

**PRODUCTION OF A RESIN-IMPREGNATED FIBER TUBE
FOR INTERNALLY LINING CONDUITS AND PIPES**

Description

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This invention concerns a process for producing a resin-saturated fibrous tube for lining conduits and pipework by impregnating a fibrous tube or a fibrous tape with a liquid resin.

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A particularly elegant way to remediate buried wastewater conduits, water lines and similar pipe systems consists in a flexible fibrous tube impregnated with liquid resin being introduced into the pipe and inflated there and thereafter the resin being cured. The problem with this is that the liquid resin can drain from the fibrous tube after impregnation or at least accumulate on the bottom side of the tube.

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It is therefore proposed in EP-B 799 397 to impregnate a three-ply glass fiber tube having an inner ply of a bulky fibrous mat and two outer plies of a woven roving fabric with a low-viscosity liquid resin and to gel an outer layer by UV irradiation. The production of a three-ply fibrous tube is of course costly and inconvenient, and it is also possible for the resin in the bulky inner ply to settle out in the downward direction during storage, resulting in a nonuniform impregnation.

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The same reference also describes an alternative procedure whereby the viscosity of the resin can be increased by means of thixotroping or thickening agents after the impregnating step to prevent leakage. But this approach is called disadvantageous since, it is stated, the rate of impregnation would be appreciably decelerated and wetting of the individual fibers would be incomplete. In addition, it is stated, that when the

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impregnated tube is wound up or folded the resin becomes squeezed out in the fold regions.

Proceeding from this basic process, the present invention has for its object to avoid the stated disadvantages and to develop a simple process for producing a resin-saturated fibrous tube. This object is achieved according to the present invention when both the initial resin and the thickened resin are adjusted to optimum viscosity.

The present invention accordingly provides a process for producing a resin-saturated fibrous tube for lining conduits and pipework by impregnating a fibrous tape with a liquid resin and winding the fibrous tape around a mandrel, or by impregnating a prefabricated fibrous tube with a liquid resin, wherein the liquid resin during the impregnating has viscosity in the range from 200 to 20 000 mPa s and, after the impregnating, is thickened such that its viscosity is in the range from 50 000 to 2 000 000 mPa s.

Fibrous tape and fibrous tube will hereinafter be known together as "fibrous structure". This fibrous structure can be for example a woven fabric, a laid fabric, a mat, a needlepunched nonwoven web or a felt or combinations thereof, and consist of glass fibers or synthetic fibers.

The liquid resin can be a solution of an unsaturated polyester or of a vinyl ester in styrene and/or an acrylic ester.

In a preferred embodiment, the fibrous structure consists of a woven glass fiber fabric or a glass fiber mat or combinations thereof. In this case, a chemical thickening agent is used, preferably an oxide or hydroxide of magnesium or calcium, for example LUVATOL from Lehmann & Voss, preferably in amounts of 0.2 to 5%

by weight and in particular of 0.3 to 1% by weight of solids, based on the resin. The thickening agent can either be used as a pulverulent solid or as a paste dispersed in a liquid vehicle. The thickening agent is
5 stirred into the resin shortly before the impregnating.

The impregnating is preferably accomplished by pulling the fibrous structure slowly through a bath filled with the liquid resin adjusted to the "right" viscosity, or
10 by blade coating or spraying the resin onto the fibrous structure or applying the resin to the fibrous structure as a liquid film. Thereafter, the resin is allowed to thicken by allowing the impregnated fibrous structure to stand for a prolonged period, preferably
15 at least one day, in particular several days, at room temperature or heating it to temperatures of not more than 80°C for several hours.

In another embodiment, the fibrous structure is a polyester fiber felt. Since felt is very dense, the
20 thickening agent can be dispensed with here and, to raise the viscosity, it is sufficient to thicken with a thixotroping agent, for example WACKER HDK from Wacker-Chemie or AEROSIL from Degussa, which are physical
25 thickening agents and act by hydrogen bonding.

The essential feature of the present invention is the optimum relationship between the viscosities during and after the impregnating. During the impregnating, it is
30 a feature of the present invention that the viscosity shall be between 200 and 20 000 mPa s. If the viscosity is too low, the resin solution will separate in the fibrous structure; if the viscosity is too high, impregnation of the fibrous structure will be
35 insufficient.

The viscosity depends on the identity of resin and on the temperature during the impregnating step, and it can be specifically adjusted for example through the

choice of polyester or vinyl ester and the concentration of the resin solution. The higher the temperature of the bath during the impregnating step, the lower the viscosity. Impregnating is preferably
5 carried out between 15 and 30°C.

After the impregnating, it is a feature of the present invention that the viscosity shall rise to 50 000 - 2 000 000 mPa s. If the viscosity is too low here, then
10 the resin will be squeezed out of the fibrous tube when the impregnated fibrous tube is being inflated in the pipework; if the viscosity is too high, then the flowability of the resin in the impregnated fibrous tube is too low, so that voids and surface defects
15 arise in the resin as it cures. The optimum final viscosity can be set in a specific manner through the choice of the type and amount of thickening agent.

In one version of the preferred embodiment, the initial
20 resin is a thin liquid and is admixed with a thixotroping agent, preferably in amounts of 0.5% to 5% by weight, based on the resin. Following addition of the thixotroping agent, the viscosity rises very rapidly to the preferred impregnating viscosity of 1000
25 to 10 000 mPa s, in particular of 2000 to 8000 mPa s. After the impregnating step, the action of the chemical thickening agent is used to thicken to the preferred final viscosity of 100 000 to 1 000 000 mPa s and in particular of 200 000 to 800 000 mPa s.

30 In the alternative embodiment involving the use of a physical thickener, the preferred final viscosity is in the range from 50 000 to 200 000 mPa s. The final viscosity can likewise be set via the type and amount
35 of thixotroping agent.

The optimum type and amount of thickening agent and of thixotroping agent is simple to determine in preliminary experiments.

The liquid resin used is preferably a photocurable resin. This photocurable resin contains a photoinitiator as described for example in EP-B 23 634. That reference also contains further details concerning
5 liquid resins and thickening agents and also the thickening and curing of the resins with UV light.

Another embodiment utilizes a free-radically curable liquid resin, which contains a peroxide initiator. In
10 this case, curing takes place by raising the temperature to above the disintegration temperature of the peroxide or, in the case of cold-curing resins, through addition of an accelerant.

15 The process of the present invention can proceed either from a fibrous tape, which is impregnated, thickened and wound about a mandrel to form a fibrous tube as described in EP-B 712 352 for example. Alternatively, it is also possible to proceed from a ready-produced
20 fibrous tube, which is directly impregnated and thickened. The impregnated fibrous tube can be provided with films on the inside and the outside and stored. To remediate pipework and conduits, the fibrous tube is drawn into the latter and inflated there, so that it
25 conforms to the inner surface and the resin is cured either by UV irradiation or free-radically through increased temperature, for example with hot water.

Claims

1. A process for remediating conduits and pipework comprising the production of a resin-saturated fibrous tube for lining the conduits or pipework by impregnating a prefabricated fibrous tube with a liquid resin, the resin being a solution of an unsaturated polyester or of a vinyl ester in styrene and/or an acrylic ester, the viscosity of the resin being raised after the impregnating, characterized in that the impregnating is performed by pulling the fibrous tube through a bath of the resin, or in that the resin is blade coated or sprayed onto the fibrous tube, and in that the liquid resin during the impregnating has a viscosity in the range from 200 to 20 000 mPa s and, after the impregnating, is thickened such that its viscosity is in the range from 50 000 to 2 000 000 mPa s.
2. A process for remediating conduits and pipework comprising the production of a resin-impregnated fibrous tube for lining the conduits or pipework by impregnating a fibrous tape with a liquid resin and winding the fibrous tape around a mandrel, the resin being a solution of an unsaturated polyester or of a vinyl ester in styrene and/or an acrylic ester, the viscosity of the resin being raised after the impregnating, characterized in that the impregnating is performed by pulling the fibrous tape through a bath of the resin, or in that the resin is blade coated or sprayed onto the fibrous tape, and in that the liquid resin during the impregnating has a viscosity in the range from 200 to 20 000 mPa s and, after the impregnating, is thickened such that its viscosity is in the range from 50 000 to 2 000 000 mPa s.

3. The process according to claim 1 or 2, characterized in that the fibrous structure consists of a woven fabric, a laid fabric, a mat, a needlepunched nonwoven web or a felt or combinations thereof, of glass fibers or synthetic fibers.
4. The process according to claim 1 or 2, characterized in that the fibrous structure consists of glass fibers and in that the resin contains an oxide or hydroxide of magnesium or calcium as thickening agent.
5. The process according to claim 4, characterized in that the resin contains 0.2% to 5% by weight of the thickening agent in the form a pulverulent solid or in the form of a paste dispersed in a liquid vehicle.
6. The process according to claim 4, characterized in that the thickening is effected by multi-day storage of the impregnated fibrous tube at room temperature or by multi-hour heating.
7. The process according to claim 4, characterized in that a thin liquid resin is first admixed with a thixotroping agent to set the preferred impregnating viscosity of 1000 to 10 000 mPa s, and in that, after the impregnating, the action of the thickening agent is used to thicken to a final viscosity of preferably 100 000 to 1 000 000 mPa s.
8. The process according to claim 1 or 2, characterized in that the fibrous structure is a felt of polyester fibers and the resin contains a thixotroping agent for thickening.

9. The process according to claims 7 or 8, characterized in that the thixotroping agent is fumed silica.
- 5 10. The process according to claim 1 or 2, characterized in that the liquid resin is a photocurable resin and contains a photoinitiator.
- 10 11. The process according to claim 1 or 2, characterized in that the liquid resin is a free-radically curable resin and contains a peroxide initiator.