Machine for winding a rib onto glass fiber rod

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Abstract. The article presents a new machine for winding a rib onto glass fiber rod. The machine allows increasing the productivity of the production line, decreasing the amount of waste from production and decreasing the noise and vibration. Article shows key parameters of the machine. A patent protects the machine.

1. Introduction

Production line for glass fiber rod is made out of several blocks that are presented below.

![Diagram of Glass Fiber Rod Production Line](image)

**Figure 1.** Glass fiber rod production line.

1 - Creel, 2 - Unit for applying the epoxy glue, 3 - Rib winder, 4 - Polymerization chamber, 5 - Cooling chamber, 6 - Pulling mechanism, 7 - Saw, 8 - Packaging system

From a several packages from the creel 1 glass fiber roving (GFR) proceeds to the unit for epoxy glue application 2. After that epoxy surplus is removed and GFR proceeds to the next unit. Unit 3 collects all the GFR into a single beam and after that the beam gets winded by a separate GFR that forms the rib of the rod. Then the rod gets into the polymerization camera 6. Saw 7 cuts the necessary length. The packaging system winds the produced glass fiber rod into bays for compact storage and transportation.
In glass fiber rod production the unit for winding the rib directly affects the productivity, safety and quality of the production. The length of the GFR in the package on the creel is six times longer than the packages that are used for the rib winding.

Also due to spiral winding the GFR used even faster. When the package on the winding unit is changed, the line has to stop, the package changed and the GFR threaded through the winder, and started again. While the package is changed, the rod is overheated inside the polymerization chamber, which then needs to be pulled out and utilized. Because the machine is often stopped more time is needed for the operator to change the package, the polymerization chamber is working to ruin the rod (electricity costs), which then is thrower away. The volume of the package for the rib winding also defines the maximum length of the finished rod.

Package which is installed parallel to the rod and at a certain distance from there it leads to the problem of imbalance which is changing while the volume of the package is changing. Imbalance leads to noise, vibration and deterioration of parts. To eliminate these problems a new design of the unit is presented below.

2. Concept

![Kinematic scheme](image1)

**Figure 2.** Kinematic scheme.

![Prototype of the winding unit](image2)

**Figure 3.** Prototype of the winding unit (b) with coaxially Installed package and winder.

1 -Glass fiber rod, 2 - Glass fiber roving, 3 - Package, 4 - Winder, 5 - Chain drive, 6 - Motor, 7 - Guide.

Motor 6 transmits rotational movement using the chain drive 5 on to winder 4 which while turning pulls on to the glass fiber roving 2 with a guide 7 and applies it on to the glass fiber rod 1 at the same time turning the package 3 as much as needed.

To assess if this option works, a prototype was made, which is shown in Figure 3. Studies conducted using the prototype in Figure 3 showed that the device lays out the thread, consuming it from the package exactly as much as necessary. The big advantage of this option is the ease of adjusting the spacing of the rib in a wide range. Figure 4 shows a 3D model of the selected option with a coaxially mounted winder and package.
Figure 4. 3D scheme of a unit for glass fiber rib winding.

$V_1$ - Velocity of the rod movement, $V_2$ - Velocity of the GFR movement from the package, $\omega_r$ - Angular velocity of the winder, $\omega_p$ - Angular velocity of the package.

The device shown in Figure 4 has the following positive properties: production costs were reduced due to the fact that the entire length of the standard package thread was rewound to the working package, which significantly reduced the number of stops. The number of burnt rods in the polymerization chamber decreased. The amount of electricity costs on unproductive heating of the polymerization chamber decreased. Since the time of non-stop operation of the machine has become much longer, the labor costs of personnel have decreased, which reduces the number of workers. Due to the reduction of equipment stops and downtime, the productivity of the entire machine has significantly increased, which has allowed to produce more glass fiber rods.

Another positive result is a significant increase in the maximum length of the finished product. Using the entire length of the standard package, it was possible to achieve the length of the finished product up to two thousand meters. This in turn has led to a significant increase in the number of customers and the expansion of the market.

Another positive quality of the installation is the reduction of its noise and vibration. Due to the fact that all the elements that are present in the installation are located coaxially relative to each other, the unit is perfectly balanced. Even the changing weight of the GFR changes evenly, and its center of gravity is as close as possible to the axis of rotation during production. Due to the fact that the imbalance of the system is minimal, this significantly reduces noise and vibration.

The spiral winding device of the production line for the production of glass fiber rods consists of two identical spiral winding units as shown in Figure 5.

Figure 5 shows a schematic solution of a spiral winding device for a production line for the production of composite reinforcement.
Figure 5. Scheme of a winding unit.

1.17 - Main pipe, 2 – Glass fiber rod, (3,4,18,19) - Ball bearings for the main pipe, (5,20) - Mechanical transmission, (6,21) - Motors, (7, 22) - Coils, (8,9,23,24) – Ball bearings between coil and winder, (10, 25) - Guides with a peephole, (11, 29) - Package, 12 - GFR, (13,26) – Holes for the connector, (14,27) Connector (1,17) keyed with the possibility of axial movement along the axis of the main pipe (1,17), (15,28) - Switches, 16 – Turned GFR supply from a standard package.

The work of each of the two units of the glass fiber rib winder in the technological line for the production of the glass fiber rods includes 3 modes, and the device operates in 4 stages. The composition and operation of the device are described in detail in [1].

In the process of operation of the unit, the glass fiber rod 2 moves inside the main pipe 1 (17) with a constant speed \( V \), and the main pipe 1 (17) rotates together with a thread guide attached to it with a peephole 10 (25) at an angular speed \( \omega \).

A winding GFR 12 is wrapped around a moving glass fiber rod 2, forming a spiral on its surface, which is characterized by the diameter of the spiral \( d \), the pitch of the turns of the spiral \( h \) and the angle of elevation of the turns of the spiral \( \alpha \). The diameter of the spiral is equal to the diameter of the glass fiber rod 2. The pitch of the turns \( h \) is obtained from the ratio

\[
h = V \frac{2\pi}{\omega} \quad (1)
\]

\( \omega \) - is the angular velocity of rotation of the main pipe 1 (17), rads\(^{-1}\).

The angle of elevation of the turns of the spiral \( \alpha \) is determined from the expression

\[
\alpha = \arctg \left( \frac{h}{\pi d} \right) \quad (2)
\]
Thus, by changing the relationship between $V$ and $\omega$, it is possible to obtain the values of the pitch of the turns of the spiral $h$ or for given value $V$ (from technological requirements) and $h$ (based on the requirements for glass fiber rod production) to obtain the necessary angular velocity of rotation of the main pipe 1 (17):

$$\omega = V \frac{2\pi}{h}$$

The winding of GFR 12, wrapping around the glass fiber rod 2, moves through the peephole of the guide 10 (25) at a speed $V_\infty$ that is determined by the addition of the longitudinal speed and the peripheral speed of the winding GFR

$$V_\infty = \sqrt{V^2 + \left(\frac{\omega d}{2}\right)^2}$$

$V_\infty$ - Consumption rate of the winding GFR, mms$^{-1}$.

The winding GFR 12 passing through the peephole winder 10 (25) with speed $V_\infty$ carrying with it the package 11 (29) with the coil 7 (22) and gives it an additional angular velocity relative to the main pipe 1 (17):

$$\omega_{don} = \frac{V_\infty}{R}$$

$\omega_{don}$ - the angular velocity of the coil 7 (22) with the package 11 (29) relative to the main pipe 1 (17), rads$^{-1}$, $V_\infty$ - the speed of consumption of the GFR, mms$^{-1}$, $R$ - is the radius of the package 11 (29), mm

Thus, the total angular velocity of the coil 7 (22) with the package 11 (29) will be:

$$\omega_{max} = \omega + \omega_{don}$$

$\omega_{max}$ - The angular velocity of the coil 7 (22) with the package 11 (29), rads$^{-1}$

In the production line in the manufacture of glass fiber rod after the passage of the GFR rod through the molding unit, the rod enters the winding unit at a constant speed.

As a result of the work, an application was prepared and a patent of the Russian Federation for an invention was obtained [1].

3. Conclusion

Based on the literature and patent review, it was found that the existing design has a number of negative factors. For their prevention technical solutions were developed, produced experimental evaluation using prototypes of the mechanisms. The main dependencies for describing the rib formation were obtained. Based on the decision, a machine was developed for implementation in available production line with drawings for the manufacture of the prototype.
References

[1] Bekker M V, Rokotov N V, Temnikov O Yu and Getunov A N 2017 *Spiral winding device for a technological line for the production of glass fiber rod.* E 04 C5 2636061