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# DEVELOPMENT OF MECHATRONIC SYSTEM UNIT FOR SLIP INTERLAYER COILED ROLLS OF GLASS FIBER

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***Abstract*—** Showing the phased development of the device, on the output part of the line for winding "asuras" (MAT) (from cut glass fibers), is shown a way of realization the so-called "hard winding". In addition, the fine stacking is achieved by slippage of inner interlayers and fine regulation of clamping force is enabled by embedded microprocessor. The solution is derived from domestic components with significant technical improvements of the final product. Since it is the export product, the effects are even more significant.

The new version of ISO 9000 does not talk about the elements of the quality system but implies a change in ways of thinking, management and approach to the problem, which results in a more efficient operation with maximum fulfillment and satisfaction of customer requirements.

***Keywords*—** reengineering, phased development, friction transmission, electromechanical systems, mechatronic system

## I. Introduction

COMPETITION and customer requirements are forcing working organizations to changes that are aimed at achieving better economic effects. Some of the most frequently asked questions are: "What is re-engineering?". "What's the difference between re-engineering and development?". "Between the re-engineering and maintenance?" [1], [2].

There are many definitions of re-engineering. One definition, which is often cited as follows: "Re-engineering, also known as simultaneous renovation and repair, is to examine and change an existing system to its reorganization into a new form, as well as the subsequent implementation of a new form" [1]. The broad definition: "Reengineering is the systematic transformation of an existing system to the new forms in order to achieve improvement: the quality of the work, the capacity of the system functionality and sustainability of the implementation, at the lowest possible cost in the shortest possible time and with the least possible risk to the consumer" [1]. This definition emphasizes that the re-engineering focuses on improving the existing system with as high return on investment, than would be the case for investing in a brand new development. Only if re-engineering is not expensive, if it not is realized in a shorter period of time, unless it is less risky or if it does not offer better value to the consumer, only then should take into consideration new developments [1].

Improvements in the process of winding measure of cut glass fiber realized in glass fiber industry ETEX - Baljevac as the terms of reference, with the aim of increasing the effectiveness of the lines contained in the increased volume of utilization of the box, expressed through increased weight thereof. Due to the specific problem, the same is achieved in stages, taking into consideration the constant improvement of the quality wound rolls in the true sense of the word.

## II. Development phases

Because of the perceived problems and specificity of winding technical and technological improvements have been implemented in stages, namely in phases. Therefore, in this paper indicate all stages of the development and design of mechatronic systems under consideration. This system is an example of an engineering approach to the problem with significant effects.

### *A. Initial (derived) solution - I stage*

The technical solution of the designed device (Fig.1) consisted of aluminum tubes on which are pulled on cardboard tubes (intended) of the desired length, which is wrapped "MAT" to a certain diameter which is dependent on the given length and "quality" winding [2] – [7].

Rotary motion aluminum tubes (1) and cardboard tube (2) obtained from the drive drum (3). Their "adhesion" to the drive drum, transmission torque and winding by means of two pneumatic cylinders (4), [2]. By this solution is not achieved overturning, the same rotational speed of cardboard tubes (wolf) and the rotational speed aluminum tubes (VSC) or the same speeds (nuk = nsc), it came to differences in the speeds of the drive drum (3) and aluminum tube (1) with a card drawn down pipe (2). This difference arises because of differences in outer diameter aluminum tube ($D_{sc}$) and inner diameter cardboard tube ($D_{uk}$) (Fig. 2). This distinction was necessary for ease of putting on and taking off cardboard tube.

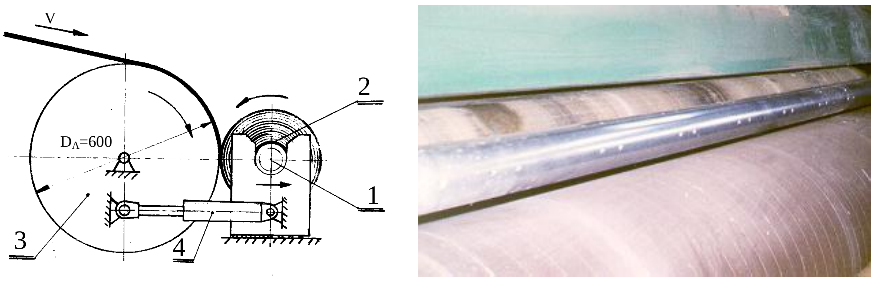
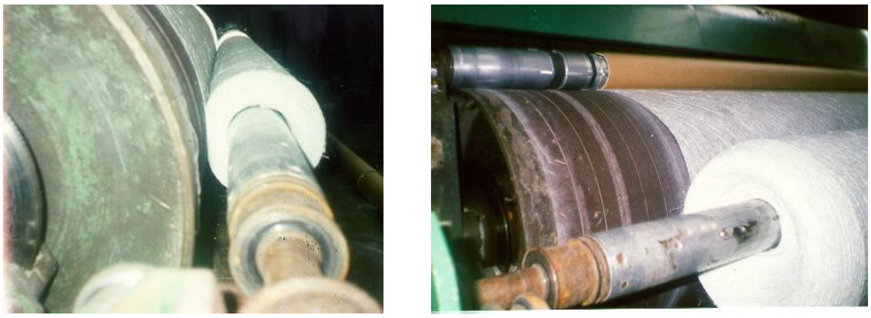



Fig. 1. Original design of the winder unit (embedded problem)



a) at the beginning of the winding b) at the end of the winding

Fig. 2. Preview of the winding process with the first embedded solution of winding of MAT

Due to the difference in diameters ($D_{uk}$> $D_{sc}$) and the frequency of rotation of the two tubes are rotated at different speeds, which leads to the appearance of "loose" winding and stretching (due to weight) of MAT-a cardboard tube, as seen in Fig. 2. This can be illustrated by (1):

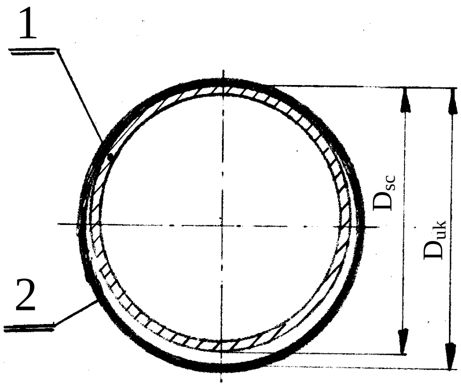



Fig. 3. Mutual ratio of Al pipes and tubes of cardboard

Fig. 4. The appearance of the first embedded tube (with and without the "gloved" cardboard tube)

$$\frac{n_{uk}}{n_{sc}} = \frac{D_{uk}}{D_{sc}} = \frac{D_{sc} + \Delta D}{D_{sc}} = 1 + \frac{\Delta D}{D_{sc}} \quad (1)$$

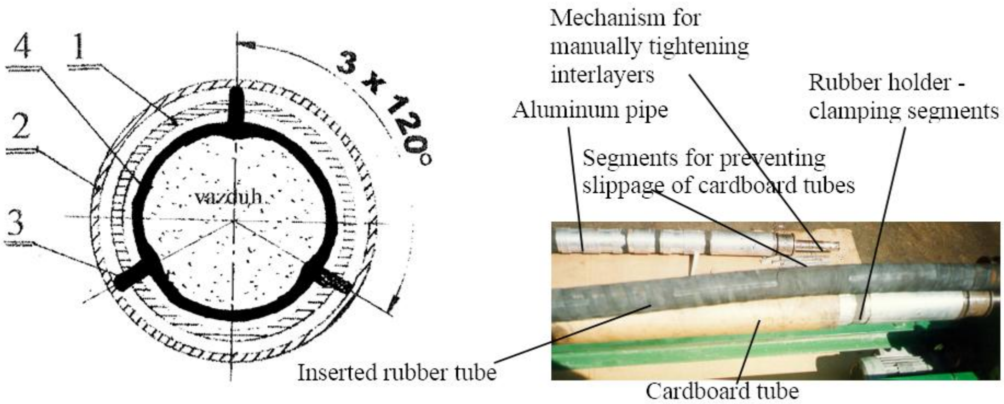
As the difference in diameters ranging (3 ÷ 5) mm It is used cardboard tube, whose outer diameter ($D_{uk}$) = 90 (mm), while the difference in their reversal, (2) with significant external effects of the system. That system is the right realized by stages:

$$\frac{n_{uk}}{n_{sc}} = 1{,}033 \div 1{,}055 \quad (2)$$

As we can see the difference in speeds is ranging in limits (3,3÷5,5)% and mass of winded 450 (gr/m$^2$) MAT width of winding 1250 (mm) ranged from (29÷33) (kg).

*B. Transnational Solution - Phase II*

At this stage, an attempt was made to find a solution that would eliminate the "built-in" problems and shortcomings. The solution consisted in the fact that are introduced indirect elements (presser) that prevent the occurrence of the relative rolling tube of cardboard in relation to the Al-tube (Fig. 5) [6], [7].




a) Pipe diameter with parts segments b) Disposition of tube with integrated traction control

Fig. 5. The new solution pipe for winding

In the interior of the alloy tube is inserted into the rubber tube (4) (airbag), which is under pressure from the air (0,5 ÷ 0,8) (bar) expands and provides indirect pressing element segments (on the tube there are 64 pieces), where they are pressed by pulling its surface the inner surface of the cardboard tube. During the trial work we have come to an optimal value of air pressure ~ 0,6 bar.

A higher value has led to permanent deformation of cartons, which made it difficult "stripping" the aluminum tubes, a smaller value is brought to re-slipping of interior surfaces of the cardboard tube in relation to the aluminum tube [6], [7].

With the new solution of aluminum tube for winding gave the correct weight to the effect of observed differences in diameter (I-phase), but remained a problem "loose" winding and stretching due to the weight (that's all the considerably greater with increasing winding diameter and increasing weights of MAT).

As interphase to derived solution has served the solution with manual clamping of interlayer slippage of already winded layers of MAT (Fig. 6). It was gained in the weight of the coiled material (3÷5)%. As it was difficult to regulate the clamping force we manually carried out test pilot plant with single-phase 300W motor with speed control with a rheostat.

*C. The new solution - III stage*

Based on this, it is necessary if it is to a greater amount of the coiled material and "proper" reeling, to establish additional tightening of internal wound layers of MAT. In other words, it is necessary to drive the electromechanical device (Fig. 8) announce the rotation frequency of aluminum pipe, and thus tubes of cardboard that is "slightly" higher than the frequency that each moment is realized the transfer of the friction drum 3 (Fig. 1) .

The system consists of three subsystems (Fig. 8) [2]-[8]: driving portion, working - the executive part of the command module.

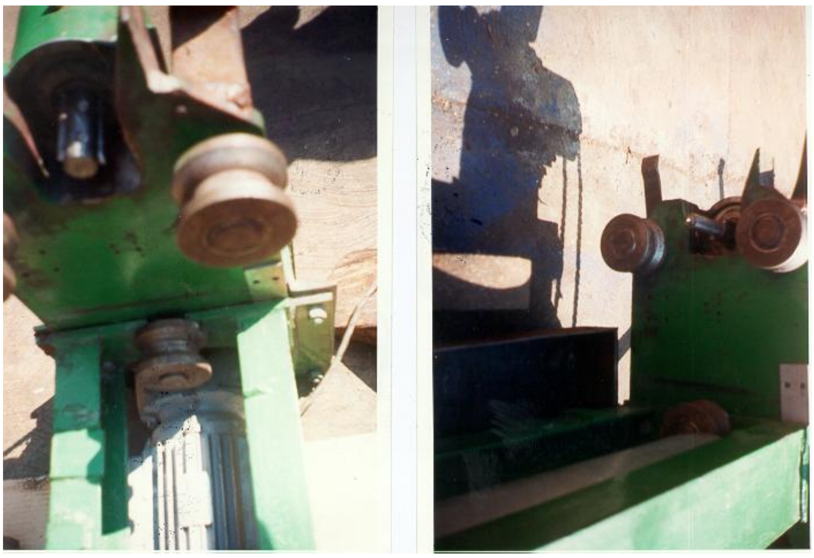


Fig. 6. Appearance of the mechanism with manual tightening – by slippage of interlayers

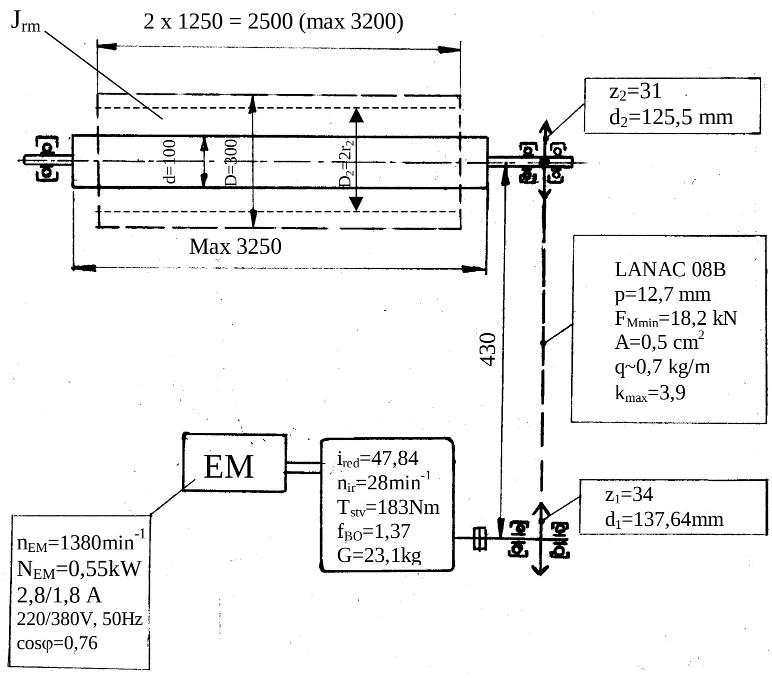



Fig. 7. Kinematic scheme of the mechanism to tighten the slippage of inner interlayers (hard reeling)

The drive part (Fig. 7 and 8) consists of a three-phase asynchronous motors 1ZKR80-A4 (1.1) of defined characteristics whose management conducted a digital speed regulator "UNIDRIVE" - SEVER Subotica [8]-[10]. The electric motor is directly attached to a reducer (1.2) (115S-3) on whose output shaft is mounted a one-way coupling (1.3) with chain (1.4).

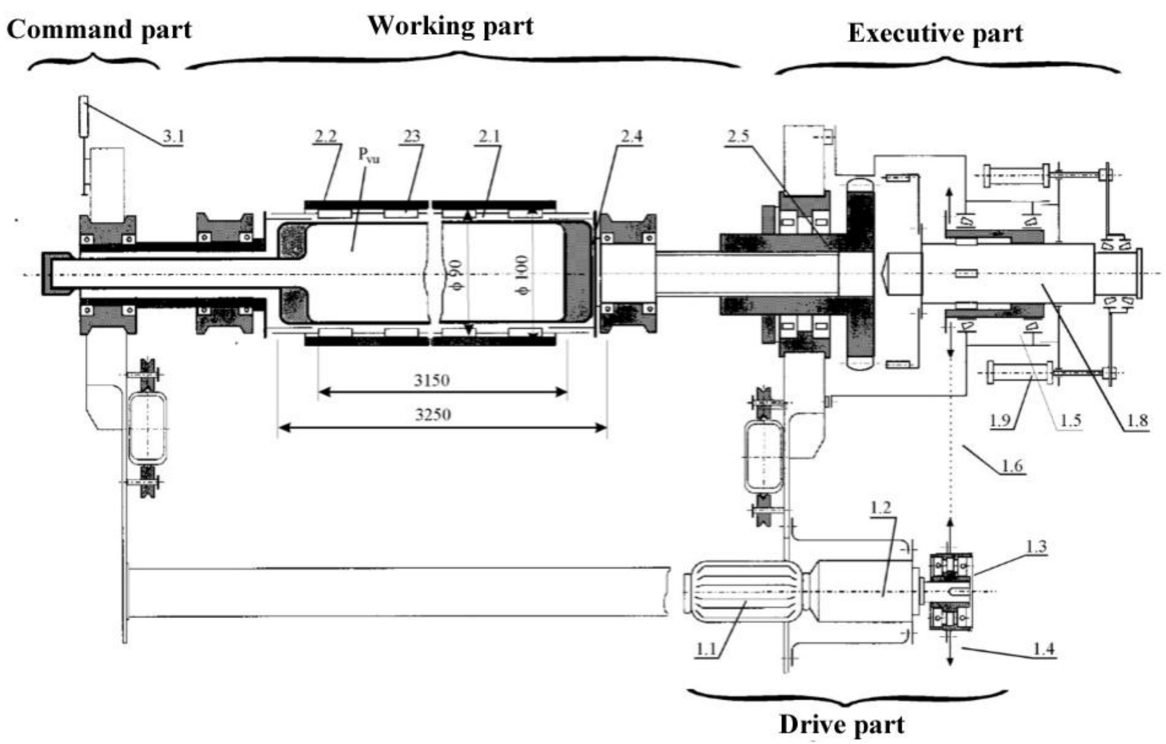



Fig. 8. Electromechanical system (device) for regulating the winding of MAT-a (functional diagram)

On-off switch coupling (1.5) is fixed to the workpiece carrier (2) and is driven by an electric motor (1.1) through the chain (1.6) and the second sprocket (1.7). Axial displacement of the hub (1.8), clip (1.5) on and off, is realized by pneumatic cylinders (1.9), [11], [12].

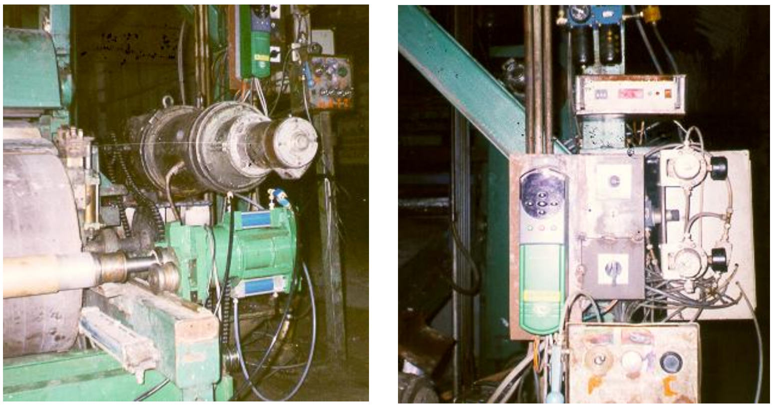


Fig. 9. Electromechanical system (device) for regulating winding of MAT

Control lever (3.1) has two positions: upper and lower (Fig. 10). When in the down position, then via a command valve (3.2) pneumatic cylinders (1.9) (Fig. 7), are drawn out so the working part of the device is idle (does not rotate), because the working tube "convex" (1.8 Hub from 2.5 connection). Also by a microswitch (3.3) is turned off the electric motor (1.1). Electric machines and attaching of the connectors is achieved by an energy-control scheme of the frequency converter AC motors.


Fig. 10. Working (upper) position control levers

When the control lever (3.1) is on the top - working position first is turned on gear coupling (2.5) and then the rotation of the tube (including electric motor)

Work principle: when the knife for cutting the default length of cut strip material, must be removed from the carrier already coiled tubes. During this time the material began to be wound onto the prepared tube (Fig. 11). Automatically by pneumatic cylinders (Fig. 11) and by the brake drum the same is guided to the working position. This operation takes (3÷5) revolutions. Joystick (3.1) are placed in the upper - working position in which, as we have seen, first involves coupling (2.5), which is reflected in the axial movement of the hub (1.8) with the teeth by means of pneumatic cylinders (1.9) (Fig. 7 and Fig. 8).

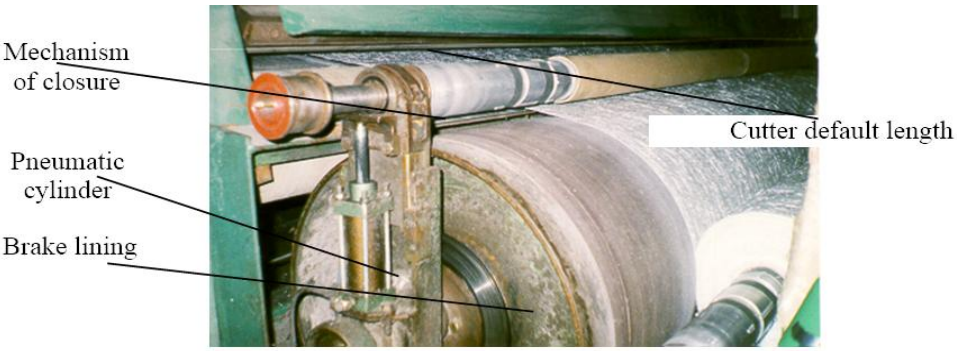



Fig. 11. The mechanism for fastening the prepared tubes for winding of MAT

This leads to the realization of connection joints - working part and via microswitch (3.3) (Fig. 10) the electric motor is turned on (1.1) (Fig. 7), which communicates via a gear and sprockets rotational movement of the workpiece (2) and starts achievement of the regulated winding process of MAT to the achievement of additional tightening of inner layers.

Fig. 12. The position of the prepared tubes for winding (upper position)

The process is the cyclic type, whose duration depends on the defined amount of longitudinal the coiled of MAT-a [13], [14]. With winding "of MAT" across the developed electromechanical system with the regulated winding (Fig. 7 and 8) was achieved the mass of finely coiled trumpets which for more than 50% of the brows of those achieved in solution phase with the same dimensions (diameter and width of the tube).

In Figure 13 is shown the situation - the moment when it was measured the length of the glass fibers (asura - MAT) mechanism excision cut off too - completed retractor and at the upper tubes began reeling of MAT. The upper tube remains in this position until the coiled tube is not disconnected from the drive mechanism. When the same disconnected automatically upper tube leading into its position (Fig. 11).

Fig. 13. The position of the new tubes for winding when it starts reeling in the upper tube

## III. CONCLUSION

The purpose of investing in the re-engineering of existing and the introduction of new technologies is because the meeting of the criteria of: functionality, cost-effectiveness, cost-effectiveness and compliance [3], [6]. As an addition, to the previous statements, etc. can be used Fig. 2 and Fig 12.

Project planning and re-engineering for: determination, describing, understanding, assessment or evaluation of technical (design and management) factors which characterize the implementation of re-engineering required new knowledge. Such projects are not implemented in the traditional manner, but must use new methods and procedures to improve work processes. Improvements in the form of "harder" winding and greater weight of coiled rolls statistics will be analyzed in the second part of the paper that will be exposed to the same meeting. Contemporary economic conditions are forcing companies to continuously improve production and customer satisfaction, Fig. 14.

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