

The invention relates to a process for producing a strip of plastic which can recover its shape under heat, in which a mat comprising strands running in the longitudinal and transverse directions of the strip is
5 embedded in a layer of plastic.

For the subsequent insulation of splices of electric cables or joints of pipelines, wrap-around sleeves have become known, which comprise a crosslinked plastic strip which is stretched in order to make it able
10 to recover its shape under heat. Such strips are laid around the splice, closed at their longitudinally running edges and heated, for example by means of a propane gas flame, and shrunk down onto the splice. An adhesive layer located on the inner surface of the strip softens during
15 shrinking and seals off the splice against moisture. This technique has proven successful and is the subject of German Patent Specification 1 525 815. However, the sleeves described there are not resistant to pressure and are sensitive to overheating, which may occur for example
20 if the propane gas flame is inexpertly handled. If the surface is damaged, the sleeves may also tear. Communication cables in particular are often operated with internal pressure in order to avoid the ingress of moisture.

In order to avoid these disadvantages, a wrap-around sleeve has been developed which comprises a woven fabric which can recover its shape under heat and is embedded in a polymer matrix. In a preferred embodiment, the woven fabric comprises longitudinally stretched and consequently heat-recoverable threads, which are woven
25 with non-heat-recoverable threads, for example of glass fibre.
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In the production of such a strip, in a process according to EP-A-0 116 390, a woven fabric is produced from prestretched crosslinked polymer threads running in
35 one direction and glass threads running transversely with respect to the polymer threads. This woven fabric is then embedded in a polymer matrix. During production, particular attention has to be paid to controlling the temperature of the embedding compound, since the

stretched threads shrink if a certain temperature is exceeded. Another major disadvantage is that bonding of the crosslinked polymer threads with the embedding compound is difficult to establish, since crosslinked
5 polymers cannot easily be adhesively bonded or fused. It is to be regarded as a further disadvantage that the reinforcing threads of non-heat-recoverable material run only in one direction. A similar process is disclosed by EP-A-0 270 132.

10 According to another proposal, which is described in the earlier German Patent Application P 38 06 660.2, a strip of a plastic is extruded, crosslinked and stretched and a plastic strip in which a woven fabric is embedded is applied to one of the surfaces by laminating.
15 In order to accomplish good bonding between the strips, the crosslinked strip has on its surface to be coated a thermoplastic uncrosslinked layer, which is co-extruded with the crosslinked layer. On account of the co-extrusion and subsequent crosslinking of only the one layer,
20 the thermoplastic layer containing the woven fabric can be bonded well to the uncrosslinked layer of the strip. Disadvantageous here, too is that exact temperature control must be ensured during the lamination. In addition, the production requires considerable
25 expenditure on machinery.

Therefore, there has long been a need for a process for producing strips which can recover their shape under heat and in the wall of which there is arranged a woven fabric which increases the strength of
30 the strip, which process is to be carried out like the process suitable for the wrap-around sleeve according to German Patent Specification 15 25 815.

The present invention is therefore based on the object of improving the process known from EP-A-0 116 390
35 and EP-A-0 270 132 to the extent that it is possible to dispense with elaborate temperature control and in which there is obtained a strip which can recover its shape under heat and has an embedded woven fabric comprising threads running both in the stretching or shrinking

direction and perpendicularly thereto of a material which is not stretchable at the stretching or shrinking temperature, i.e. is tension-resistant.

5 This object is achieved in the case of a process of the type mentioned at the beginning in that, according to the invention, first of all a mat or a woven fabric of crossing strands of unstretchable or only slightly stretchable material is shaped, at least the strands running in one direction being shaped in the manner of a
10 helix, in that the mat or the woven fabric is embedded in a polymer material, in that the polymer material is crosslinked after the embedding process, then heated, and in that the strip thus produced is stretched in the heated state in the direction of the strands running in
15 the form of a helix and is cooled in the stretched state.

It is to be regarded as the major advantage of the invention that, as in the case of the strips according to German Patent Specification 15 25 815, the polymer matrix can recover its shape under heat, and the
20 woven fabric is embedded as a reinforcing layer in the polymer matrix. On account of the helical path of the strands, the woven fabric itself has a stretching reserve, although the material of the strands themselves is not stretchable, so that the strip with the embedded
25 woven fabric can be stretched to the customarily used degrees of stretching of 400% and more. During stretching, the length of lay increases and the diameter of the helix decreases. In an extreme case, the helix is deformed into a stretched strand. Upon heating, the
30 polymer strand onto which the strand is wound softens and then joins in the stretching process, providing the required freedom of movement for the helix. During the subsequent shrinking process, the strand then lays itself into the polymer matrix over an irregular path.

35 With particular advantage, each of the strands shaped in the manner of a helix is wound helically onto a polymer strand of any desired cross-section. As a result, a dimensionally stable mat or a dimensionally stable woven fabric can be produced, which can be drawn

off from a supply reel without deforming the mesh width and can be fed to the embedding installation.

The embedding of the mat or of the woven fabric in the polymer material is performed by extruding or
5 laminating. What is important here is that the polymer material penetrates into the spaces between the meshes, so that a single-layered article in strip form with an embedded reinforcing layer is obtained.

The polymer strand onto which the strand is
10 helically wound preferably consists of a thermoplastic uncrosslinked polymer. As a result, it is ensured that it bonds well with the polymer material, likewise in the thermoplastic uncrosslinked state.

A particularly advantageous development of the
15 invention is that the mat or the woven fabric is encapsulated in a continuous operation with a silane-grafted polyethylene by extrusion, in that the silane-grafted polyethylene is crosslinked in the presence of water or water vapour, in that the crosslinked strip is heated to
20 a temperature above the crystalline melting point of the polyethylene, is stretched at this temperature by at least 40% and is cooled in the stretched state. It goes without saying that other types of crosslinkage are also suitable, such as for example peroxide crosslinkage or
25 radiation crosslinkage. The particularly preferred type of crosslinkage is distinguished, however, by a low expenditure on machinery.

Expediently, a virtually endless mat is produced from warp and weft threads, the warp threads being
30 straight-running threads of substantially unstretchable material and the weft threads comprising a thermoplastic polymer strand having a helical wound surround of one or more threads of substantially unstretchable material, in that [sic] the mat or the woven fabric is embedded
35 continuously in a polymer material, in that [sic] the polymer material is crosslinked, in that [sic] mouldings are detached from the strip and in that [sic] the mouldings are heated, stretched in the heated state and are cooled in the stretched state. Suitable as material for

the unstretchable strands or threads are, for example, cotton threads, metallic threads or glass threads, which may be made up of twisted or stranded together or multiple-wound individual threads. It is also possible
5 for a plurality of threads to be wound onto the polymer strand, a combination of the abovementioned materials also being conceivable. If a silane-grafted polyethylene is used as the polymer matrix, a strand of polyethylene is likewise expediently to be preferred as the support
10 for the strand of unstretchable material.

According to a further advantageous refinement of the invention, the strip is crosslinked to different degrees, seen in cross-section, to be precise in such a way that there is a higher degree of crosslinking, of for
15 example 25-50%, in the wall regions facing the object to be enveloped and a lower degree of crosslinking, of for example 5-25%, in the wall regions facing away from the object. Since, as determined by tests, the susceptibility to tearing increases with an increasing degree of
20 crosslinking, the strip produced in this way is less susceptible to tearing.

The strip is advantageously produced by co-extrusion of at least two layers, the layers consisting of polyethylene grafted to different degrees. This
25 crosslinking of polyethylene by grafting on silanes and subsequent storage in a moist atmosphere is particularly suited for this process, since different amounts of added crosslinking agents and/or catalysts allow a plurality of layers to be produced with different degrees of cross-
30 linking, so that the strip exhibits a sandwich-like structure. By virtue of the sandwich structure, the tear strength of the strip is increased considerably in comparison with a homogeneous strip of the same wall thickness by a mechanical synergistic effect.

35 As already mentioned above, it is necessary that the polymer layers fed to the woven fabric from both sides bond with each other. With a narrow mesh width of the woven fabric, difficulties may arise here under certain circumstances, since the polymer material is then

unable to penetrate the meshes owing to its high viscosity. This problem is solved in that the wound-around polymer strand or strands are woven with different spacing from one another. Thus, it is possible, for example, to weave for instance two or three polymer strands with relatively small spacing from one another and the next group of two or three polymer strands with a greater spacing from the previous group. The spacing between the groups is to be chosen large enough that the polymer layers can bond together at this point.

The invention is explained in more detail with reference to the exemplary embodiments represented diagrammatically in Figures 1 to 6.

Figure 1 shows a mat or a woven fabric 1, which is made up of crossing threads 2 and 3. The thread 3 comprises a polyethylene strand 3a, onto which a thread 3b of another material is helically wound. The threads 2 and 3b consist of an unstretchable material, such as for example glass, cotton, metal etc. With particular advantage, the threads 2 and 3b comprise a multiplicity of multiple-wound glass threads. The helical winding-on gives rise to an excess length or stretching reserve, so that the threads 3 are stretchable.

During the stretching process, the diameter of the polymer threads 3a decreases, and consequently so too do the clear intervals of the helically wound-on threads 3b. In an extreme case, the threads 3b run parallel in straight lines next to one another after the stretching process. The spacing of the threads 2 increases during stretching by the stretching factor. Such a woven fabric 1 can be produced in great lengths on a normal loom.

A woven fabric represented in Figure 1 can be embedded in a polymer matrix in a continuous operating process. Such a strip is shown in Figure 2, in which the polymer matrix is denoted by 4.

For the production of the strip 5, first of all the polymer thread 3 is produced by extrusion and, after cooling down, is wound around by a multiple-wound glass thread 3b with a relatively short length of lay.

Example:

	Polyethylene thread	Diameter:	1	mm
	Glass thread	Diameter:	0.05	mm
	Length of lay of the glass			
5	thread	Diameter:	1	mm

Such a thread 3 is stretchable at most by a factor of about 4. The thread 3 is worked as a weft thread in a loom (not shown) with a multiplicity of multiple-wound glass threads 2 of about 0.05 mm diameter, running in as warp threads, to form a woven fabric.

As Figure 3 shows, the woven fabric 1 is drawn off continuously from a roll 6 and introduced into the crosshead 7 of an extruder 8 and embedded there in the polymer matrix 4. The strip 5 thus produced is then cut into sublengths 9, which are stretchable transversely to the direction of extrusion, as indicated by the arrows.

As the material for the polymer matrix, a mixture of

	50 parts	polyethylene
20	40 parts	ethylene-vinyl acetate copolymer
	and 10 parts	carbon black

is prepared and processed into granules. The granules are filled together with about 1% by weight vinylmethoxysilane into the funnel of the extruder 8 and are moulded around the woven fabric 1 to form a strip with a wall thickness of about 4 mm.

In the case of a multilayered structure of the strip, it can be produced by co-extrusion of, for example, two layers, the woven fabric 1 being arranged between these layers. If it is wished to achieve different degrees of crosslinking of the layers, the proportion of vinylmethoxysilane has to be reduced, for example to 0.2 to 0.5% by weight.

The detached sublengths are then crosslinked in

the presence of water vapour at about 95°C. It goes without saying that the sublengths 9 also cannot be detached until after the crosslinking of the strip 5.

The crosslinked sublengths 9, which are also referred to as blanks, are then stretched in a stretching frame (not shown) to about 4 times their length. This stretching operation is carried out at a temperature of about 120 - 150°C, the polymer strand 3a also softening and being reduced in its cross-section by the stretching process and consequently not hindering the change in shape of the helically wound thread 3b.

The stretched strip then has a wall thickness of about 1 mm. In the stretched state, the strip is cooled to room temperature and is ready for use, in other words, when re-heated, the strip has the tendency to shrink back into the shape produced during extrusion.

Figures 4 to 6 show various embodiments of fabric-reinforced wrap-around sleeves or collars.

According to Figure 4, the wrap-around sleeve has the form which has become established for the enveloping of cable splices. The strip 5 has on its longitudinal edges two webs 11 and 12 and also a fin 13 extending beyond the region of the web 12. After laying the strip around the splice joint, the fin 13 goes under the region of the web 11. By pushing over a rail (not shown) as known from German Patent Specification 15 25 815, the strip 5 is held in its tubular form. For the purpose of sealing off the sleeve, the strip 5 also has on its surface facing the splice an adhesive coating which is known per se and is not referred to any more specifically. The wrap-around sleeve represented in Fig. 4 differs from the known sleeve according to German Patent Specification 15 25 815 in that there is arranged within the wall of the strip 5 the woven fabric 1, which extends into the region of the webs 11 and 12. This woven fabric 1 increases the tear strength and pressure resistance of the strip 5 at shrinking temperature.

Figure 5 shows another example of a wrap-around sleeve. The strip 5 is folded around in a loop-like

manner at its longitudinal edges, there being arranged inside the loops in each case a flexible rod 14 and 15, for example of stranded together or multiple-wound glass threads. After shaping the strip 5 around the cable splice, these rods 14 and 15 are gripped around by the rail described above. The loops are formed by adhesively bonding and/or by stitching or clamping the mutually overlapping regions. The folding of the strip edges around the rods 14 and 15 may be performed directly after the extrusion operation, because then a fusing-together of the not yet crosslinked overlapping regions is possible. Here too, the woven fabric 1 extends up to the longitudinal edges of the strip 5, that is to say the edge regions of the woven fabric 1 wrap around the rods 14 and 15.

Figure 6 shows a further advantageous refinement. The rods 14 and 15 are wrapped around by the woven fabric 1. This embodiment can be produced in a particularly advantageous way in that the longitudinal edges of the woven fabric 1 are wrapped around the rods 14 and 15, forming a loop in each case, the mutually overlapping regions are secured by stitching and subsequently this structure is encapsulated with the polymer matrix in the extruder. Here too, the thickenings formed by the rods 14 and 15 serve as means which are gripped around by the closure rail.



Patent Claims

1. Process for producing a strip (5) of plastic which can recover its shape under heat, in which a mat (1) comprising strands (2, 3) running in the longitudinal and transverse directions of the strip (5) is embedded in a layer (4) of plastic, characterized in that first of all a mat or a woven fabric (1) of crossing strands (2, 3b) of unstretchable or only slightly stretchable material is shaped, at least the strands (3b) running in one direction being shaped in the manner of a helix, in that the mat or the woven fabric (1) is embedded in a polymer material (4), in that the polymer material (4) is crosslinked after the embedding process, then heated and in that the strip (5) thus produced is stretched in the heated state in the direction of the strands (3b) running in the form of a helix and is cooled in the stretched state.
2. Process according to Claim 1, characterized in that each of the strands (3b) shaped in the manner of a helix is wound helically onto a polymer strand (3a).
3. Process according to Claim 1 or 2, characterized in that the embedding of the mat or of the woven fabric (1) in the polymer material (4) is performed by extruding or laminating.
4. Process according to Claim 2 or 3, characterized in that the strand (3b) is wound helically onto an uncrosslinked thermoplastic polymer strand (3a).
5. Process according to one or more of Claims 1 to 4, characterized in that the mat or the woven fabric (1) is encapsulated in a continuous operation with a silane-grafted polyethylene by extrusion, in that the silane-grafted polyethylene is crosslinked in the presence of water or water vapour, in that the crosslinked strip (1) is heated to a temperature above the crystalline melting point of the polyethylene, is stretched at this temperature by at least 40% and is cooled in the stretched state.
6. Process according to one or more of Claims 1 to



5, characterized in that a virtually endless mat (1) is produced from warp and weft threads (2, 3), the warp threads (2) being straight-running threads of substantially unstretchable material and the weft threads (3) comprising a thermoplastic polymer strand (3a) having a helical wound surround of one or more threads (3b) of substantially unstretchable material, in that the mat or the woven fabric (1) is embedded continuously in a polymer material, in that the polymer material is cross-linked, in that mouldings (9) are detached from the strip (5) and in that the mouldings (9) are heated and stretched in the direction of the polymer strands (3a) and are cooled in the stretched state.

7. Process according to one or more of Claims 1 to 6, characterized in that cotton threads, glass fibres or metallic threads are used as the unstretchable material (2, 3b).

8. Process according to one or more of Claims 1 to 7, characterized in that the strip (5) is crosslinked to different degrees, seen in cross-section, in such a way that there is a higher degree of crosslinking, of for example 25-50%, in the wall regions facing the object to be enveloped and a lower degree of crosslinking, of for example 5 to 25%, in the wall regions facing away from the object.

9. Process according to Claim 8, characterized in that the strip (5) is produced by co-extrusion of at least two layers, the layers consisting of polyethylene grafted to different degrees.

10. Process according to one or more of Claims 1 to 9, characterized in that the wound-around polymer strand or strands (3) are woven with different spacing from one another.