

DESCRIPTION

Subject of the invention is a method for producing multi-layer pipe conduit components, such as pipes and couplings, of plastics material, inorganic filler material and glass fibres in the centrifugal casting process. In the case of a method known from WO-A-86/0546 the entire quantity or at least a substantial part of the plastics material initially in liquid or molten state is introduced into a rotating mould. Subsequently, filler materials or reinforcing material in the form of fibres and/or filler are fed in steps to the cylindrical mould, wherein it is essential for success that the entire quantity or at least a substantial part of the plastics material is initially introduced into the mould and subsequently filler and/or reinforcing material dispersed therein. The glass fibres serving as reinforcing material in particular shall be accommodated in the inner and outer zones, which are separated from one another by a relatively thick middle layer of filler material and resin, whereby a pipe with three layers is formed. However, the method of separately feeding the individual ingredients of the pipe wall has led to various disadvantages in practice. Particularly when making pipe conduits of relatively small diameters and correspondingly small wall thickness, the glass fibre reinforced layers cannot be produced dense enough to guarantee leakproofness of the pipe and in addition, the glass requirement is relatively high.

For avoidance of these disadvantages there is therefore proposed in accordance with the invention a method for producing multi-layer pipe conduit components of plastics material, inorganic filler material and glass fibres in the centrifugal casting process according to claim 1. With this method it is on the one hand possible, independently of the pipe conduit diameter and thus independently of the thickness or the position of the individual layers, to achieve in each layer the optimum content of filler material or glass for the particular application and on the other hand it is also possible to non-detachably interconnect the layers in that they integrate with each other. According to the invention this is achieved thereby that for the formation of the non-detachably interconnected, individual layers a flowable mixture of fine-grained

pulverulent filler material and resin in a weight ratio higher than 1:2 is fed to a rotating mould and a predetermined separation of resin and filler material is produced inside the generated layer by controlling the rotational speed of the mould during a predetermined time, whereafter glass fibres are so fed to the mould, which is rotating at a predetermined rotational speed, that these penetrate at least into the inner region of the layer that has become resin-enriched by the separation, whereupon this process is then repeated at least once.

Depending on requirements, several layers consecutive from the outside to the inside may thus be produced, whereby the quantity and the mixing ratio of the respective fed mixture, the kind of filler material, the rotational speed of the mould, the quantity and size of the supplied glass fibres, as well as the formation time for the individual layers may be matched to the type and size of the pipe conduit component to be produced. Experiments have in fact irreproachably shown that the produced pipe components can have considerably improved strength and density compared to known pipes even with smaller wall thicknesses and with less expensive glass.

In the following are described in more detail some examples of the method according to the invention by reference to the drawing, wherein in the schematic drawing there shows:

Fig. 1 the wall cross-section with the corresponding layered construction of a pipe,

Fig. 2 the corresponding cross-section of a pressure-free pipe,

Fig. 3 the corresponding cross-section of a coupling,

Fig. 4 a section through a pipe coupling and a part of the associated pipe,

Fig. 5 a section through a pipe wall according to Example 6, and

Fig. 6 a section through a pipe wall according to Example 7.

The term "separation" as used here is to be understood as follows:

A mixture, serving for formation of a mould, of resin and filler materials and with a content of filler materials of x percent by weight is fed into a rotating mould. After a time the average value of the filler material in each half of the applied layer is determined. If it amounts to y percent by weight in the inner part, then the separation SEP in percent is

$$SEP = (1 - y/x) \cdot 100$$

If the measurements do not amount to half of the filler materials, this is separately indicated.

Example 1 for producing a pressure pipe:

A mixture consisting of two parts by weight filler material and one part by weight polyester resin was fed into a rotating mould with an inner diameter of 225 mm. The rotational speed was 543 revolutions per minute corresponding to a g-value of 33. After two minutes a separation of 7.05% was reached, whereby the resin content in the outer layer was 20% by weight and in the inner layer 38% by weight. Cut glass fibres (rovings) were introduced centrifugally at a rotational speed of 380 revolutions per minute into the inner layer.

Subsequently, the same mixture of filling material and resin was added at a rotational speed of 380 revolutions per minute, corresponding to a g-value of 16.1. After one minute a separation of 6.1% appeared in this second layer. Cut rovings penetrated into the two layers, as represented in Fig. 1 by wavy lines and percentage indications, in which the lower wall edge represents the pipe inner surface. This process was repeated twice and subsequently a cover layer 0.4 mm thick of a flexible resin was supplied. After completed curing, a pipe was obtained with a wall structure as shown in Fig. 1. The outer layer contained almost no glass fibres, because the filler material content was so high there that the fibres were not able to penetrate as in the other layers. The inner layer consisting of flexible resin was characterised in that in the cured state its elongation at rupture is greater than 10%

Example 2 for producing a pipe for open-air conduits, thus for pressure-free use:

A mixture consisting of two parts by weight filler material and one part by weight resin was fed into a rotating mould with an inner diameter of 315 mm at a rotational speed of 438 revolutions per minute, corresponding to $g = 34$. After two minutes the separation amounted to 7.0%. Cut rovings were then fed at a rotational speed of

254 revolutions per minute into the inner resin-enriched layer. A mixture of filler material and resin and with 71% by weight filler material was then fed at a rotational speed increased to 438 revolutions per minute. After three minutes the separation that had taken place was as follows: In two thirds of the layer thickness the filler material content amounted to 80% and in the other third 55%. Cut rovings were fed centrifugally into this resin-enriched layer and subsequently a further thin layer of flexible resin. After curing, a pipe was obtained with a wall structure as illustrated in Fig. 2.

Example 3 for producing a pipe coupling:

A mixture consisting of 60 parts by weight filler material and 100 parts by weight polyester resin was fed into a rotating mould with an inner diameter of 347 mm, until a layer thickness of 4mm was obtained. The rotational speed amounted to 203 revolutions per minute and g is 8. After three minutes the separation obtained was 67% and the content of filler material amounted to 50% by weight in the outer part and 16.7% by weight in the inner part. 50 mm long rovings were centrifugally fed into both layers. The process was then repeated once.

A mixture consisting of 100 parts by weight filler material and 100 parts by weight polyester resin was then fed at the same rotational speed. After 30 seconds the separation obtained was 50% and the content of filler material amounted to 33% in the inner part and 60% in the outer part of this third layer. Short glass fibres with a length of 20 mm were then centrifugally fed into both layers. The process was then once repeated. After the curing the required slots could be ground in. A coupling ring having a wall as shown in Fig. 3 was thus obtained. This ring may be used with pipes having an outer diameter of 340 mm.

As is clear from the preceding examples, the weight ratio of the components of filling material and resin of the respectively used mixture was always larger than 1:2, wherein the actually present weight ratio in the individual layers of the completed pipe conduit component was produced by the respective separating process.

In the case of very fine filler materials and a weight ratio of 2:1 and above between filler material and resin, the viscosity may be as high as 5000 cps or higher. At such viscosities the separation is very low and lies, at normal rotational speeds and treatment times, in the order or magnitude of 2 to 5%. At the same time, high contents of filler material, as well as high viscosities, are obtained in both layer parts. In order, nevertheless, to obtain a high strength of the pipe conduit component to be produced, whether a pipe or a coupling, a great number of thin layers must be generated. It turned out that with pipes having a diameter between 200 and 400 mm and a wall thickness of 10 mm, the layer thickness at which optimum economy may be obtained is from 0.1 to 0.7 mm. This is explained in the following examples:

Example 4:

A mixture of 200 parts by weight filler material and 100 parts by weight polyester resin was fed into a rotating mould with an internal diameter of 225 mm. This mixture had a viscosity of 6000 cps.

The rotational speed was 350 revolutions per minute. After 30 seconds a separation of 2% was obtained; cut rovings were then introduced. The thickness of the individual layer amounted in total to 0.65 mm. After the process was repeated 9 times, a pipe with a wall thickness of 6.5 mm was obtained. The glass fibre content was 15% by weight, the bursting pressure 50 bar.

Example 5:

The single step for generating a 0.65 mm thick layer, as described in the foregoing Example 4, was repeated 20 times in a rotating mould with an internal diameter of 253 mm, so that a ring came into being, from which could be ground ring-shaped grooves to produce a pipe-coupling with an internal diameter $D_i = 227$ mm, of which Fig. 4 illustrates a wall cross-section. This coupling can be used for a working pressure of 10 bar for pipes with an outer diameter of 225 mm.

Example 6:

A mixture consisting of 200 parts by weight filler material and 100 parts by weight polyester resin, and having a viscosity of 6000 cps, was introduced into a mould at rotational speed of 350/min and having an inner diameter of 225 mm. Glass fibres in the form of cut rovings were introduced immediately thereafter, whereby the material used was not more than that required for a maximum thickness of 0.65 mm of the individual layer. This process was then repeated 8 times. When pure resin was added after a waiting time of one minute, a pipe wall as shown in Fig. 5 is obtained, wherein the layers supplied with pure filler material nevertheless also contained some glass fibres.

Example 7:

The process according to Example 4 was repeated 8 times, whereby, as in Example 6, the glass fibres were introduced immediately after feeding the mixture of filler material and resin. Two partial layers or regions were formed nine times, one of which contained mainly mixture of filler material and resin and a few glass fibres, but the other contained glass fibres impregnated with mixture of filler material and resin as described before and shown in Fig. 6.

Subsequently, a mixture of filler material and resin was fed and after a waiting period of about one minute glass fibres were added and at the end pure resin.

Suitable filler materials are aluminium hydroxide, very fine quartz powder, powder of various types of clay, dolomite powder and chalk (calcium carbonate). These powdered inorganic filler materials, which have a grain size of less than 0.1 mm, may be used in pure form or in mixtures.

Supplementary materials such as quartz sand, feldspar, etc., with a grain size of 0.1 to 1.0 mm can also be added in usual manner in the process. This is normally done in the middle layers, particularly with thick-walled pipes, such as for example checking pipes.

Example 8:

A mixture consisting of 150 parts by weight filler material and 100 parts by weight resin is fed by means of a lance into a rotating mould with an inner diameter of 1228 mm and a length of six meters. The lance had an advance speed of 6 m/min and was withdrawn again at the same speed after the feeding of the mixture. Then the mould was fed with glass fibres in the form of cut rovings of 50 mm length at the same constant horizontal speed by means of the lance. Two layers were formed: An outer layer with about 75% filler material and 25% resin and a reinforcing layer with about 35% glass fibres and a matrix of filler material and resin.

The pipe was then built-up further by applying several coats of sand, glass fibres and the 150:100 ratio mixture of filler material and resin. Layers were produced, which contained about 3% glass fibres, 18% resin, 27% filler material and 52% sand.

An additional coat of the mixture of filler material and resin was then formed and the lance withdrawn. Then, glass fibres only were fed and finally resin only.

A pipe with a wall thickness of 25 mm was thus obtained. The pipe had a stiffness of 11200N/m^2 and a deformation of 19% at rupture.

It has proved that carbonate powder is particularly suited as filler material or as component of the filler material; even though carbonate is not acid-resistant, it has proved that very good results are obtained with such filler materials. Thus, for example, the corrosion resistance of glass-fibre-reinforced products can be increased, particularly of such products as are subject to a high bending stress, such as for example pipes embedded in the ground.

If a glass-fibre-reinforced pipe is stressed in circumferential direction and is used for sulphuric acid, internal cracks may come about. The sulphuric acid penetrates through these cracks in the pipe wall and

reaches the glass fibres. These are attacked by the sulphuric acid and CaO-groups are removed from the surface of the glass. The result will be a very large reduction in the bending strength of the pipe and a failure. This mechanism is referred to as "strain corrosion" by specialists. In order to increase the resistance against "strain corrosion" the conventional E-glass is replaced by the so-called ECR-glass. Glass fibres of ECR-glass are more expensive than those of E-glass and are more difficult to obtain. No "strain corrosion" occurs through the use of filler materials containing carbonate.

In order to obtain an increased strength it is expedient to work with fibres having various lengths. Suitable for this purpose is a mixture of short, medium and long fibres, for example 10 to 16 mm, 20 to 30 mm and 35 to 60 mm.

The invention is not limited to the production of pipe conduit components with a small diameter. The invention can also be used with large diameters. In the case of pipes of a diameter of 600 mm and more the invention can be used in particular for making the inner pipe region, i.e. the barrier layer.

In order to obtain an adequate strength, known pipe components of this kind are produced with the aid of expensive polyester resins, for example vinyl esters. This has bearing on the fact that due to the high exothermic temperatures which arise in thick-walled pipe components, for example couplings, high internal stresses arise. These internal stresses lead to delaminations and perviousness, unless resins of high strength and adhesiveness to glass fibres are used. Through the present invention it is possible to produce couplings that are about 60% less expensive and have higher internal pressure resistance than known couplings.

In the examples to be understood by the expression "normal polyester resin" are resins based on the orthophtalic acids or isophtalic acids. However, the invention is not limited to these two types of polyester resins. Depending on the purpose of use, resins, such as terephtalic acid resins, bisphenol resins and vinyl resins can also be used. This is advantageous with the use of resins with high elongation at rupture; in particular, this is important with pressure pipes. The elongation at rupture shall then be as high as 3 to 4%, which may be made higher through addition of flexible resins.

The carbonate containing filler materials are particularly suited for making pipes and couplings for ground-embedded pipe conduits.



CLAIMS

1. Method for producing multi-layer pipe conduit components of plastics material, inorganic filler material and glass fibres in the centrifugal casting process, characterised thereby that for the formation of individual non-detachably interconnected layers a flowable mixture of fine-grained pulverulent filler material and resin in a weight ratio greater than 1:2 is fed to a rotating mould and a predetermined separation of resin and filler material is produced in the forming layer by control of the mould rotational speed during a predetermined time, after which glass fibres are so fed to the mould rotating at predetermined rotational speed that these penetrate at least into the inner layer region which has become resin-enriched by the separation, whereupon this entire procedure is repeated at least once.
2. Method according to claim 1, characterised thereby that flowable mixture consists of fine-grained pulverulent filler material and a polyester resin in the weight ratio greater than 1:2.
3. Method according to claim 2 for producing a pipe component for conduits with high internal pressure loading, characterised thereby that formation of the layers succeeding one another from outside to inside a filler material and resin mixture in the weight ratio 1:1 or greater is fed each time to the mould at a rotational speed leading to a G value greater than 15.
4. Method according to claim 3, characterised thereby that a filler material and resin mixture in the weight ratio of 2:1 is used for the formation of each layer, wherein a greater separation is produced in the radially outer layer than in the remaining layers and wherein after the feed of the filler material and resin mixture glass fibres are so fed to each layer that in the radially outer layer these penetrate only into the inner region of this layer that has become resin-enriched, but in the remaining layers also penetrate into the layer region that has become weak-in resin.



5. Method according to claim 2 for producing a pipe component for open-air conduits, characterised thereby that a filler material and resin mixture in the weight ratio greater than 1:1 is used for the formation of the layers succeeding one another from outside to inside and that the filler material and resin mixture for the radially outer layer has a greater weight ratio than that for the radially inner layer, wherein the separation in the two layers is so controlled that a greater region of the radially outer layer is weak in resin and rich in filler material than in the radially inner layer and wherein the feed of glass fibres to the two layers is so effected that the glass fibres penetrate each time only into the layer regions that have become resin-enriched.

6. Method according to claim 2 for producing a coupling, characterised thereby that filler material and resin mixtures in the weight ratio of at least 1:1 are used for the formation of the layers succeeding one another from outside to inside and that the separation in the individual layers is so controlled that the radially outer layers contain inner layer regions richer in resin than the radially inner layers, wherein the feed of glass fibres is so effected that the radially inner layers contain fewer glass fibres, which however pass through all layers, than the radially outer layers, and wherein after curing of all layers the grooves intended for the reception of sealing rings are ground into the radially inner layers.

7. Method according to claim 2, characterised thereby that a mixture of fine-grained filler material and polyester resin is used, the viscosity of which is so high that the separation is smaller than 5%, and that the individual layers are so thin that the impregnation of the glass fibre layer substantially arises thereby that a part enriched with resin penetrates into the glass fibre layer from the filler material and resin mixture.

8. Method according to claim 7, characterised thereby that the individual layers are produced in a thickness of less than 0.7 millimetres.



9. Method according to claim 8, characterised thereby that a greater separation is produced in the outermost layer than in the succeeding layers.

10. Method according to claim 8, characterised thereby that a greater separation is produced in the innermost filler material and resin layer than in the preceding layers.

11. Method according to claim 9 or 10, characterised thereby that the thickness of the innermost glass fibre layer is at least 30% greater than the thickness of the other glass fibre layers.

12. Method according to one of claims 1 to 11, characterised thereby that a powder from the group aluminium hydroxide, quartz powder, gypsum, powder of different types of clay, dolomite powder and chalk (calcium carbonate) or a mixture of at least two of these powders is used as fine-grained pulverulent filler material, wherein the diameter of the powder particles is smaller than 0.1 millimetres.

13. Method according to one of claims 1 to 12, characterised thereby that a polyester resin on the basis of orthophtalic acids or isophtalic acids or a terephtalic acid resin, a bisphenol resin or a vinyl resin with or without addition of a flexible resin is used as resin.

14. Method according to one of claims 1 to 13, characterised thereby that cut glass fibres of the same or different lengths are used, for example of 10 to 16 millimetres, of 20 to 30 millimetres and of 30 to 60 millimetres.

15. Method according to one of claims 1 to 14, characterised thereby that a layer of a supplementary material with a grain diameter of 0.1 to 1 millimetre is subsequently applied to at least one glass fibre layer.



16. Method according to claim 15, characterised thereby that sand, quartz sand or feldspar is used as supplementary material.

17. Pipe conduit component, thus pipe or pipe coupling, of polyester resin, filler material and glass fibres, characterised thereby that it is so built up from thin-walled layers merging into one another that layers with and layers without glass fibres succeed in alternation, wherein the layers free of glass fibres contain at least 50% by weight of filler material and the layers containing glass fibres contain at least 30% by weight of filler material.