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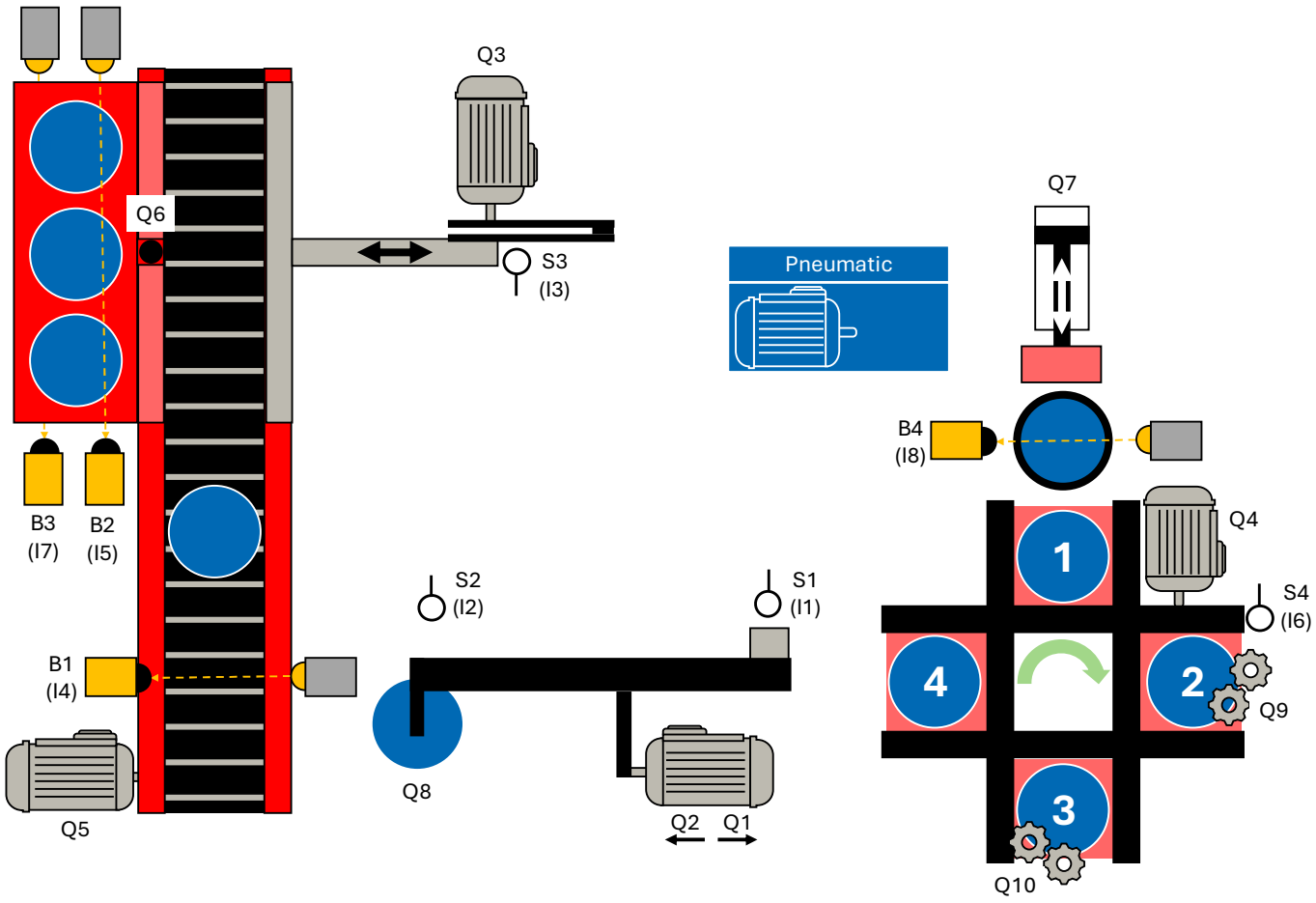
KNOWLEDGE | SOFTWARE | AUTOMATION

24V production line

Model description



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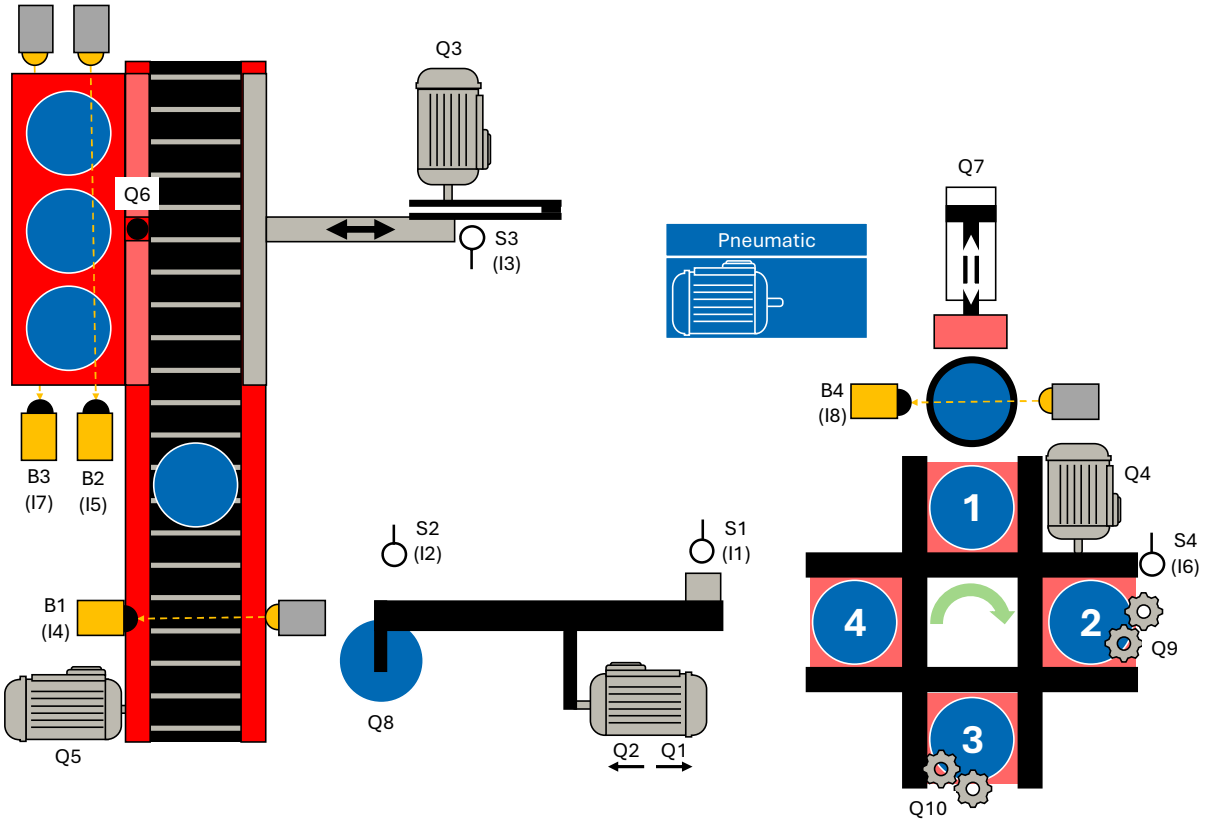
1.1 System description

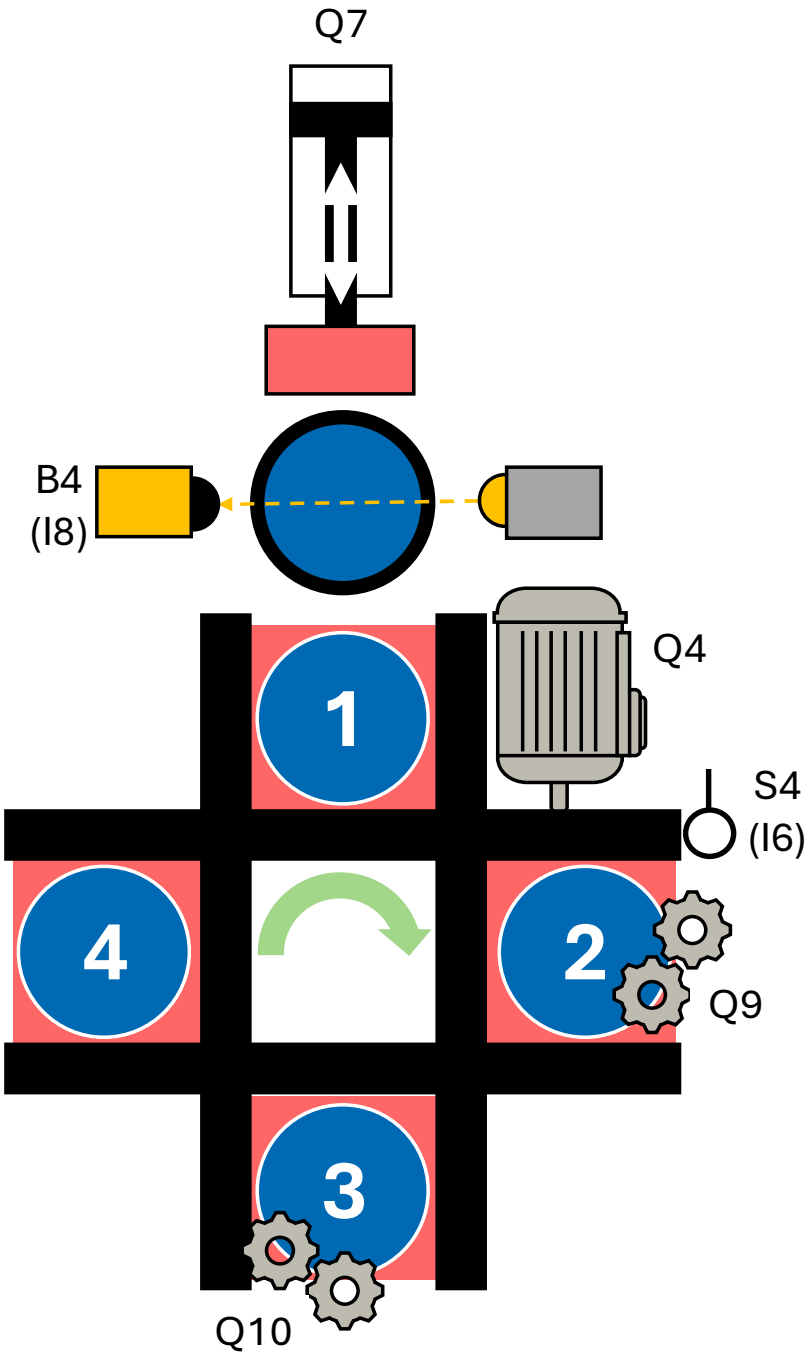
The "24V production line" model consists of a turntable with four stations, a transfer unit and a transport line.



Picture 1 System diagram

Turntable

The rotary table consists of four stations, all of which the workpiece must pass through in sequence. The table can be rotated clockwise by activating output Q4. The correct alignment of the four nests below the respective stations is signaled by the limit position switch S4, which is wired as a normally open contact.
The turntable may only be moved when the slider (Q7) is in the home position and the transfer unit does not actuate the limit position switch S2.



Picture 2 System diagram - turntable

Station 1 - Magazine

The storage magazine is located in the first station of the rotary table. The workpieces are stored here. If the magazine is not empty, the light barrier B4 is interrupted and therefore supplies a 0 signal.
If there is a workpiece in the magazine and the nest of the rotary table is empty, a workpiece can be pushed into the nest by activating the slider (Q7). As long as the slider is activated, the rotary table must not move. The slider may only be actuated when the turntable is in position (S4 actuated).

Station 2 - Drilling

The first machining station is located in the second station of the rotary table. This is where the blank from the magazine is drilled. The drilling process is started by activating output Q9.
The drilling process may only be started when the turntable is in position (S4 actuated). The turntable must not be moved during the drilling process.

Station 3 - Welding

The second processing station is located in the third station of the rotary table. This is where the previously drilled workpiece is welded. The welding process is started by activating output Q10.
The welding process may only be started when the turntable is in position (S4 actuated). The turntable must not be moved during the welding process.

Station 4 - Handover

In the fourth station of the rotary table, the finished workpiece is picked up by a transfer unit and transferred to the transport line. The transfer unit may only pick up the workpiece when the turntable is in position (S4 actuated). As long as a workpiece is in the transfer station, the rotary table must not be moved.

Converter

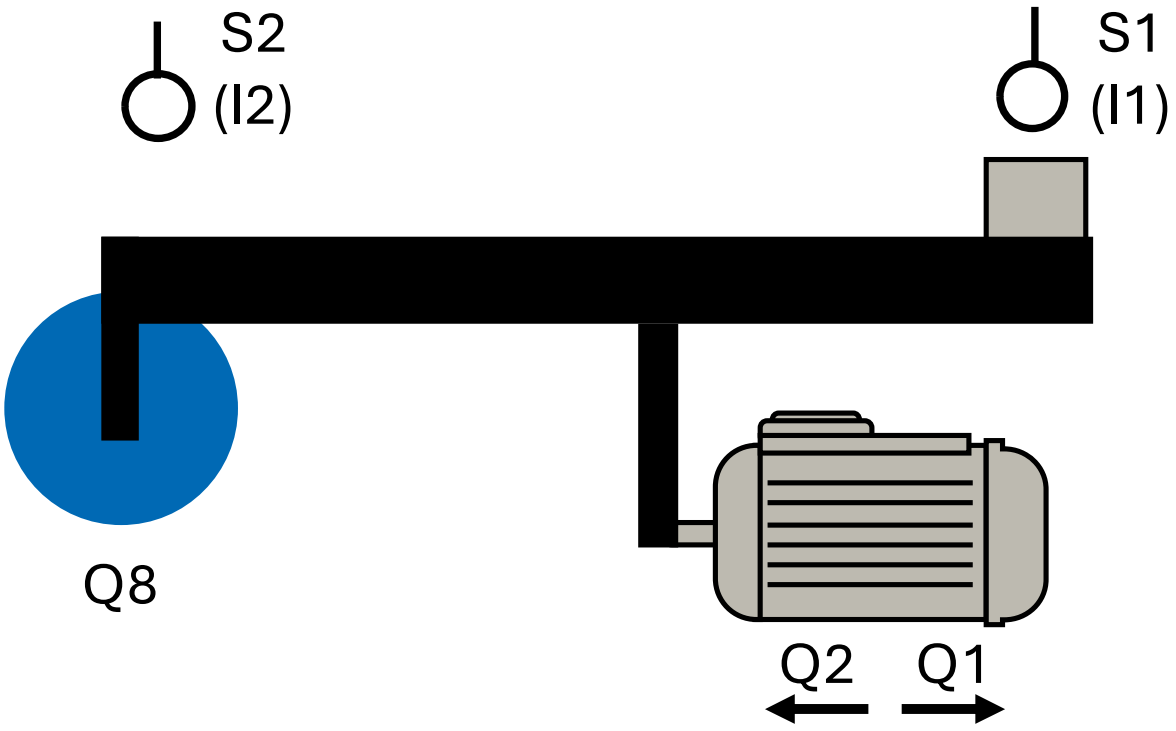
The transfer unit picks up the finished workpieces from the rotary table, from the transfer station, and places them on the conveyor belt.
The transfer unit is moved by a motor that can be controlled in 2 directions. The transfer unit can be moved in the direction of the turntable via output Q1. If Q2 is activated, the transfer unit is moved in the direction of the conveyor belt. The end positions are monitored by switches S1 (conveyor belt end position) and S2 (turntable end position). These provide a 1 signal when actuated.

To avoid overloading the motor, it may only be controlled in the respective direction until the end position is reached.

The movements between the transfer unit and turntable as well as the transfer unit and conveyor belt must be interlocked.

- If the transfer unit is in the end position on the side of the turntable, it must not be moved. The transfer unit may only be moved in the direction of the turntable if it is in position (S4 actuated).
- If the transfer unit is in the end position on the conveyor belt side, the conveyor belt must not be moved. The transfer unit may only be moved in the direction of the conveyor belt if it is not occupied (B1 not interrupted).

To pick up the workpiece from the turntable, the vacuum gripper can be controlled via output Q8.



Picture 3 System diagram - converter

Transport route

The transport section receives the workpieces from the transfer unit and guides them to the end of the belt. As soon as 3 workpieces are ready on the belt, they are discharged onto a pallet by a pusher.

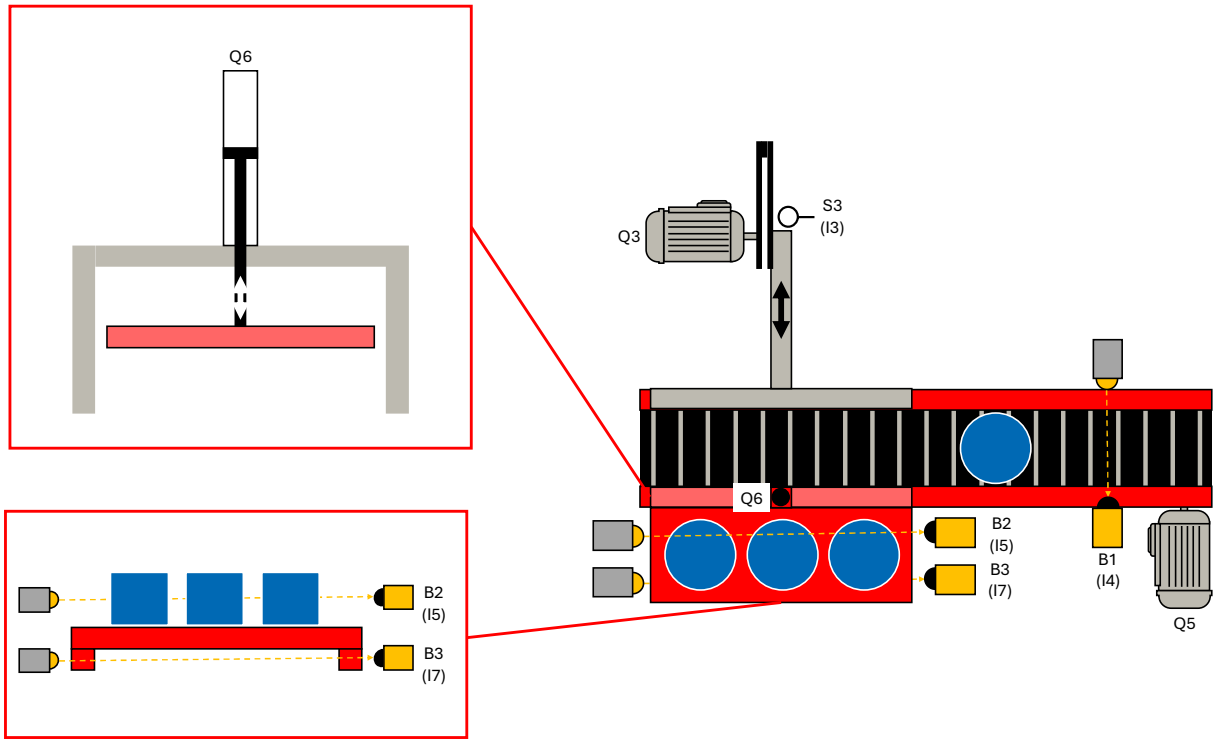
The conveyor belt is driven by a motor that can be controlled via output Q5. It may only be moved when the slider is in the home position, the separator is closed and the transfer unit is not on the side of the belt (S1 not actuated).

The transport process begins when the transfer unit has placed a new workpiece on the belt. This action is detected by a light barrier (B1 interrupted).

If a pallet is ready, light barrier B3 is interrupted. If there are workpieces on it, light barrier B2 is interrupted.

The separator can be closed by activating Q6. If Q6 is not activated, the separator is in the upper end position.

The slider can be controlled using Q3. The rotary movement of the motor is converted into the translatory movement of the slider by a mechanism. If the motor rotates through 360°, the slider has completed a full stroke. The home position is monitored by S3. This supplies a 1 signal in the actuated state.



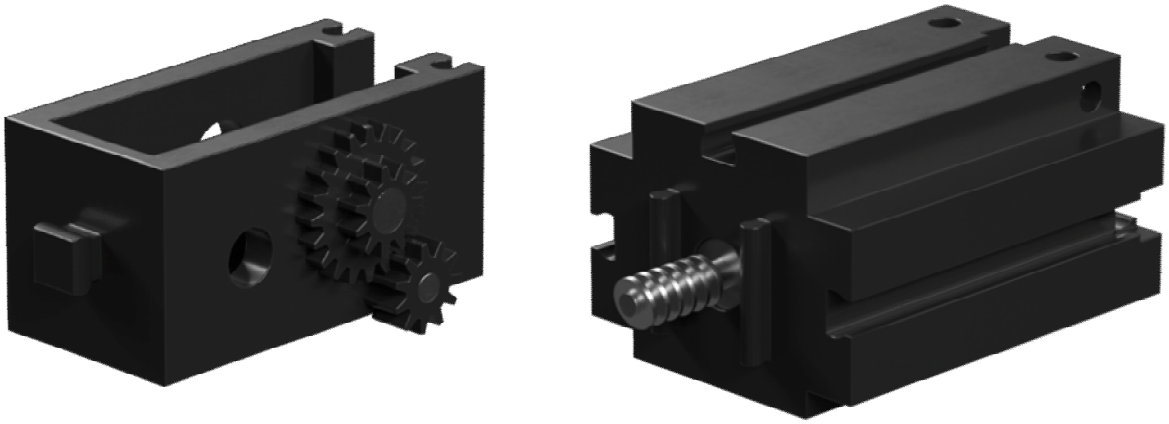
Picture 4 System diagram - conveyor belt

1.1.1 Sensors / actuators

The following components are installed in the model:

Mini motor

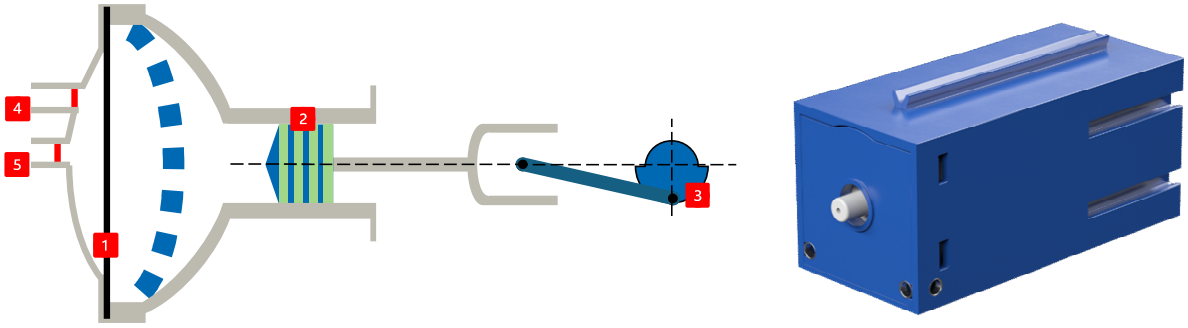
The movement of the conveyor belt, the transfer unit, the drilling unit and the rotary movement of the turntable are driven by a mini-motor. This compact motor is a permanently excited DC machine that can be used together with a plug-on U-gear. The rated voltage of the motor is 24 V and the maximum current consumption is 400 mA. This results in a maximum torque of 6.92 mNm and an idling speed of 10,910 rpm. The U-gear has a ratio of 64.8:1 and a lateral output.



Picture 5 U-gearbox and mini-motor

Compressor

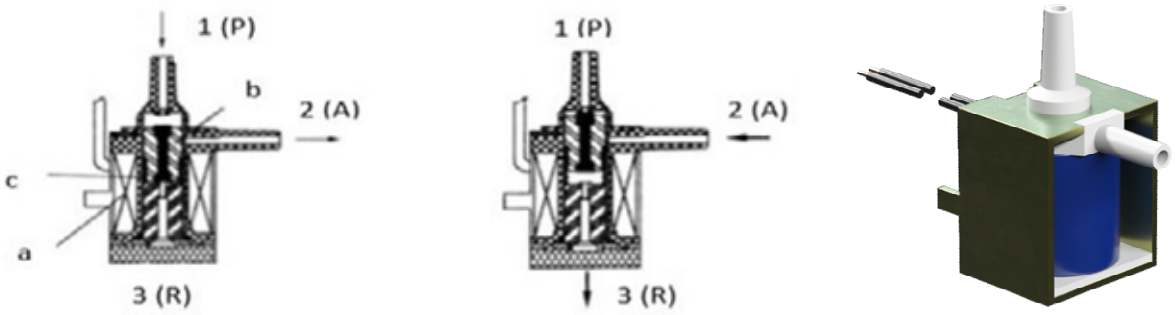
A diaphragm pump is used as the compressed air source.
Such a diaphragm pump consists of two chambers that are separated from each other by a diaphragm (1). In one of these two chambers, a piston (2) is moved back and forth by an eccentric (3), which reduces or increases the volume in the other chamber. If the piston moves to the right, the diaphragm is pulled backwards, causing air to be sucked into the second chamber via the inlet valve (4). If the piston moves to the left, the diaphragm pushes the air out of the pump head via the outlet valve (5). The compressor used here is operated with a nominal voltage of 24 V and generates an overpressure of 0.7 bar. The maximum current consumption of the compressor is 36 mA.



Picture 6 Functional diagram and compressor

3/2-way solenoid valve:

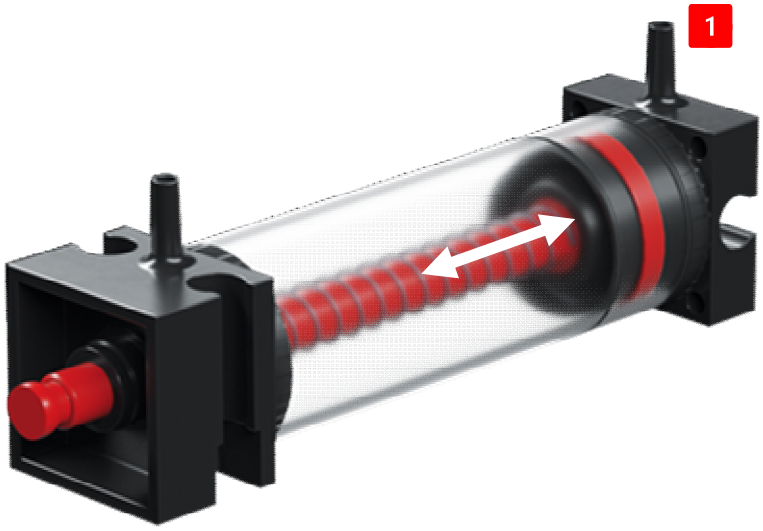
3/2-way solenoid valves are used to control the pneumatic cylinders. These switching valves have three connections and two switching states. The switching operations are carried out by a coil (a), which works against a spring (c). When a voltage is applied to the coil, the movable core (b) of the coil moves against the spring due to the Lorentz force, thereby opening the valve. In this case, opening means that the compressed air connection (current designation: 1, old designation: P) is connected to the cylinder connection (2, previously A). When this tension is released, the spring pushes the core back in and closes the valve again. In this position, the cylinder connection (2, formerly A) is connected to the vent (3, formerly R).



Picture 7 Functional diagram and solenoid valve

Pneumatic cylinder:

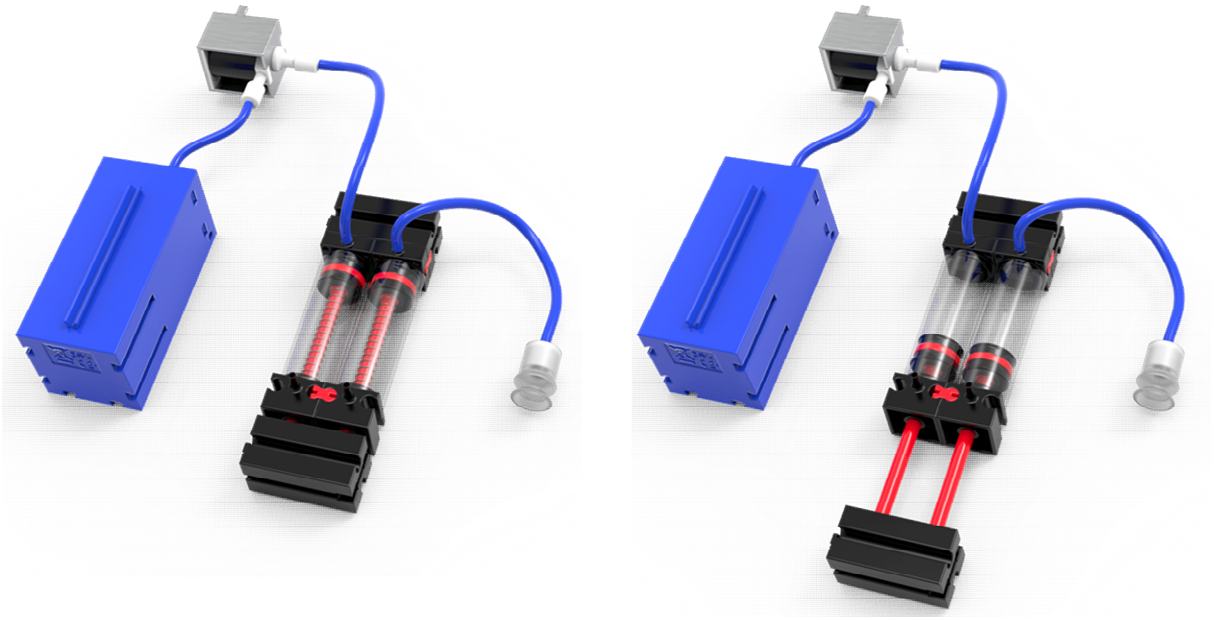
Single-acting cylinders with springs are installed in the model. These are controlled via the 3/2-way solenoid valves. In pneumatic cylinders, a piston divides the volume of the cylinder into two chambers. A pressure difference between these two chambers results in a force that acts on the piston, thereby displacing it. This displacement corresponds to a change in volume of both chambers. The installation of a return spring eliminates the need for a second air connection with a 3/2-way valve. When the 3/2-way solenoid valve is opened, the air generated in the compressor flows to port 1 of the cylinder and pushes the piston forward against the spring force. To do this, the piston rod extends forwards. When the solenoid valve closes the air supply, the spring pushes the piston back to its initial position.



Picture 8 Pneumatic cylinder

Vacuum cups

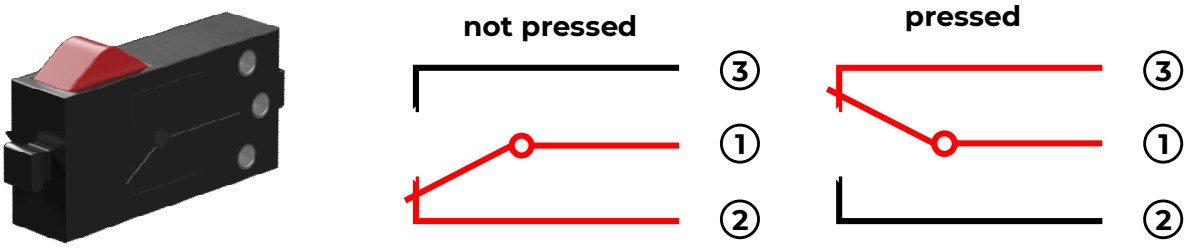
The suction function of the vacuum gripper is performed by two pneumatic cylinders that are controlled by a 3/2-way solenoid valve. Two cylinders are mechanically coupled to create a vacuum in the vacuum gripper, i.e. a pressure that is lower than the ambient pressure. If overpressure is then applied to one cylinder, both piston rods extend, resulting in an increase in volume in the chamber closed by the suction cup. This increase in volume is accompanied by a reduction in pressure in this chamber.



Picture 9 Left: Vacuum off; Right: Vacuum on

Mini push-button

Mini push-buttons are used as reference switches. In a point-to-point movement, for example the transfer unit, they are used to determine the end position. The mini push-button used here is equipped with a changeover contact and can be used both as a normally closed contact and as a normally open contact.
When the button is pressed, there is a conductive connection between contact 1 and contact 3 (normally open contact), while the connection between contact 1 and contact 2 is disconnected (normally closed contact).



Picture 10 Mini push-button and circuit diagram

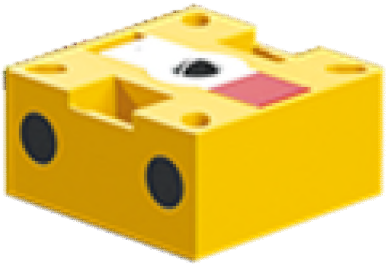
LED

The LED is an electronic component that converts electrical energy into light. The abbreviation LED is derived from the English "Light Emitting Diode". In this model, LEDs are used to generate light for the light barriers.
The building block can be recognized by the imprint "+" and "L". Another feature is the glass body. This has a beam focus so that the light rays are not scattered but hit the phototransistor in parallel.

Picture 11 LED of the light barrier

Phototransistor

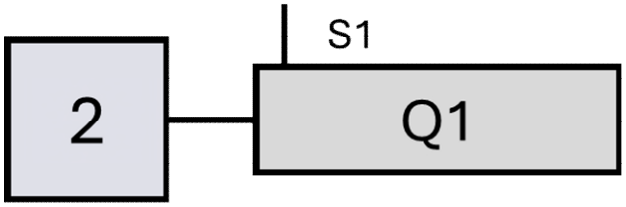
The phototransistor is an electronic component that reacts to the incidence of light. Phototransistors usually only have two leads - the collector and the emitter. The base is replaced by the incident light. If the light from the LED hits the phototransistor, it switches the current flow. This behavior can be evaluated by programming.



Picture 12 Phototransistor of the light barrier

Connection

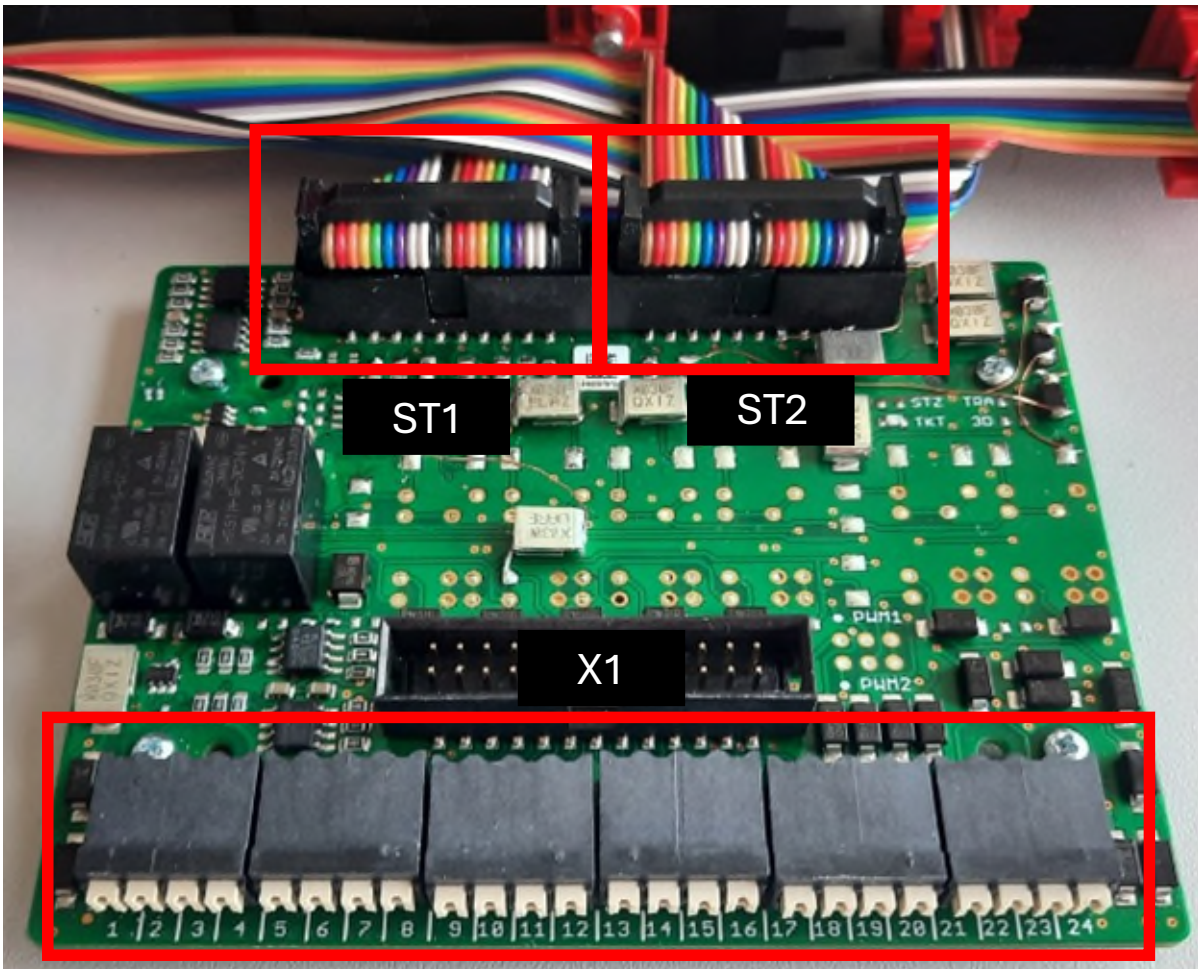
- The limit switches (S1 - S4) are wired as normally open contacts.
- The light barriers (B1 - B4) provide a 1 signal if the light beam is not interrupted.
- Care must be taken to ensure that the movement of the converter is only activated until the corresponding limit switch is reached, as otherwise it may block and be overloaded.
  The control should therefore be a continuous action with a condition.



Picture 13 Example

The compressor does not need to be activated separately. When one of the valves is activated, it is automatically switched on as well.

The model's sensors and actuators are connected to the ST1 and ST2 terminals on the circuit board using ribbon cables.
Terminal strip X1 is available as an interface between the model and the control unit.



Picture 14 Connection board model

The operating resources are laid out according to the following allocation plan:

Clamp	Function	BMK	Address	Icon
1	Power supply (+) - Actuators	24V DC		
2	Power supply (+) - Sensors	24V DC		
3	Power supply (-)	0V		
4	Power supply (-)	0V		
5	Limit position switch Converter Pos. hinge	S1 (I1)		
6	Limit position switch Converter Pos. turntable	S2 (I2)		
7	Limit position switch Slider home position	S3 (I3)		
8	Light barrier tape	B1 (I4)		
9	Light barrier pallet top	B2 (I5)		
10	Rotary table limit switch in position	S4 (I6)		
11	Light barrier pallet bottom	B3 (I7)		
12	Light barrier magazine	B4 (I8)		
13				
14				
15	Transfer unit in the direction of the turntable	Q1		
16	Converter in the direction of the belt	Q2		
17	Motorized pusher (palletizing)	Q3		
18	Motor turntable	Q4		
19	Motor Band	Q5		
20	Valve separator	Q6		
21	Valve Magazine	Q7		
22	Vacuum valve	Q8		
23	Motor drill	Q9		
24	Welding lamp	Q10		

Table 1 Terminal strip assignment diagram X1

For quick and easy assignment, the absolute and symbolic addresses of the variables from the automation system can be entered in the "Address" and "Symbol" columns.

Clamp	Function	BMK	Color
1	Motor converter	Q1 / Q2	Brown
2			Red
3	24V	S1 (I1)	Orange
4	Limit position switch Converter Pos. hinge		Yellow
5	24V	S2 (I2)	Green
6	Limit position switch Converter Pos. turntable		Blue
7	Motorized pusher (palletizing)	Q3	Violet
8	GND		Gray
9	24V	S3 (I3)	White
10	Limit position switch Slider home position		Black
11	24V	B1 (I4)	Brown
12	Light barrier tape		Red
13	Motor Band	Q5	Orange
14	GND		Yellow
15	24V	B3 (I7)	Green
16	Light barrier pallet bottom		Blue
17			Violet
18			Gray
19	24V	B2 (I5)	White
20	Light barrier pallet top		Black

Table 2 Terminal strip assignment diagram ST1

Clamp	Function	BMK	Color
1	Valve separator	Q6	Brown
2	GND		Red
3	Valve Magazine	Q7	Orange
4	GND		Yellow
5	Motor turntable	Q4	Green
6	GND		Blue
7	24V	S4 (I6)	Violet
8	Rotary table limit switch in position		Gray
9	Vacuum valve	Q8	White
10	GND		Black
11	Motor drill	Q9	Brown
12	GND		Red
13	24V	B4 (I8)	Orange
14	Light barrier magazine		Yellow
15	Welding lamp	Q10	Green
16	GND		Blue
17	Compressor	Q6 / Q7 / Q8	Violet
18	GND		Gray
19	24V	LED Magazine	White
20	Light barrier pallet top		Black

Table 3 Terminal strip assignment diagram ST2

1.2 Functional description

The "24V production line" model consists of a turntable with four stations, a transfer unit and a transport line.

A workpiece is pushed from the magazine onto the rotary table by means of a cylinder, where it must pass through the 2 processing stations "Drilling" and "Welding". It is then made available at the "transfer" station.

The transfer unit picks up a finished workpiece from the "transfer" station of the rotary table and places it on the conveyor belt.

If a workpiece is at the beginning of the belt, it is conveyed to the end.
If there are 3 workpieces at the end of the conveyor belt, they are pushed onto a waiting empty pallet by the pusher with the divider open.

1.2.1 Home position

The basic position of the individual modules is defined as follows:

Turntable

The turntable is in position (S4 actuated).

Station 1 - Magazine

The slider is retracted (Q7) and not activated.

Station 2 - Drilling

No processing operation is active (Q9) not activated.

Station 3 - Welding

No processing operation is active (Q10) not activated.

Station 4 - Handover

The converter is not in the station (S2 not activated).

Converter

The converter is located between the two stations. Neither of the two end positions is actuated (S1 not actuated, S2 not actuated).
The vacuum cup (Q8) is not activated.

Transport route

The divider (Q6) is not closed.
The slider is in the rear end position (S3 actuated).
If the pusher is not in the home position, it can only be moved to the home position when the divider is open. A pallet must also be available, as there is no guarantee that the belt is empty and potential workpieces could be pushed off the belt by the pusher.

1.2.2 Automatic sequence

The functionality of the system can be subdivided into several separate processes. The interface between the individual parts of the system is the transfer of a workpiece.

Transport route

The transport section receives the workpieces from the transfer unit and guides them to the end of the belt. As soon as 3 workpieces are ready on the belt, they are discharged onto a pallet by a pusher.

The conveyor belt is driven by a motor that can be controlled via output Q5. It may only be moved if the slider is in the home position (S3 actuated), the separator is closed (valve Q6 actuated) and the transfer unit is not on the side of the belt (S1 not actuated).

The transport process begins when the transfer unit has placed a new workpiece on the belt. This action is detected by a light barrier (B1 interrupted). The motor runs for a predefined period of time, which is selected so that the workpiece is transported safely and reliably to the end of the belt.

The workpieces are counted on the belt. As soon as three workpieces are ready at the end of the belt, the ejection process can be started.
For this step, an empty pallet must be available (B3 interrupted, B2 not interrupted) onto which the workpieces can be placed. The separator (Q6 not activated) opens and the pusher (Q3 activated) pushes the workpieces onto the pallet.
After the workpieces have been pushed onto the pallet, the slider returns to its home position (S3 actuated) and the divider closes again.

The pusher may only be activated when the conveyor belt is stationary, the divider is open and an empty pallet is available.
The divider may only be opened when the conveyor belt is stationary.

A delay time of 500 milliseconds must be provided for opening and closing the separator.

Converter

The movements between the transfer unit and turntable as well as the transfer unit and conveyor belt must be interlocked.

- If the transfer unit is in the end position on the side of the turntable, it must not be moved. The transfer unit may only be moved in the direction of the turntable if it is in position (S4 actuated).
- If the transfer unit is in the end position on the conveyor belt side, the conveyor belt must not be moved. The transfer unit may only be moved in the direction of the conveyor belt if it is not occupied (B1 not interrupted).

To pick up the workpiece from the turntable, the vacuum gripper can be controlled via output Q8. After transferring to the conveyor belt, the vacuum must be switched off by resetting output Q8, which releases the workpiece. The transfer unit must then leave the conveyor belt again.

A delay time must be selected for vacuum build-up and release so that the workpiece can be safely picked up and set down.

Station 1 - Magazine

The supply magazine is located in the first station of the turntable.
If there is a workpiece in the magazine and the nest of the rotary table is empty, a workpiece can be pushed into the nest by activating the slider (Q7). As long as the slider is activated, the rotary table must not move. The slider may only be actuated when the turntable is in position (S4 actuated).
The slider must be activated for a defined period of time. This must be selected so that the workpiece is safely placed on the turntable.

Station 2 - Drilling, Station 3 - Welding

The sequence in the processing stations is the same, so a function sequence can be planned and programmed here, which is called up twice.
The machining process is started when a raw part is in the station and runs for a defined period of time (drilling: 3 seconds; welding: 5 seconds). Once the workpiece is finished, the status must be changed from raw part to finished part.
Processing can only take place when the turntable is in position (S4 actuated).

Turntable

The functionality of the rotary table does not have to be realized via a step chain. A logic controller is sufficient at this point.

The table can be moved if,

- a workpiece is in the nest of the magazine (1).
- a finished part is in one of the two processing stations (2/3).

The table may not be moved as long as

- a workpiece is in the nest of the transfer station (4).
- a raw part is in one of the two processing stations (2/3).
- the slider (Q7) is not in the home position.
- the transfer unit is in the end position on the turntable.

The table must be moved until it is back in position (S4).

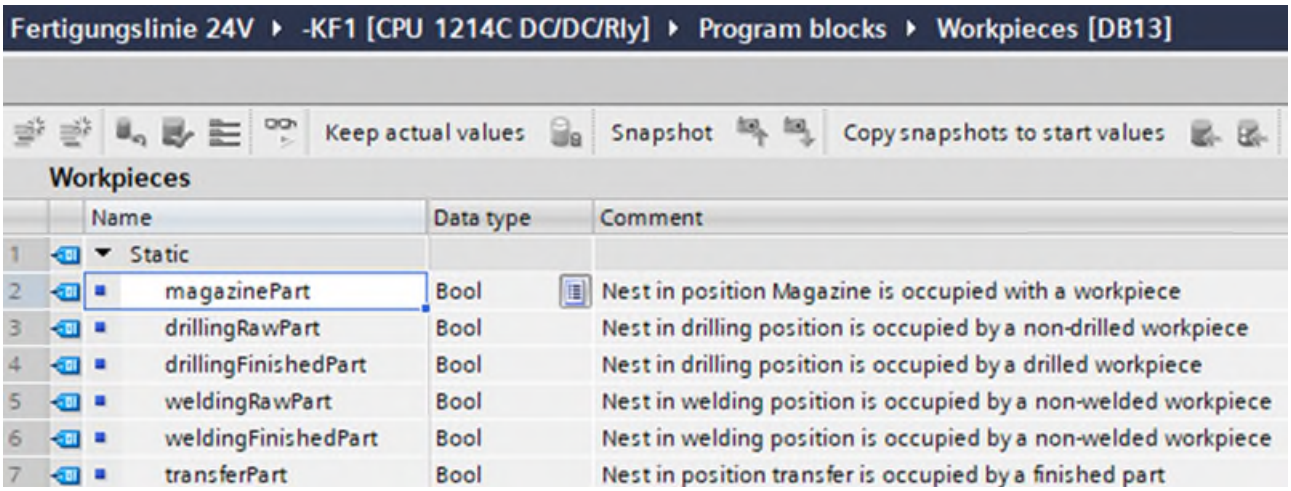
If the table has been turned to the next position (positive edge S4), the workpiece data must also be rotated by one station.

1.2.3 Workpiece management

If there is already a workpiece in nest 1 of the rotary table, no further workpieces may be pushed onto the table from the magazine.
Workpieces in the processing stations (2/3) may only be processed once. If there is no workpiece or a workpiece that has already been processed in the station, the process must not be started.

As the turntable has no sensors to detect these states, this information must be stored internally in the control unit.
Global variables must be declared in the controller for this purpose. These can be declared as flags or, in the case of Siemens, preferably in a global data block.

A data module that displays the information of the individual places on the turntable could look like this:



Picture 15 Example of workpiece management

A possible procedure could look like this:
A new workpiece from the magazine is only pushed onto the turntable if the "magazinTeil" variable has the value "FALSE". After the workpiece has been pushed onto the table, the variable is set to "TRUE".

If the table rotates by 90°, the information from "magazinTeil" is written to the variable "bohrenRohteil" and " magazinTeil" is reset. The drilling process is only started in the station if this variable has the value "TRUE". Once drilling is complete, the variable "drillRoughPart" is set to "FALSE" and "drillFinishedPart" is set to "TRUE".

By rotating the table again, the information from "drillFinishedPart" is written to the variable "weldRoughPart" and "drillFinishedPart" is reset. Welding is only started in the station if this variable has the value "TRUE". Once the process has been completed, the variable "weldBody" is set to "FALSE" and "weldFinishedPart" is set to "TRUE".

By rotating again, the information from "weldFinishedPart" is written to the variable "transferPart" and "weldFinishedPart" is reset. If "transferPart" has the status "TRUE", the workpiece can be picked up by the converter. The variable is reset when the workpiece is picked up.