

Method for using a spray nozzle to spray on a layer of plaster, and tunnel or viaduct provided with a layer of plaster of this type

5 The present invention relates to a method for using a spray nozzle to spray on a layer of plaster, in which a plaster mixture to be sprayed out and a pressurized propellant gas, such as air, are fed to the spray nozzle and the gas and plaster mixture are brought together in the spray nozzle in order to be sprayed out of the nozzle.

10 A method of this type is known, although it does not deal with a layer of plaster so much as a mixture of cement or grout. The spraying of a cement/grout mixture is used in tunnel construction to finish walls and ceiling of a passage which has been drilled or hewn out of rock.

15 It is known from the oil industry to apply a mixture of vermiculite, cement and water as a layer of plaster to steel structural parts in order to provide them with a fireproof layer. However, a mixture of vermiculite, cement and water of this type cannot be sprayed onto a substrate in an automated manner by means of a spray nozzle, on account of the fact that, for example, the spray nozzle becomes blocked, the spray material is not uniformly applied to the substrate, the spray material applied to the substrate has an
20 undesired spread in density. This means that it is not readily possible to use a mixture of vermiculite, cement and water of this type as a fireproof layer on very large surfaces.

It is an object of the present invention to provide a method which allows a plaster mixture comprising a phyllosilicate, such as vermiculite, cement and water and any
25 added plasticizers and/or setting accelerators, to be sprayed on as a layer of plaster by means of a spray nozzle.

According to the invention, in the method of the type described in the introduction the above object is achieved through the fact that the plaster mixture comprises cement,
30 water and a phyllosilicate, in particular vermiculite, and through the fact that the plaster mixture is fed to the spray nozzle with a density of approximately 690 to 860 kg/m^3 . After setting on the substrate, the plaster mixture reaches a high density, such as density of greater than 1000 kg/m^3 . Densities in the range from 1100 to 1310 kg/m^3

have proven achievable in practice, making the plaster mixture eminently suitable for use as a fireproof layer. The Applicant has found that if the mixture of phyllosilicate, cement and water is supplied to the spray nozzle with the abovementioned density, this mixture can be sprayed successfully, with the aid of a pressurized gas, in particular air, via a spray nozzle without the spray nozzle becoming blocked or unsuitable in some other way for the automated spraying of a mixture of this type onto large surface areas. In this context, the Applicant has found in particular that it is advantageous if the plaster mixture is fed to the spray nozzle with a density of 700 to 840 kg/m³, and it is particularly preferred if the plaster mixture is fed to the spray nozzle with a density of 750 to 820 kg/m³.

Since in particular blockage of the nozzle is reliably avoided, in accordance with the invention it is in this case preferred if, prior to the spraying operation, the plaster mixture is made up by mixing a dry mixture of phyllosilicate, in particular vermiculite, and cement with water in such a manner that the plaster mixture obtained has a density within the abovementioned ranges. The dry mixture has a density, for example, of between 450 and 520 kg/m³. After it has been made up, the plaster mixture will generally be fed to the spray nozzle by means of a pump. By ensuring that the density of the plaster mixture has a density within the range at which the plaster mixture is ultimately fed to the spray nozzle as soon as it is made up, it is possible to considerably reduce the risk or extent of the density departing from the abovementioned ranges as it is being conveyed to the spray nozzle, which is of benefit to the structure of the plaster mixture.

To substantially prevent the spray nozzle from becoming blocked, according to the invention it is preferred if the sprayed plaster mixture is under a pressure of 4 to 4.7 bar, in particular, a pressure of 4.2 to 4.5 bar, on the outlet side, in the spray opening, of the spray nozzle. Where the present text and the text which follows refers to pressures, it will be clear to the person skilled in the art that these are excess pressures with respect to atmospheric pressure.

To prevent undesired compaction of the plaster mixture as it is being conveyed to the spray nozzle, according to the invention it is preferable if the plaster mixture is fed to

the spray nozzle in such a manner that the pressure of the plaster mixture is at most 8 bar, preferably at most 7 bar. The Applicant has found that 7 to 8 bar is a critical value for a plaster mixture, in particular a mixture comprising vermiculite, cement and water. How a supply of this nature is to be effected will be clear to a person skilled in the art as a function also of the distance which is to be spanned during supply. This involves selecting a suitable type of pump and if the distances are relatively great if appropriate using a plurality of pumps which are each selected or set in such a way that the pressure at the exit side of the pump in question does not exceed the abovementioned 7 to 8 bar.

10

In order to prevent undesired compression and resultant blockages, presumably caused by the formation of lumps, in the spray nozzle, according to the invention it is preferable for the propellant gas to be at a pressure of 4 to 7 bar at the entry side of the spray nozzle.

15

To enable the plaster mixture to be sprayed reliably onto a substrate taking account in particular of the density of the plaster mixture and to a lesser extent also taking account of the pressures prevailing in the spray nozzle, according to the invention it is preferable for the opening of the spray nozzle during spraying to be held at a distance of 1.0 to 2.5 m, in particular 1.5 to 2 m, from the substrate which is to be provided with the layer of plaster. The result of this is that the plaster mixture, when it reaches the substrate, will strike this substrate with sufficient force to ensure that the layer of plaster sticks sufficiently securely, so that it can set without falling off the substrate.

25 The Applicant has found that to achieve sufficient bonding, the layer of plaster can be sprayed onto a substantially dry substrate or at least that it is not necessary to wet the substrate in advance in order to improve adhesion.

The Applicant has found that the method according to the invention can be used particularly successfully for a substrate made from concrete of strength class B45 or above, such as strength classes B50, B60 or B65, or even a still higher strength class.

30

To enable the method according to the invention to be used to apply a layer of plaster

with a good coverage, according to the invention it is preferable for the spray opening, during spraying, to be moved in translation, as seen transversely to the spraying direction, with a rotational movement superimposed on this translational movement. This results in a type of helical, elongate spraying pattern with overlapping adjoining spiral zones.

To provide a visual check of the thickness of the layer of plaster applied during spraying of the layer of plaster and in this way to make it possible to ensure a specific minimum plaster layer thickness, according to the invention it is preferable for the substrate which is to be provided with a layer of plaster to be provided, prior to the layer of plaster being sprayed on, with pins which are positioned transversely with respect to the said substrate and which have a length equal to 1 to 3 mm less than a predetermined desired thickness of the layer of plaster, the plaster mixture then being sprayed on until the tips of the respective pins are no longer visible or at least no longer project out of the layer of plaster. The pins can in this case be positioned at intervals of greater than 0.5 meter, in particular at intervals of from 1 to 2 meters.

According to a further aspect, the present invention relates to a method for applying a fireproof layer to the wall of a tunnel or viaduct which faces the road, the fireproof layer being a layer of plaster which is applied using the method according to the invention.

According to yet another aspect, the present invention relates to a tunnel or viaduct provided with a layer of plaster sprayed on using the method according to the invention or provided with a fireproof layer applied using the method according to the invention for applying a fireproof layer.

The present invention will be explained in more detail below with reference to a highly diagrammatic drawing in which:

30

Figure 1 shows a highly diagrammatic illustration of a spray nozzle with plaster mixture feed, propellant gas feed and a jet of sprayed plaster mixture;

Figure 2 shows a highly diagrammatic, partially perspective view of a tunnel which is being provided with a layer of plaster using the method according to the invention;

Figure 3 shows a highly diagrammatic illustration of a production line for making up a plaster mixture and spraying it in accordance with the invention; and

Figure 4 shows a highly diagrammatic illustration of a spraying pattern from the spray nozzle which is preferred in accordance with the invention.

Fig. 1 shows a highly diagrammatic view of a spray nozzle 1 with an entry side 7 and an exit side 8. A hose 2 which is used to supply the plaster mixture 3 is connected to the entry side 7. A propellant gas feed line 4, via which in this case compressed air 5 is supplied, is also connected to the entry side 7. In the spray nozzle 1, the compressed air 5 is combined with the plaster mixture 3 which is to be sprayed in a manner which is known per se, for example by setting the plaster mixture in rotation via a tangential centripetal feed, in such a manner that a sprayed jet 6 of plaster mixture and air emerges at the exit side 8. According to the invention, the plaster mixture advantageously consists of a mixture of vermiculite, cement, water and if appropriate plasticizers and/or setting accelerators. This mixture is made up before being fed to the spray nozzle by a mixture of vermiculite and cement, as is commercially available under the name Fendolite M II, which is marketed by Cafco/Reppel. Fendolite M II is entirely of mineral origin, is lightweight, fiber-free and has the particular property of remaining completely passive in the event of a fire. After the plaster layer has set, bound water is present between the individual sheets of the vermiculite grain insulation material, providing an additional insulating effect.

To enable the mixture of vermiculite, cement and water to be sprayed, according to the invention it has proven very important for this plaster mixture to be fed to the spray nozzle with a density in the range from 700 to 840 kg/m³, in particular a density in the range from 750 to 820 kg/m³, at the entry side 7, approximately at the location indicated by 9. To ensure that the propellant gas on the one hand has a sufficient spraying action and on the other hand does not excessively influence the density of the plaster mixture, the compressed air 5 is supplied in accordance with the invention at a

pressure of 4 to 7 bar at the entry side 7, approximately at the location indicated by 10. In particular, it is ensured that the plaster mixture in the spray nozzle, i.e. approximately at the location of 11, after it has been combined with the propellant gas 5, is at a pressure in the range from 4 to 4.7 bar, in particular in the range from 4.2 to 4.5 bar. If the mixture of the vermiculite, cement and water and propellant gas is sprayed out of the spray nozzle at this level of pressure, the Applicant has found that the spray nozzle can be used for prolonged periods of time for spraying a layer of plaster on to large surface areas without the spray nozzle becoming blocked in the meantime.

10

Referring now to fig. 2, with the method according to the invention it is highly advantageously possible to line the inner wall of a tunnel with a fireproof layer of vermiculite, cement and water. In the process, the spray nozzle 1 is controlled by means of a spraying robot 12 and in accordance with the invention is advantageously held at a distance L of 1 m to 2.5 m from the substrate which is to be sprayed, in this case the tunnel wall. The distance L will preferably lie in the range from 1.5 to 2 m.

15

The spraying robot comprises a laser which scans the surface which is to be sprayed between two diagonally opposite corners, in such a manner that the spraying robot is aware of the precise form of the surface which is to be sprayed and can control the spray nozzle accordingly, so that the surface which is to be sprayed is lined completely uniformly with a layer of plaster, in particular with a minimum guaranteed layer thickness. The spraying robot will in this process during spraying constantly adapt the position of the spray nozzle to the measured unevenness. To ensure that a uniform layer of plaster with good coverage is obtained during spraying, according to the invention it is preferable for the spraying robot 12 to control the spray nozzle 1 during spraying in such a manner that it follows a spraying pattern corresponding to that shown in fig. 4, i.e. the spray nozzle 1 is controlled so as to execute a translational, whether straight or curved, movement 13 with the rotational movement superimposed on it, in such a manner that the spraying pattern follows a type of helical pattern, as highly diagrammatically indicated in fig. 4.

20

25

30

To ensure that the layer of plaster remains attached to the tunnel wall with a very high

level of reliability even in the event of exposure to fire, according to the invention it is preferable for the tunnel wall to be lined with a mesh structure before the layer of plaster is sprayed onto it, which mesh structure will be embedded in the layer of plaster after the layer of plaster has been sprayed on. A mesh structure of this type is very
5 diagrammatically indicated by 14 in fig. 2.

To allow visual inspection in order to be especially certain after the operation has finished that the layer of plaster has a certain predetermined minimum thickness over the entire surface (which is very important in connection with fireproofing) and if
10 appropriate to enable any problems of this nature to be corrected while the layer of plaster is being sprayed on, according to the invention it is highly preferable if, before the layer of plaster is sprayed on, the substrate which is to be lined is provided with a number of pins 15 which project from the substrate over a height which is approximately equal to approximately 1 to 3 mm less than the predetermined desired
15 minimum thickness of the layer of plaster. Pins 15 of this type will in particular be provided at certain intervals in accordance with a preferably regular pattern. A pattern of this type may be a square grid pattern with intervals of approximately 1 to 2 meters between the adjacent pins 15.

Reference will now be made to fig. 3, which provides a highly diagrammatic illustration of an overall installation which can be used to carry out the method according to the invention. This overall installation comprises a diagrammatically indicated train of carriages. The rear side of this train is formed by an exchangeable carriage or exchangeable carriages with stocks of raw material. These stocks of raw
25 material will in particular comprise a dry mixture of vermiculite and cement. The stocks of raw material may also comprise water for making up the plaster mixture. The stocks of raw material may also comprise compressed-air cylinders or spraying by means of a spraying robot. These stocks of raw materials may be provided on different carriages. These stocks of raw materials are diagrammatically indicated by 15. There is
30 a buffer silo, in particular for the dry mixture of vermiculite and cement, provided in front of the carriage carrying the stocks of raw material. A double mixing installation 17 is provided in front of the buffer silo carriage 16. This double mixing installation 17 comprises two batch mixers which can be provided on one carriage or if appropriate on

two carriages. These batch mixtures can alternate in terms of mixing mode, in which case one is always in mixing mode for making up a portion of plaster mixture and the other is full of plaster mixture which has been made up for supply to the spray nozzle 1. This supply of the plaster mixture to the spray nozzle 1 takes place via a hose 2 and one or more pumps 20. In accordance with the invention, the pumps 20 are in particular set in such a manner that the pressure of the plaster mixture at the exit side is at most 7 to 8 bar, preferably at most 7 bar. The pump used may in particular be what is known as a progressive (or progressing) cavity pump. This is a pump of the so-called single screw type. In a progressive cavity pump of this type, a rotor rotates inside a stator, the stator being a twisted cavity with an oval cross section. The stator is in this case generally made from a natural or synthetic rubber, from steel or from plastic and the rotor is generally made from steel.

The spray nozzle 1 can end in the form of a spray lance 25 where the plaster mixture together with the propellant gas leaves the spray nozzle.

An energy carriage 19 from which electrical energy can be supplied to the various components of the train with carriages is generally also incorporated in the train of carriages. Finally, a spraying robot carriage, on which the spray nozzle is provided and from which the spraying of plaster mixture will take place, is incorporated at the front of the train.

Claims

1. A method for using a spray nozzle to spray on a layer of plaster, in which a plaster mixture to be sprayed out and a pressurized propellant gas, such as air, are fed
5 to the spray nozzle and the gas and plaster mixture are brought together in the spray nozzle in order to be sprayed out of the nozzle, characterized in that the plaster mixture comprises a phyllosilicate, in particular vermiculite, cement and water, and in that the plaster mixture is fed to the spray nozzle with a density of approximately 690 to 860 kg/m³.
10
2. The method as claimed in claim 1, in which the plaster mixture is fed to the spray nozzle with a density of 700 to 840 kg/m³.
3. The method as claimed in claim 2, in which the plaster mixture is fed to the spray
15 nozzle with a density of 750 to 820 kg/m³.
4. The method as claimed in one of the preceding claims, in which prior to the spraying the plaster mixture is made up by mixing a dry mixture of phyllosilicate and cement with water in such a manner that the plaster mixture obtained has a density as
20 described in one of claims 1-3.
5. The method as claimed in one of the preceding claims, in which the plaster mixture in the spray opening of the spray nozzle is at a pressure of 4 to 4.7 bar, in particular a pressure of 4.2 to 4.5 bar.
25
6. The method as claimed in one of the preceding claims, in which the plaster mixture is fed to the spray nozzle in such a manner that the pressure of the plaster mixture is at most 8 bar, preferably at most 7 bar.
- 30 7. The method as claimed in one of the preceding claims, in which the propellant gas on the entry side of the spray nozzle is at a pressure of 4 to 7 bar.
8. The method as claimed in one of the preceding claims, in which during the

spraying the opening of the spray nozzle is held at a distance of 1.0 m to 2.5 m, in particular 1.5 m to 2 m, from the substrate which is to be provided with the layer of plaster.

9. The method as claimed in one of the preceding claims, in which the substrate
5 which is to be provided with the layer of plaster is substantially dry or at least is not wetted in advance.

10. The method as claimed in one of the preceding claims, in which the substrate
10 comprises concrete of strength class B45 or above, such as B50, B60 or B65, or if appropriate higher.

11. The method as claimed in one of the preceding claims, in which during the
spraying, the spray nozzle is moved in translation, as seen transversely to the direction
of spraying, with a rotational movement superimposed on this translational movement.

15

12. The method as claimed in one of the preceding claims, in which the substrate
which is to be provided with a layer of plaster is provided, prior to the plaster layer
being sprayed on, with pins which are positioned transversely with respect to the said
substrate, which pins have a length equal to 1 to 2 mm less than a predetermined
20 desired thickness for the layer of plaster, and in which the plaster mixture is sprayed on
until the tips of the corresponding pins are no longer visible or at least no longer project
out of the layer of plaster.

13. A method as claimed in claim 12, in which the pins are positioned at intervals of
25 greater than 0.5 meter, in particular at intervals of 1 to 2 meters.

14. A method for applying a fireproof layer to the wall of a tunnel or viaduct facing
the road, the fireproof layer being a layer of plaster which is applied using the method
as claimed in one of claims 1-13.

30

15. A tunnel or viaduct provided with a layer of plaster sprayed on using the method
as claimed in one of claims 1-13 or provided with a fireproof layer applied using the
method as claimed in claim 14.