also be desirable to provide an underfoot structure comprising such a material which does not undergo significant plastic deformation immediately a shoe is worn, so allowing it to be tried on by a number of people intermittently before purchase without any significant permanent deformation to the contours of any one person's foot.

15 Summary of the Invention

According to the invention, a mixture comprises a visco-elastic material having a viscosity in the range of 1×10^5 to 1×10^7 Poise and a particulate filler. Such a mixture can be provided as a pad in the sole of a shoe, to support the metatarsal/toe crest area of the foot. For example, in one aspect of the invention, an insole comprises a well in its front part and, contained within the well, the above-defined mixture.

Description of Invention

25 The visco-elastic material is of a viscosity such that it is capable of plastic flow at the temperatures normally found under the foot when wearing shoes, i.e. around 30 to 35°C. The viscosity of the visco-elastic material is in the range of 1×10^5 to 1×10^7 Poise, preferably 1×10^5 to 5×10^6 Poise. Viscosity is calculated by use of a shear creep test on the undiluted material at 20°C using a Rheometrics Stress Rheometer RSR and an applied shear stress of 100 Pa until steady state constant shear rate is achieved. The time for such steady state to be achieved is usually around 1 to 2 hours.

The visco-elastic material should have chemical properties and a volume that are substantially unaffected

by water. Suitable visco-elastic materials are polymers, such as polyisobutenes, polymeric phthalate esters, uncured elastomeric polymers plasticised with high molecular weight polymeric plasticisers, tackifier resins, silicone and borosilicone putties, high molecular weight polyol resins and low molecular weight uncured nitrile rubbers. Preferred materials are polyisobutenes, particularly Oppanol B10, B12, B15 and B50 and mixtures thereof, made by BASF (Oppanol is a registered Trade Mark). Mixtures of the Oppanol B products allow fine tuning of the time taken for the material to respond to the application of pressure by deforming (such a time is called the response time).

Materials having similar visco-elastic properties to polyisobutene, in particular plastic flow under load, are suitable for use in the invention.

The molecular weight of the visco-elastic material is chosen such that the requisite viscosity properties are obtained. The range of molecular weights of any particular visco-elastic material should be narrow, and there should be substantially no low molecular weight species, as these may be capable of migrating from the mixture and into the shoe structure.

The visco-elastic material is mixed with a particulate filler material. The filler aids in the provision of elastic cushioning under foot, and in the minimisation of slump or flow of the visco-elastic material under conditions where no external load is applied. Suitable fillers include cork granules, rubber particles, rubber microballoons and vermiculite. Preferred fillers, in particular for minimisation of slump, have non-spherical particles, such as cork granules and vermiculite. The filler usually has a density in the range of 10 to 1000, preferably 10 to 100, kg/m^3 . The filler's density is usually less than that of the visco-elastic material; lower density minimises slumping.

Typically, the particulate filler has a particle size of from 0.5 to 2 mm, preferably 0.5 to 1.5 mm, or even

smaller, e.g. as formed by grinding cork granules. Ideally, the filler should not occupy more than 70% by volume of mixture, and preferably the amount of filler is in the range from 35 to 60% by volume. The reason for
5 minimising the filler in this way is to allow significant plastic flow under foot-loading pressures in a relatively short time period.

The time for the mixture to undergo significant plastic flow under load, for instance when used in a shoe
10 structure and subjected to successive foot/ground contacts during wear, is typically in the range 10 minutes to 8 hours.

The mixture is provided by mixing together the visco-elastic polymeric material and the filler. Mixing may
15 require an elevated temperature to lower the viscosity of the visco-elastic material temporarily, and to allow calendering of the mixture to a defined sheet thickness.

If, for thorough and substantially uniform mixing of the filler with the visco-elastic material it is necessary
20 to use elevated temperatures, the filler must necessarily withstand such temperatures. For example, when the visco-elastic material is an Oppanol B product the filler must withstand temperatures of at least 100°C. Such
temperatures temporarily lower the viscosity of the Oppanol
25 B and thereby aid the dispersion of the filler in the mixture.

The mixture can then be laid directly into a pre-formed well or depression in the front part of a conventional insole. The mixture is then covered by a
30 sheet which can be sealed at its edges with the insole board, or can overlap the edges of the insole board and then be sealed to the insole board. The sheet secures the mixture within the well.

Alternatively, the mixture can be directly laid onto
35 an insole of a shoe, or into a pre-formed depression formed therein, and then covered by an innersole.

The term insole is used to describe the layer of the shoe sole upon which traditional lasting operations are performed. The term innersole is used to describe the layer of the shoe sole which contacts the foot. Therefore, from ground to foot a typical shoe sole construction is outsole, insole and innersole in that order.

A laminate of the invention comprises the visco-elastic material/filler mixture between two sheets of materials which may be polymeric films or sheets of a non-woven material. The sheet materials can be sealed at their edges, for example by welding or heat-sealing, or can be formed integrally with one another, to form a bag to encapsulate the visco-elastic material/filler mixture. The sheet materials can act to separate the visco-elastic material/filler mixture from the remainder of a shoe structure, so preventing leakage of the visco-elastic material and any undesirable interaction with, for example, adhesive bonds within the structure.

The sheet materials typically have a thickness of from 25 to 200 μm . They may be of polymeric materials such as polyurethane elastomers, plasticised PVC and olefinic polymers, and non-woven materials comprised of fibres of materials such as polypropylene, polyethylene, viscose or wood pulp. The sheet materials can be the same or different, and one sheet material can comprise an insole board.

The laminate typically has a thickness in the range 0.5 to 6 mm, preferably 1 to 3 mm.

When the laminate is made separately from the shoe and insole, it is typically calendered between two sheets, and then cut to shape, optionally with bonding of the sheets at their periphery. The laminate can then be secured to an insole, or into a well therein, by a further sheet of material adhered to the side of the laminate not adjacent the insole which overlaps the edges of the insole. Alternatively, the laminate can be laid on an inner sole and covered by an insole.

Depending on the visco-elastic material used, laying of the mixture and/or calendering of the mixture may require an elevated temperature, usually the same temperature as that used in mixing, to facilitate these processes.

Optionally a foam layer may be interposed between the laminate and the insole to form a composite, and which provides extra elastic cushioning during the trying-on of a shoe in a store and during initial wear. The foam layer can be an open-cell or a closed-cell foam, which responds quickly to applied pressure and moulds quickly, but substantially elastically, to the wearer's foot. The foam layer typically comprises a closed-cell polymeric foam, for example flexible polyethylene or polyethylene/ethyl vinyl acetate (PE/EVA) foam which has been chemically blown from a solid sheet of material using infra-red radiation to activate a blowing agent in the sheet. Such a foam may have a density of from 20 to 100 kg/m³ to give elastic and compression set properties that are suitable for offering the correct feeling of cushioned comfort underfoot. Such a foam layer preferably has a maximum thickness of 5 mm, and more preferably has a thickness in the range of 1 to 3 mm.

Compression set is the property of recovering of a deformable material after a specified period of time after the release of a compression deflection which has been applied for a specified period of time. A low compression set is characteristic of an elastic deformation, such as the foam layer described above undergoes on the application of a compression deflection, i.e. that caused by under-foot pressure. A high compression set is characteristic of a permanent deformation, such as the plastic flow of the visco-elastic material/filler mixture, or a laminate thereof, on the application of a compression deflection caused by under-foot pressure.

Additionally, in the laminate a further optional feature may be incorporated, in the form of height-limiting

seams. The seams are formed by spot or line-welding the two sheets together at positions near the front edge of the laminate to create a "pin cushion", quilted or striped format of welds that limit the maximum height of such a pad, for example, to 6 mm when fully conformed in the region under the toe crest. This optional feature may be necessary to avoid the visco-elastic material/filler mixture accumulating towards the front of the laminate as a result of the shear forces exerted on the pad during walking.

The novel mixture, or a laminate, composite or pad containing it, is particularly useful in the region of the foot under and around the metatarsal heads, including the toe crest region. In ladies' court shoes, in particular, the metatarsal head regions are subjected to higher underfoot pressure than other regions of the forefoot. By moulding to the metatarsal and toe crest region, a mixture of the invention increases the contact area between the foot and the shoe around these regions, and distributes the pressure over a larger area, thereby diminishing the higher pressures under the metatarsal heads.

When the invention is used in the metatarsal and toe crest regions further advantages are achieved, as the mixture, by conforming to the shape of the foot, prevents the foot sliding forward in the shoe, and also allows a better grip by the foot of the shoe. These advantages are particularly important in ladies' court shoes.

Example

A visco-elastic material/filler mixture was provided by mixing at 140°C Oppanol B12 (from BASF) with 0.5 to 2 mm sized cork granules having a density of 30 to 60 kg/m³, to give a mixture having a 50:50% v/v ratio of Oppanol B12:cork. The mixture was then calendered between two 50 µm thick polyethylene films to an overall laminate thickness of 1.8 mm, which was then cut to a shape suitable for incorporation into a 1.5 to 2.5 mm deep pre-formed well, or depression, formed in the forepart of a

conventional fibrous insole board by the application of heat and pressure. A further 50 μm polyethylene film was laminated and adhered to the top of the laminate, such that this further film overlapped the insole board well boundaries and sealed the laminate within the insole board well.

A collapsible polyethylene/ethyl vinylacetate (PE/EVA) foam of 30 to 40 kg/m^3 density and 2 mm initial thickness, manufactured by Alveo-Sekisui (UK) Limited, was adhered to the laminate construction, such that the PE/EVA foam overlapped the edges of the polyisobutene/cork laminate, and extended to the boundaries of the forepart of the insole board. The insole board containing the laminate of the present invention and the further layer of collapsible foam was then used as normal in the shoe lasting and subsequent manufacturing steps.

After the shoe manufacturing steps, an innersole of a good quality leather was adhered to the exposed face of the PE/EVA foam to complete the assembly.

The maximum weight of the underfoot comfort structure described was below 10 g, and it occupies less than 2 mm of the toe-box height of the shoe. It is therefore particularly applicable to the provision of comfort in ladies' court shoes, in which there are severe restrictions on the thickness and weight allowable for such underfoot comfort structures.

CLAIMS

1. A mixture of visco-elastic material having a viscosity in the range of 1×10^5 to 1×10^7 Poise at 20°C and a particulate filler.
- 5 2. A mixture according to claim 1 wherein the visco-elastic material is a polymeric material.
3. A mixture according to claim 2 wherein the polymeric material is polyisobutene.
4. A mixture according to any preceding claim wherein the
10 filler comprises not more than 70% by volume of the mixture.
5. A mixture according to any preceding claim wherein the filler has a particle size in the range from 0.5 to 2 mm.
6. A laminate comprising a mixture according to any
15 preceding claim laminated between two sheets.
7. A laminate according to claim 6 wherein the sheets encapsulate the mixture.
8. A laminate according to claim 5 or claim 6 wherein the sheets comprise polymeric film material.
- 20 9. A laminate according to any of claims 6 to 8 having a thickness in the range from 1 to 5 mm.
10. An elastically-deformable pad comprising a mixture or laminate according to any preceding claim.
11. A composite comprising a laminate according to any of
25 claims 6 to 9 and a layer of polymeric foam material.
12. An insole comprising a well in its front part and, contained within the well, a mixture or laminate according to any of claims 1 to 9.
13. An insole according to claim 12 further comprising a
30 sheet enclosing the mixture within the well.
14. An insole according to claim 13 further comprising a layer of polymeric foam material laminated to the sheet.
15. A shoe comprising, in the sole supporting the metatarsal/toe crest region of the foot, a pad according to
35 claim 10.
16. A shoe according to claim 15 that is a ladies' court shoe.