

BACKGROUND OF THE INVENTION

Field of the invention

The field of the invention relates to the construction of a boot sole, and more particularly pertains to a new and improved safety boot sole construction to prevent puncturing of the sole by high energy and high velocity projectiles thus affording greater protection to an individual's foot without over-restricting movement.

Description of the Prior Art

U.S. Pat. No. 5,237,758 to Zachman : this uses semi-elliptical sections intersecting at loops with adjacent webbs of adjacent loops intersecting with flexible rods directed through the intersecting loops to minimize lateral displacement of adjacent webs.

U.S. Pat. No. 5,285,583 to Aleven: this uses a protective layer composed of plastic and including and including a flexible forepart portion having an insole board bonded to its bottom surface and a fabric liner bonded to its top surface during the process of moulding the protective plastic layer. The plastic used by Aleven is molten plastic injected in the final bonding process.

International Patent DE 4214802, by ZEPF H, to SPORTARTIKELFABRIK UHL GMBH KARL : A multi-layer boot sole having a walking surface, a damping intermediate sole, and an upper insole. The base is a thermo-plastic moulding, or is made of metal, ceramic or graphite, in which multi-filament organic or inorganic reinforcing fibers are embedded in the form of a mat, or woven or knitted structure. The elastic profiled portions are formed on the underside of the base by injection moulding or pressing. The base can contain only a single layer of woven fibres, its total thickness being approximately 0.5 mm.

Aleven achieved strength and impact resistance from a plastic plate in the sole and the use of a fabric mesh was to reinforce the plastic and not to provide impact resistance. ZEPF H, could only achieve a single layer of not more than 0.5mm thickness of woven fibers through injection moulding or pressing. Aleven made no discussion of metal, ceramic or graphite materials. So far, techniques to use aramid, ceramic, or graphite fibers in the construction of a boot sole in thicknesses to prevent puncturing of the sole by high energy and high velocity projectiles has not been mentioned or made feasible due to problems in rigidity and bonding.

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SUMMARY OF THE INVENTION

The boot soles described in the prior art are insufficient against blast and projectile protection when it is desired to conserve toe-to-heel flexion in order to enable running, jumping and to clear obstacles such as rope ladders, rope climbing, small steps, and with sufficient feel or sensitivity to detect edges, pits, and small stones. To attain this, the present invention provides a blast and fragment resistant polyester- and/or polyether-based polyurethane boot sole comprising embedded protective material in which the material is embedded throughout the entire sole and is composed of at least one woven polyaramid (Kevlar) layer, the density of which is less than or equal to 5 oz per square yard. Increasing density and additional layers of woven polyaramid fibers increases the blast and fragment resistance.

It is also an object of the present invention to provide a boot sole with good adhesion between the various polyaramid (Kevlar) layers and/or graphite fiber bundles, inspite of the poor intrinsic adhesion between the polyaramid fibres, graphite fibres, and the polyurethane. Due to the extreamly thin coating of the various polyaramid (Kevlar) and/or graphite fiber bundles prior to weaving and/or due to the relatively loose or course weave of the polyaramid (kevlar) fibres, the polyurethane is able to penetrate between the fibres, allowing the various layers to be well bonded together, thereby preventing the peeling apart of the sole in subsequent use.

According to the invention, polyaramid (Kevlar) and/or graphite fibers can be coated thinly with polyester or polyether based polyurethane before they are woven into the required mat form, this will greatly improve adhesion between the polyaramid and polyurethane material.

Also according to the invention, polyester (PET) fibres can be interwoven with or between the (coated or uncoated) polyaramid (Kevlar) fibers to improve adhesion between the polyaramid and polyurethane material.

Also according to the invention, carbon graphite fibres can be interwoven with or between the polyaramid (Kevlar) layers to further strengthen and to stiffen the sole.

Also according to the invention, a woven layer of mineral fibres, notably ceramic fibres or S-glass fibres, can be included into the boot sole to act as a fire wall for protection against hot gasses with temperatures of between 1500-3000 deg F.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexes drawings wherein:

(Please note: Drawings are not scaled technical drawings but are meant to convey the principal of the invention.)

Figure 1 : Drawing illustrating embodiment 1. Shows the side view of the whole boot including the outer (lower), middle, and upper sole. The single layer of polyaramid (Kevlar) layer is illustrated, embedded in the middle sole.

Figure 1-A : Is an expanded view of the sole construction showing the outer (lower) sole and middle sole, and the relative place of the embedded polyaramid (kevlar) layer.

Figure 1-B : Is an expanded view of the sole construction showing the outer (lower) sole, middle sole, and upper sole and the relative place of the embedded polyaramid (kevlar) layer.

Figure 2 : Drawing illustrating embodiment 2. Shows the side view of the whole boot including the outer (lower), middle, and upper sole. The multi-layers of polyaramid (Kevlar) layer is illustrated, embedded in the outer (lower) sole and middle sole.

Figure 2-A : Is an expanded view of the sole construction showing the outer (lower) sole and middle sole, and the relative place of the embedded multi-layers of polyaramid (kevlar) layer.

Figure 2-B : Is an expanded view of the sole construction showing the outer (lower) sole, middle sole, and upper sole and the relative place of the embedded multi-layers of polyaramid (kevlar).

Figure 3 : Drawing illustrating embodiment 5. Shows the side view of the whole boot including the outer (lower), middle, and upper sole.

Figure 3-A : Is an expanded view of the sole construction showing the outer (lower) sole and middle sole, and the relative place of the embedded thick ceramic cloth in the middle sole.

Figure 3-B : Is an expanded view of the sole construction showing the outer (lower) sole, middle sole, and upper sole and the relative place of the thinner ceramic cloth in the upper sole.

Figure 4 : Drawing illustrating embodiment 5. Shows the side view of the whole boot including the outer (lower), middle, and upper sole.

Figure 4-A : Is an expanded view of the sole construction showing the outer (lower) sole and middle sole, and the relative place of the embedded thick S-Glass cloth in the middle sole.

Figure 4-B : Is an expanded view of the sole construction showing the outer (lower) sole, middle sole, and upper sole and the relative place of the thinner S-Glass cloth in the upper sole.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the first embodiment (FIG. 1) of this invention, the composite safety boot sole is made in a traditional multi-stage mould which is commonly used in the polyurethane shoe soling industry.

The polyester- and/or polyether-bases polyurethane is first injected into a composite sole mould cavity to form the outer (lower) sole such that its density is typically in the range of 500-2000 kg/m³.

After removal of the top plate of the mould for the outer (lower) sole, one thick layer of polyaramid (kevlar) woven material is placed onto the outer (lower) sole which remains in the mould cavity.

According to the invention, to allow good adhesion and/or penetration to/by the polyurethane, the polyaramid (Kevlar) fiber bundles can be precoated with polyester- and/or polyether-based polyurethane prior to weaving.

According to the invention, to allow good adhesion and/or penetration to/by the polyurethane, the density of the polyaramid layer is at least 5 oz per sq yard, preferably 15 oz per sq yard for each ply of woven polyaramid material.

This thick polyaramid layer preferably consists of bundles of polyaramid in crowfoot or leno weave with 70%-90% in the X to Y direction (that is perpendicular to toe-to-heel), and 10-30% in the toe-to-heel direction.

The thickness of the layer of the polyaramid layer is typically 0.11 inches, using Kevlar 49 in 7100 denier bundles with tensile strength of 43,000 PSI and modulus 19 million PSI with a 0.07 inch diameter polyaramid fibers.

At this stage a polyester- and/or polyether-based polyurethane is injected into the mould cavity containing the outer (lower) sole at the base of the sole, to form the middle sole such that the polyurethane has a typical density of < 1000 kg/m³.

Due to the penetration of the polyurethane into and through the polyaramid layer good adhesion is achieved between the outer (lower) and middle soles, with the polyaramid layer sandwiched in between.

At this stage, the boot can be directly attached to the polyurethane composite sole comprising of the outer (lower) and middle soles, or a third, upper sole can be added on top of the middle sole for enhanced comfort. In this latter case, the outer (lower) and middle soles as described above are left in the mould cavity and polyester- and/or polyether-based polyurethane is injected into the mould cavity, directly on top of the middle sole.

A shoe sole made according to the above method with the preferred 15 oz per sq yard polyaramid layer is effective in providing blast and fragment resistance to 60 grain projectile with a velocity of 1350 fps. It also conserves good toe-to-heel flexion in order to enable running, jumping and to clear obstacles such as rope ladders, rope climbing, small steps etc, while avoiding the peeling apart of the sole in subsequent use.

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In the second embodiment (FIG. 2) of this invention 0-2 layers of polyaramid woven layers are placed into the mould cavity which forms the outer (lower) sole.

The polyaramid layers consist preferably of polyaramid fibers of 0.01 inch diameter, woven together to form a layer of about 0.04 inches.

The polyester- and/or polyether-based polyurethane is first injected into a composite shoe sole mould cavity to form the outer (lower) sole such that its density is typically in the range 500-2000 kg/m³.

After removal of the top plate of the mould for the outer (lower) sole, a further 2-6 layers of the same polyaramid (Kevlar) woven material as embedded into the outer (lower) sole is placed onto the outer (lower) sole which remains in the base of the mould cavity.

At this stage a polyester- and/or polyether-based polyurethane is injected into the mould cavity to form the middle sole such that the polyurethane has a typical density of < 1000 kg/m³.

Due to the penetration of the polyurethane into and through the polyaramid layer good adhesion is achieved between the outer (lower) and middle soles with the polyaramid layers sandwiched in between.

At this stage, the boot can be directly attached to the polyurethane composite sole comprising of the outer (lower) and middle soles, or a third, upper polyurethane sole can be included for enhanced comfort. This is achieved by allowing the outer and middle soles (made by the process above) to remain in the mould cavity and by injecting polyester- and/or polyether-based polyurethane onto the middle sole.

A shoe sole made according to the above method is even more effective in providing blast and fragment resistance due to the multiple polyaramid layers.

In a third embodiment of this invention, the polyaramid layers as described in embodiments 1 and 2 are interwoven with polyester (PET) fibers and the boot sole is made in the same manner as described in embodiments 1 and 2.

The use of interwoven polyaramid and polyester (PET) fibers has the advantage of further increasing the adhesion of the polyurethane material to the embedded protective layer(s). Due to the intrinsically superior adhesion between polyurethane and polyester.

In a fourth embodiment of this invention, the polyaramid layers as described in embodiments 1, 2 or 3 are interwoven with carbon graphite fibers having 12K TOW and a tensile strength of 470,000 PSI and modulus of 35 million PSI and the boot sole is made in the same manner as described in embodiments 1, 2 or 3.

The use of interwoven carbon graphite fibers has the advantage of further increasing strength and stiffness and of improving wear resistance.

In a fifth embodiment of this invention, the outer (lower) and middle boot sole are made as in embodiments 1-4. In addition, a layer of composite ceramic/polyavimid fibers is included into the middle or upper sole.

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The thicker 0.05 inch ceramic fibers where 70-90% of the ceramic fibers woven into a crowfoot or leno weave in the X-Y direction (perpendicular to the toe-to-heel direction) and with 10-30% of ceramic fibers in the toe-to-heel direction are embedded in the middle sole above the polyaramid (kevlar) layer(s) (FIG. 3-A). The thin (0.025 inch) composite layer of ceramic/polyavimid fibers preferably consists of standard bidirectional weave and is embedded in the upper sole (FIG. 3-B).

The boot sole incorporating this composite layer of ceramic/polyaramid fibers allows for protection against hot gasses, with a temperature resistance of 3000 degrees F. during the very brief duration of the blast.

In a sixth embodiment of this invention the outer (lower) middle boot sole is made as in embodiments 1-4. In addition a layer of composite S-Glass fibers is included into the middle or upper sole.

The thicker 0.05 inch ceramic fibers where 70-90% of the S-Glass fibers woven into a crowfoot or leno weave in the X-Y direction (perpendicular to the toe-to-heel direction) and with 10-30% of S-Glass fibers in the toe-to-heel direction are embedded in the middle sole above the polyaramid (kevlar) layer(s) (FIG. 4-A). The thin (0.025 inch) composite layer of S-Glass fibers preferably consists of standard bidirectional satin weave and is embedded in the upper sole (FIG. 4-B).

The boot sole incorporating this composite layer of S-Glass fibers allows for protection against hot gasses with a temperature resistance of 1,500 degrees F. for the very brief duration of the blast.

As to the manner of usage and operation of the instant invention, the same should be apparent from the above disclosure and according no further discussion relative to the manner of usage and operation of the instant invention shall be provided.

With respect to the above description then, it is to be realised that the optimum dimensional relationships and materials for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specifications are intended to be encompassed by the present invention.

Therefore, the fore going is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art it is not desired to limit the invention to the exact construction and operation shown and described and accordingly all suitable modifications and equivalents may be resorted to falling within the scope of the invention.

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What is claimed is:

1. A blast and fragment resistant polyester- or polyether-based polyurethane boot sole comprising embedded protective material characterised in that the material is embedded through the entire sole and is composed of at least one woven polyaramid (Kevlar) layer. The density of which is less than or equal to 15 oz per sq yard.
2. The sole according to claim 1, characterised in that in the embedded material consists of only thick polyaramid (Kevlar) woven layer, the thickness of which is at least 0.07 inches.
3. The sole according to claim 1 characterised in that the embedded material includes at least 3 polyaramid (Kevlar) woven layers, the thickness of each layer being less than 0.06 inches, bonded together by the polyurethane material.
4. The sole according to any given one of the above claims characterised in that the polyaramid fibers comprising the polyaramid (Kevlar) layers are interwoven with polyester (PET) fibers and/or the polyaramid (Kevlar) fibers are thinly coated with polyester- and/or polyether-based polyurathane prior to weaving.
5. The sole according to any given one of the above claims characterised in that the polyaramid fibers comprising the polyaramid (Kevlar) layers are interwoven with carbon graphite fibers.
6. The sole according to any given one of the above claims characterised in that the embedded materials include at least one layer of mineral fibers.
7. The sole according to claim 6 characterised in that the mineral fibers consist of ceramic fibers.
8. The sole according to claim 6 characterised in that the mineral fibers consist of S-Glass fibers.

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