

Assembly machine and a method for manufacturing reinforcement structures

Field of the Invention

The present invention relates to an automated assembly machine for manufacturing
5 rebar structures, such as rebar cages or engineered meshes, in multiple dimensions.
The assembly machine comprises at least one robot unit capable of moving along the
production area, while the cage or mesh is preferably fixed in the longitudinal direc-
tion during the assembly process. The longitudinal rebar elements and the transverse
rebar elements are preferably loaded into the assembly machine in an automated pro-
10 cess.

Background of the Invention

During construction it is known to embed reinforcing rebar cages or engineered mesh-
es into the concrete to strengthen and hold the concrete structure in tension. Such re-
bar cages or engineered meshes may be pre-fabricated at a production facility and then
15 transported to the building site. This reduces the total assembly time and improves the
quality of the assembled cage or mesh.

The rebar cages may be assembled manually using a jig system where the stirrup units
are individually positioned along the jig system after which the longitudinal rods or
20 bars are fed manually through each of the stirrup units. The worker then secures each
longitudinal rod to the stirrup units by either spot welding, a mechanical connection or
by tying a steel wire around the stirrup unit and longitudinal rod or bar at the cross-
ings. However, this manual assembly process is highly labour intensive and time con-
suming. Today it may take several hours to few days to complete a cage structure for a
25 team of 5-10 workers.

The stirrup units of a rebar cage may instead be pre-assembled using an assembly ma-
chine where the worker manually loads the stirrup units into the machine stirrup unit.
Afterwards, the machine automatically welds the stirrup unit to longitudinal wires in a
30 pre-determined position and moves the structure to the next position where the next
stirrup unit is welded in place. The pre-assembled stirrup units are then placed in an-
other assembly machine for assembly of the cage structure.

Alternatively, the rebar cages may be assembled using another machine where the worker initially positions the stirrup units along a holding frame, and then manually feeds a first set of longitudinal rods through the stirrup units. The longitudinal rods are resting on a number of supporting arms distributed along the holding frame. The worker then raises the support arms into a first vertical position relative to the stirrup units and manually welds the longitudinal rods to each stirrup unit. The support arms are afterwards lowered and a second set of longitudinal rods are manually fed into the machine. The support arms are then raised to a second vertical position, and the worker then manually welds the longitudinal rods to each stirrup unit.

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In above machines, the worker has to manually feed the longitudinal rods into the machine from one end. This requires a corresponding amount of free spacing in order to feed the rods into the machine as well as unloading the finished cage. A known problem with moving cages is that it is difficult maintaining the precision as the cage is moved back and forth during the assembly process.

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Instead of manually placing stirrup units in the machine, a continuous wire may be fed from coils and automatically welded onto the longitudinal rods via a welding unit as the longitudinal rods are rotated around a rotation axis. However, the longitudinal rods are still manually being fed into this machine and it can only handle rods with max diameter of 16mm.

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The above machines are only capable of handling rods with a diameter less than 16 millimetres. Cages comprising thicker rods have to be assembled manually, typically by 4 to 10 workers. The above mentioned semi-automated machines are also not capable, or very limited and restricted in terms of freely placing the stirrup units next to each other with approximately zero spacing.

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Engineered meshes may be assembled in a fully-automated machine where the longitudinal rods are fed onto a loading table where the longitudinal rods are spaced apart. The arrangement of longitudinal rods is then transferred to a stationary welding station. The transverse rods may be stored in a magazine above the welding heads and then continuously fed onto the longitudinal rod arrangement. Alternatively, the transverse rods may be fed onto a second loading table where the transverse rod arrange-

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ment is then transferred onto the longitudinal rods. The welding heads then weld the transverse and longitudinal rods together to form the engineered mesh as the longitudinal rods are being pulled through the welding station and onto an unloading table. However, this machine takes up a lot of space in the production area, and is only able to handle rods with an absolute max diameter of 20 millimetres. The machines on the market today all weld with resistance welding which require a lot of power.

US 2018/0333764 A1 discloses an assembly machine for manufacturing reinforced mesh structures, where adjacent rebar meshes are interconnected by means of a plurality of spacer rods. The assembly machine comprises a production area in the form of a receiving table, where two robot units moveable arranged on a rail are arranged on both sides of the receiving table. A loading unit with a magazine for storing the spacer rods is arranged at one end of the receiving table, wherein a further robot unit is used to load the individual spacer rods from the magazine and to a first robot unit on either side of the receiving table. A second robot unit on either side of the receiving table is used to weld the spacer rods to the rebar meshes while the first robot unit holds the spacer rod in an installation position. A crane is used to lift the rebar meshes onto the receiving table.

Object of the Invention

An object of the invention is to provide an assembly machine and method that solves the above mentioned problems for all diameters.

Another object of the invention is to provide an assembly machine and method that reduces the total assembly time and is much less labour intensive.

Yet another object of the invention is to provide an assembly machine and method that take up less space in the production area.

A further object of the invention is to provide an assembly machine and method that allows for the manufacture of two- or three dimensional reinforcement structures using the same machine setup.

Description of the Invention

One object of the invention is achieved by an assembly machine for manufacturing of reinforcement structures, such as rebar cages or meshes, comprising:

- a production area extending in a longitudinal direction and in a transverse direction,
 - 5 - a first loading unit arranged relative to the production area, the first loading unit being configured to load a number of rebar elements into the assembly machine,
 - at least one moveable robot unit arranged relative to the production area, the at least one moveable robot unit comprising at least one robotic arm configured to be fitted with at least one tool, wherein the at least one moveable robot unit is configured to
 - 10 move along the production area in the longitudinal direction, characterised in that the assembly machine further comprises:
 - a plurality of support arms arranged relative to the production area, each of the support arms extending in the transverse direction,
 - at least one support element configured to hold a number of transverse rebar elements in at least one fixed position in the longitudinal direction, the at least one support
 - 15 element being arranged relative to the support arms,
- wherein the first loading unit is configured to load a number of longitudinal rebar elements into the assembly machine in the longitudinal direction.

20 This provides a compact assembly machine that has a smaller overall footprint compared with conventional assembly machines. This also provides a multi-functional assembly machine capable of manufacturing complex two-dimensional as well as three-dimensional reinforcement structures using the same machine setup and space. The present assembly machine is able to manufacture cages or meshes with any kind

25 of rod or bar diameter. The present assembly machine thus acts as a fully-automated assembly machine configured to assemble cages or meshes in a fully-automated process. Preferably, the present assembly machine is further configured to load the longitudinal rebar elements and/or the transverse rebar elements in a fully-automated process.

30 Furthermore, the cage or mesh structure is kept stationary in the present assembly machine, thus fewer components are required compared to conventional assembly machines in which the cage or mesh structure is moved through the machine. The cages and meshes may thus be manufactured with higher precision.

The present assembly machine comprises a production area extending in the longitudinal direction and further in the transverse direction in which the cage or mesh is assembled. A plurality of support arms are distributed along the production area in the longitudinal direction. Each support arm is configured to provide support for all or
5 some of the longitudinal rebar elements. The support arms may each extend partly or fully along the production area in the transverse direction. The support arms may further be arranged along one or both sides of the production area.

A plurality of support elements are further distributed along the production area in the
10 longitudinal direction. The support elements each comprises an upper part configured to receive and hold at least one transverse rebar element and a lower part configured to provide support for the upper part.

In example, the upper part may comprise projecting teeth, fingers or pins between
15 which the transverse rebar element may be placed. The upper part may be adjustable or interchangeable so that it may be adapted to the desired cage or mesh structure, as described later. In example, the lower part may comprise support legs, support feet or mounting brackets so that the support elements may be positioned within the production area, and optionally removed when not used. Alternatively, the individual support
20 elements may be configured as a dolly wagon, or be arranged on a set of rails, so that the finish cage or mesh structure may be removed while resting on the support elements. The dolly wagon may be a robotic dolly wagon.

A first loading unit is arranged relative to the production area, e.g. at one end, and
25 extends in the longitudinal direction. The first loading unit may be configured to transfer all longitudinal rebar elements onto the support arms in one step. Alternatively, the first loading unit may comprise a separator configured to separate the longitudinal rebar elements individually or in groups before transferring them onto the support arms. The longitudinal rebar elements may thus be automatically loaded into the assembly machine via the first loading unit. This setup may be suited for slim production
30 halls as it takes up less space in the transverse direction.

The first loading unit may comprise a loading structure configured to move between a loading position, a number of holding positions and optionally a retracted position in

the orthogonal direction. In example, the first loading unit may be adjustable in height so that the loading structure may be raised or lowered using a local drive unit. Alternatively, the first loading unit may comprise one or more pillars, where the loading structure may slide or move along a rail or track on the pillar using the local drive unit. The drive unit may in example, but not limited to, be a gas spring, a linear actuator, a telescopic actuator, a toothed belt system or a ball screw, where the drive unit may be operated using electrics, pneumatics, hydraulics or any combinations thereof. This allows the loading structure and thus the longitudinal rebar elements to be automatically raised or lowered relative to the support arms. In conventional assembly machines, the longitudinal rebar elements cannot be raised or lowered in the orthogonal direction.

The loading structure may comprise a plurality of actively driven rollers or belts arranged on individual drive shafts or a common drive shaft. A local drive unit may be used to drive the rollers. This allows the longitudinal rebar elements to be transferred onto the support arms in the longitudinal direction.

A cutting unit may be arranged relative to the first loading unit for cutting each longitudinal rebar element into the desired length. Alternatively or additionally, a bending unit may be arranged relative to the first loading unit for bending the longitudinal rebar elements into the desired profile. The longitudinal rebar elements may thus be cut and/or bend in a fully-automatic step before they are fed into the first loading unit. This saves man hours and reduces the amount of manual labour associated with fabricating the longitudinal rebar elements.

Instead of automatically bending and/or cutting the longitudinal rebar elements, this may be done manually or semi-automatically in a cutting or bending area. The pre-cut and pre-bend longitudinal rebar elements may then be transferred to the first loading unit. This may be desired for cages or meshes having a complex profile.

According to one embodiment, the at least one moveable robot unit comprises a first moveable robot unit with a first robotic arm and a second moveable robot unit with a second robotic arm, the first robotic arm being configured to fit with a first tool and the second robotic arm being configured to fit with a second tool.

The present assembly machine comprises at least one moveable robot unit with at least one multi-axial robotic arm which may be fitted with one or more tools for performing different tasks, such as welding or binding. The robot unit may be arranged on a base moveably connected to a rail, a track or a frame, wherein a local drive unit, e.g. a motor, may be configured to move the base with robot along the rail, track or frame. Optionally, the robot unit may be moveably connected to a further rail or frame, wherein another local drive unit, e.g. a motor, may be configured to further move the base with robot along that further rail or frame. The robot unit may thus be moved in at least one direction, preferably in the transverse direction, the longitudinal direction and/or an orthogonal direction perpendicular to the transverse and longitudinal direction. The cage or mesh structure is thus kept stationary while the robot unit is moved back and forth during the assembly. Whereas in conventional assembly machines, the robot unit is kept stationary while the cage or mesh is moved back and forth during the assembly.

In example, the robot unit(s) may be arranged on a rail, track or frame positioned on one or both sides of the production area. Alternatively, the robot unit(s) may be suspended from a common frame, track or rail positioned a distance above the production area. The position of the robot units may thus be adapted to the layout of the manufacturing facility.

Preferably, a first moveable robot unit with a first robotic arm and a second moveable robot unit with a second robotic arm may be arranged relative to the production area. The first or second moveable robot units may be connected to individual rails or frames or a common rail or frame. Individual drive units or a common drive unit may be used to move the robot unit back and forth along the rail or frame. Alternatively, at least two moveable rotor units each with a robotic arm may be arranged on one or both sides of the production area. This saves time and allows different task to be performed at the same time. This further allows the robot units to be moved individually or synchronously.

The first and second robotic arms may be fitted with different types of tools used during the manufacture of the cage or mesh. In example, the first and second tools may be a welding tool, a binding tool, a gripping tool or another suitable tool. The first tool

and/or the second tool may be adapted to fit the profile of the cage or mesh structure and/or the individual rebar elements. The first and/or second tool may also be a multi-tool, e.g. a welding and gripping tool, configured to perform multiple tasks using the same tool. The individual tools for each robot unit may be stored in a tool kit or holder
5 at the robot unit, thereby the robot unit to quickly change tools. Alternatively, the tool kit or holder may be located at one end of the rail or frame. This increases the multi-functionality of the robot units.

Each robot unit may be fitted with one or more sensors or cameras which are connect-
10 ed to a controller. The controller may be configured to control the movement of the robotic arm based on the input signals from the sensors. This allows the tool to be positioned correctly relative to the cage or mesh. Optionally, the controller may use the input signals from the sensors to compensate for misalignment between the respective longitudinal and transverse rebar elements.

15 According to one embodiment, the plurality of support arms is configured to move between a retracted position and at least a loading position or a holding position in at least an orthogonal direction.

20 One or more sets of support arms may be distributed along the production area, wherein each set may be arranged to support a dedicated number of longitudinal rebar elements. Preferably, a set of first support arms is used to support a first set of longitudinal rebar elements, a set of second support arms is used to support a second set of longitudinal rebar elements, and so forth. The individual sets of support arms may be
25 distributed along one or both sides of the production area. If arranged on both sides of the production area, the individual support arms may be aligned or offset relative to each other in the longitudinal direction. The individual support arms may thus extend the entire width of the production area, or a portion thereof. This may be desired for cage or mesh structures having a complex design.

30 Each of the first and second support arms may comprise a first part that may extend in the transverse direction on which the longitudinal rebar elements may rest. Each of the first and second support arms may further comprise a second part providing support for the first part and the longitudinal rebar elements. One or more of the first support

arms and/or the second support arms may comprise at least one moveable part, e.g. the first part, which may be moved relative to another stationary part, e.g. the second part. This allows the support arms to move away from the assembled cage or mesh. This also allows the support arm to move into a compact configuration, which takes up less space when not in use and provides easier access to the other components.

Preferably, the first support arms and/or the second support arms may be configured to move between a retracted position, a holding position and optionally a loading position. In example, the second part may be adjustable in height so that the first part may be raised or lowered in the orthogonal direction using a local drive unit. Alternatively, the second part may be formed as one or more pillars, where the first part may slide or move along a rail or track on the pillar using the local drive unit. The drive unit may in example, but not limited to, be a gas spring, a linear actuator, a telescopic actuator, a toothed belt system or a ball screw, where the drive unit may be operated using electrics, pneumatics, hydraulics or any combinations thereof. This allows the first part and thus the longitudinal rebar elements to be automatically raised or lowered relative to the transverse rebar elements. This is advantageously when the stirrup units have a complex design. In some conventional assembly machines, the worker has to manually activate the raising or lowering of the longitudinal rebar elements.

The second part may define a single support point or multiple support points depending on the configuration of the support arms, the layout of the assembly machine and the width of the production area.

According to one embodiment, at least one of the support arms comprises a first part and a second part, where the first part comprises means for further moving the longitudinal rebar elements in at least the transverse direction.

In another configuration, the first part may be configured to rotate in the transverse plane around a rotation axis in the orthogonal direction. Alternatively, the first part may be configured to pivot in the orthogonal plane around an axis in the longitudinal direction. The pivotal or rotational movement may be controlled using a suitable local drive unit. The movement of the first part may be combined with the abovementioned movement of the second part. This allows the first part to move away from the cage or

mesh structure and provide a more flexible movement of the support arm. In conventional assembly machines, the support arms are only able to move in the height direction (i.e. the orthogonal direction).

- 5 In another configuration, the first part may be configured to extend or retract in the transverse direction relative to the second part. The first part may slide or move along a rail or track arranged on top of the second part using the above local drive unit or another local drive unit. The movement of the first part may be combined with the abovementioned movement of the second part. This also provides a more flexible
10 movement of the support arm and thus a more flexible movement of the longitudinal rebar elements.

- Alternatively or additionally, the first part may be fitted with local moveable means for actively moving the longitudinal rebar elements in one or both transverse direc-
15 tions. The moveable means may be a transport chain or belt, but other types of mechanisms may also be used. The chain or belt may be fitted with teeth or fingers for separation of the longitudinal rebar elements. This allows the longitudinal rebar elements to be moved between any transverse holding position and any installation position relative the transverse rebar elements. When combined with the raising or lowering of
20 the support arms, the longitudinal rebar elements may thus be moved freely relative to the transverse rebar elements. This allows the longitudinal rebar elements to be positioned in any transverse or orthogonal position within an enclosed spacing of the stirrup units.

- 25 The local moveable means may extend continuously along the first part, or be split into sections. One or more stop elements, e.g. a pin or tap, may be arranged relative to the moveable means, wherein the stop element may be used to hold the longitudinal rebar element in place relative to the transverse rebar element. The stop elements may be adjustable so that their individual positions relative to the moveable means may be
30 adapted to the particular design of the stirrup units. This allows the longitudinal rebar elements to automatically be held in place relative to the transverse rebar elements. In some conventional assembly machines, the worker manually has to pull the longitudinal rebar elements into contact with the stirrup units before the two rebar elements can be welded together.

Alternatively, the stop element may be a rotatable finger capable of rotating around a rotation axis on the support arm, e.g. on the first part. The finger may have a curved or arc-shaped profile where the longitudinal rebar element is held in place by the pressure applied by the finger. Alternatively, the above pin or tap may be slidable or movable arranged relative to the transport chain or belt so that it is able to push the longitudinal rebar element into place relative to the transverse rebar elements. The rotational or linear movement may be controlled by the abovementioned local drive unit or a separate local drive unit. In this configuration, the stop element acts as the local moveable means and the longitudinal rebar elements are resting on a top surface or a roller of the first part.

The local moving means may comprise at least one open-ended space configured to receive one or more longitudinal rebar elements, the longitudinal rebar elements may be arranged in at least one layer and/or in at least one column inside this open-ended space. The open-ended spaces may be defined by a plurality of projecting teeth or fingers of the transport chain or belt. Each open-ended space has a predetermined profile with a width and a depth adapted to the profile of the longitudinal rebar elements. Optionally, a local clamping or gripping mechanism may be used to hold the longitudinal rebar elements in place. This allows the local moveable means to receive and hold multiple longitudinal rebar elements.

According to one embodiment, at least one of the support arms comprises at least one set of rollers for passively or actively moving the longitudinal rebar elements in at least the longitudinal direction.

The first part of the support arm may comprise a top surface configured to act as a contact surface for the longitudinal rebar elements. The top surface may be curved, e.g. has an arc-shaped profile, to guide the longitudinal rebar elements onto the top surface during loading. The top surface may be covered with a durable material, such as steel, to reduce wear on the first part and partly also reduce friction. This allows the longitudinal rebar elements to be passively guided onto the support arms in the longitudinal direction.

Alternatively, the first part may comprise at least one roller with the rotation axis extending along the length of the first part. The roller may be configured to passively guide the longitudinal rebar elements over the support arm in the longitudinal direction. In example, the roller may be a low-friction roller.

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The first part may instead comprise a plurality of actively driven rollers arranged on individual drive shaft or a common drive shaft. The rollers may be arranged in pairs and/or have a tapered profile. A local drive unit may be used to drive the rollers. The rotation axis of each roller may extend substantially parallel to the transverse plane of the first part. This allows the longitudinal rebar elements to be actively moved in the longitudinal direction. This may be desired for very long rebar elements or if the rebar elements have to be transferred from one section to another section, as described later. The rollers may be made of metal and coated/covered with a rubber material, alternatively the rollers may be made of a plastic material.

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According to one embodiment, at least the first support arms or the second support arms are configured to be moved individually and/or synchronously relative to each other.

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The support arms within one set may be moved, e.g. raised or lowered, in synchronously or individually, as described later. Further, the first set of first support arms and the second set of second support arms may be moved synchronously or individually. The controller or a local control unit may control the movement of first and second support arms. This allows the support arms to be moved together into a loading position. This also allows the individual support arms to be moved away from the cage or mesh structure to enable the transverse rebar elements (e.g. stirrup units) to be moved along the longitudinal rebar elements.

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According to one embodiment, the assembly machine further comprises a second loading unit configured to load the transverse rebar elements into the assembly machine.

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A second loading unit may be arranged relative to the production area, e.g. at the opposite end. The second loading unit may be configured to the pre-assembled stirrup

units, or the pre-fabricated transverse rebar elements, into the assembly machine. The second loading unit may be configured to load the transverse rebar elements or stirrup units directly into the support elements. Alternatively, the second loading unit may be configured to transfer the transverse rebar elements or stirrup units to the moveable
5 robot unit, which then may load the transverse rebar elements or stirrup units into the support elements.

The second loading unit may be configured as a conveyor system, a robot unit with a robotic arm, a feeding system, a crane unit or another suitable loading unit. The conveyor system may be a floor or overhead based conveyor system. The conveyor system may utilise a conveyor belt, a conveyor chain or rollers to carry the transverse rebar elements or stirrup units from a sub-assembly station or loading interface to the support elements or an unloading interface. The unloading interface may be arranged relative to the moveable robot unit so that the robotic arm can grab the individual
10 transverse rebar elements or stirrup units and place them in their individual installation positions. This allows the transverse rebar elements or stirrup units to be automatically loaded into the assembly machine.

The second loading unit may further comprise a holding area in which a plurality of transverse rebar elements or stirrup units may be temporary stored before being loaded into the support elements. This allows the transverse rebar elements or stirrup units to be loaded in bundles and then gradually fed into the assembly machine.

According to one embodiment, a sub-assembly station is arranged relative to the second loading unit, the sub-assembly station is configured to assemble the transverse rebar elements into a number of stirrup units.

Preferably, a sub-assembly station may be arranged relative to the second loading unit, where the sub-assembly station may be configured to assemble the transverse rebar elements into stirrup units. The sub-assembly station may comprise an assembly area, e.g. an assembly table, in which the stirrup unit may be assembled. The assembly area, or assembly table, may be adapted for fit different sizes and shapes of stirrup units. The sub-assembly station may comprise a robot unit with a robotic arm, e.g. moveable or stationary robot unit, configured to automatically assemble the stirrup unit. The
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stirrup units may thus be pre-assembled in a fully-automated process, which is advantageously if the stirrup units have a complex design. This also allows the same machine setup to be used to manufacture stirrup units of different sizes and shapes.

5 Alternatively, the assembly process may be performed manually by a worker.

A magazine configured to hold the individual transverse rebar elements may be arranged relative to the sub-assembly station. The individual transverse rebar elements may then be transferred to the production area, either manually or via the robot unit.

10 The magazine may be adaptable to fit different sizes and shapes of transverse rebar elements for the assembly of different stirrup units. Alternatively, the magazine may be interchangeable so that it can be exchanged with another magazine. This allows the magazines to be pre-loaded separately.

15 According to one embodiment, the production area is divided into a number of sections, wherein at least one set of support arms is arranged in each section.

The production area may be divided into one or more sections in the longitudinal and/or transverse direction. Each section may comprise at least one set of support
20 arms and at least one set of support elements, as described above. Each section may be operated independently or in corporation as described later. This allows for the manufacture of relative short cage or mesh structures as well as relative long cage or mesh structures using the same machine setup.

25 Similarly, the first loading unit may be divided into one or more sections in the longitudinal and/or transverse direction. Each section may comprise at least one loading structure, as described above. Each section may be operated independently or in corporation as described later.

30 According to one embodiment, the longitudinal rebar elements and/or the transverse rebar elements have a diameter of 16 millimetres or more.

The present assembly machine setup is particular suited for the manufacture of 3D reinforcement structures, such as rebar cages, and also 2D reinforcement structures,

such as engineered meshes. The transverse elements may be shaped as stirrup units or transverse rods or bars. The longitudinal rebar elements may be shaped as longitudinal rods or bars. Unlike conventional assembly machines, the present assembly machine is able to handle longitudinal rods and/or transverse rods having a diameter between
5 6-55 millimetres, preferably of 16 millimetres or more. Further, conventional assembly machines are specifically designed for just one type of reinforcement structure.

Another object of the invention is achieved by a method of manufacturing reinforcement structures, such as rebar cages or meshes, comprising:

- 10 - providing an assembly machine, the assembly machine comprising a production area extending in a longitudinal direction and in a transverse direction, where a plurality of support arms and a plurality of support elements are distributed along the production area, and the assembly machine further comprises at least one moveable robot unit with at least one robotic arm arranged relative to the production area, the at least one
15 robotic arm being configured to be fitted with at least one tool,
- loading a plurality of transverse rebar elements into the support elements of the assembly machine,
- further loading a plurality of longitudinal rebar elements onto the support arms of the assembly machine in the longitudinal direction,
- 20 - moving the at least one moveable robot unit along the production area, and securing the longitudinal rebar elements to the transverse rebar elements, e.g. by a welding or binding process, using the at least one moveable robot unit.

The present method provides an automated process for the manufacture of rebar cages
25 as well as engineered meshes. Further, it allows the cage or mesh structure to be manufactured with a higher precision as the cage or mesh structure is kept stationary while the robotic arm is moved along the production area. The present method is particularly suited for the manufacture of cages or meshes where at least the longitudinal rods have a diameter of 6-55 millimetres, preferably 16 millimetres or more.

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The finished cage or mesh may be transferred out of the present assembly machine in the transverse direction or in the longitudinal direction dependent on the particular configuration. In conventional assembly machines, the finished cage or mesh is only able to be removed in the longitudinal direction.

The transverse rebar elements are initially loaded into the support elements manually by a worker, or automatically using a second loading unit, as described later. This allows the transverse rebar elements to be placed in predetermined longitudinal position relative to each other.

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Optionally, the support elements may be adapted to the size and shape of the transverse rebar elements prior to loading the transverse rebar elements. This may be manually by the worker. Alternatively, the adaption of the support elements may be performed automatically using a controller, which controls the operation of actuating means used to adjust the receiving means of the support elements. This allows for the manufacture of different cage or mesh structures using the same machine setup.

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The support element may comprise one or more receiving means for receiving the transverse rebar elements. The receiving means may further fix the transverse rebar elements in the orthogonal plane during the assembly. The receiving means may be coupled to an adjustment mechanism for adjusting the position of the receiving means relative to the other receiving means. The adjustment mechanism may be an elongated hole in which the receiving means is able to slide. An actuator may be used to move the receiving means along the hole and an electronically activated clamp may be used to fix the receiving means in a particular position. Other adjustment mechanisms may also be used.

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The receiving means may comprise a row of open-ended spaces or spring loaded clamps for receiving the rebar elements. Other receiving means may also be used. Linear actuators may be used to adjust the position of the individual receiving means in the transverse direction and/or in the orthogonal direction. Further, actuators may be used to adjust the distance between the individual support elements. This allows the support elements to be adapted to fit the profile of the stirrup units.

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According to one embodiment, the transverse rebar elements are pre-assembled into a number of stirrup units, e.g. via another robot unit with a robotic arm, which are then loaded into the support elements.

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The transverse rebar elements may be loaded directly into the support elements using a second loading unit, wherein the second loading unit may extend into the production area for positioning the transverse rebar elements. Alternatively, the moveable robot unit may be used as a loading unit for loading the transverse rebar elements. This allows the transverse rebar elements to be automatically loaded into the support elements.

Preferably, the transverse rebar elements are pre-assembled into stirrup units at a sub-assembly station, and then transferred into the support elements. The individual rebar elements may be manually laid up in a production area of the sub-assembly station and then manually secured to each other to form the stirrup unit. Alternatively, the individual rebar elements may be secured to each other by a robot unit with a robotic arm, thereby allowing the stirrup units to be produced in a semi-automated process. Alternatively, the robot unit may position the individual rebar elements in the production area, and further secure the individual rebar elements to each other. This allows the stirrup units to be produced in a fully-automated process.

The pre-assembled stirrup units may then be manually loaded into the support elements by the worker. Instead, the second loading unit may be used to directly load the stirrup units into the support elements. Alternatively, the second loading unit may transfer the stirrup units to the moveable robot unit which then loads the stirrup units into support elements. This allows the stirrup units to be automatically loaded into the support elements.

According to one embodiment, a number of first support arms are moved into a first holding position before a number of first longitudinal rebar elements are loaded onto the first support arms.

Preferably, the longitudinal rebar elements are loaded onto the support arms using a first loading unit. The first loading unit may firstly be moved into the loading position, and then a number of first longitudinal rebar elements may be fed into the first loading unit. This may be performed via a feeding system and/or a cutting station. The feeding system may comprise feeding elements, e.g. a conveyor system, which may be ex-

tended and/or moved into position relative to the first loading unit before feeding the longitudinal rebar elements into the first loading unit.

5 The loading structure may be formed by a single loading section or divided into multiple loading sections, as mentioned earlier. The number of loading sections used during the loading process may be adapted to the length of respective longitudinal rebar elements.

10 The support arms, or a number of first support arms, of at least one section may be moved into a first holding position. Further, the first loading unit may be moved into a first loading position corresponding to the first holding position. The first longitudinal rebar elements may then be transferred onto the support arms, e.g. the first support arms. The orthogonal movements of the support arms and first loading unit may be performed simultaneously or independently. This allows the longitudinal rebar elements to be positioned within a particular enclosed spacing defined by the design of the stirrup units.

According to one embodiment, the method further comprises the steps of:

- 20 - further moving at least a number of second support arms into the first holding position, before
- loading the first longitudinal rebar elements onto at least one of the first and second support arms.

25 A number of second support arms of another section may further be moved into alignment with the first support arms of the above one section in the first holding position. The first longitudinal rebar elements may then be transferred onto both the first and second support arms. Alternatively, the first longitudinal rebar elements may be transferred onto the first support arms and then further transferred onto the second support arms. The orthogonal movements of the support arms and first loading unit may be performed simultaneously or independently. This allows longitudinal rebar elements to be transferred into a particular section and then positioned within a relative short enclosed spacing defined by a sub-set of stirrup units. This further allows longitudinal rebar elements to be positioned within a relative long enclosed spacing extending over more than one section.

If such case designs were to be manufactured using conventional assembly machines, then the worker has to manually push or pull the longitudinal rebar elements past the stirrup units and into its desired position within the case structure. The worker may also attempt to insert the longitudinal rebar element between adjacent stirrup units from the exterior. However, this is a time consuming and complex process that involves a great risk of the worker getting hurt.

The number of first support arms may be equal to or differ from the second support arms. This allows the number of support arms used in each section to be adapted to the particular design of the stirrup units and/or to the length of the particular longitudinal rebar element.

The above mentioned steps may be repeated until all longitudinal rebar elements have been positioned within the stirrup units. The number of holding positions may be adapted to the particular design of the stirrup units. Also, the number of first and second longitudinal rebar elements may be adapted to the particular design of the stirrup units.

According to one embodiment, the method further comprises the steps of:

- moving the first support arms out of the first holding position,
- further moving the first support arms or a number of second support arms into at least a second holding position, before
- loading at least a number of second longitudinal rebar elements onto the first or second support arms.

After unloading the first longitudinal rebar elements, the first loading unit may be moved back into the loading position. A number of second longitudinal rebar elements may then be transferred to the first loading unit.

The support arms, or the first support arms, may be moved into a second holding position. Further, the first loading unit may be moved into a second loading position corresponding to the second holding position, e.g. when the first support arms are still in the first holding position. The second longitudinal rebar elements may then be transferred onto the support arms, e.g. the first support arms. The orthogonal movements of

the support arms and first loading unit may be performed simultaneously or independently. This allows the longitudinal rebar elements to be positioned within another enclosed spacing defined by the design of the stirrup units.

5 Alternatively, a number of second support arms may be moved into the second holding position. This may be done while the first support arms still are in the first holding position, or when the first support arms are moved to another position. Similarly, the loading unit may be loaded with the second longitudinal rebar elements and moved
10 into the second loading position while the first support arms still are in the first holding position. The second longitudinal rebar elements may then be transferred onto the second support arms. This may be desired, if the design of the cage or mesh structure allows the use of two sets of support arms within one or more sections. This may be preferred, if the cage or mesh structure comprises one or more relative short enclosed spaces.

15 The number of first support arms may be equal to or differ from the second support arms. This allows the number of support arms used to support the longitudinal rebar elements to be adapted to the particular design of the stirrup units.

20 The abovementioned steps may be repeated until all longitudinal rebar elements have been positioned within the stirrup units. The number of holding positions may be adapted to the particular design of the stirrup units. Also, the number of first and second longitudinal rebar elements may be adapted to the particular design of the stirrup units.

25 According to one embodiment, at least one of the first or second longitudinal rebar elements, when in the first or second holding position, is further moved in the transverse direction into position relative to the transverse rebar elements prior to being secured to the transverse rebar elements.

30 In one or more of the holding positions, all or some of the respective longitudinal rebar elements may be moved to transverse installation positions via the local moveable means. This may be done before the robot unit(s) are moved along the cage or mesh structure, or in a combined step.

In example, one longitudinal rebar element may be moved to its transverse installation position and the robot unit(s) may be moved along the cage or mesh structure to secure that longitudinal rebar element to the transverse rebar elements, e.g. stirrup units. Another longitudinal rebar element may be moved to its transverse installation position and the robot unit(s) may be moved back along the cage or mesh structure to secure that longitudinal rebar element to the transverse elements. The step is repeated until all longitudinal rebar elements are secured to the transverse rebar elements.

Alternatively, all longitudinal rebar elements may be moved into their respective transverse installation positions in one step. The robot unit(s) may then be moved along the cage or mesh structure to secure all longitudinal rebar element to the transverse rebar elements.

According to one embodiment, the method further comprises the steps of:

- assembling a first part of the reinforcement structure, wherein one portion is left unassembled for assembling a second part of the reinforcement structure,
- moving the first part in the longitudinal direction from a first position to a second position,
- further assembling at least the second part of the reinforcement structure in continuation of the first part, wherein the unassembled portion of the first part is integrated into the second part.

The present machine setup further enables larger reinforcement structures to be assembled in a running process. Preferably, the larger reinforcement structure may be assembled in a fully-automated process using the present assembly machine. No modifications or extending of the production area is needed. This further increase the functionality of the present assembly machine compared to the conventional assembly machines. This may be suited for slim production facilities where limited production area is available.

A first part of the large reinforcement structure may be assembled, as described earlier, wherein an end portion of the first part is left unassembled. The first part is then moved in the longitudinal direction partly out of the production area so that the end

portion remains within the production area, e.g. using the above dolly wagon or rail system.

5 Further longitudinal rebar elements and further transverse rebar elements are loaded into the present assembly machine, as described earlier. The further longitudinal may then be moved into position so that a corresponding end portion overlap the end portion of the first part. Further, one or more transverse rebar elements may be positioned with the overlapping area. The rest of the second part is then assembled, as described earlier. The process may be repeated for additional parts of the larger reinforcement
10 structure.

The finished larger reinforcement structure may then be moved out of the production area for storage and/or transport.

Description of the Drawing

15 The invention is described by example only and with reference to the drawings, wherein:

- Fig. 1a-c shows an exemplary embodiment of an assembly machine according to the invention,
- 20 Fig. 2 shows a first step of assembling a cage structure according to the invention,
- Fig. 3 shows a second step of assembling the cage structure,
- Fig. 4 shows a third step of assembling the cage structure,
- Fig. 5 shows a fourth step of assembling the cage structure,
- 25 Fig. 6 shows a fifth step of assembling the cage structure,
- Fig. 7 shows a sixth step of assembling the cage structure,
- Fig. 8 shows a seventh step of assembling the cage structure,
- Fig. 9 shows an eighth step of assembling the cage structure,
- Fig. 10 shows an eighth step of assembling the cage structure,
- 30 Fig. 11 shows an exemplary embodiment of the support element,
- Fig. 12 shows the support arm with an exemplary embodiment of the local moveable means.
- Fig. 13a-d show four alternative embodiments of the support arm,

In the following text, the figures will be described one by one, and the different parts and positions seen in the figures will be numbered with the same numbers in the different figures. Not all parts and positions indicated in a specific figure will necessarily be discussed together with that figure.

5 **Reference list**

1. Assembly machine
2. Production area
- 2a. First section
- 2b. Second section
- 10 3. Support arms
- 3a. First support arms
- 3b. Second support arms
4. Support elements
5. First loading unit
- 15 6. Longitudinal rebar elements
- 6a. First longitudinal rebar elements
- 6b. Second longitudinal rebar elements
7. Feeding system
8. Sub-assembly station
- 20 9. Holding unit
10. Transverse rebar elements
11. Robot unit
12. Stirrup units
13. Second loading unit
- 25 14. First robot unit
15. Second robot unit
16. Local moveable means
- 16a. First local moveable means
- 16b. Second local moveable means
- 30 17. Cage structure
- 17a. Unassembled end
18. Receiving means
19. Transverse direction

- 20. Rail
- 21. First part
- 22. Second part
- 23. Orthogonal direction
- 5 24. Longitudinal direction

Detailed Description of the Invention

Figs. 1a-c show an exemplary embodiment of an assembly machine 1 comprising a production area 2 extending in a longitudinal direction and in a transverse direction. Here, the production area 2 is divided into two sections 2a, 2b each comprising a number of support arms 3 and a number of support elements 4.

A first loading unit 5 is arranged relative to the production area 2 at one end, wherein the first loading unit 5 is configured to load longitudinal rebar elements 6 into the assembly machine 1. A feeding system 7 is arranged relative to the first loading unit 5, as illustrated in fig. 1b, and configured to feed the longitudinal rebar elements 6 into the first loading unit 5. The longitudinal rebar elements 6 are preferably cut into length using a cutting unit (not shown). Here, the first loading unit 5 is divided into two loading sections.

A sub-assembly station 8 is arranged relative to the production area 2, where a holding unit 9 is arranged next to the sub-assembly station 8. The holding unit 9 is configured to hold a number of different transverse rebar elements 10. The transverse rebar elements 10 are positioned in the sub-assembly station 8 and secured to each other using a local robot unit 11 with a robotic arm to form a number of stirrup units 12. A second loading unit 13 is arranged relative to the production area 2, e.g. at the other end or at one side, and the sub-assembly station 8. The second loading unit 13 is configured to feed the pre-assembled stirrup units from the sub-assembly station 8 to a moveable robot unit.

A first moveable robot unit 14 with a first robotic arm is arranged along one side of the production area 2. The first robot unit 14 is configured to load the stirrup units 12 into the individual support elements 4 so that they are fixed in the longitudinal direction.

A second moveable robot unit 15 with a second robotic arm is arranged along the opposite side of the production area 2. The first robotic arm can be fitted with a first tool and the second robotic arm can be fitted with a second tool. The first and second robot units 14, 15 optionally comprise a magazine for storing the various tools used for each robot unit. Both the first and second robot units 14, 15 are configured to move along a rail extending along the production area 2.

For illustrative purposes, the tools of the first and second robot units 14, 15 are not shown on the following figures.

10

Fig. 2 shows a first step of a method of assembling a reinforcement structure in the form of a cage structure. The transverse rebar elements 10 are loaded onto the holding unit 9, e.g. remotely from the sub-assembly station 8. The individual transverse rebar elements 10 are then laid up in the sub-assembly station 8 and secured to each other using the local robot unit 11. The stirrup units 12 are thus pre-assembled in an automated process.

Fig. 3 shows a second step of assembling the cage structure where pre-assembled stirrup units 12 are transferred from the sub-assemble station 8 to an unloading interface via the second loading unit 13. At the unloading interface, the first robot unit 14 grips each stirrup unit and moves into position relative to a particular support element 4.

Fig. 4 shows a third step of assembling the cage structure where stirrup units 12 are individually placed in the support elements 4 in predetermined longitudinal positions using the first robot unit 14. After loading a stirrup unit 1 into a particular support element 4, the first robot unit 14 moves back to the second loading unit 13 and grips another stirrup unit 12.

Here, a number of first support arms 3a in the first section 2a are lowered to a retracted position while a number of second support arms 3b in the second section 2b are raised to an upper position. After a predetermined number of stirrup units 12 have been loaded into the support elements 4, the second support arms 3b in the second section 2b are lowered to the retracted position. Alternatively, the first and second support arms 3a, 3b are both placed in the retracted or upper position.

This process is repeated until all stirrup units 12 have been loaded into the support elements 4.

5 Fig. 5 shows a fourth step of assembling the cage structure where the longitudinal rebar elements 6 are transferred into the feeding system 7, e.g. from the cutting unit.

The loading structure of the first loading unit 5 is moved into a loading position. After which, a number of first longitudinal rebar elements 6a are fed onto the loading structure of the first loading unit 5. Here, the first longitudinal rebar elements 6a extends
10 over both loading sections of the first loading unit 5.

Fig. 6 shows a fifth step of assembling the cage structure where the loading structure of the first loading unit 5 is moved to a first unloading position. At the same time, the support arms 4 are moved into a first holding position. The first unloading position is
15 aligned with the first holding position.

The first longitudinal rebar elements 6a are then loaded onto the support arms 4. Here, the first and second support arms 4a, 4b both comprise a set of rollers (also shown in fig. 7) arranged on a supporting frame. The rollers are configured to move the longitudinal rebar elements 6 in the longitudinal direction during loading.
20

Fig. 7 shows a sixth step of assembling the cage structure where local moveable means 16 on the support arms 4 are used to further move the first longitudinal rebar elements 6a into contact with the stirrup units 12 in the transverse direction. Here, two
25 sets of local moveable means 16a, 16b are used to move the first longitudinal rebar elements 6a in both transverse directions. The first longitudinal rebar elements 6a are held in place by the force applied by the local moveable means 16.

Here, the local moveable means 16 are shaped as curved fingers each of which is rotatable connected to the supporting frame. When rotated in one direction, the fingers
30 are able to contact the longitudinal rebar element 6a and push it into contact with the stirrup units 12.

Fig. 8 shows a seventh step of assembling the cage structure where the first and second robot units 14, 15 are securing the first longitudinal rebar elements 6a to the individual stirrup units 12 as they move along the production area 2. The first and second robot units 14, 15 may move synchronous or independently during the securement.

5

The first longitudinal rebar elements 6a are secured to each stirrup unit 12 when moving forward in one longitudinal direction. Alternatively, the first longitudinal rebar elements 6a are secured to a number of stirrup units 12 when moving forward and to the remaining stirrup units 12 when moving backwards.

10

Once the securement of the first longitudinal rebar elements 6a is complete, the local moveable means 16 are released. Here, the local moveable means 16 are released by rotating the fingers in the opposite direction.

15

Fig. 9 shows an eighth step of assembling the cage structure where the support arms 4 are to a second holding position. At the same time, the first loading unit 5 is moved back to the loading position (as indicated in fig. 4) and a number of second longitudinal rebar elements 6b are fed into the loading structure of the first loading unit 5.

20

The loading structure is afterwards moved to a second unloading position corresponding to the second holding position, as indicated in fig. 5. The second longitudinal rebar elements 6b are then loaded onto the first and second support arms 4a, 4b. The second longitudinal rebar elements 6b are moved into contact with the stirrup units 12 and secured to them in the same manner as mentioned above.

25

This process repeated until all longitudinal rebar elements 6 have been moved into position relative to the stirrup units 12 and secured to each stirrup unit 12.

30

Fig. 10 shows a ninth step of assembling the cage structure where the first and second support arms 4a, 4b are moved to the retracted position and thus away from the cage structure. The assembled cage structure 17 is then moved out of the production area, e.g. by lifting it using an overhead crane.

As illustrated, one or both ends of the cage structure 17 are left unassembled. The unassembled end 17a is intended to be integrated into another cage structure. This can be achieved by placing the unassembled end 17a into an end of another cage structure, and then securing the two cage structures. Alternatively, the cage structure 17 is partly
5 out of the production area 2 so that the unassembled end 17a of the cage structure 17 is left inside the production area 2, thus allowing it to be integrated into another cage structure during assembly.

Fig. 11 shows the support element 4 with a generally L-shaped body where the lower
10 part of the body acts as support feet for placement of the support element 4. The upper part is here configured as an adjustable, e.g. telescopic, part for adjusting the position of the receiving means 18 in the orthogonal direction. Here, the receiving means 18 is shaped as an elongated plate with a plurality of open-ended spaces each adapted to the stirrup units.

15 The support element 4 optionally further comprises other receiving means (shown in fig. 3) placed on the side of the stirrup units 12 for further fixing the stirrup units in the orthogonal plane. These receiving means may also be adjustable, e.g. telescopic, for adjusting their positions.

20 Fig. 12 shows a second embodiment of the local moveable means 16' where the fingers of the local moveable means 16 are replaced with a pivotal stop element. The stop element is biased using a spring so that, once the longitudinal rebar element have moved over the stop element, it moved back into its biased position.

25 The local moveable means 16' further comprises an actuator, preferably a linear actuator, for moving the stop element and thus the longitudinal rebar element 6 into contact with the stirrup units 12. Once the longitudinal rebar elements 6 have been secured, the stop element is moved back to its initial position.

30 Fig. 13a-d show four exemplary embodiments of the support arms 4. In fig. 13a, the support arm 3 is arranged on a rail (indicated by lowermost arrow) so that it is able to be moved in the transverse direction 19 relative to the rail 20 on which the first or second robot unit 14, 15 is placed.

The support arm 3 comprises a first part 21 and a second part 22. Here, the second part 22' is an extendable part so that the support arm 3 is able to be moved in the orthogonal direction 23. Optionally, the second part 22' may also be extended in the longitudinal direction 24.

5

The first part 21 extends in the transverse direction 19 and comprises local moveable means 16''. Here, the local moveable means 16'' is shown as a transport chain or belt configured to move the longitudinal rebar elements 6 into a transverse position.

10 The support arm 3 alternatively comprises a pivotal first part 21', as illustrated in fig. 13b. The pivotal first part 21' can pivot around a pivot axis. The support arm 3 alternatively comprises a moveable first part 21'', as illustrated in fig. 13c. The moveable first part 21'' is able to rotate in the transverse plane.

15 The support arm 3 alternatively comprises a rotatable second part 22'', as illustrated in fig. 13d. The rotatable second part 21'' is able to rotate around a rotation axis.

Common for the embodiments in fig. 13a-d is that at least a part of the support arm 3 is able to be moved away from the cage or mesh structure.

20

CLAIMS

1. An assembly machine for manufacturing of reinforcement structures, such as rebar cages or meshes, comprising:
- 5 - a production area (2) extending in a longitudinal direction and in a transverse direction,
- a first loading unit (5) arranged relative to the production area (2), the first loading unit (5) being configured to load a number of rebar elements into the assembly machine (1),
- 10 - at least one moveable robot unit (14, 15) arranged relative to the production area (2), the at least one moveable robot unit (14, 15) comprising at least one robotic arm configured to be fitted with at least one tool, wherein the at least one moveable robot unit is configured to move along the production area (2) in the longitudinal direction, **characterised in that** the assembly machine (1) further comprises:
- 15 - a plurality of support arms (3) arranged relative to the production area (2), each of the support arms (3) extending in the transverse direction,
- at least one support element (4) configured to hold a number of transverse rebar elements (10) in at least one fixed position in the longitudinal direction, the at least one support element (4) being arranged relative to the support arms (3),
- 20 wherein the first loading unit (5) is configured to load a number of longitudinal rebar elements (6) into the assembly machine (1) in the longitudinal direction.
2. The assembly machine according to claim 1, **characterised in that** the at least one moveable robot unit comprises a first moveable robot unit (14) with a first robotic arm
- 25 and a second moveable robot unit (15) with a second robotic arm, the first robotic arm being configured to fit with a first tool and the second robotic arm being configured to fit with a second tool.
3. The assembly machine according to any one of claims 1 or 2, **characterised in that**
- 30 the plurality of support arms (3) are configured to move between a retracted position and at least a loading position or a holding position in at least an orthogonal direction.

4. The assembly machine according to claim 3, **characterised in that** at least one of the support arms (3) comprises a first part (21) and a second part (22), where the first part (21) comprises means for locally moving the longitudinal rebar elements in at least the transverse direction.
- 5
5. The assembly machine according to claim 3 or 4, **characterised in that** at least one of the support arms (3) comprises at least one set of rollers for passively or actively moving the longitudinal rebar elements (6) in at least the longitudinal direction.
- 10
6. The assembly machine according to any one of claims 3 to 5, **characterised in that** at least first support arms (3a) or second support arms (3b) are configured to be moved individually and/or synchronously relative to each other.
- 15
7. The assembly machine according to any one of claims 1 to 6, **characterised in that** the assembly machine (1) further comprises a second loading unit (13) configured to load the transverse rebar elements (10) into the assembly machine (1).
- 20
8. The assembly machine according to claim 7, **characterised in that** a sub-assembly station (8) is arranged relative to the second loading unit (13), the sub-assembly station (8) is configured to assembly the transverse rebar elements (10) into a number of stirrup units (12).
- 25
9. The assembly machine according to any one of claims 1 to 8, **characterised in that** production area (2) is divided into a number of sections, wherein at least one set of support arms (3) is arranged in each section.
- 30
10. The assembly machine according to any one of claims 1 to 9, **characterised in that** the longitudinal rebar elements (6) and/or the transverse rebar elements (10) have a diameter of 16 millimetre or more.
11. A method of manufacturing reinforcement structures, such as rebar cages or meshes, comprising:
- providing an assembly machine (1), the assembly machine (1) comprising a production area (2) extending in a longitudinal direction and in a transverse direction, where

- a plurality of support arms (3) and a plurality of support elements (4) are distributed along the production area (2), and the assembly machine (1) further comprises at least one moveable robot unit (14, 15) with at least one robotic arm arranged relative to the production area (2), the at least one robotic arm being configured to be fitted with at least one tool,
- 5 - loading a plurality of transverse rebar elements (10) into the support elements (4) of the assembly machine (1),
- further loading a plurality of longitudinal rebar elements (6) onto the support arms (3) of the assembly machine (1) in the longitudinal direction,
- 10 - moving the at least one moveable robot unit (14, 15) along the production area (2), and securing the longitudinal rebar elements (6) to the transverse rebar elements (10), e.g. by a welding or binding process, using the at least one moveable robot unit (14, 15).
- 15 12. The method according to claim 11, **characterised in that** the transverse rebar elements (10) are pre-assembled into a number of stirrup units (12), e.g. via another robot unit (11) with a robotic arm, which are then loaded into the support elements (4).
- 20 13. The method according to claim 11 or 12, **characterised in that** a number of first support arms (3a) are moved into a first holding position before a number of first longitudinal rebar elements (6a) are loaded onto the first support arms (3a).
14. The method according to claim 13, **characterised in that** the method further comprises the steps of:
- 25 - further moving at least a number of second support arms (3b) into the first holding position, before
- loading the first longitudinal rebar elements (6a) onto at least one of the first and second support arms (3a, 3b).
- 30 15. The method according to claim 13, **characterised in that** the method further comprises the steps of:
- moving the first support arms (3a) out of the first holding position,

- further moving the first support arms (3a) or a number of second support arms (3b) into at least a second holding position, before
- loading at least a number of second longitudinal rebar elements (6b) onto the first or second support arms (3a, 3b).

5

16. The method according to any one of claims 13 to 15, **characterised in that** at least one of the first or second longitudinal rebar elements (6a, 6b), when in the first or second holding position, is further moved in the transverse direction into position relative to the transverse rebar elements (10) prior to being secured to the transverse rebar elements (10).

10

17. The method according to any one of claims 11 to 16, **characterised in that** the assembly machine (1) further comprises a first moveable robot unit (14) with a first robotic arm, the first robotic arm being fitted with a first tool, and a second moveable robot unit (15) with a second robotic arm, the second robotic arm being fitted with a second tool, wherein the first and second robot units are moved synchronous or independently along the production area (2).

15

18. The method according to any one of claims 11 to 17, **characterised in that** the transverse rebar elements (10), preferably the pre-assembled stirrup units (12), are loaded into the support elements (4) using the at least one moveable robot unit (14, 15).

20

19. The method according to any one of claims 11 to 18, **characterised in that** the method further comprises the steps of:

25

- assembling a first part of the reinforcement structure, wherein one portion (17a) is left unassembled for assembling a second part of the reinforcement structure,
- moving the first part in the longitudinal direction from a first position to a second position,
- further assembling at least the second part of the reinforcement structure in continuation of the first part, wherein the unassembled portion (17a) of the first part is integrated into the second part.

30