Summary

In an aspect, the present disclosure refers to a device for the automated, planar application of flowable substances to a construction-side surface of walls or construction-side-mounted wall studs, comprising a motor-driven movable carriage which can be moved laterally back and forth parallel to the wall, an upwardly projecting vertical beam mounted on the movable carriage, and a plurality of outlet nozzles mounted vertically one above the other on the vertical beam for spraying the flowable substance to the construction-side surface, wherein the outlet nozzles can be moved by a motor individually relative to each other or in individual groups relative to adjacent groups of outlet nozzles laterally towards and away from the construction-side surface.

In an aspect, the present disclosure refers to a method for the automated, planar application of flowable substances to a construction-side surface of walls or construction-side-mounted wall studs by means of the device according to the above aspect. Individual outlet nozzles or one or more groups of outlet nozzles are moved by a motor away from and/or towards the construction-side surface depending on the detection of a construction-side projection or a niche or protruding sections of wall studs.

In an example, the disclosure is therefore to create a device and a method enabling a simpler, faster and primarily more cost-effective application of flowable substances to a construction-side surface of walls or construction-side-mounted studs.

This is achieved, in an example, by a device for the automated, planar application of flowable substances to a construction-side surface of walls or construction-side-mounted wall studs, comprising at least one motor-driven movable carriage which can be moved laterally back and forth parallel to the wall, an upwardly projecting vertical beam mounted on the movable carriage, and a plurality of outlet nozzles mounted vertically one above the other on the vertical beam for spraying the flowable substance to the construction-side surface, wherein the outlet nozzles can be moved by a motor individually relative to each other or in individual groups relative to adjacent groups of outlet nozzles laterally towards and away from the construction-side surface.

The disclosure provides that numerous outlet nozzles arranged one above the other apply the substance in large strips to the surface as the movable carriage moves. However, as the surface of the building on the wall side is not necessarily planar, but sometimes has protruding parts, e.g. balconies, panellings, protruding beams in the ceiling area, roofings, etc., the previous devices could not treat large areas in one piece. Rather, the device had to be dismantled prior to such projections and reinstalled after the projections, and in the area of such projections, work then had to be done entirely by hand.

However, the disclosure provides that outlet nozzles are moved further away from the surface by a motor, for example before reaching an outwardly projecting beam, so that these outlet nozzles do not collide with the projection but move out of the way in the direction away from the surface. However, the rest of the outlet nozzles remain positioned in the appropriate proximity to the surface to be treated. As this adjustment of the outlet nozzles is preferably carried out by a motor in a direction perpendicular to the surface, no conversions are necessary, in particular no manual conversion of the device is required. The device moves along its entire path, so that a strip section is covered with paint, for example, preferably over a height of several meters in a single pass.

Depending on the traveling speed of the outlet nozzles relative to the surface, the amount of substance dispensed via the outlet nozzles is so high for one and the same layer of substance that the entire required application amount is applied during a single pass, i.e., multiple passes or a serpentine-like movement pattern, or a cross pattern are not necessary to apply paint to a wall. This significantly reduces application time.

Likewise, the serpentine-like movement pattern which is unavoidable with manual paint application due to the size of the surface relative to the width of a paint roller is no longer necessary. To date, this is also the case with known automatic facade or painting machines or the few mobile robots due to the small path width which can only be achieved using a single spray nozzle. A significant loss of time is unavoidable with a conventional path-like painting process, and the countless changes in the direction of application during the paint application result in multiple applications. This is almost completely eliminated by the above example. The time saved is even greater and the amount of substance used in the application is determined only by the quality requirements of the application specification. The previously desired generous overlap of all directly adjacent spray paths is also avoided. Manufacturers of paint spray technology and equipment and paint producers recommend a 50% overlap between each path to ensure a streak-free, opaque coating and spray pattern. The example reduces the areas with overlap to preferably 5 - 10% of the surface to be coated.

The disclosure does not necessarily require that all outlet nozzles can be moved by a motor laterally towards and away from the construction-side surface, but several, preferably at least four, outlet nozzles must have this vertical movability to be able to treat niches or projections on the wall.

The outlet nozzles can be vertically movable by a motor individually relative to each other or in groups relative to other groups of outlet nozzles. This allows the outlet nozzles, or at least some of the outlet nozzles, to be adjusted in terms of their distance from each other and from the floor, so that, on the one hand, the overlap of the adjacent spray cones can be optimally adjusted and, on the other hand, also the height of the treated area during a moving operation of the movable carriage.

In particular, those outlet nozzles that can be moved horizontally can also be moved vertically individually or in groups. In addition, outlet nozzles which cannot be moved horizontally can or should, if present, be adapted to be moved vertically, more specifically individually or in groups.

Where reference is made to a “movable carriage”, this also includes several movable carriages which are moved together one behind the other or next to each other, e.g. a movable carriage on which the beam with the outlet nozzles is attached, and a separately driven movable carriage or a coupled trailer which carries material to be applied or pumps or an electric battery as an energy supply. Supply lines may be provided between the movable carriages.

Optionally, the vertical beam can also be adjustable/changeable in the vertical extent thereof, in particular by means of a motor, so that the device can be adapted to the room height. For this purpose, it is useful if the vertical beam is extendable or telescopic. An alternative thereto is that vertical segments of the vertical beam lie next to each other in the retracted state and are partially overlapping and possibly partially offset with respect to each other in the extended state. This has advantages especially in interior spaces as the vertical beam can be precisely adapted to the actual room height. The adjustment of the vertical beam can be motorized, e.g. by means of driven pulling means or a spindle drive.

This vertical length adjustability can be combined particularly well with the vertical motorized adjustability of the outlet nozzles. For example, the optimum distances between the outlet nozzles can thus be set from top to bottom independently of the set height of the vertical beam.

The number of outlet nozzles is matched to the maximum extension length of the vertical beam. This ensures that the spray cones of adjacent outlet nozzles overlap just enough. If the extension length is shorter, outlet nozzles can be switched off, for example, if the overlap of the spray cones is too large or too many spray cones overlap each other. This can particularly affect lower outlet nozzles, which may still be positioned stacked on top of each other.

If, due to the given application height, there is too much overlap of the spray cones despite some of the outlet nozzles being switched off and no further outlet nozzles can be switched off without creating a faulty area in the paint application, this is corrected by exchanging the spray heads of the outlet nozzles accordingly to produce an appropriate overlap and not to waste any material to be applied.

One variant of the example provides for vertically aligned, additional outlet nozzles for spraying lower sides or upper sides of construction-side projections or wall studs.

For example, such lower sides or upper sides of projections, e.g. balconies or parapets, must also be treated as automatically as possible, which is achieved by the device according to the example due to additional outlet nozzles. In particular, these additional outlet nozzles are not intended to also spray the vertical sections of the walls, i.e. these additional outlet nozzles basically serve a different purpose and are aligned or adapted to be aligned differently (perpendicular to the surface to be treated), and may also have a different spray cone.

The additional outlet nozzles are mounted, for example, on a holder which can be moved vertically on the vertical beam. This vertical movability makes it possible to move the outlet nozzles, for example, from the bottom towards the lower side of a balcony to be sufficiently close to the surface to be treated. The movable holder also allows these additional outlet nozzles to be moved such that they avoid obstacles on the construction side. This is particularly necessary for the wall studs, which are sprayed by means of the device on the side surfaces, but also on the lower sides and the upper sides.

Alternatively or in addition to this holder, these additional outlet nozzles can be moved vertically by a motor individually relative to each other or in groups relative to other groups of outlet nozzles, just as it was possible for the previously mentioned outlet nozzles for application on the side surfaces. This is also necessary to optimally avoid protrusions and to be able to spray at an optimal distance.

These additional outlet nozzles can also be arranged on a beam arm which is fastened to the holder and mounted so that it can pivot vertically up and down. Due to this beam arm, it is possible to simply pivot the additional outlet nozzles into the vertical plane or, more generally, perpendicular to the surface to be treated when they are not needed, so that they do not protrude laterally and thus increase the risk of collision. They do not get dirty from the spray mist of the other outlet nozzles, either. The beam arm is only pivoted in the horizontal plane if this is necessary at certain positions of the movable carriage, namely where an upper side or a lower side is to be sprayed.

To automate the device according to the disclosure, a sensor system and a control device coupled to the sensor system are provided. The sensor system can scan the construction-side surface such that it can detect protrusions and niches. The control device, in turn, is programmed and designed to control a lateral, motorized adjustment of the outlet nozzles towards and away from the construction-side surface depending on the presence of protrusions and niches. The device recognizes, through self-learning, where the exhaust nozzles would collide with a construction-side part and moves them (and thus of course the corresponding mount for these exhaust nozzles) away from the surface. This is only possible to the extent that the vertical beam itself would not collide with the projection.

Each time the device is started, the installed components are recognized and the sensor system is automatically calibrated. During application of the coating, it is possible to determine the respective current position of each individual outlet nozzle on the respective linear axis and with respect to the floor, the respective distance of the

spray head relative to the surface to be sprayed, the operating state of each of the outlet nozzles (open or closed), and the type of spray nozzle. The integrated sensor system allows the axes and spray nozzles to be controlled.

Optionally, the outlet nozzles can however be moved up to the vertical beam, as seen in the direction of movement, and only project a few centimeters laterally in the direction of the surface to be treated.

To enable the treatment to be carried out in just a few passes again, preferably, as mentioned, in just one pass, the disclosure, according to one variant, provides for several sensors which are arranged vertically one above the other and are part of the aforementioned sensor system. These multiple sensors detect the entire surface to be treated by the outlet nozzles when the movable carriage moves. This means that the aforementioned obstacles, but also niches where the outlet nozzles may possibly have to be moved closer to the wall, are detected in a single pass. The device does not have to move back and forth multiple times and/or move sensors up and down to scan the surface to be painted afterwards, but one pass, preferably in which the material is applied at the same time, is sufficient to scan and simultaneously adjust the outlet nozzles based on the scan results.

If substances are to be applied during the travel back and forth, it is advantageous if sensors are provided laterally of the vertical beam in both of its directions of movement and not only on one side of the vertical beam. These sensors are in particular arranged one above the other, more specifically on the vertical beam or, of course, on a unit attached to the vertical beam.

Repairing imperfections and cracks, for example in a plaster base, is just as time-consuming as the planar application of flowable materials. The device according to the disclosure is configured so as to also include appropriate means to repair these imperfections. For this reason, the sensor system is configured to detect imperfections and/or defective spots on the surface. An automatic repair means for applying repair compound is part of the device, as is a wiper to smooth the repair compound applied to the imperfection or defective spot. This repair means may be configured to be vertically movable, so that it sits on a 3-axis robot, or it is also possible to provide several vertically stacked repair means, so that each of these repair means is responsible for a specific height range of the surface measured from the bottom. As the repair means does not have to apply a repair compound over more than 50 cm or several meters in height in a planar manner, it is sufficient if the repair means is able to cover a height range (path width) of approximately 1 to 70 cm and then to penetrate into other height

ranges by means of height adjustment to smooth the defective spots or imperfections there.

Preferably, the repair means is also arranged on the vertical beam.

The sensor system should be configured such that it can detect the applied layer thickness without contact, more specifically can detect without contact, to open-loop or closed-loop control the applied mass. This means that the device according to the disclosure reacts immediately if a little too little or a little too much mass has been applied and then controls the amount of flowable substance dispensed from the nozzles depending on the detected layer thickness. The applied layer thickness can be determined, for example, by means of ultrasonic detection.

It is also possible to determine the layer thickness indirectly by calculation based on the flow rates per outlet nozzle, taking the sprayed area measured by the sensor system during movement into account, and also taking the distance, the speed of movement and the time in the open operating state of the outlet nozzle(s) and the viscosity of the flowable substance into account.

Optionally, the sensor system can also detect the roughness of the surface, and the control device is then programmed to open-loop or closed-loop control the amount of flowable substance dispensed by the nozzles depending on the determined roughness of the surface. More substance must be dispensed for a rough substrate which must be painted or should be washed afterwards than for smooth plaster.

The outlet nozzles should have a discharge angle which is aligned with the distance between the outlet nozzles such that the substance application of the adjacent nozzles only overlaps minimally. In particular, the aim is to achieve an overlap which is oriented towards material consumption without violating the quality criteria of an even application, taking the entire surface to be sprayed into account.

The outlet nozzles are preferably mounted individually or in groups of outlet nozzles to assigned single-axis, linearly movable linear actuators which can preferably be adjusted to any position. These linear actuators can be retracted, i.e. moved away from the surface, to make room for the projection on the surface. Which outlet nozzles must have which degrees of freedom can be determined by the application and the wall geometry.

To design the device according to the disclosure as simply, cost-effectively and as optimized as possible and also not to increase the complexity thereof, it is preferable to

to the construction-side surface. As already explained above, these outlet nozzles can also be moved by a motor individually relative to each other or in individual groups relative to adjacent groups of outlet nozzles laterally towards and away from the construction-side surface.

The upper movable carriage(s) may be coupled to the lower movable carriage, in particular mechanically, to be moved together. However, this is not absolutely necessary.

Generally, a movable carriage and a trailer/further movable carriage for material or energy can also be coupled to each other on the same level via lines.

As the device according to the disclosure should also be easily convertible for applying other substances, e.g. convertible from plaster application to paint application or from water application to paint application, it is usually necessary to change the outlet nozzles. These are typically optimized for a specific substance. To make this change as easy as possible, the outlet nozzles can be attached to a module support on the vertical beam and, together with the module support, form a unit which can be detached from the vertical beam. In this case, the device can be sold with several module supports, each having specific outlet nozzles, as a modular unit. The user then simply attaches the appropriate unit of module support with the corresponding outlet nozzles to the vertical beam. Such a modular design also allows for quick replacement in the event that outlet nozzles are defective or clogged. Cleaning the outlet nozzles can also be significantly easier if the entire module support is removed and then cleaned at ground level, where it is more easily accessible.

One possibility of the disclosure is that the device has outlet nozzles over the entire movement height, and then a further rail is placed above these outlet nozzles for a higher wall to attach a movable carriage there, which then either holds the extended vertical beam or to which a separate vertical beam is attached to spray the upper part of the wall with a substance. However, a further possibility is that the unit of outlet nozzles, whether or not it is arranged on a module support, is attached to a base which is mounted on the vertical beam and can be moved vertically and linearly by a motor. This is explained below using an example. The wall is 3 meters high. The outlet nozzles extend over a height of 2.5 m, for example, and can thus cover a band in a height of 2.5 m along the even higher wall with paint. However, the vertical beam is for example even higher, so that the base with the outlet nozzles coupled thereto is moved up one unit after the first application path to spray the remaining 0.5 m high strip, for example, on the return travel.

An alternative thereto is that the outlet nozzles are mounted on their own movable slides which can be adjusted vertically in relation to each other and which are movably mounted on the vertical beam. These slides carry at least one outlet nozzle, optionally also two or more outlet nozzles which have a fixed vertical distance from each other. The slides are moved by a motor vertically relative to each other to optimally space the outlet nozzle(s) from the outlet nozzle(s) of the adjacent slide. This can also be perfectly combined with a vertical beam which can be adjusted (is extendable or telescopic) in its vertical extension.

As the device is to be used for industrial buildings, the supply of substance is an important aspect. Excessively long lines lead to enormously high pumping pressures and also to the fact that too much substance remains in the line system when the device is switched off, which would have a strongly negative effect as to the drying, functionality and longevity of individual assemblies of the device. For this reason, the disclosure provides in one variant that a material container/material carriage coupled to the movable carriage and traveling therewith for receiving the flowable substance and/or a pump system coupled to the movable carriage and traveling therewith for pumping the flowable substance from the material container to the outlet nozzles are provided. There are several variants here. On the one hand, the material container and/or the pump system can be carried on the movable carriage itself, or, alternatively, a second material and/or pump carriage coupled to the movable carriage travels therewith.

If rails are arranged in multiple levels with multiple movable carriages above each other, a material container and a pump system may be assigned to each movable carriage to reduce the pump pressure, i.e. each movable carriage can guide its own material container and/or its own pump system.

As there are conditions in which it is not possible to supply power from the mains or there is no reliable mains current, it is advantageous if the device can be operated temporarily, more specifically at least temporarily by a battery. This means that the drives of the device can run only on the battery for at least a certain period of time. This makes it possible, for example, to apply material which is in the material container for processing in the event of power failure, or to pump the line system empty.

The disclosure also relates to a method for the automated, planar application of flowable substances to a construction-side surface of walls or construction-side-mounted wall studs by means of the device according to the disclosure. Individual outlet nozzles or one or more groups of outlet nozzles are moved by a motor away from and

then back to the construction-side surface, depending on the detection of a construction-side protrusion or niche or protruding sections of wall studs.

As already explained above with regard to the device, the layer thickness of the substance applied to the construction-side surface is determined by sensors and, depending thereon, the quantity of substance ejected is open-loop or closed-loop controlled during the further movement of the movable carriage to achieve a constant quality. In this variant, defective nozzles can also be detected immediately, because too little substance is applied in the area covered by them.

The method and device according to the disclosure serve in particular to apply paint, varnishes, water, plaster, coating material or flame retardant, the device being equipped with other outlet nozzles, i.e. converted, for applying other substance.

The individual outlet nozzles can also be switched individually, such that, for example, when a door or window appears during spraying, the corresponding outlet nozzles which would otherwise spray the door or window area are switched off.

The aforementioned individual features of the method and the device also relate conversely to the device and the method.

Further features and advantages of the invention will become apparent from the description and drawings below, to which reference is made.

The drawings show:

Figure 1 a side view of a building with a device according to the invention set up in front of the building to carry out the method according to the invention,

Figure 2 a side view of the building with the device according to Figure 1,

Figure 3 a more detailed front view of a slightly modified device according to the invention,

Figure 4 an option for a drive for the device according to the invention in a horizontal direction,

Figure 5 a detailed view of a variant of the device according to the invention in the area of a vertical beam,

Figure 6 a more detailed side view of part of the device according to the invention as shown in Figure 5,