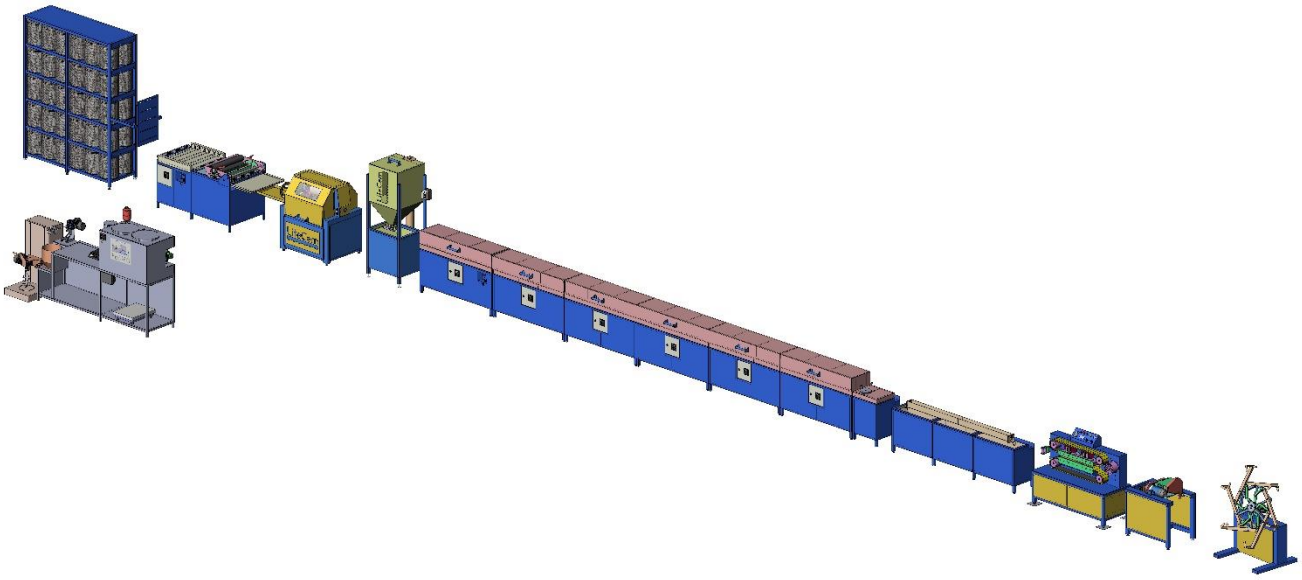
DATASHEET

SERVICE MANUAL

LiteCem Arm

LINE FOR MANUFACTURING FIBER REINFORCED POLYMER BARS



Nezhin, Ukraine

2020

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1.Introduction

The manual covers such questions as installing, launching, operating, servicing, maintaining the line for manufacturing fiber reinforced polymer (FRP) rebars, and contains information about the design of the line.

The line LiteCem Arm has been designed for a batch manufacturing of composite bars and ribbed (deformed section) rebars. Coating bars with sand is available. The line manufactures composite bars and rebars of diameters from 4 up to 22 mm.

When operating the line, observe strictly all instructions and recommendations set forth in the manual and basic accessories technical documentation.

The line is designed for an indoor operation at ambient temperature from +5 up to +40°C.

When the ambient temperature is below zero, the user should provide thermal insulation of the installation.

The installation should be connected to three-phase alternating current mains at frequency of 50 Hz with a dead-grounded neutral via a residual current device.

Since the line LiteCem Arm has been assembled of own produced high-quality units, as well as imported and domestic manufactured accessories, it works continuously for 24 hours per day with one service break (max. 30 min.).

Production process of the line is automated and user-friendly (manual operation is available).

The following materials can be used for manufacturing a product:

- glass roving;
- basalt roving;
- carbon tow;
- binding components based on epoxy-diane resin.

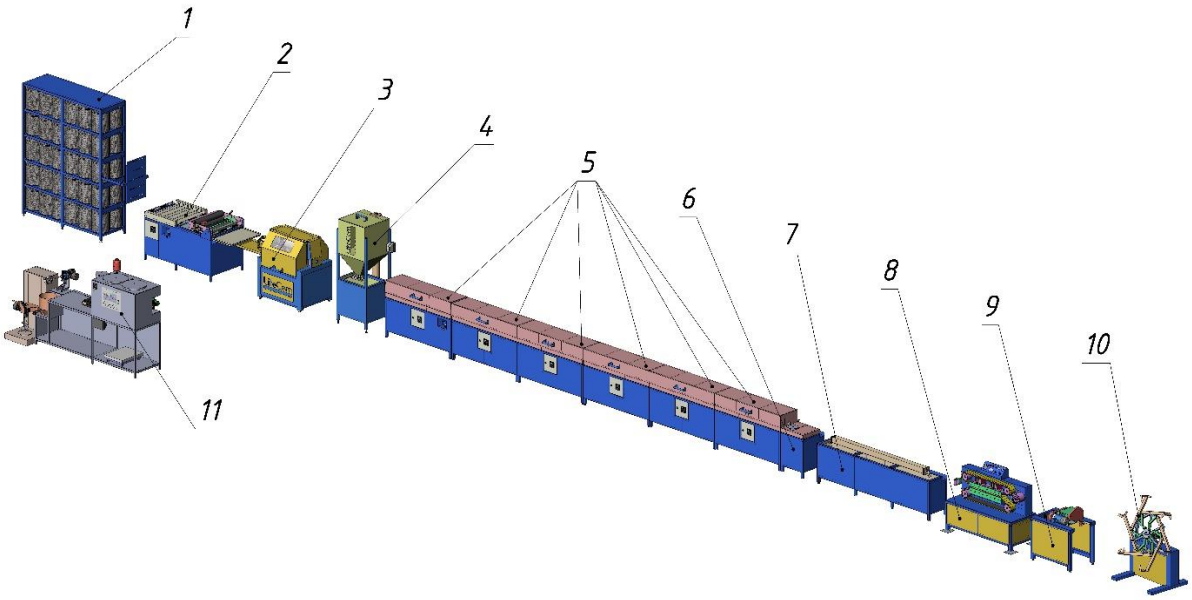


Fig. 1 General view of the line LiteCem Arm

1. *Creel; 2. Impregnating bath; 3. Forming unit; 4. Sand hopper; 5. Polymerization chamber; 6. Bypass unit; 7. Cooling bath; 8. Pulling unit; 9. Cutoff unit; 10. Winder; 11. Binder preparing station*

Table 1 Specifications of the line LiteCem Arm

Name	LiteCem ARM
Air consumption	200 L/h
Power consumption*	41,5 kW
Current type of mains electricity	Three-phase alternating current
Frequency of current	50-60 Hz
Voltage	380-400 V
Quantity of motors used for the line	6
Motor characteristics of a twisting mechanism	AIR 80 A6 U3 0,75 kW Im 1081, 1000 rpm
Motor characteristics of a profile forming unit	AIR 90 LB3 U3 1,1 kW 1t1081, 750 rpm
Gear motor characteristics of a pulling unit	Worm, single-stage, 0,75 kW, 1500 rpm
Motor characteristics of a centrifugal pump	0,75 kW 60 L/min
Productivity of the FRP rebars production line	2-8 m/min
Maximum distance of a cutoff device displacement along a profile trajectory	324 mm
Rotational speed of a cutoff wheel	5500 rpm
Maximum value of a pulled profile	20 mm
Length of a finished profile	set by an operator
Overall dimensions:	
Length	25000 mm
Width	3200 mm

Height	2300 mm
Area required to set up the line	85 m^2
Parameters of roving bobbins used for winding yarn (in a forming unit)	Roving bobbins for internal unwinding with a cardboard core
Weight, kg	max. 8
Internal diameter of a cardboard core	mm: 76,5 ± 0,5
External diameter of a bobbin, mm:	max. 200
Bobbin height	mm: 275
Nominal air flow rate of a spot exhaust ventilation**	10700 m^3/h

* nominal power consumption of the line in work;
** a spot exhaust ventilation system is not included to a standard scope of supply of the line LiteCem Arm.
- parameters are technologically designed and may deviate upward or downward in practice. At a customer's request, the line having other specifications is allowed to be manufactured.

The manufacturer shall not be liable for unauthorized design modification and changes in technical specifications!

Table 2 Scope of supply

LiteCem Arm – The line for manufacturing fiber reinforced polymer rebars	Weight of one unit, kg	Dimensions L x W x H, mm	Quantity
Creel	220	2500 x 600 x 2350	2
Impregnating bath	183	2020 x 830 x 1040	1
Forming unit	300	1300 x 960 x 1200	1
Sand hopper	145	800 x 700 x 1900	1
Polymerization chamber	126	1500 x 520 x 1020	6
Bypass unit;	55	510 x 520 x 800	1
Cooling bath	135	2570 x 450 x 870	1
Pulling unit	520	1500 x 600 x 1250	1
Cutoff unit	138	900 x 600 x 1020	1
Winder	100	800 x 1000 x 1450	1
Control console	70	780 x 730 x 1350	1
Binder preparing station (FGRC20/02)	342	3120 x 760 x 1800	1
Total	3184	26000 x 960 x 2350 *	

* Overall dimensions of the line exclude a control console (Fig. 15, p. 19) and a binder preparing station (Fig. 27, p. 28).

2.Technical Description

2.1. Creel

A creel is designed for a convenient placing and using of roving bobbins with internal unwinding. The creel has an open shelf space structure. Creel capacity is 60 roving bobbins with internal unwinding. A frame (4) is detachable and can have three positions: straight (as shown on the figure), rotated by 45 degrees to the right or left.
These positions allow installing the creel at the angle of 90 degrees to the line in case of lack of space at a workshop.

Control a surface wear of guide pins and yarn guide eyelets (rings). If required, replace.

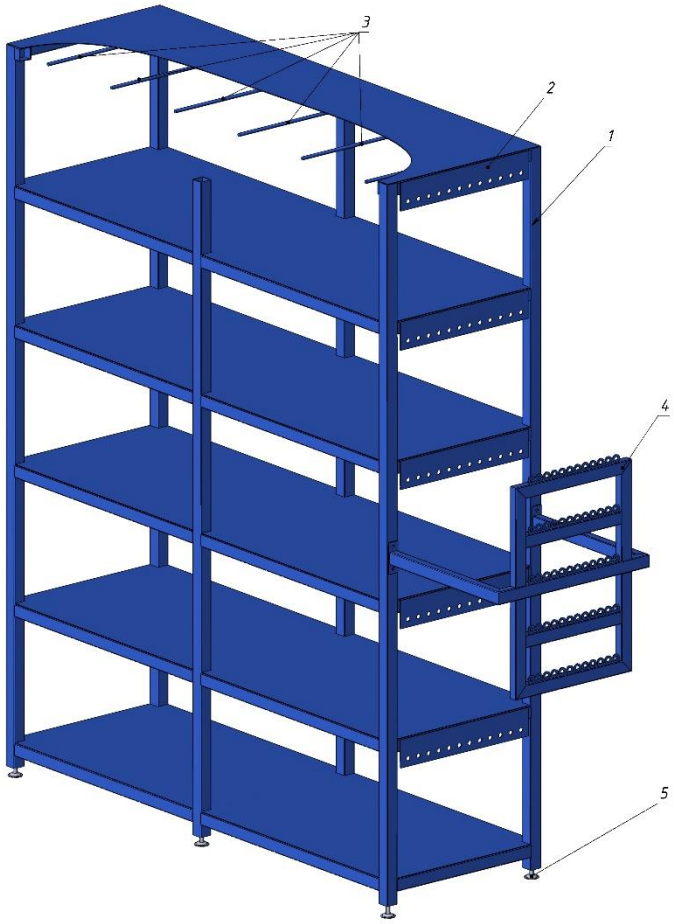


Fig. 2 Creel

1. Frame; 2. Slab with yarn guide eyelets; 3. Guide pins; 4. Frame with yarn guide eyelets; 5. Support leg;

2.2. Impregnating Bath

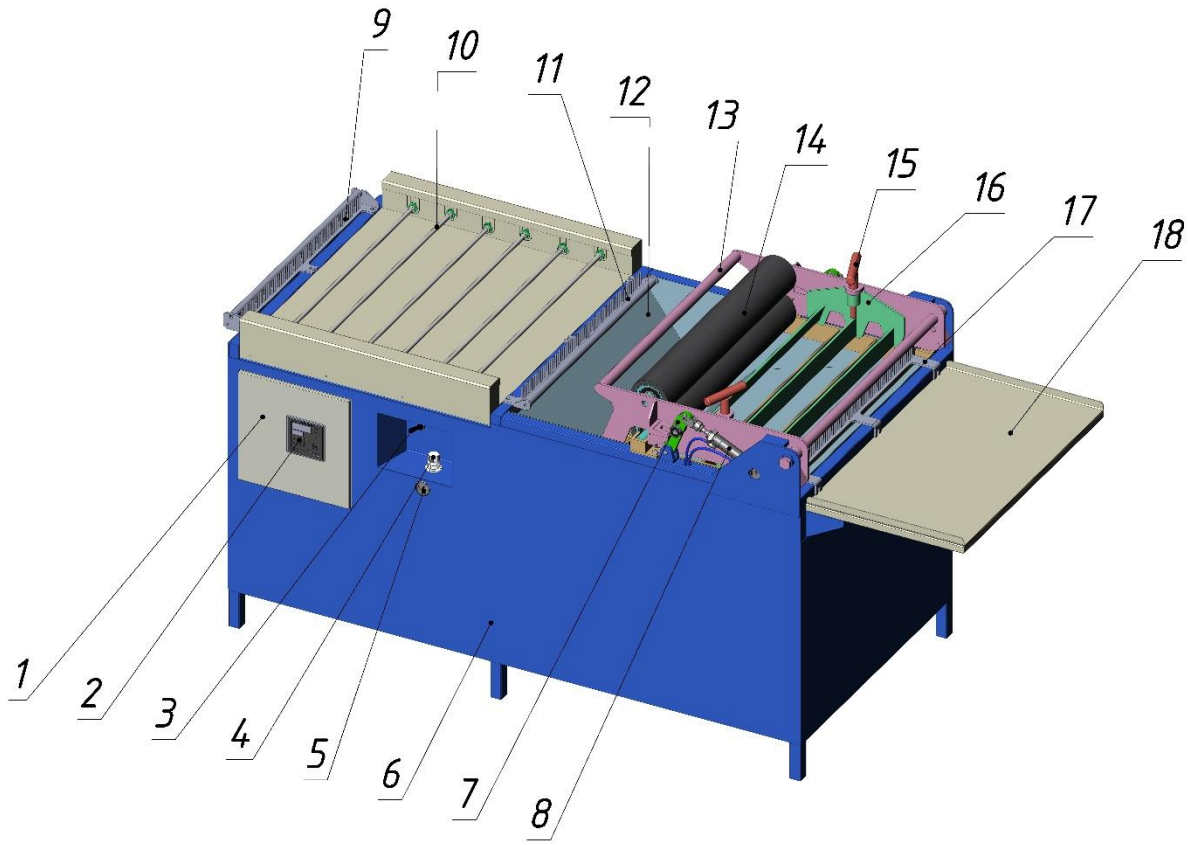


Fig. 3 Impregnating bath

1. Control panel; 2. Temperature controller; 3. Pneumatic selector valve; 4. Pneumatic gear reducer; 5. Manometer; 6. Frame; 7. Fixing lever; 8. Pneumatic cylinder; 9. Front guide bar; 10. Thermoelectric heater; 11. Middle guide bar; 12. Bath; 13. Swing frame; 14. Squeegee rollers; 15. T-shaped lever; 16. Squeegee frame; 17. Back guide bar; 18. Tray for resin;

The impregnating bath is used for pre-drying up to 60 roving yarns in order to dry out a lubricant, impregnating with a polymer binder, and wringing out surpluses.
A section for heating a roving is equipped with guide bars (9 and 11) having separating pins and six thermoelectric heaters (10) used to remove a lubricator, which negatively affects an impregnation degree of roving yarns with a binder.
An impregnation section consists of a bath (12), which maximum capacity is 40 liters, and a swing frame (13) fitted with wringing units.
The swing frame structure provides a quick opening, a convenient adjusting of squeeze rollers pressing force, an immediate and full access to parts required a thorough cleaning after a working period.
A roving yarn submerged into the bath (12) reaches the lowest point, goes through rollers (14), which are set in motion by the yarn itself, and goes through a squeegee frame from which the yarn is supplied for winding. The bottom of the

bath (12) is equipped with a ceramic heater which keeps the temperature of a binder within the set limits if premises temperature is lower than required. The bath is also fitted with a tray for resin (18) which is used for collecting drops of a binder falling from roving yarns.

Fig. 4 Opened impregnating bath

2.3. Forming Unit

A forming unit is designed to form ribs on impregnated roving yarns, i.e. forming an additional double helix made of a winding roving yarn twisted preliminary. The forming unit also twists yarns, so a twisting process doesn't require any auxiliary equipment.

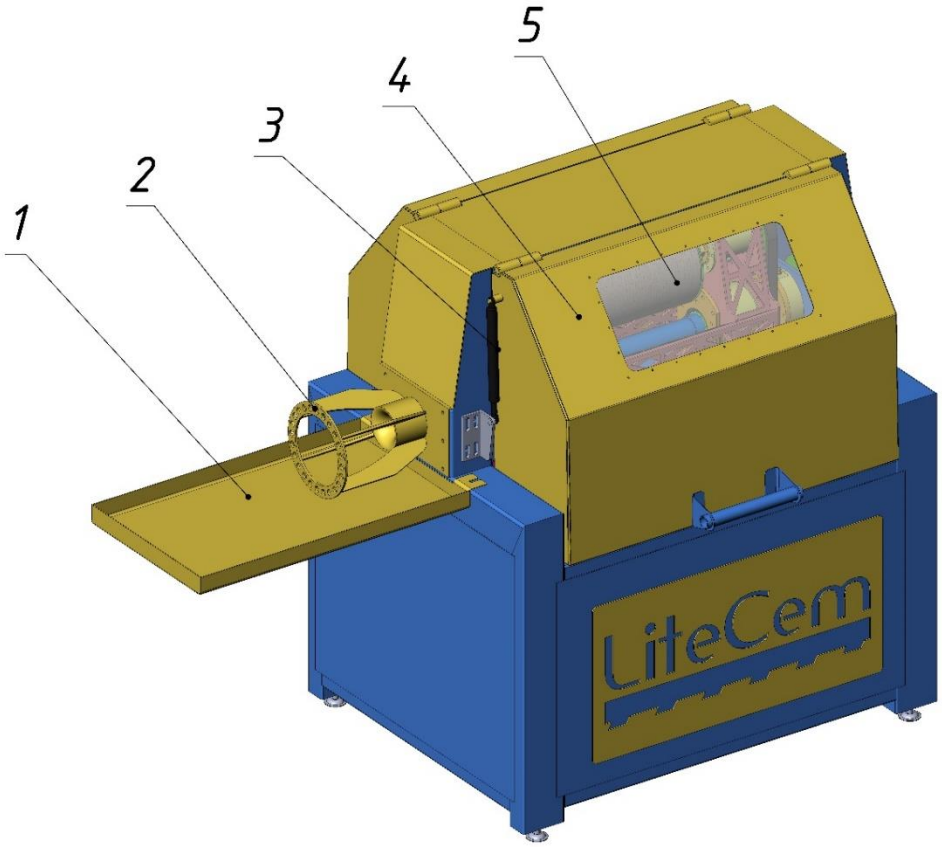


Fig. 5 Forming unit

1. Tray for resin; 2. Receiving yarn ring; 3. Gas lift; 4. Hinged lid; 5. Twisting mechanism;

A frame of a unit is equipped with protective hinged lids (5), which prevent a staff from getting injuries during the work, a receiving yarn ring (2) used to form a reinforced circular cross section profile, a tray for resin drops (1). A twisting mechanism is operated with variable frequency drivers, thus adjusting a winding pith and a twisting of a winding yarn is possible. A winding drive by means of a belt, a pulley (2) and a shaft (3), rotates a frame (1) with all fitted assemblies. A twisting drive by means of a belt, a pulley (16), a shaft (15), a sprocket (14), a chain (10) and a sprocket (11), rotates a detachable shaft of a dog (25). The dog (19) rotating along with a bobbin twists yarns.

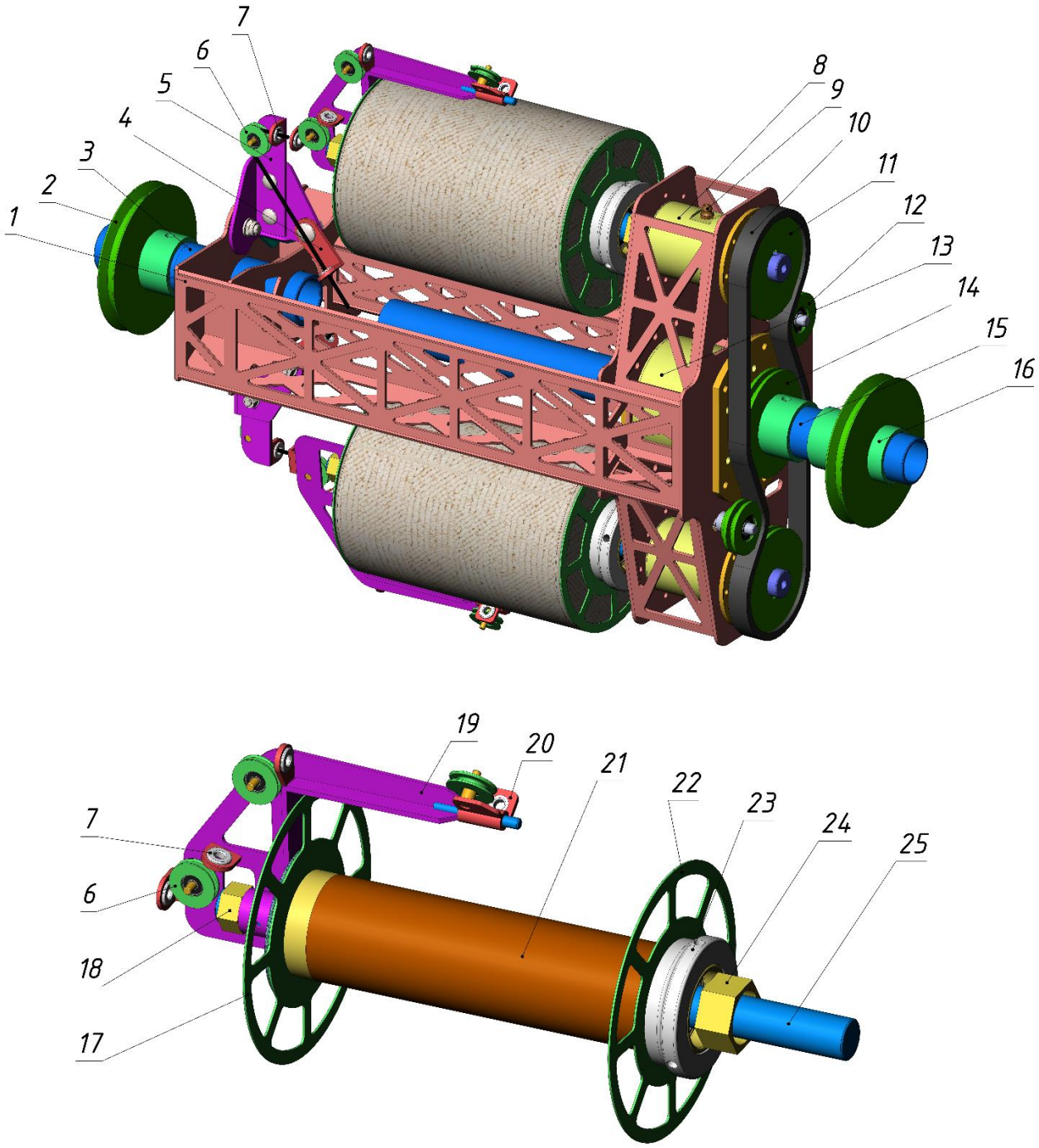


Fig. 6 Winding mechanism

1. Frame; 2. Pulley of winding mechanism; 3. Hollow shaft of winding mechanism; 4. Guide yarn carrier; 5. Flap frame; 6. Roller; 7. Yarn guide eyelet; 8. Twisting mechanism housing; 9. Grease fitting; 10. Twisting drive chain; 11. Sprocket of twisting (driven); 12. Tensioner sprocket; 13. Winding mechanism housing; 14. Sprocket of twisting (driver); 15. Hollow shaft of twisting mechanism; 16. Pulley of twisting mechanism; 17. Spool side; 18. Nut; 19. Dog; 20. Receiving yarn carrier; 21. Spool body; 22. Spool side (detachable); 23. Lock; 24. Nut; 25. Dog shaft;

2.4. Sand Hopper

A sand hopper is designed to coat a FRP rod with sand. To manufacture uncoated FRP rebars, close a shutter (4) and detach a tray (5). The sand hopper is also fitted with a screw feeder (9) to supply sand back to an upper hopper.

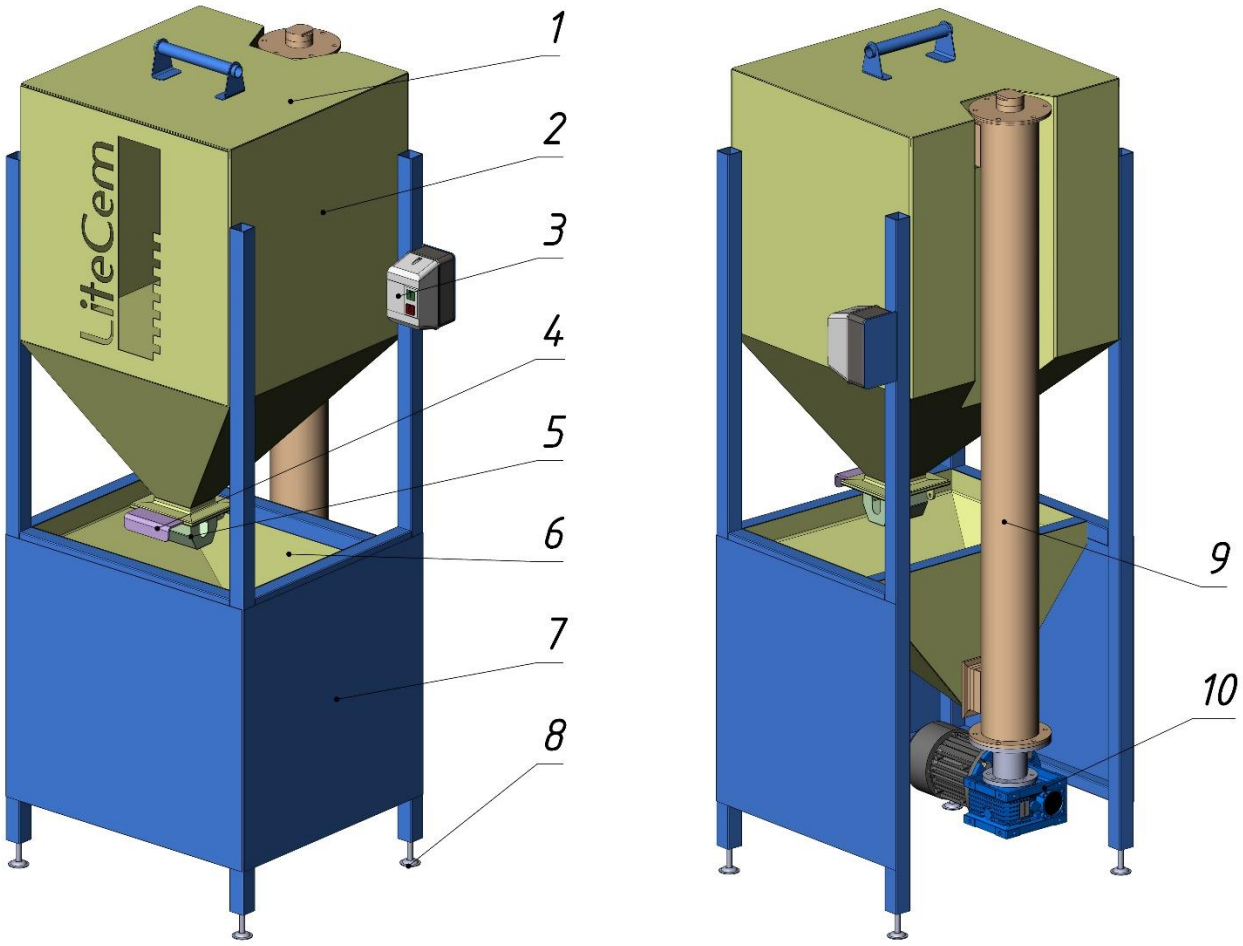


Fig. 7 Sand hopper

1. Lid; 2. Storage hopper; 3. Starter; 4. Shutter; 5. Detachable tray; 6. Receiving hopper; 7. Frame; 8. Support leg; 9. Screw feeder; 10. Gear motor;

2.5. Polymerization Chamber

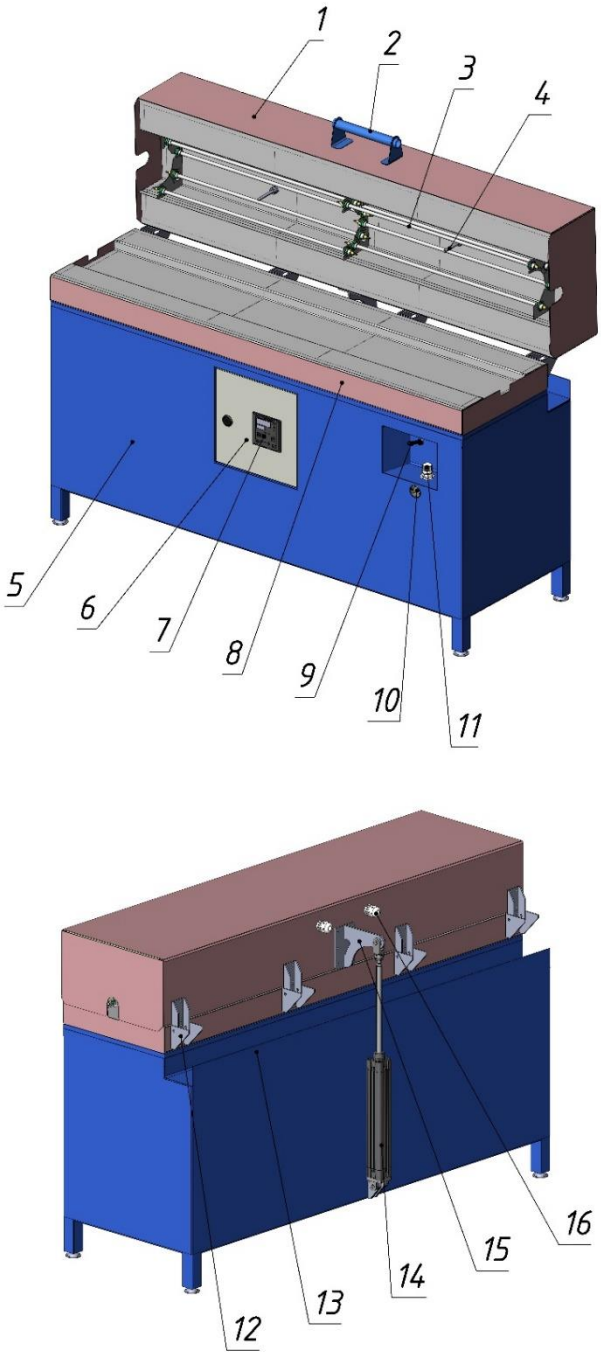


Fig. 8 Polymerization chamber

1. Upper section; 2. Handle; 3. Thermoelectric heater; 4. Thermocouple; 5. Frame; 6. Control panel; 7. Temperature controller; 8. Bottom section; 9. Pneumatic selector valve; 10. Manometer; 11. Pneumatic gear reducer; 12. Loop; 13. Cable tray; 14. Pneumatic cylinder; 15. Bracket; 16. Cable inlet;

The polymerization chamber is designed to heat a binding component of a formed FRP rod in order to start a polymerization process.

The chamber has two separated heating sections – the first section is from the left and the second section is from the right (in the direction of a FRP rod movement) – which are controlled with a two-channel temperature controller (7).
The first section is fitted with controls for opening/closing of upper sections of all chambers, thus simplifying a start of the line. As a pneumatic selector valve (9) has a self-reset to a middle position, so a manual opening of the upper section is also available.
The back of a frame (5) has a cable tray (13) for electrical and pneumatic wiring.

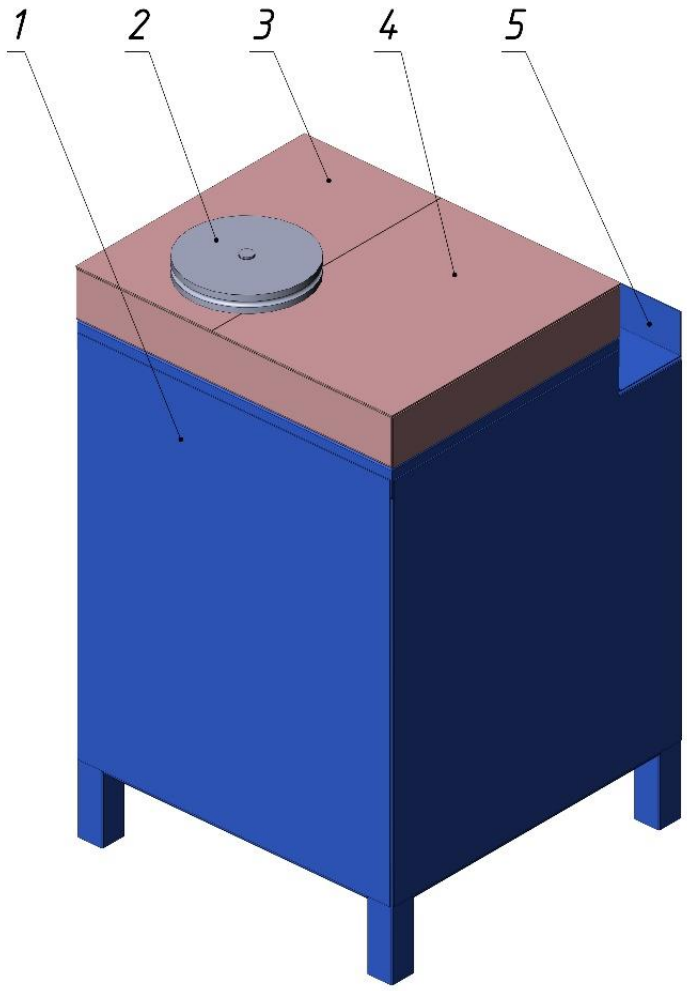


Fig. 9 Bypass unit

1. Frame; 2. Bypass wheel; 3. Case; 4. Lid; 5. Cable tray;

2.6. Bypass Unit

A bypass unit is used to draw aside a cold or heated (in the final polymerization chambers) FRP rod which will be processed further with third-party equipment.
In standard mode, a bypass wheel is hidden under a lid (4), so it doesn't interfere with a FRP rod to pass through.
A flank section of a frame (1) repeats a section of a frame and a tray of a polymerization chamber.

2.7. Cooling Bath

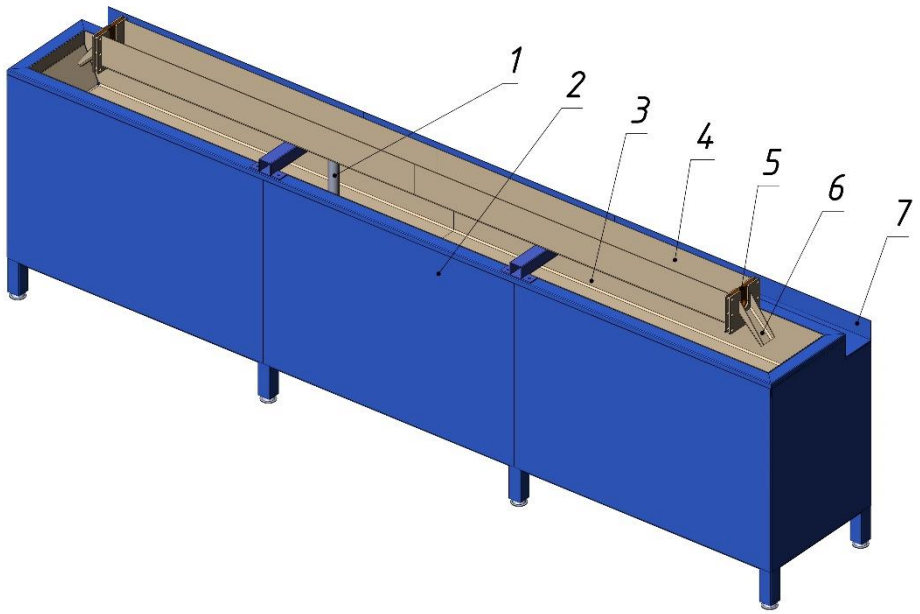


Fig. 10 Cooling bath

1. Feedpipe; 2. Frame; 3. Bath-reservoir; 4. Upper bath groove; 5. Rubber sheet; 6. Drain nose; 7. Cable tray;

A cooling bath is designed to reduce gradually temperature of a FRP rod coming out of a polymerization chamber. Water circulated in a closed cycle is used as a heat transfer fluid. An agent used to prevent defrosting in cold months, if the line has a long pause in work, is also allowed to be applied.

Required volume of water is 70 L. During the work, some amount of liquid is dragged along with a wet FRP rod and also evaporates, therefore the water level should be monitored and periodically refilled.

2.8. Pulling Unit

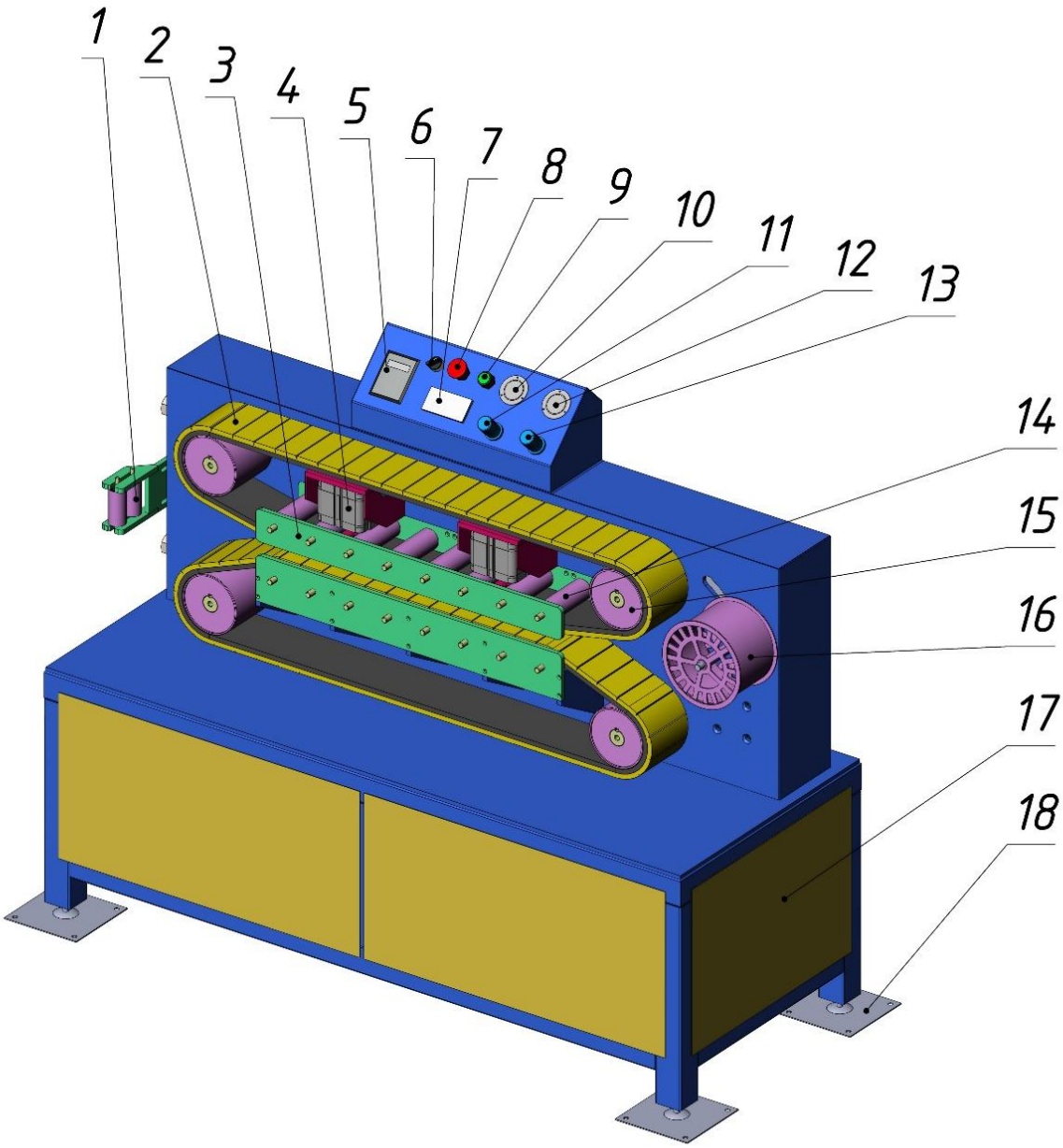


Fig. 11 Pulling unit

1. Guide rollers; 2. Rubber belt; 3. Clamping frame; 4. Pneumatic cylinder; 5. Control panel of drive; 6. Cooling bath power; 7. Impulse counter; 8. Emergency stop; 9. Forced cutoff; 10. Manometer of clamp; 11. Gear reducer of clamp; 12. Manometer of cutoff; 13. Gear reducer of cutoff device; 14. Clamp down roller; 15. Drive drum; 16. Counting wheel; 17. Frame; 18. Fixed support leg;

A pulling unit is used to pull a FRP rod at a set speed.

Fig. 12 Control panel of requency controller

The unit is equipped with a control panel of a frequency controller (5), (Fig. 12) which operates a drive and provides a possibility of operating the unit in a manual mode. When press the START/DIST button, operating is carried out with a remote control panel (Fig. 15, p. 19), according to a protocol Modbus RTU. To operate a drive from a local panel, including a possibility of reverse, use STOP/RESET, START/MAN. buttons and potentiometer. The button (8) is used for an emergency stop of the pulling unit drive. .

A body of the pulling unit is also fitted with controls to operate a cooling bath and a cutoff unit (Fig. 13, p. 17).

Guide rollers (1) are used to position a FRP rod on belts (2), thus belts have uniform wear. A pneumatic gear reducer (11) is used to supply compressed air to pneumatic cylinders (4) that move down a frame (3) forcing rollers (14) to press down pulling belts (2). Length of FRP rebars is precisely tracked due to a counting wheel (16) rotating freely under a FRP rod.

2.9. Cutoff Unit

A cutoff unit is designed to cut off a ready FRP rod to a specified length. The cutoff process is fully automatic, so there is no need in an operator's intervention after adjusting.

Controls are located on the pulling unit and consist of a manometer (12), a pressure reducing valve (13), a button of a forced cutoff (9).

For a preliminary acceleration, an impulse counter, shortly before cutting, supplies power to an electric motor (8) which rotates a high-speed spindle and a cutoff wheel. When a required length has been reached, a pneumatic cylinder (11) impacts on a cutoff carriage to fix a FRP rod. A second pneumatic cylinder (5) used to move a cutoff plate down actuates simultaneously. After fixing a FRP rod, the carriage follows it and carries out cutting. When cutting is finished, a limit switch (4) actuates the pneumatic cylinder (11) which releases a grip. The carriage is reverted to its initial position by means of a mechanical reverse and a counterweight (13).

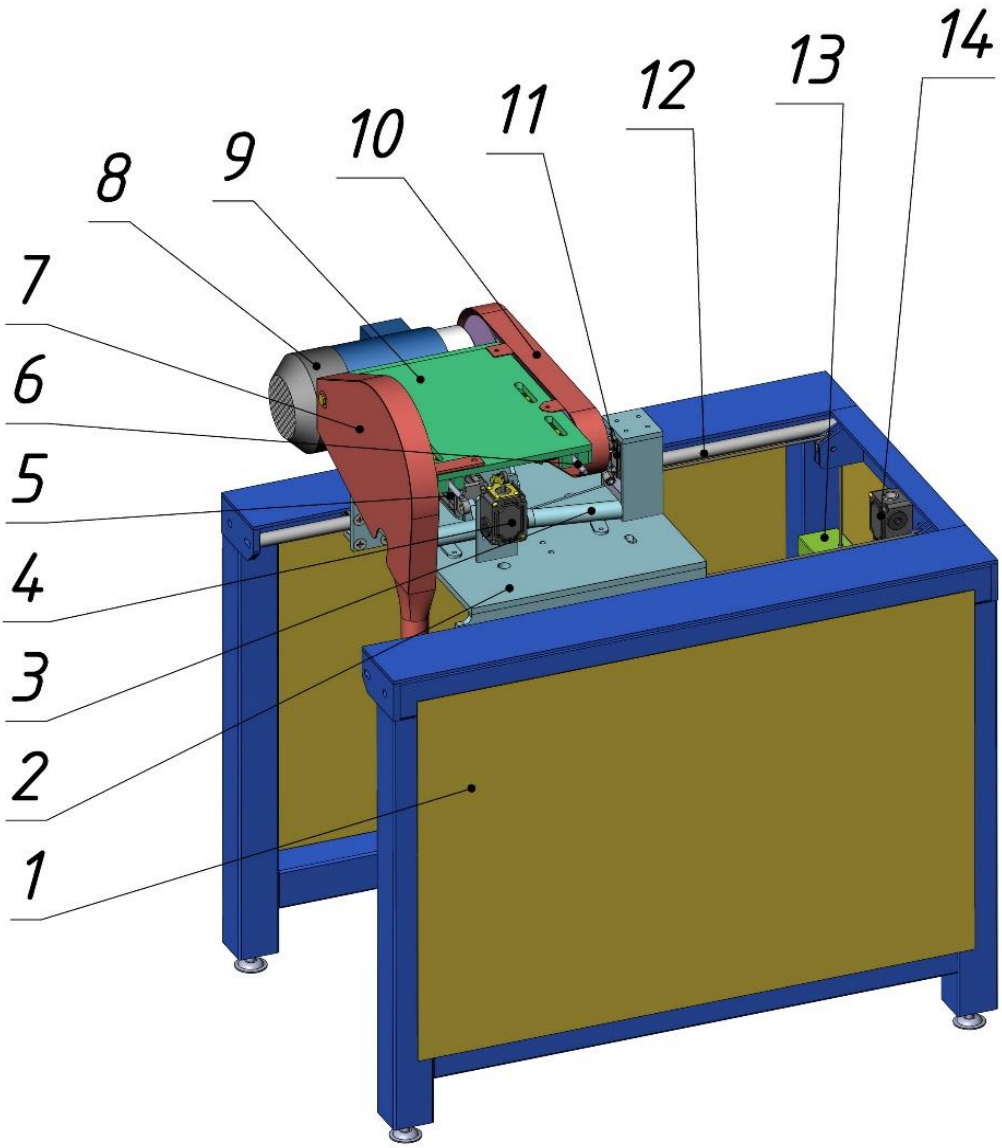


Fig. 13 Cutoff unit

1. Frame; 2. Carriage; 3. FRP rod guide tube; 4. Limit switch; 5. Pneumatic cylinder (cutoff); 6. Tensioner; 7. Cutoff wheel case; 8. Motor; 9. Cutoff plate; 10. Belt case; 11. Pneumatic cylinder (grip); 12. Linear slideway; 13. Counterweight; 14. Emergency limit switch;

2.10. Winder

A winder is designed to coil the FRP rebar of diameter up to 10 mm in coils up to 100 m in length and 1000 mm in diameter.

An arm (4) has a guide tube to pull easily a FRP rod through at the start of winding. A planetary gear (8) is joined with all arms (4) by means of levers (5). The planetary gear has two positions.

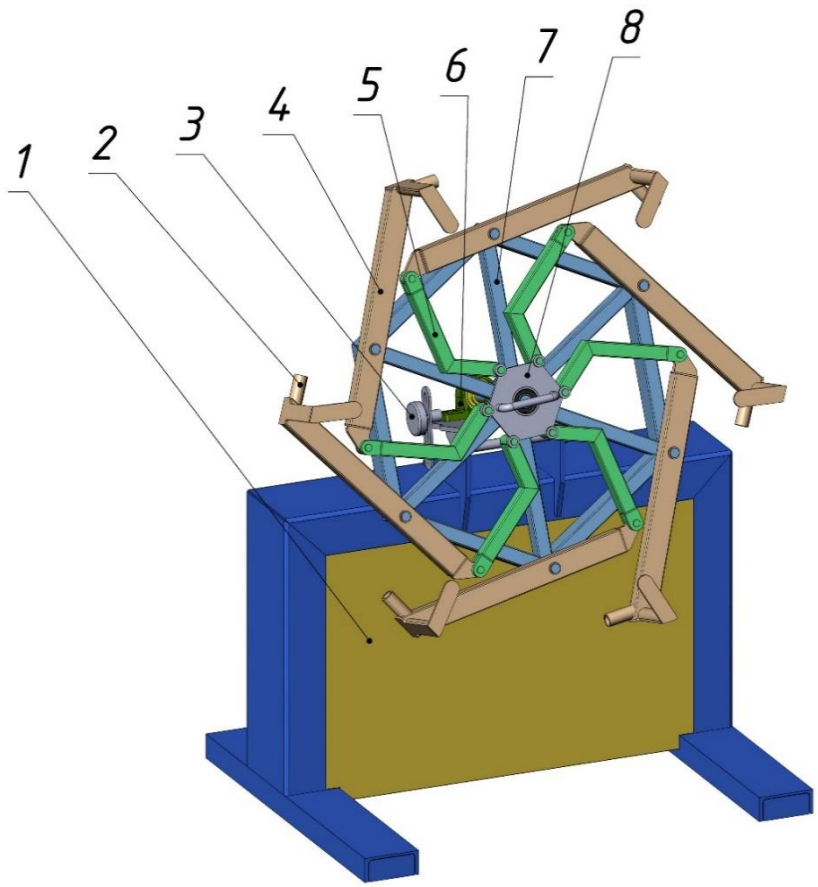


Fig. 14 Winder

1. Frame; 2. Guide tube; 3. Slope adjusting screw; 4. Arm; 5. Lever; 6. Bearing; 7. Turntable; 8. Planetary gear;

In the limit clockwise position, the winder is closed and ready for work; its tips have a minimum diameter. When the planetary gear (8) is in the limit counterclockwise position, the winder is opened and tips of arms have a sufficient diameter to remove a FRP rebar coil easily.

The winder is supplied with an additional set of arms (4) to provide a possibility of winding coils of 1200 mm in diameter.

2.11. Control Console

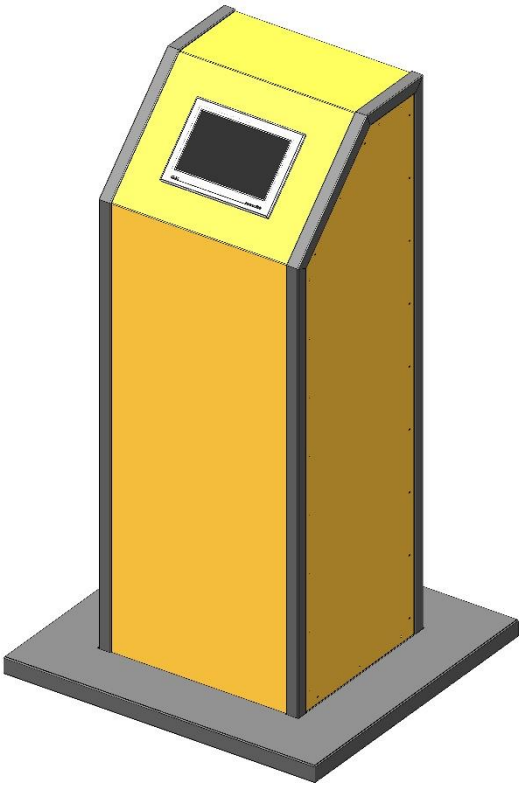


Fig. 15 Control console

A control console consists of an operator touchscreen and a control panel fitted with automatic circuit-breakers of the line sections.

2.12. Operator Touchscreen

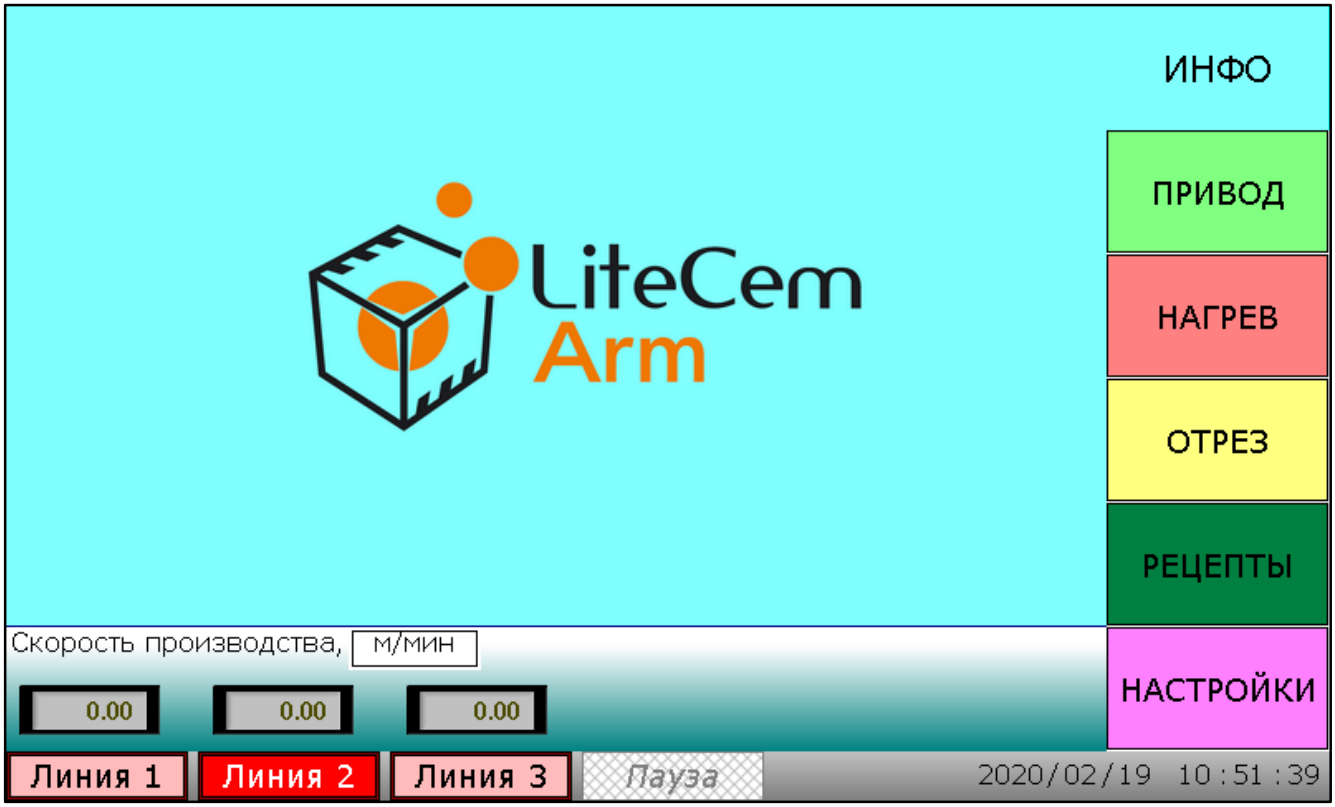


Fig. 16 Operator touchscreen. Basic information screen.

An operator touchscreen is a graphic sensor display showing information incoming from devices of the line. The operator touchscreen allows also controlling all the devices. It should be noticed that devices installed on the line LiteCem Arm work independently from the external control, i.e. switching off the touchscreen won't stop the production process. The line can be stopped only with automatic circuit- breakers (Fig. 15, p. 19).

Software of the touchscreen allows managing up to five lines LiteCem ARM which have from one to seven polymerization chambers (**Ошибка! Источник ссылки не найден.**, p. **Ошибка! Закладка не определена.**).

A **Ошибка! Источник ссылки не найден.** shows the display appearing after switching on the touchscreen. Switches of an active line, current date and time are at the bottom of the screen. In this example using of four lines is shown: the second line is active and the fourth is on a pause (see Fig. 23, p. 26). At the right of the screen are menu buttons:

- INFO – a screen with productivity indicators showing readings that depend on a switch position: 'm/min' or 'm/shift'.

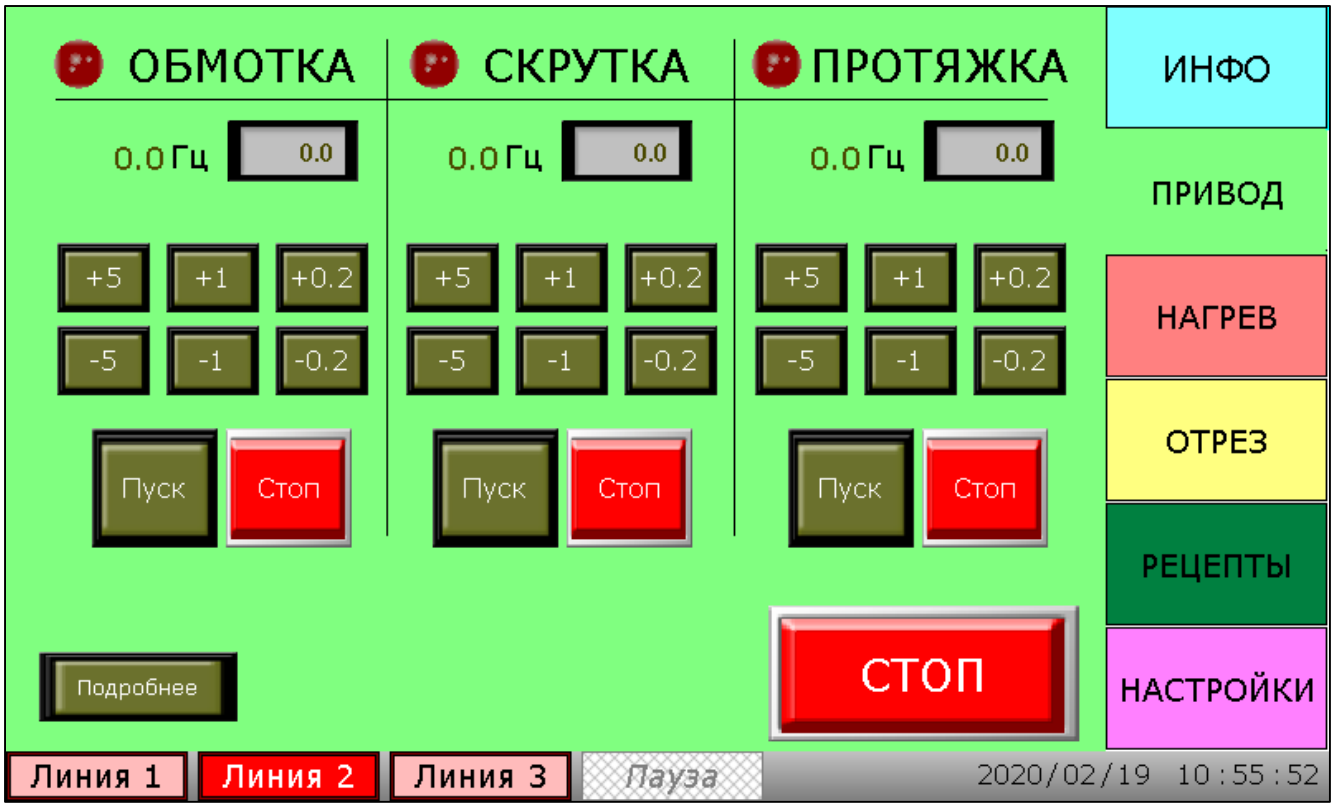


Fig. 17 Drive control screen.

- DRIVE – a screen having controls of a frequency controllers drive. ‘Winding round’ and ‘Twisting’ are used to control a forming unit. ‘Pulling’ is used to control a pulling unit. A desired rotational speed of a motor (from 0 to 100 Hz) is set in an input field.
  The ‘Start’ and ‘Stop’ buttons are used to turn on/off a drive; they have step control of speed: ‘+/-5’, ‘+/-1’, ‘+/-0.2’. The general STOP turns off simultaneously all three drives. To open a window with additional information relating to a status of frequency controllers, press and hold the ‘Show more’ button.

- HEATING – a screen to operate two-channel temperature controllers. Each channel consists of a relay status indicator, a current temperature indicator and an input field of a set point. A quantity of chambers selected in settings is displayed to a screen (see. Fig. 22, p. 25). Using of six chambers is shown in this example. The ‘Keep heating’ / ‘Restart heating’ button is used to assign a selected value to all polymerization chambers; it is used during short work breaks. Holding the ‘Show more’ button opens a window showing a temperature graph of polymerization chambers.

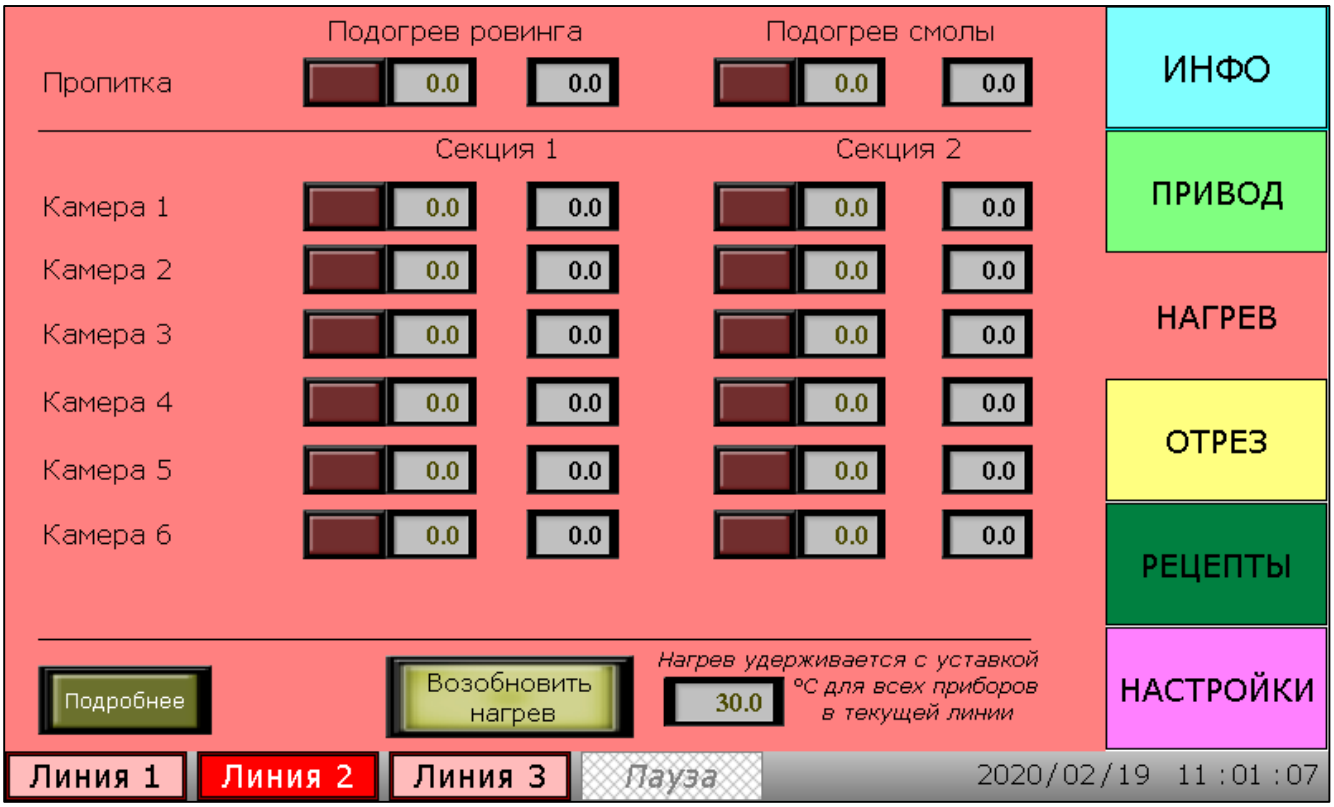


Fig. 18 Heating control screen.

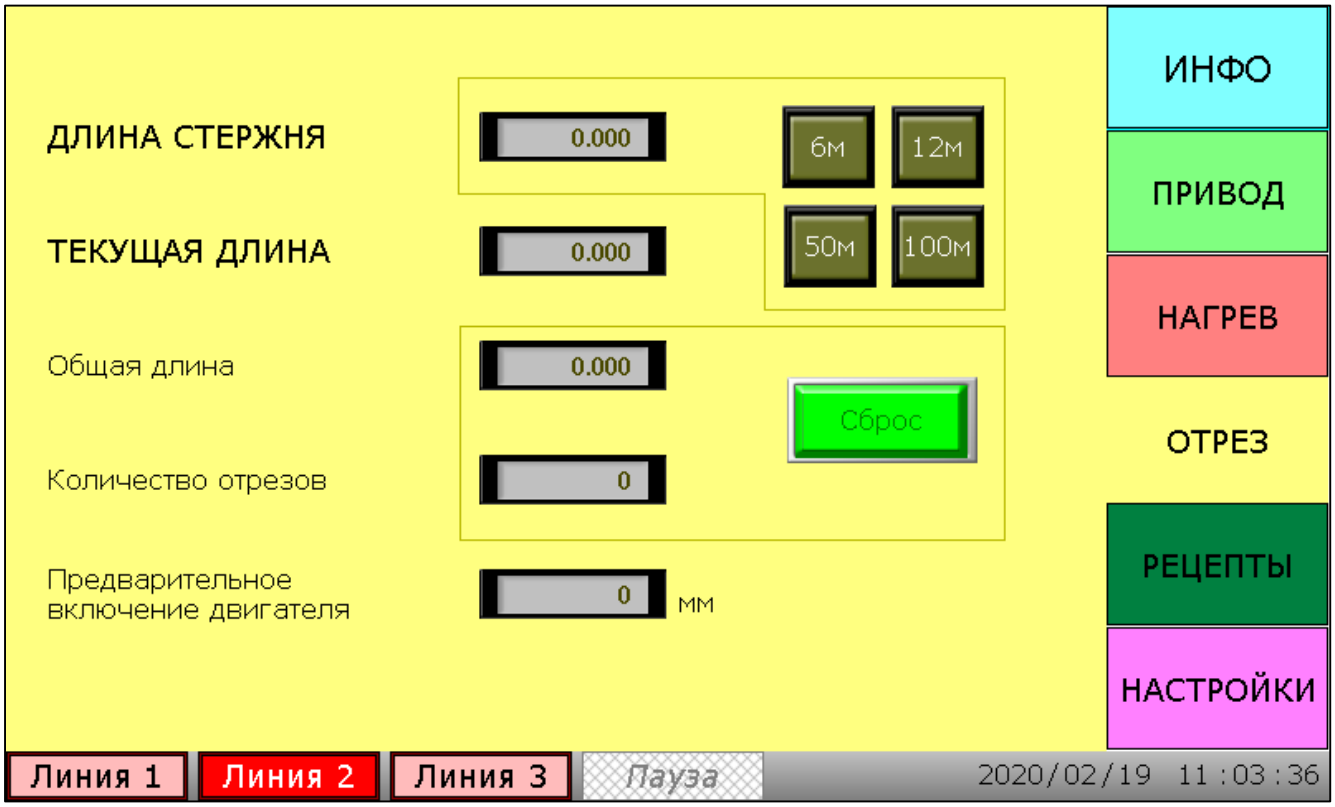


Fig. 19 Cutoff control screen.

- CUTOFF – a screen to control a cutting of a FRP rod. A required cut length is entered in a field ‘Length of rod’. Buttons with preset values - 6, 12, 50, 100 meters – can also be used. Fields ‘Total length’ and ‘Quantity of cuts’ show standard line operation information (data will be incorrect in case of losing connections or appearing interferences on the line). Pressing the ‘Reset’ button clears all values. A motor prestart of a cutoff unit (Fig. 13, p. 17) is carried out via a second channel of an impulse counter, which accelerates a cutoff wheel within a few millimeters of a FRP rod stroke before cutting starts. Care must be taken to ensure that the value is sufficient for full acceleration.

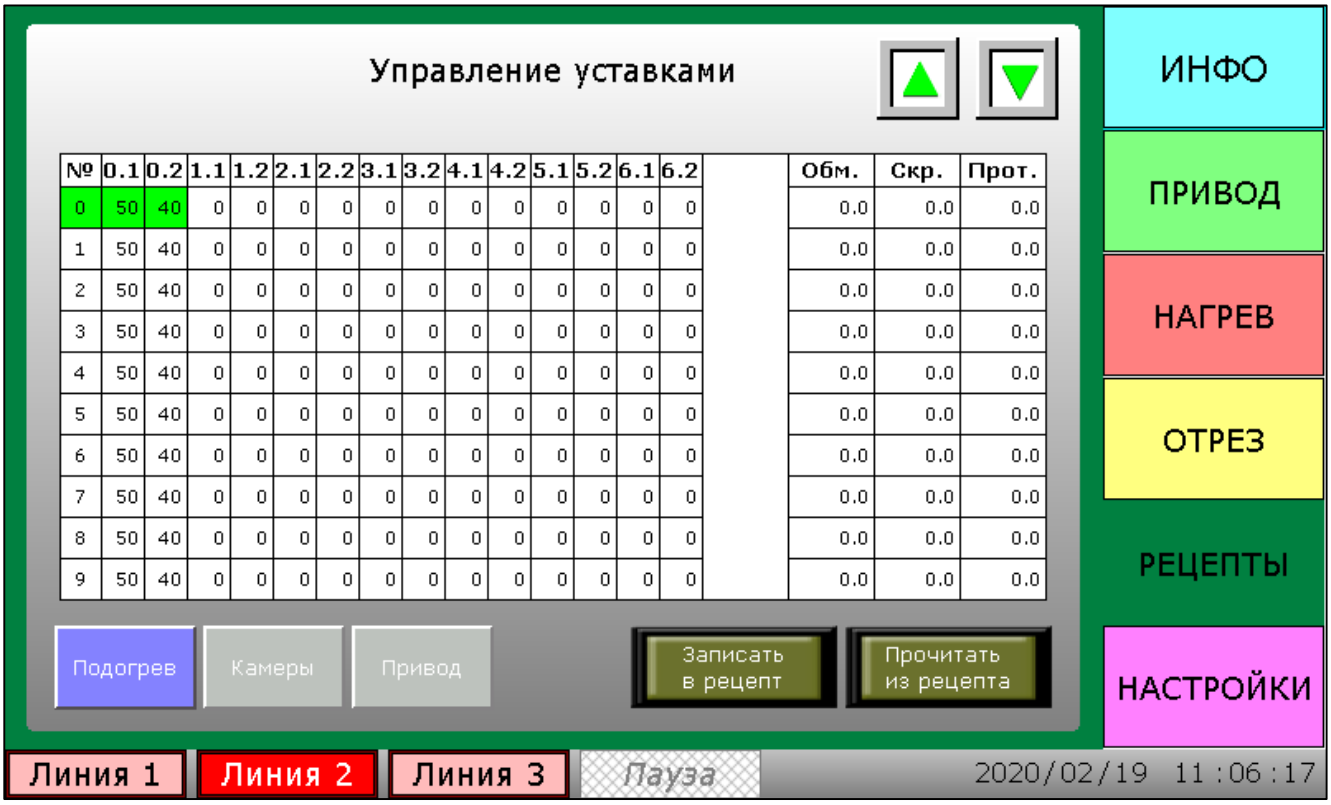


Fig. 20 Set points control screen.

- RECIPES – this screen is used to store in memory and read from memory set points values of temperature indicators and drive rotational rate values of frequency controllers. There are ten cells in total. Cells are switched with triangle buttons located at the top of the screen. ‘Heating’, ‘Chambers’, ‘Drive’ buttons are used to select a section of devices. Inactive polymerization chambers will be hidden in the table. The ‘Insert in recipe’ button is used to save current values in memory. The ‘Read from recipe’ button reads

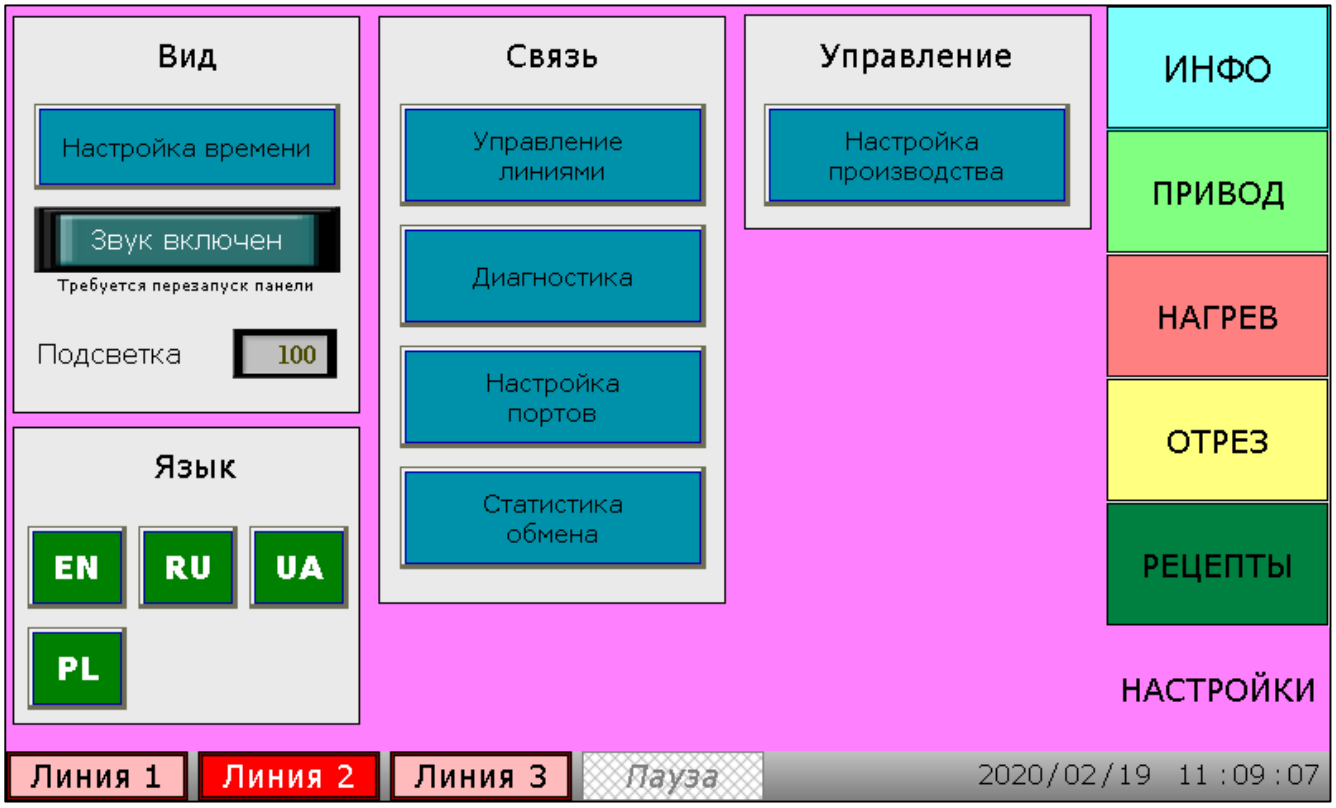


Fig. 21 Settings screen.

values from the panel memory and insert them in devices selected. As information is stored in permanent memory, it doesn't disappear when power switches off.

ATTENTION! If a production plant consists of more than one line, displaying data and operating DRIVE, HEATING, CUTOFF, RECIPE control screens will be available only for an active line.

- SETTINGS – a screen having buttons of various settings.
- 'Factory settings' – a window where an operator selects quantity of lines as well as quantity of polymerization chambers in each line. Settings are stored in non-volatile memory.

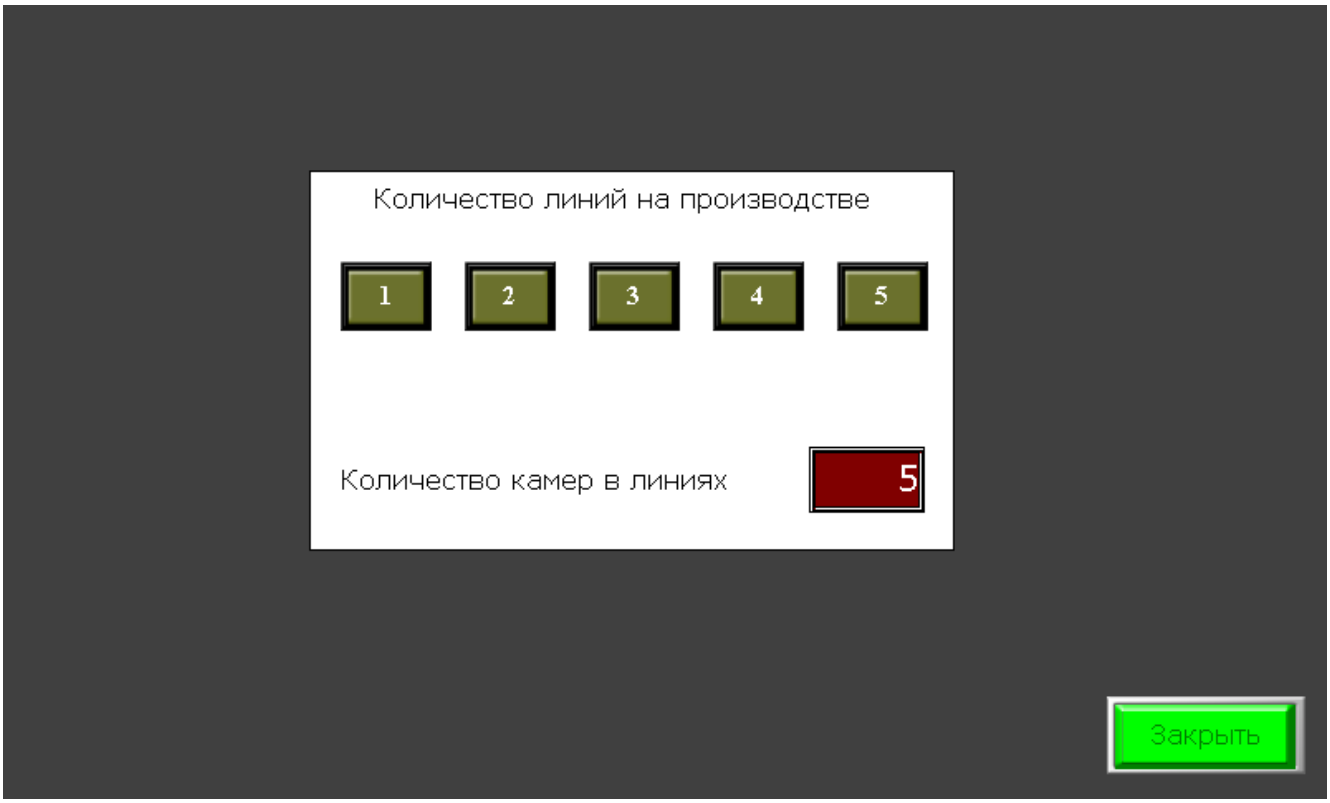


Fig. 22 Factory settings window.

- ‘Lines control’ – a window to set up a polling of devices. When polling a disabled device, a panel may work slowly; its interface may freeze and an accuracy of total length calculations and quantity of cuts is not guaranteed. Switches-indicators of polling of each device are displayed in a table at the left of a window. Inactive lines and polymerization chambers are hidden. Switches are very useful if one or several devices of the line should be turned off, e.g. if there is a need to reduce quantity of polymerization chambers or to apply a bypass unit (Fig. 9, p. 13) and third-party equipment, a pulling unit can be turned off (‘Pulling’ and ‘Counter’). Holding the ‘Addressing devices’ button punches up a prompt – devices addresses on Modbus network – instead of switchers in the table. Switches in a group ‘Lines activated’ are used to disconnect the whole line from polling by means of putting it on a pause. The ‘Polling devices’ switch manages the poll of all devices. Statuses of all switches, except ‘Polling devices’, store in non-volatile panel memory.

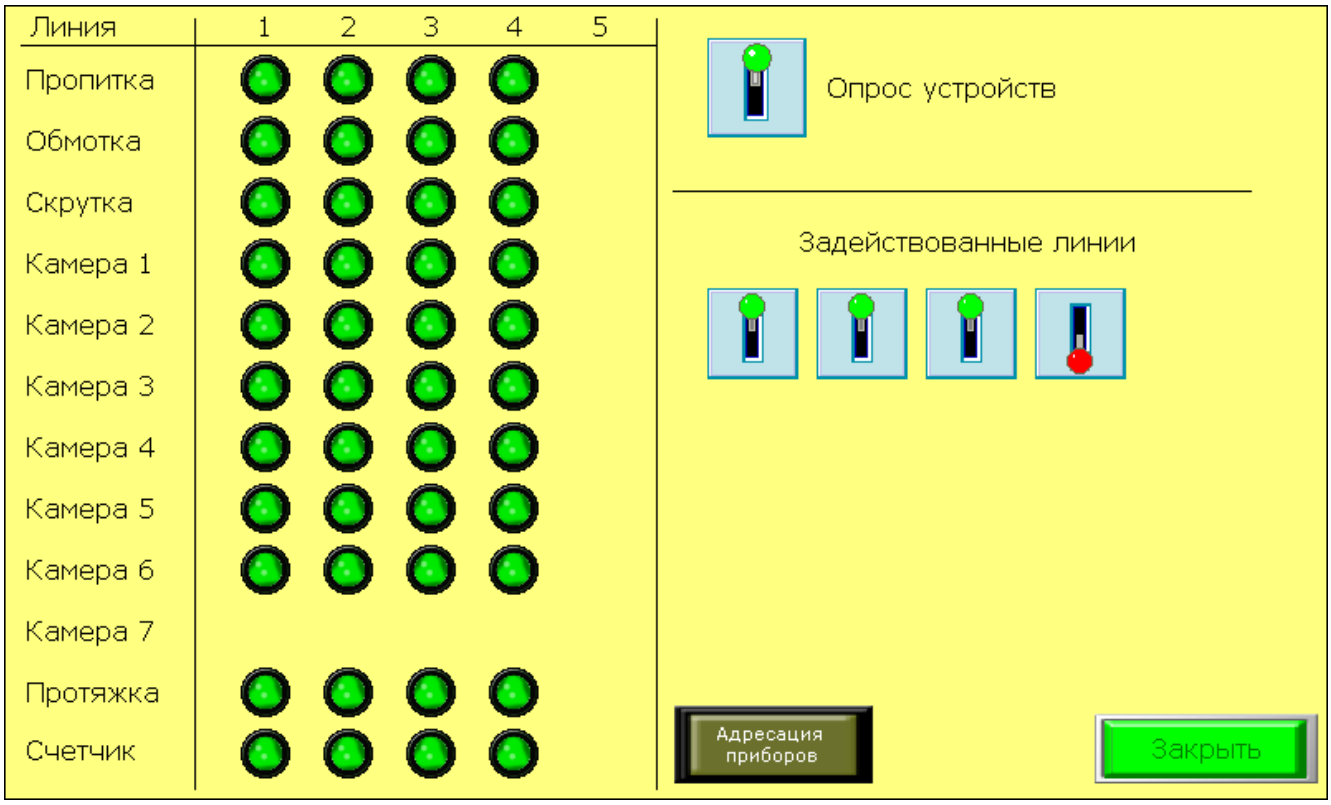


Fig. 23 Lines control window

- ‘Ports setting’ – a window with panel settings in a Modbus RTU network. Temperature controllers and impulse counters use a PLC port. Frequency controllers use a DOWNLOAD port.

- ‘Exchange statistics’ – a window to diagnose connection problems. Under normal operation, only quantity of transmitted data packets will rise. A minimized version of the window can be displayed at the bottom of the panel for convenience.

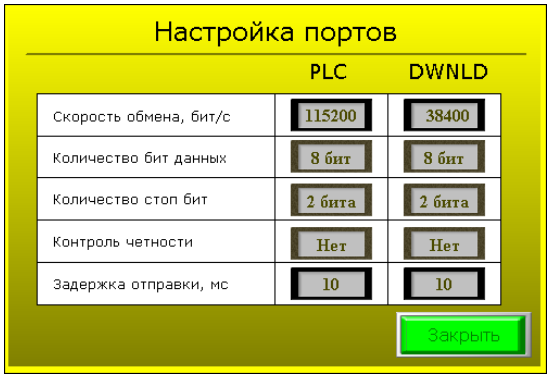


Fig. 25 Port setting window

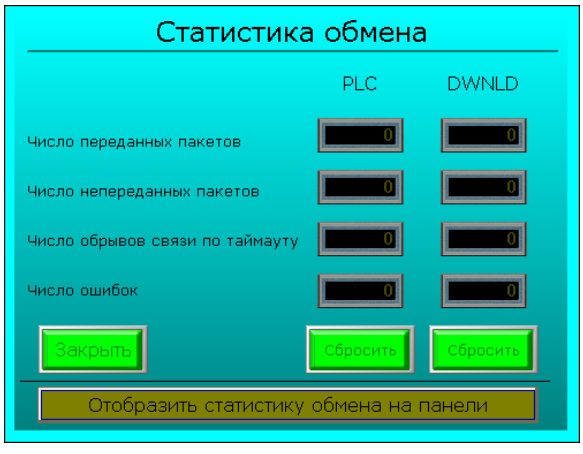


Fig. 24 Exchange statistics window

- ‘Diagnostic’ – a window to see addresses of devices caused a fault.

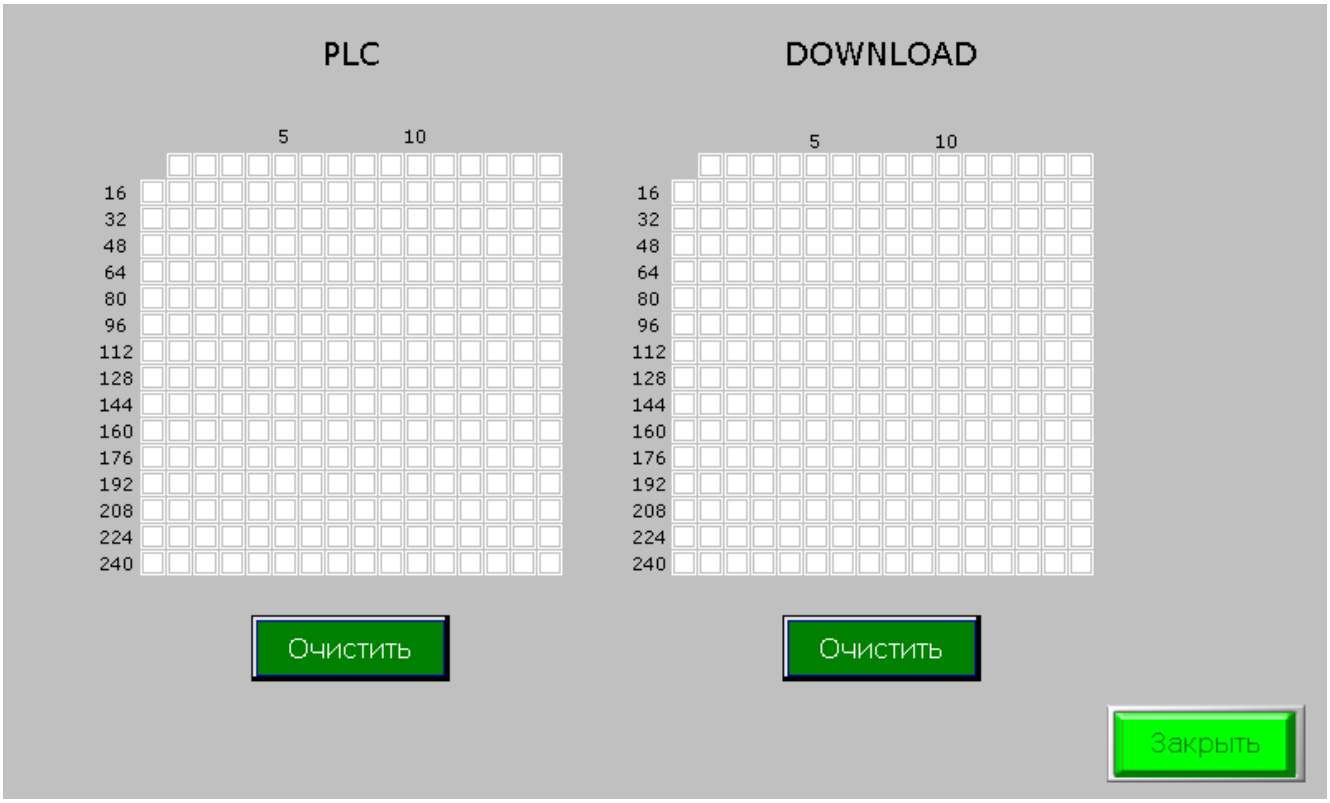


Fig. 26 Diagnostic window

An operator panel software is designed to operate along with equipment as follows:

- OVEN FCV1. Vector frequency controller
- OVEN TPM202. Two-channel meter and controller
- OVEN SI30. Impulse counter

All devices have a RS-485 built-in interface module and work via Modbus RTU protocol. They are set as per Fig. 25.

2.13. Binder (Resin) Preparing Station

A binder preparing station is designed to batch and prepare a binder.
Water circulated in a closed cycle is used as a heat transfer fluid. An agent used to prevent defrosting in cold months, if the line has a long pause in work, is also allowed to be applied.
The major components of mass are a resin and a hardener storing in tanks with a general water jacket (13). A recommended temperature is 45…50°C.

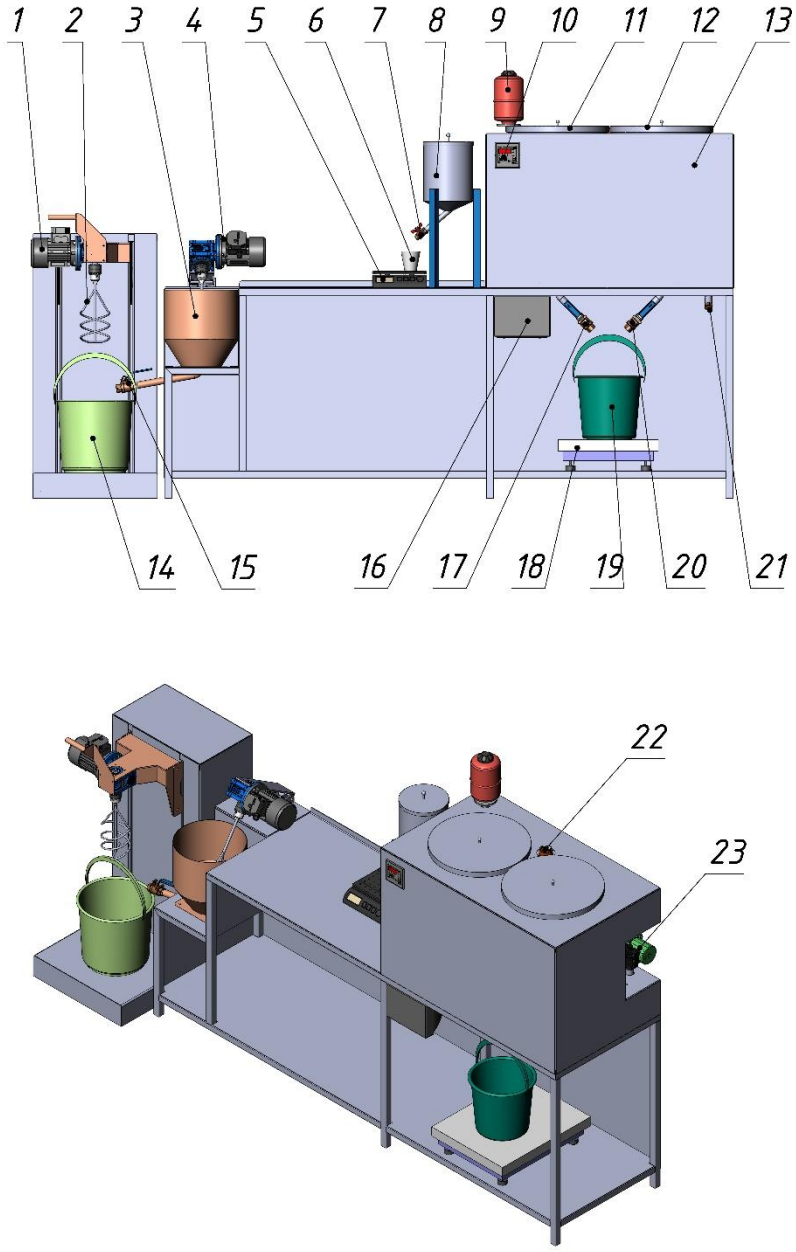
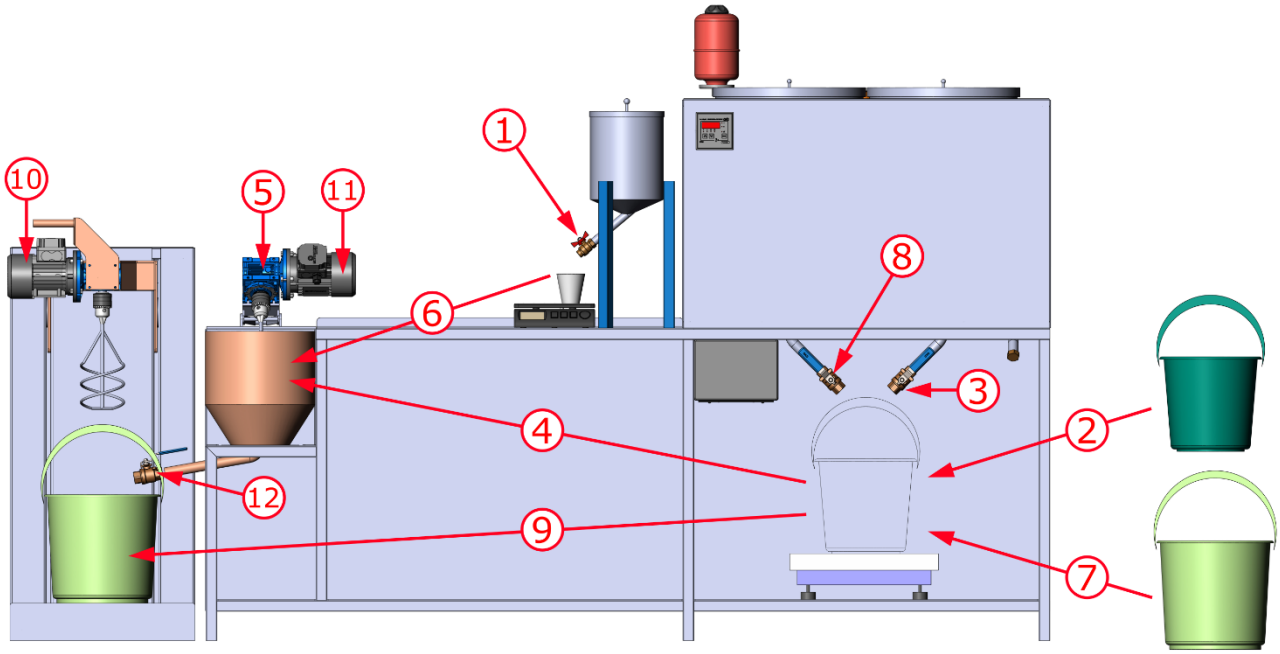


Fig. 27 Binder preparing station

1. Gear motor of resin mixer; 2. Industrial whisk; 3. Hardener mixing vessel; 4. Gear motor of hardener mixer; 5. Bench scales; 6. Plastic cup ; 7. Accelerator vessel tap; 8. Accelerator vessel; 9. Expansion vessel; 10. Temperature indicator; 11. Resin tank lid; 12. Hardener tank lid; 13. Framework for water jacket of resin and hardener; 14. 18 L bucket for mixing resin; 15. Tap of hardener mixing vessel; 16. Weight controller; 17. Resin vessel tap; 18. Platform scale; 19. 10 L bucket for mixing hardener; 20. Hardener vessel tap; 21. Drain plug; 22. Thermo-electric heater; 23. Circulator pump;

3.Production Process

3.1. Sequence of Preparing Binder



1. Weigh a required amount of an accelerator using a bench scales.
2. Put a bucket for hardener (10 L) onto a platform scale.
3. Open a hardener vessel tap and, tracking weight controller readings, pour a required amount of hardener. Close the tap.
4. Pour the hardener from the bucket (10 L) into a hardener mixing vessel.
5. Turn on a motor to mix the hardener with an accelerator.
6. Pour the accelerator from a plastic cup into the hardener mixing vessel. Mixing time is min. 2 minutes.
7. Put a bucket for resin (18 L) onto the platform scale.
8. Open a resin vessel tap and, tracking weight controller readings, pour a required amount of resin. Close the tap.
9. Put the bucket for resin (18 L) onto a platform of a resin mixing device.
10. Put a carriage of a resin mixing device down and turn on a motor.
11. Turn off the motor for mixing a hardener with an accelerator.
12. Open a tap of a hardener mixing vessel in order to trickle the prepared hardener into the resin. Close the tap.

3.2. Batches of Binder Components

The following components are used to prepare a binder.

- Epoxy resin 1000 weight parts
- Hardener MTHPA 750 weight parts
- Accelerator UP-1 45 weight parts

3.3. Threading Roving Yarn

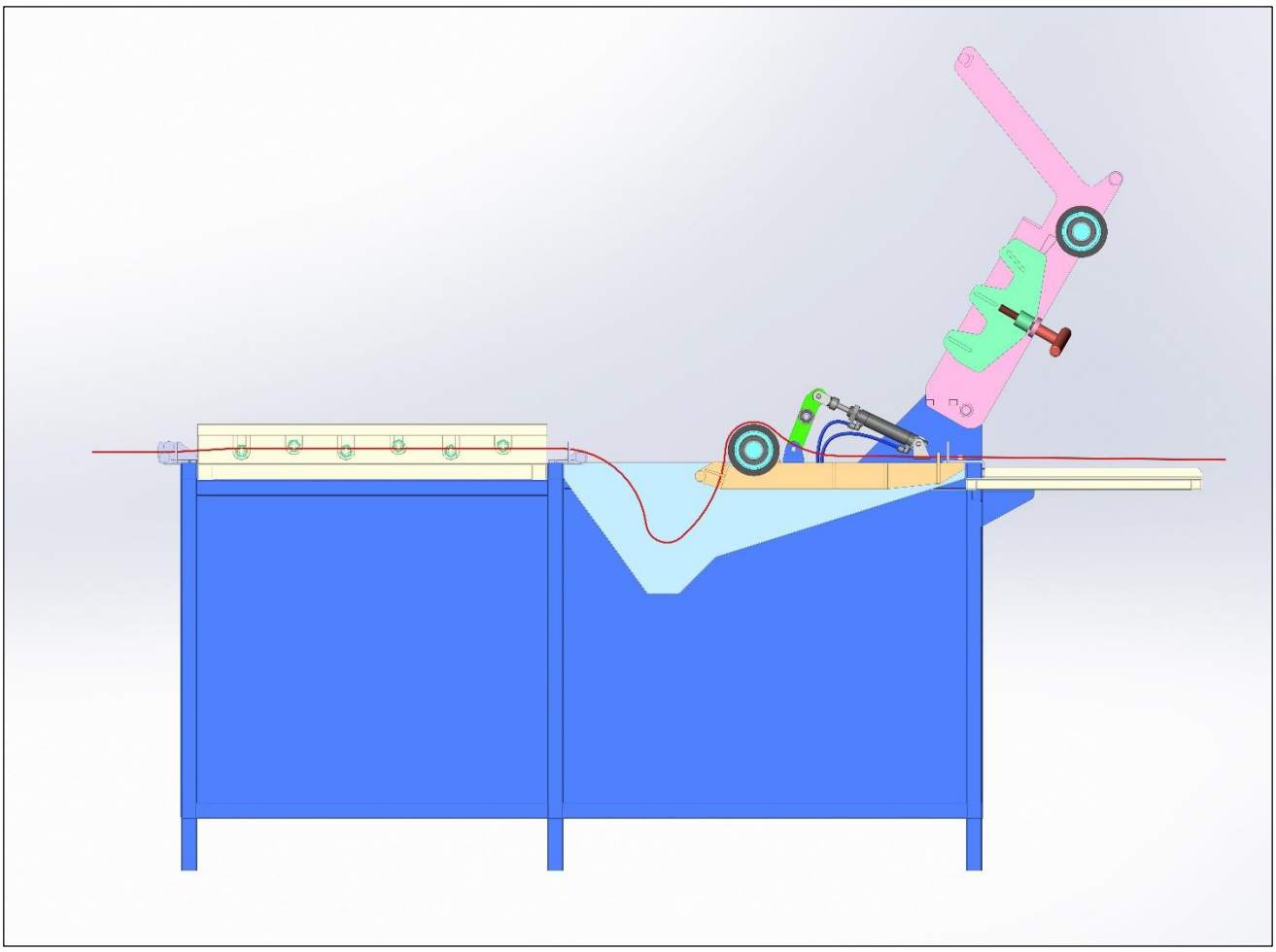


Fig. 28 Laying roving yarns in an impregnating bath.

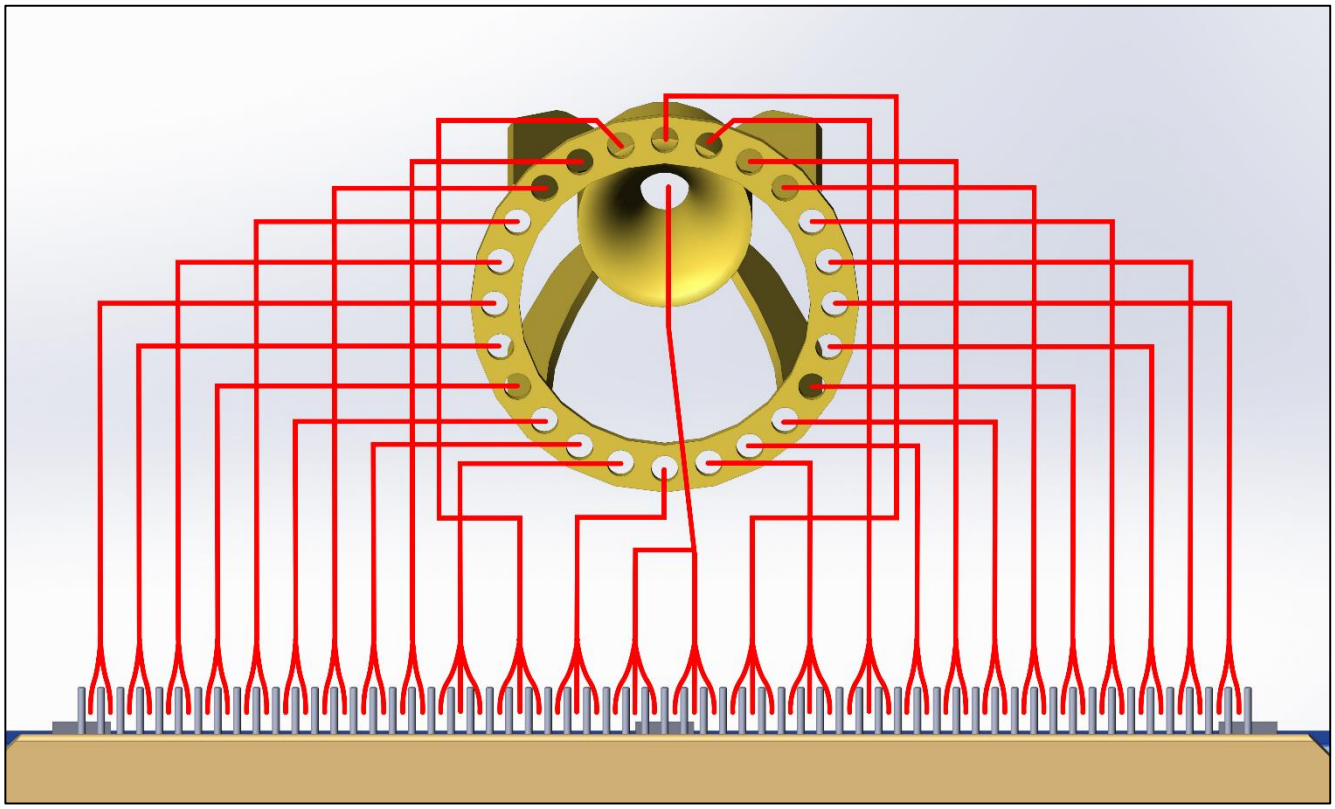


Fig. 29 Threading roving yarn through a receiving ring of a forming unit

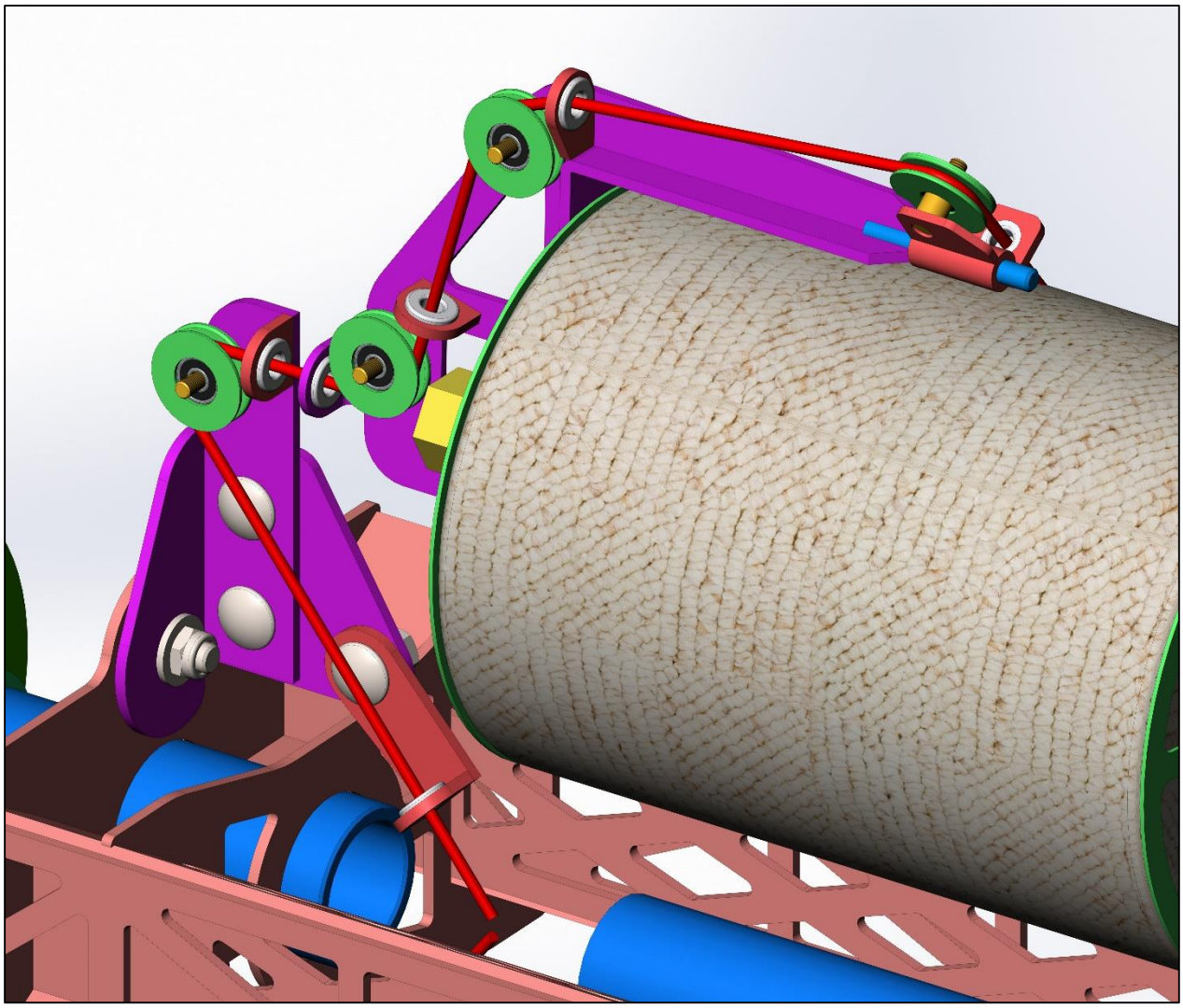


Fig. 30 Threading a winding yarn

4.Installing and Adjusting

4.1. Premises Requirements

An area for the line LiteCem Arm should be prepared on the basis of dimensions given in the Table 2, quantity of lines, and a required width of aisles corresponding to fire safety requirements.
The line should be installed on a solid base, which allows a rigid fixation of equipment. Maximum elevation difference of the base is ± 15 mm. When aligning all units has been finished, the line is fixed to the floor.
Exhaust hoods of a mechanical ventilation must be installed above polymerization chambers at the minimum height that will be sufficient for a convenient opening of upper sections of chambers. (Ventilation elements are not included to the scope of supply).

4.2. Installing and Connecting up

A control console (Fig. 15, p. 19) is installed at 1,5–2 m from a forming unit. When installing additional 2-5 lines, the position of control console can be changed.
A staff involved in installing and connecting up mains electricity should have a relevant permit.

4.3. Network RS-485

Observe the following rules when connecting up a signal network RS-485.

- Use a signal cable having minimum two twisted pairs (a special cable RS-485, UTP cat 5). One pair (PLC port) is used for temperature controllers and an impulse counter; second pair (DOWNLOAD port) is used for frequency controllers.
- T-shape taps are not allowed; all units should be connected up in one line. An operator touchscreen can be set in any segment of network.
- Ends of each twisted pair should have a respective device (i.e. shouldn’t hang down) and a termination resistor (120 Ohm). OVEN FCV1 frequency controllers have a built-in resistor, which is connected with a switch.
- Recommended maximum length of a network RS-485 is 1200 meters.

5.Safety Precautions

5.1. General Requirements

Employees are allowed to operate the line only after acquainting with the service manual.
The line must be disconnected before carrying out a cleaning, and preventive maintenance and repair works.
The line LiteCem Arm must be operated according to safety regulations for using epoxy resins, fire and electrical safety, general requirements for operating pneumatic devices, and general requirements for cargo handling operations.

- Only employees over 18 years old are allowed to operate the line. Before operating the line, workers have to study the service manual, the installation design and operating principles; have to complete a training program on safety and electrical safety. The staff has also to have a work permit to operate this equipment.
- Electrical equipment is allowed to be connected to the mains only after a full completion of assembling and installing works.
- When equipment is in operation, an area of working mechanisms must be free of foreign objects.
- A cleaning of equipment, preventive maintenance and repair works have to be carried out when the line is disconnected.

Operating the line, observe general electrical safety regulations for working with equipment of voltage up to 1000 V.
A production area must be equipped with a mechanical ventilation (is not included to the scope of supply).
An operational staff involved in fulfilling works as per the manual must thoroughly observe safety requirements.
The owner holds responsibility for ensuring safety precautions.

STRICTLY FORBIDDEN!

- Carry out the maintenance, repair works, inspect tension of belts and chains when electrical equipment is powered;
- Start or carry on operating the line when a fault of any unit or a power supply system has been detected;

- Operate the line without rubber gloves;
- Work at the production site without wearing protective clothing and respirators.
- Leave a hinged lid (4) of a forming unit open when the line is turned on. Open the lid when a mechanism is active;
- Allow foreign objects to get into a screw feeder (9) of a sand hopper. It's forbidden to clean it when powered;
- Leave upper sections (1) of polymerization chambers open when the line is active;
- Leave the line powered after finishing the operation and during long pauses in work;
- Presence of unauthorized people or any animals when the line operates.
- Delegate control of the line to unauthorized people.

- **ATTENTION**!

Electrical equipment must be well earthed.

All rotary parts of mechanisms and heating elements of the active line must be enclosed.

A work area shouldn't be cluttered. Lighting must be provided in the evening time, according to the standards EN 12464-1:2016.

Electrical equipment, starters and earth wires must be in a good state. When operating electrical equipment, follow regulatory documents: EN 60204-1:2006/AC:2010; EN 61000-6-2:2005/AC:2005; EN 61000-6-4:2007/A1:2011; EN ISO 13857:2008

Before carrying out repair works and maintenance, disconnect equipment from the power supply and put up a restrictive sign on a starter.

The restrictive sign is not allowed to be removed and equipment is not allowed to be turned on until a work supervisor gives a permission.

5.2. Description of Safety Signs

Electric shock hazard

Caution. Noxious and allergic (irritating) substances

Caution. Cutting shafts

Caution. Automatic start of equipment

Caution. Hot surface

Caution. Risk of crushing hands

Caution. Pinch point hazard

Warning. Dangerous (miscellaneous dangers)

Wear protective gloves

Respirators must be worn

6.Maintenance

ATTENTION! Disconnect the line for manufacturing fiber reinforced polymer rebars from the power supply before starting inspection or maintenance procedures.

To keep the line in a proper operation condition, rigidly observe and fulfill all instructions and requirements of the service manual.

Maintenance (M) is a key and essential preventive measure to provide reliable work of equipment between scheduled repairs and to reduce a total amount of repair works. Maintenance includes a supervision over equipment operation, equipment care, keeping equipment in an operation condition, carrying out scheduled technical inspections, technical adjustments, flushing, cleaning, blowing, and etc.

Maintenance represents a set of measures intended to provide a trouble-free running of the line and an increase of service life under operating conditions.

Maintenance of the line is carried out by a service staff or, in certain cases, by qualified specialists.

Maintenance is carried out during a work break, non-work days and shifts. A short stop of equipment (disconnecting networks) is allowed as per local instructions. A time for downtime to carry out scheduled (planned) maintenance is specially allotted.

There is scheduled and unscheduled maintenance. Unscheduled maintenance consists of a supervision over equipment operation, operational maintenance, keeping equipment in an operation condition, including:

observing operational conditions and equipment work schedule according to the manufacturer’s instruction;

loading equipment according to data stipulated in the Datasheet; transshipping equipment is forbidden, except cases stipulated in the service manual;

strict observance of working regimes established under the given conditions;

keeping the required cooling regime of heat-affected equipment parts and units;

monthly lubrication, external cleaning of equipment and premises;

strict observance of a stopping procedure of production units specified in the manufacturer’s manual;

immediate stop of equipment in case of malfunctions causing a fault of equipment; taking measures to remedy such faults;

detecting a level of wear of units and parts, which are easily accessible to inspect, and carrying out timely replace;

inspecting a heating of contacting and rubbing surfaces, inspecting a condition of lubricating and cooling systems; purging and draining pipelines and special devices;

inspecting a condition of earth wires (earthing), a heat insulation, an anticorrosive protection, and a condition of enclosing devices, etc.;

inspecting for absence of liquid and gas leakages.

All malfunctions of equipment detected during unscheduled maintenance must be noted in a repair log by an operational staff and fixed by the operational and maintenance staff in the shortest time.
Scheduled maintenance consists of diagnosing equipment, adjusting mechanisms, cleaning, lubricating, purging, refilling or replacing insulation materials and lubrication oils, detecting operational defects and safety violation, specifying compositions and a scope of work that should be fulfilled during the next overhaul or routine repair.

ATTENTION!
Failing to observe maintenance instructions may cause a fault of equipment and void the warranty

6.1. General Maintenance Procedures

Scope of work:

- An exterior inspection to detect defects of the line condition and work in general;
- Inspection of correctness of switching over and executing commands coming out from a control console;
- Inspecting a condition of a guide clamping frame of a pulling unit;
- Inspecting a condition of linear slideways and bearings of a carriage of a cutoff unit;
- Inspecting and tightening fixing parts;
- Inspecting and tightening fixing elements of rotary parts;
- Inspecting an emergency limit switch of a cutoff unit for the correct operation;
- Inspecting protective shields, casings and lids;
- Inspecting equipment units for absence of vibration;
- Inspecting an equipment noise level;

- Inspecting heating of units' bearings;
- Inspecting a clamp safety of a FRP rod;
- Inspecting lubrication elements and pneumatic systems (absence of leaking lubricants, leakproof of pneumatic systems, existence of condensate, oil level of sizing (lubricant)).

Additional works:

- Opening lids of rotary assemblies of a forming units to inspect and check a condition of mechanisms;
- Checking smooth running of drives and gear reducers;
- Diagnosing worn-out parts that should to be replaced during the closest routine (overhaul) repair;
- Replacing worn-out parts that won't withstand the operation till the next inspection or planned repair;
- Cleaning, repairing, or replacing belts, chains, straps;
- Flushing rubbing surfaces, which are not protected against dust;
- Adjusting equipment and handing it over to a master.

6.2. Maintenance of Impregnating Bath

- Inspect fasteners tightening torque of power contacts of thermoelectric heaters. Carry out minimum once every 4 months;
- Inspect fasteners of power supply contacts of a control panel applied for a yarns heater (dryer). Inspection is carried out minimum once every 4 months;

ATTENTION! Inspecting power contacts of thermoelectric heaters and equipment of a yarns heater control panel must be carried out only when equipment is fully disconnected.

- Check an operation of temperature controllers and thermocouples (inspection of temperature controllers and thermocouples feedback when measuring temperature of a working area). Checking is carried out before each start of the installation;
- Inspect a pneumatic drives system for working pressure and leakproof. Inspecting is carried out before each start of the installation and, on a periodic basis, during the operation;

- Check whether squeegee rollers contact evenly. Inspecting is carried out before each start of the installation;

- Inspect wear of squeegee rollers bearings. Inspection is carried out at least once every week;
- Clean all elements of the unit to remove residues of a polymer binder and a fiberglass roving. Cleaning is carried out minimum three times a week and every time when the unit is stopped for a routine (overhaul) repair or for any other reasons requiring a downtime for over 40 minutes.

ATTENTION! When using cleaning solvents for components of the impregnating bath, observe safety requirements when working with special liquids (NPAOP 35.3-7.04-87) and safety requirements when working with epoxy resins (NPAOP 24.1-1.02-81).

6.3. Maintenance of Forming Unit

ATTENTION! Before starting maintenance works, wait until a winding mechanism completely stops. Equipment must be disconnected from the power supply.

- Visual inspection and cleaning of the forming unit elements (yarn guide eyelets, rollers, spinnerets, and other elements contacting with a basic and a winding roving) from residues of a polymer binder and a fiberglass roving. Inspecting is carried out when required, but not less than once per working shift;
- Inspecting all rotary elements of winding and twisting mechanisms for backlashes (minimum once a week);
- Lubricating support bearing assemblies (without demounting by means of tool) is fulfilled through a grease fitting. It's carried out minimum once a week;
- Inspecting a tension of belts, drive chains;
- Inspecting a condition of drive belts for cracks, segregations, elongation (minimum once a month);
- Inspecting a chain drive of rotational axes of a twisting mechanism for elongation and lubrication;

- Lubricating chains is carried out not less than once a week. Before lubricating, clean dirt and residues of an old lubricant from chains. It's recommended to use a benzine BR-1 'Galosha' for cleaning and a gear oil for lubricating;
- Visual inspection of an operation of motor cooling fans must be carried out after each start of the installation and periodically during the operation;
- Inspect fasteners of motors power supply contacts;
- Diagnosing support rotary assemblies of a forming unit base.

ATTENTION! Diagnosing malfunctions of support assemblies must be agreed with the manufacturer. In case of detecting a fault, an assembly is replaced.

- Inspect yarn guide eyelets, yarn guide rings and a receiving yarn ring for wear or damages (surface wear, chips, cracks). Inspecting must be carried out before each start of the installation.

6.4. Maintenance of Polymerization Chamber

- Clean carbon deposits and residuals caused with a polymerization process off sections of a polymerization chamber. Cleaning is carried out if the need arises, but not less than once every two working shifts;
- Visual inspection of fasteners tightening torque of power contacts of thermoelectric heaters. Contacts must be inspected before each start of the installation. Tightening is carried out not less than once every three weeks.

ATTENTION! Inspecting fasteners tightening torque of thermoelectric heater power contacts of polymerization chamber sections must be carried out only when equipment is fully disconnected.

- Check a pneumatic drives system for working pressure and leakproof.

6.5. Maintenance of Cooling bath

- Cleaning fine glass particles off a basic bath-reservoir and an upper bath groove. Change water in the reservoir. It's carried out when needed, but not less than once a week;
- Blowing out the whole circulation system and purging hoses. To carry out visual inspection of an impeller, disassemble partially a circulator pump (once every two months, if the first clause is fulfilled);
- Replacing polyurethane glands. They are replaced when worn out.

6.6. Maintenance of Pulling Unit

- Visual inspection of a conveyor belt working surface (polyurethane tracks) must be constantly carried out during the operation. Keep the tracks surface from fouling or any other lubricants (greases). An excess amount of water shouldn't enter an engagement surface between tracks and a FRP rod;
- Lubricating vertical guideways and driver and driven sprockets rolling assemblies. Lubricating is carried out through grease fittings installed directly on bearings assemblies. Carry out lubrication once every 1-2 months;
- After lubricating all assemblies, wipe off lubricant surpluses by using a dry duster (cleaning cloth) to prevent sticking dust and fiberglass to sliding and rotating elements of the unit.

ATTENTION! Wiping off lubricant surplus must be carried out when the line is fully disconnected.

- Visual inspection of an operation of motor cooling fans must be carried out after each start of the installation and periodically during the operation;
- Inspect a pneumatic drives system of a clamping frame for a leakproof. It's carried out once a month.

6.7. Maintenance of Cutoff Unit

- Daily visual inspection of all rotary parts of a cutoff unit, cleansing, blowing out, inspecting a drive belt for nicks and cracks;
- Check tightening of a driven pulley and a retaining nut of a cutoff wheel before each start of the line;
- Inspecting a cutoff wheel condition and level of wear;
- Before each start, check all actuators of lowering and cutoff mechanisms;
- Keep precision longitudinal guide shafts of the cutoff unit clean. If required, carry out lubricating (only after cleansing). Use a small amount of lubricant for greasing;
- Lubricating support bearings of a spindle shaft of the cutoff mechanism is carried out through a grease fittings installed on a shaft body (one-two times a month).

6.8. Maintenance of Binder Preparing Station

- Periodic control of a water level in a water jacket. If required, change water;
- Water must be drained if the station is not used in cold months and stored in unheated premises, and has no anti-freezing agents;
- Visual inspection of locking quality of ball valves. If there is a leakage of ball valves, replace them immediately.

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Remedy Faults

Table. 3 Possible malfuntions of the line

Malfunction	Remedy Faults
Breakage of a yarn in an impregnating bath	Stop the line; Pull through and tie a yarn up; Start the line.
Breakage of a winding yarn in a forming unit	Stop the line; Tie a winding yarn up to a basic rod; Start the line.
A FRP rod bumps into a cut-off mechanism	The line stops AUTOMATICALLY; Feed a rod to a cutoff mechanism; Start the line.
Breakage of a counterweight wire rope of a cutoff unit	Stop the line; Replace a wire rope; Start the line.
A cutoff mechanism jams, deformation of a cutoff wheel	Stop the line; Replace a cutoff wheel; Start the line.

8.Appendix

8.1. Electric Circuit Diagram

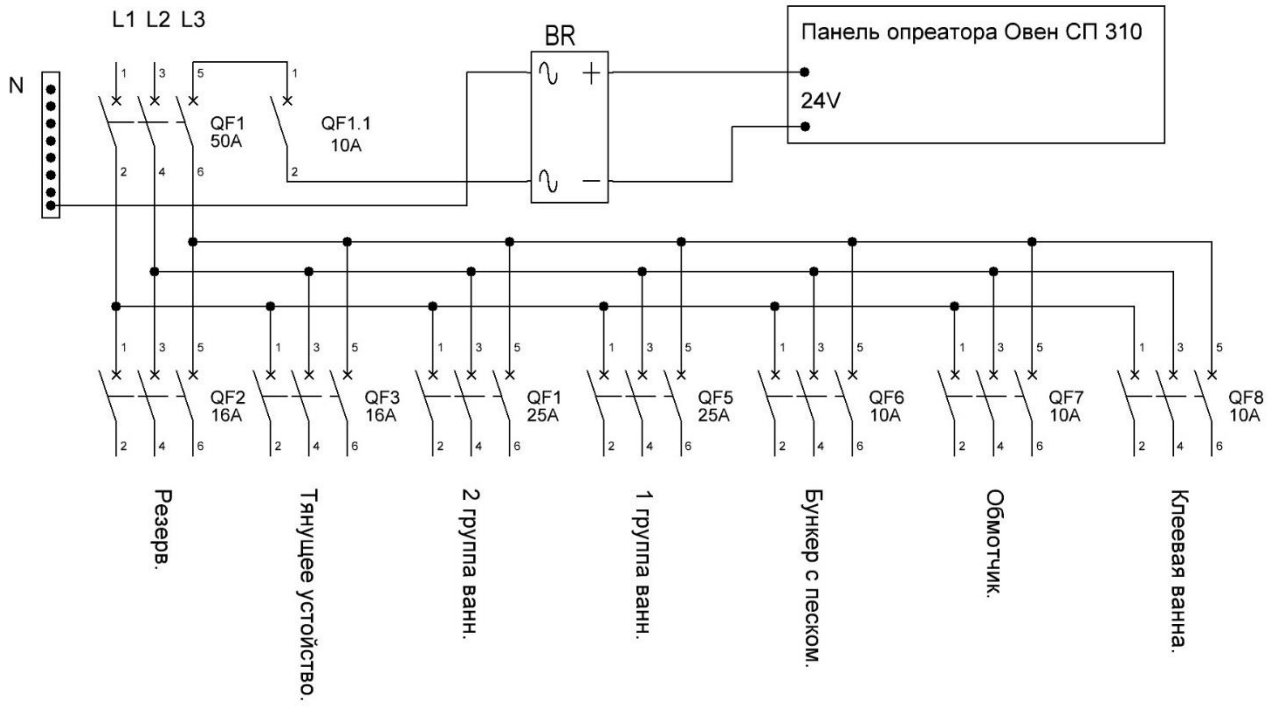

Fig. 31 Electric diagram of control console

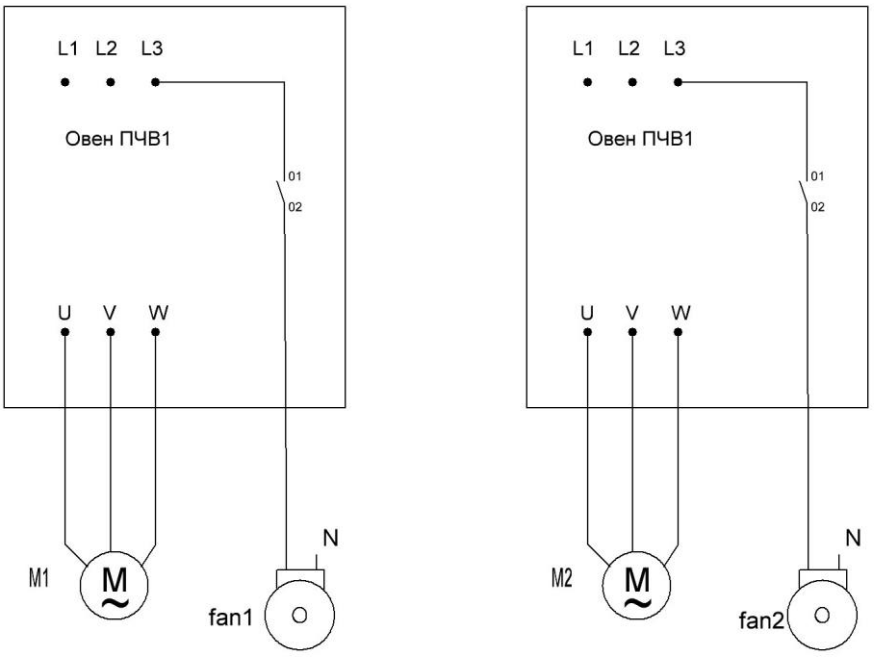

Fig. 32 Electric circuit of forming unit

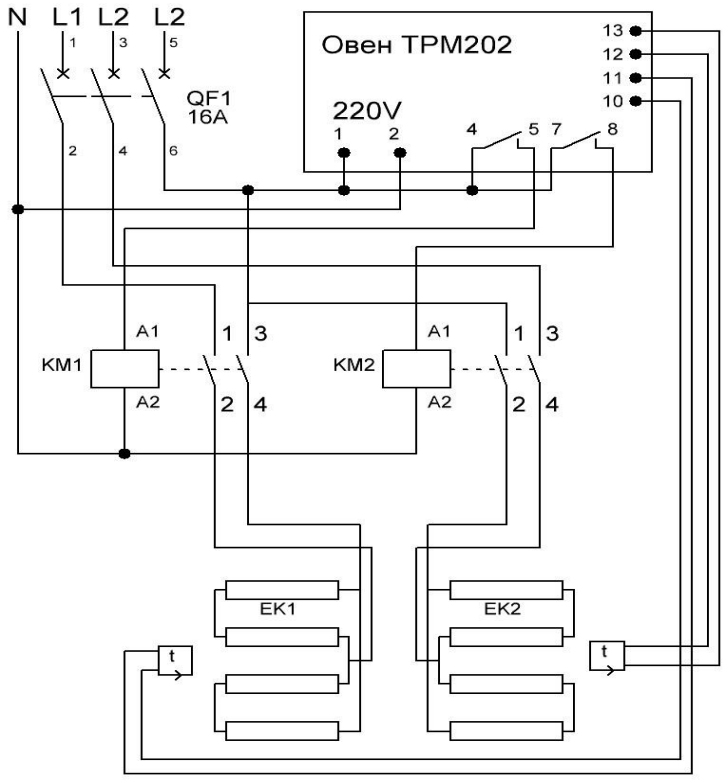

Fig. 33 Electric circuit of chamber

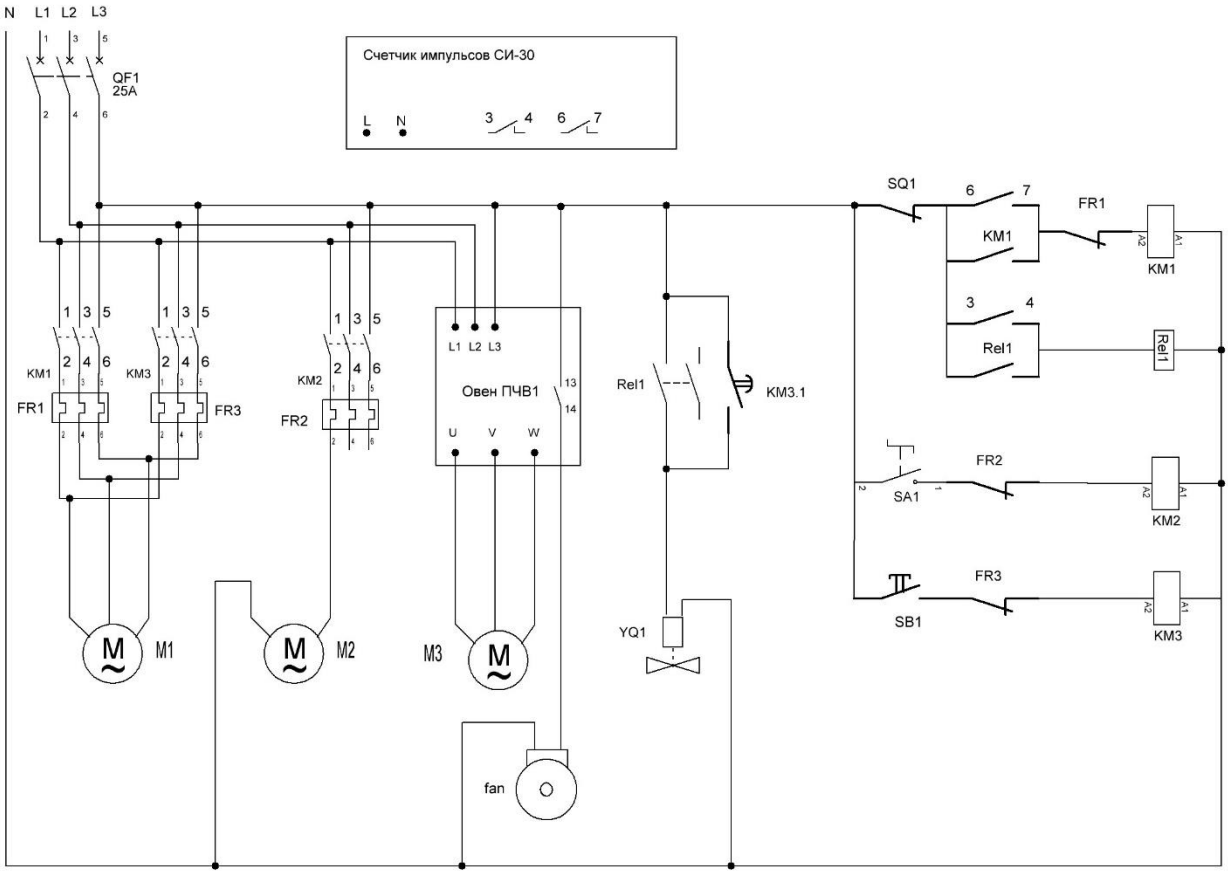

Fig. 34 Electric circuit of pulling unit