The tool is advantageously a torque driver, a brush, a roller, a measurement verification element, a nozzle, a scanner, a gripper, or a camera.

A further teaching of the invention provides that the at least one workstation is a station for opening or closing the formwork or a cover of the formwork, a station for retrieving the concrete tubbing; a station for cleaning the formwork, a station for preparing the formwork for subsequently introducing concrete, a station for equipping the formwork with at least one element of the concrete tubbing, a station for verifying the measurements of the formwork, a station for filling the formwork with concrete, and/or a station for treating the surface of the introduced concrete of the concrete tubbing. It is advantageous here for the at least one element to be a seal, a protective liner, a reinforcement element, a sensor, in particular a temperature sensor, a dewatering element, a plastic element, and/or an erector anchor.

A further teaching of the invention provides that at least two production lines which are disposed in parallel and have at least two parallel workstations are provided.

A further teaching of the invention provides that the robot is displaceable between at least two parallel workstations of the at least two parallel production lines.

A further teaching of the invention provides that at least one production plant for making reinforcements for the tubbings is disposed upstream, said tubbings preferably being temporarily stored in a store.

A further teaching of the invention provides that at least one workstation is of modular construction.

A further teaching of the invention provides that the curing station is constructed from individual curing chambers which are preferably embodied as a standard ISO container.

A further teaching of the invention provides that the curing station has a plurality of planes disposed on top of one another.

The object is furthermore achieved by a method for producing concrete tubbing of a tunnel lining system having at least one formwork, in particular by a production plant ~~as claimed in one of claims 1 to 10~~, said method comprising the following steps:

1. disposing, preferably at the precise position, a formwork (10) at a location or in a respective workstation (210, 220, 230, 240, 250, 260) along at least one production line (200) of the production plant (100);
2. if required, identifying the type of formwork in the workstation (210, 220, 230, 240, 250, 260) or at the location;
3. moving a robot (140) along a travel route (120) to the work station (210, 220, 230, 240, 250, 260) or at the location with a travel element (130) at which the robot (140) is arranged with a base (131);

~~3~~ 4. if required, picking up ~~the~~ a tool (150) required for carrying out an operating step by a robot (140);

~~4~~ 5. displacing ~~a~~ the base (131) of the robot (140) along ~~a~~ the travel route (120) and/or ~~a~~ the crossbeam ~~(131)~~ for the X/Y-alignment with a position required for carrying out the operating step at the workstation (210, 220, 230, 240, 250, 260) or at the location;

~~5~~ 6. carrying out and completing the operating step by the robot (140) using the tool (150) required to this end;

~~6~~ 7. if required, checking the completion of the operating step, preferably by the robot (140), using ~~a~~ the tool (150) conceived to this end;

~~7~~ 8. if required, repeating steps ~~3~~ 4 to ~~6~~ 7 for carrying out a further operating step at the workstation (210, 220, 230, 240, 250, 260) at the location;

~~8~~ 9. transporting the formwork (10) to the next workstation (210, 220, 230, 240, 250, 260) along the transport route or curing station (300);

10. if necessary, moving the robot (140) to a further work station (210, 220, 230, 240, 250, 260) or a further location along the travel route (110) by moving the travel element (130);

~~9~~ 11. if required, repeating steps 3 to ~~8~~ 10 for carrying out an operating step at the next workstation (210, 220, 230, 240, 250, 260) or at the next formwork at the next location.

By using the method according to the invention it is possible to enhance the quality of the production of tubbings in a simple manner. At the same time the input of material in the production of tubbings can be precisely detected and evaluated in a simple manner. It is additionally possible for the production processes of each individual tubbing to be documented in a simple manner. As a result thereof, in the context of each individual tubbing produced, it is possible for the production of said tubbing to be tracked and thus simultaneously also the production process to be subsequently verified in the assembled tunnel.

A further teaching of the invention provides that the tool is a torque driver, a brush, a roller, a measurement verification element, a nozzle, a scanner, a gripper, or a camera.

A further teaching of the invention provides that the at least one workstation is a station for opening and closing the formwork or a cover of the formwork, a station for retrieving the concrete tubbing a station for cleaning the formwork, a station for preparing the formwork for subsequently introducing concrete, a station for equipping the formwork with elements of the concrete tubbing, a station for verifying the measurements of the formwork, a station for filling the formwork with concrete, and/or a station for treating the surface of the introduced concrete of the concrete tubbing.

A further teaching of the invention provides that the replaceable tool is retrieved from or deposited in a storage space which is displaceable by the robot or situated on the workstation.

A further teaching of the invention provides that an operating step is opening or closing the formwork or the cover of the formwork, retrieving the concrete tubbing, cleaning the formwork, preparing the formwork for subsequently introducing concrete, equipping the formwork with at

110 of the production line 200. The travel route 120 here has in each case one track 122, the latter being provided on both sides of the production line 200. The two tracks 122 are connected to a crossbeam 130 which is displaceable in the direction of the double arrow E on the travel route 120. A base 131 is disposed on the crossbeam 130 so as to be movable in the direction of the double arrow F on the lower side of the crossbeam 130. Moving here in an exemplary manner takes place by way of a drive 132.

A robot 140 is disposed on the base 131. The robot 140 has arms 141, pivot joints 142 and/or rotary joints 143 as well as drives 144. Furthermore, a tool 150 is disposed on that end of the robot 140 that lies opposite the base 131. The tool 150 here is preferably embodied so as to be replaceable such that different tools 150 can be used depending on the operating step to be carried out.

As a consequence of the displacement capability of the crossbeam 130 in the direction of the double arrow E along the travel route 120, as well as of the displacement capability of the base 131 in the direction of the double arrow F along the crossbeam 130, it is possible for the base 131 of the robot 140 to be disposed in the X/Y-direction above the production line 200. As a result of the construction of the robot 140 it is furthermore possible for the tool 150 to be disposed at any arbitrary point (X, Y, Z) in the space of the production line 200 such that work on or in the formwork 10 can be carried out by the respective tool 150 using the robot 140 by way of the tool 150 of the latter.

Depending on the workstations 210 – 260, the disposal and embodiment of the latter, and the operating steps to be simultaneously carried out therein, it is possible to provide one or else a plurality, illustrated here are two, crossbeams 130 and robots 140 in the production line 200.

The tools 150 here can be kept ready in a toolbox (not illustrated), either directly on the crossbeam 130 or at the respective workstation 210 – 260, such that the robot ~~150~~ 140, the latter having an interchangeable tool connector system (not illustrated), for example, is able to connect to a tool, remove the latter from the respective box, carry out the operating step, place the tool 150 back into the box after the operating step has been completed, and release said tool.

A first embodiment of the formwork 10 (see figs. 5 to 10) is disposed above a pedestal 11 of the transport means 112, for example. The formwork per se has a base 12 by way of which said formwork is able to be disposed on the pedestal 11. An interior space 17 as a concrete tray is provided above the base, said interior space 17 being formed by a floor 16 and internal walls of

Alternatively, this step takes place at the second workstation 220, as is provided here. After the positionally accurate transfer which between all workstations is performed also by way of the data system in conjunction with the memory-programmable controller, for example, the formwork 10 is situated so as to be in the exact position at the second workstation 220. Here too, the formwork and/or the tubbing 500 is again correspondingly identified and detected. As has already been described above, the pre-cured tubbing 500 here in an exemplary manner is now correspondingly retrieved from the formwork 10 so as to initiate the further steps such as, for example, moving the pre-cured tubbing 500 to a curing store 800.

Subsequently, corresponding checking can again take place. This data also is again transferred to the data system. After checking and clearance, the formwork 10, still present as an opened formwork here, is then transported to the third workstation 230. At this point in time, the formwork 10 is empty, opened and not cleaned.

The formwork 10 is introduced in the exact position at the third workstation 230 as well. In addition, the formwork 10 can in turn be recognized here correspondingly. The determination of the state of the formwork 10 can optionally also be carried out at this point in time, in particular in terms of the positions and unfolding angles of the individual walls 14, 15.

Based on this data, the memory-programmable controller transmits the corresponding items of information and operating instructions to the robot 140.

The crossbeam 130 and/or the base 131 of the robot 140 are moved to the respective required target points. Furthermore, the robot 140 is equipped with the corresponding tool 150, for example in that the robot 140 connects to the corresponding tool 140 and retrieves the latter at a storage location.

The corresponding operating step is then carried out, wherein movements of the crossbeam, of the base as well as of the component parts of the robot 140 may be superimposed in order for the corresponding operating step to be carried out. Unless otherwise required, aforementioned movements for optimization here may be dispensed with.

At the third workstation 230, corresponding cleaning of the opened formwork 10 and preparing the surfaces of the formwork 10 that later are in contact with concrete, such as the floor 16, the internal faces of the lateral walls 14 and the end walls 15 as well as of the concrete installation parts 26, for example, is carried out by applying a release agent such as, for example, formwork oil.

distributed. It is also possible for the aforementioned operating steps to be carried out only at one workstation, or on more or fewer workstations than described, respectively.

The control procedure of the method described above, or of the production plant 100, respectively, here takes place as described by means of a memory-programmable controller in which the corresponding operating steps and the associated positions of the robot 140 as well as of the respective tools 150 are stored or processed, respectively. This is combined with a corresponding data processing system/data storage system in which the corresponding parameters are stored, or to which the corresponding data of the sensors or detection tools, respectively, is added and correspondingly provided to the controller for carrying out the individual operating steps.

It is possible for the operational safety to be enhanced by way of the production plant 100 described above as well as the described method in conjunction with the described controller. Furthermore, material can be saved, wherein a precise and consistent use of the materials takes place. It is furthermore possible for a high and constant level of quality to be achieved and maintained. Furthermore, the production process for each individual tubbing can be documented with the corresponding checking data. In conjunction with the identification of the individual tubbing it is thus furthermore possible for the corresponding production process for each individual element in the completed tunnel to be documented. It is furthermore possible for the method and the production plant 100 to be continuously improved in a simple manner by modifications to the controller as well as changes to the tools, or for a re-use of the individual components to be enabled after the tunnel construction project has been completed.

Figures 16 to 23 show a second embodiment of a production plant 100 according to the invention. The production plant 100 here is embodied as a carousel plant, for example. A plant for producing reinforcement baskets 600, in which the reinforcements for the tubbings 500 can be produced in an automated manner, for example by means of welding robots, is disposed upstream of the production plant. The completed reinforcement baskets are temporarily stored in a reinforcement baskets store 700 so as to ensure that the tubbing production of the production plant 100 is delinked from delivery and quality issues of external reinforcement baskets producers. A store 800 for the completed concrete tubbings is connected to the production plant 100, in which store 800 said completed concrete tubbings achieve their final hardness for the installation in the tunnel by storage over time. The production plant 100 furthermore has a curing plant 300.

The production plant 100 here has a plurality of production lines 201, 202, 203. In this exemplary embodiment, the individual production lines 201, 202, 203 are in each case provided with a

Patent claims

1. A production plant for producing concrete tubbing (500) of a tunnel lining system having at least one formwork (10) for producing the concrete tubbing (500), wherein the production plant is provided either as a carousel plant having at least one production line (200) with at least two workstations (210, 220, 230, 240, 250, 260) setup each for carrying out at least one operating step for producing the concrete tubbing (500) and with at least one transport route (110) between the at least two workstations (210, 220, 230, 240, 250, 260) on which the at least one formwork (10) can be moved between the at least two work stations (210, 220, 230, 240, 250, 260) on which path the at least one formwork (10) is moved between the at least two work stations (210, 220, 230, 240, 250, 260) ~~which for, carrying out in each case at least one operating step for producing the concrete tubbing (500), has at least one production line (200) having at least two workstations (210, 220, 230, 240, 250, 260) and having at least one transport route (110) between the at least two workstations (210, 220, 230, 240, 250, 260)~~, or as a stationary plant having at least two stationary formworks (10) ~~which are disposed so as to be stationary~~, wherein the required operating steps for producing the concrete tubbing (500) are ~~in each case~~ carried out on the formworks (10) each, and having at least one curing station (300) for curing concrete which, for producing the concrete tubbing (500), has been filled into the formwork (10), wherein ~~characterized in that~~ at least one robot (140) is provided for carrying out the at least one operating step at one of the at least two workstations (210, 220, 230, 240, 250, 260) or the at least two formworks (10), wherein ~~in that~~ at least one travel route (120) is provided for moving the robot between the at least two work stations (210, 220, 230, 240, 250, 260) or the at least two stationary formworks (10) ~~which~~ wherein the travel route (120) at least partially extends along or transversely to the at least one production line (200), or along or transversely to the at least two stationary formworks (10), is provided, wherein the travel route (120) connects the at least two work stations (210, 220, 230, 240, 250, 260) or the at least two stationary formworks (10), and wherein ~~in that~~ at least one travel element (130) is provided which is moveable along the travel route (120), and on which the at least one robot (140) is disposed by way of a base (131) and by way of which the at least one robot (140) is at least partially displaceable along or transversely to the at least one production line (200) or the at least two stationary formworks (10) ~~is provided~~.

2. The production plant as claimed in claim 1, ~~characterized in that~~ wherein the base (131) of the at least one robot (140) on the at least one travel element (130) is movable along the travel element (130) into the workstation (210, 220, 230, 240, 250, 260).

3. The production plant as claimed in claim 1 or 2, ~~characterized in that~~ wherein the travel route (120, 162) is disposed, preferably on pillars (121), above the workstation (210, 220, 230, 240, 250, 260) or the formwork (10), or is disposed next to the workstation (210, 220, 230, 240, 250, 260) or the formwork (10).

4. The production plant as claimed in one of claims 1 to 3, ~~characterized in that~~ wherein the travel route (120, 162) has in each case at least one track (122) on one side or both sides along or transversely to the at least one production line (200) or formwork (10).

5. The production plant as claimed in claim 4, ~~characterized in that~~ wherein the travel element (130) is at least one crossbeam which by way of the ends thereof is in each case displaceable on the at least one ~~a~~ track (122), and/or on which the base (131) of the at least one robot (140) is disposed so as to be displaceable across the workstation (210, 220, 230, 240, 250, 260).

6. The production plant as claimed in one of claims 1 to 5, ~~characterized in that~~ wherein the robot (140) has a tool (150) and is embodied such that the tool (150) is movable and pivotable in the space of the workstation (210, 220, 230, 240, 250, 260).

7. The production plant as claimed in claim 6, ~~characterized in that~~ wherein the tool (150) is embodied so as to be replaceable on the robot (140).

8. The production plant as claimed in claim 7, ~~characterized in that~~ wherein the replaceable tool (150) is contained in a storage space which is displaceable by the robot (140) or situated on the workstation (210, 220, 230, 240, 250, 260) or in the region of the formwork (10).

9. The production plant as claimed in one of claims 6 to 8, ~~characterized in that~~ wherein the tool (150) is a torque driver, a brush, a roller, a measurement verification element, a nozzle, a scanner, a gripper, or a camera.

10. The production plant as claimed in one of claims 1 to 9, ~~characterized in that~~ wherein the at least one workstation (210, 220, 230, 240, 250, 260) is a station for opening or closing

the formwork (10) or a cover of the formwork (10), a station for retrieving the concrete tubbing (500), a station for cleaning the formwork (10), a station for preparing the formwork (10) for subsequently introducing concrete, a station for equipping the formwork (10) with at least one element (510) of the concrete tubbing (500), a station for verifying the measurements of the formwork (10), a station for filling the formwork (10) with concrete, and/or a station for treating the surface of the introduced concrete of the concrete tubbing (500).

11. The production plant as claimed in claim 10, ~~characterized in that~~ wherein the at least one element (510) is a seal, a protective liner, a reinforcement element, a sensor, in particular a temperature sensor, a dewatering element, a plastic element, and/or an erector anchor.

12. The production plant as claimed in one of claims 1 to 11, ~~characterized in that~~ wherein at least two production lines which are disposed in parallel and have at least two parallel workstations are provided.

13. The production plant as claimed in claim 12, ~~characterized in that~~ wherein the robot is displaceable between at least two parallel workstations of the at least two parallel production lines.

14. The production plant as claimed in one of claims 1 to 13, ~~characterized in that~~ wherein at least one production plant for making reinforcements for the tubbings (500) is disposed upstream, said tubbings (500) preferably being temporarily stored in a store.

15. The production plant as claimed in one of claims 1 to 14, ~~characterized in that~~ wherein at least one workstation (210, 220, 230, 240, 250, 260) is of modular construction.

16. The production plant as claimed in one of claims 1 to 15, ~~characterized in that~~ wherein the curing station (300) is constructed from individual curing chambers (330) which are preferably constructed as a standard ISO container.

17. The production plant as claimed in one of claims 1 to 16, ~~characterized in that~~ wherein the curing station (300) has a plurality of planes disposed on top of one another.

18. A method for producing concrete tubbing (500) of a tunnel lining system having at least one formwork (10), in particular by a production plant (100) as claimed in one of claims 1 to 17, said method comprising the following steps:

1. disposing, preferably at the precise position, a formwork (10) at a location or in a respective workstation (210, 220, 230, 240, 250, 260) along at least one production line (200) of the production plant (100);
2. if required, identifying the type of formwork in the workstation (210, 220, 230, 240, 250, 260) or at the location;
3. moving a robot (140) along a travel route (120) to the work station (210, 220, 230, 240, 250, 260) or at the location with a travel element (130) at which the robot (140) is arranged with a base (131);

~~3~~ 4. if required, picking up ~~the~~ a tool (150) required for carrying out an operating step by a robot (140);

~~4~~ 5. displacing ~~a~~ the base (131) of the robot (140) along ~~a~~ the travel route (120) and/or ~~a~~ the crossbeam ~~(131)~~ for the X/Y-alignment with a position required for carrying out the operating step at the workstation (210, 220, 230, 240, 250, 260) or at the location;

~~5~~ 6. carrying out and completing the operating step by the robot (140) using the tool (150) required to this end;

~~6~~ 7. if required, checking the completion of the operating step, preferably by the robot (140), using ~~a~~ the tool (150) conceived to this end;

~~7~~ 8. if required, repeating steps ~~3~~ 4 to ~~6~~ 7 for carrying out a further operating step at the workstation (210, 220, 230, 240, 250, 260) at the location;

~~8~~ 9. transporting the formwork (10) to the next workstation (210, 220, 230, 240, 250, 260) along the transport route or curing station (300);

10. if necessary, moving the robot (140) to a further work station (210, 220, 230, 240, 250, 260) or a further location along the travel route (110) by moving the travel element (130);

~~9~~ 11. if required, repeating steps 3 to ~~8~~ 10 for carrying out an operating step at the next workstation (210, 220, 230, 240, 250, 260) or at the next formwork at the next location.

19. The method as claimed in claim 18, ~~characterized in that~~ wherein the tool (150) is a torque driver, a brush, a roller, a measurement verification element, a nozzle, a scanner, a gripper, or a camera.

20. The method as claimed in claim 18 or 19, ~~characterized in that~~ wherein the at least one workstation (210, 220, 230, 240, 250, 260) is a station for opening or closing the formwork (10) or a cover of the formwork (10), a station for retrieving the concrete tubbing (500), a station for cleaning the formwork (10), a station for preparing the formwork (10) for subsequently introducing concrete, a station for equipping the formwork (10) with at least one

element (510) of the concrete tubbing (500), a station for verifying the measurements of the formwork (10), a station for filling the formwork (10) with concrete, and/or a station for treating the surface of the introduced concrete of the concrete tubbing (500).

21. The method as claimed in one of claims 18 to 20, ~~characterized in that~~ wherein the replaceable tool (150) is retrieved from or deposited in a storage space which is displaceable by the robot (140) or situated on the workstation (210, 220, 230, 240, 250, 260).

22. The method as claimed in one of claims 18 to 21, ~~characterized in that~~ wherein an operating step is opening or closing the formwork (10) or the cover of the formwork (10), retrieving the concrete tubbing (500), cleaning the formwork (10), preparing the formwork (10) for subsequently introducing concrete, equipping the formwork (10) with at least one element (510) of the concrete tubbing (500), verifying the measurements of the formwork (10), filling the formwork (10) with concrete, or treating the surface of the introduced concrete of the concrete tubbing (500).

23. The method as claimed in claim 22, ~~characterized in that~~ wherein the at least one element (510) is a seal, a protective liner, a reinforcement element, a sensor, in particular a temperature sensor, a dewatering element, a plastic element, and/or an erector anchor.

~~24. The method as claimed in one of claims 18 to 23, characterized in that the tool (150) is a torque driver, a brush, a roller, a measurement verification element, a nozzle, a scanner, a gripper, or a camera.~~

~~25. A control of the method as claimed in one of claims 18 to 24, in particular in conjunction with a production plant (100) as claimed in one of claims 1 to 10, in which operating steps are implemented at workstations (210, 220, 230, 240, 250, 260) or at a location in that data and/or sensor data is evaluated, a robot (140) based on the data and/or sensor data is positioned at an X/Y-position along a production line, a tool (150) based on the data and/or sensor data is selected for carrying out the operating step, and the operating step is carried out by transferring control data to the robot (140) and/or the tool (150).~~

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