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MODERNISATION OF THE TECHNOLOGICAL LINE FOR THE PRODUCTION OF MOISTURE RESISTANT CABLE LAMINATES

Key words

Moisture resistant cable laminate, super absorbent powders, powder spread, binding agent spraying.

Summary

The article presents the technology of the production of moisture resistant electrical and telecommunications cable laminates and the means of the modernisation of the technological line for their manufacture. Two innovative devices for the spread of superabsorbents and binding agents over the non-woven base developed and implemented within the framework of the modernisation. The technical solution applied in the devices enabled improvement in the quality of manufactured goods and improvement in the efficiency and profitability of the production process. The results of the verification tests of the developed devices are shown.

Introduction

Electrical and telecommunications cables are a crucial element of the contemporary economic infrastructure. The costs of the maintenance of this infrastructure depend, among others, on the operational time of the cables. One of the most important factors determining the durability of the cables placed directly in the ground or in the cable channel is the density of the external coating covering the wire system. The key element in improving the density of that coating that is used in present day cables are the moisture resistant non-woven coatings that protect the cable against the longitudinal water penetration.

They have the form of a tape in which the cable is wrapped, and the sealing factor is the superabsorbent present in the non-woven fabric. When the external insulation gets damaged, the superabsorbent plays the role of the dynamic protection against moisture spreading. As a result of its increased expansion under the water influence, the absorbent fills the gaps in the cable and does not allow the water to flow along it.

The cable shielding tapes usually have the form of a two- or three-layered composite. The structure of the two-layered tapes is as follows: the base non-woven fabric-superabsorbent. In the three-layered tapes the structure is the base non-woven fabric-superabsorbent-non-woven cover.

The coatings are produced in a technological line [1, 2] as shown in Fig. 1.

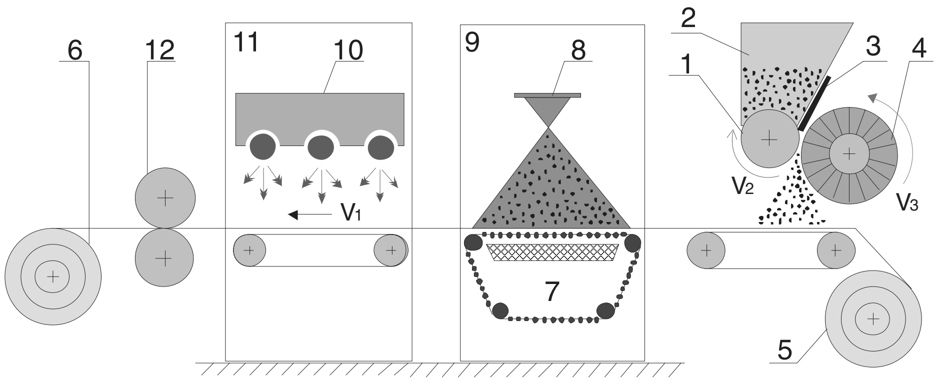

Fig. 1. Technological diagram of the line for the production of moisture resistant coatings: 1 – grooved roller, 2 – powder container, 3 - squeegee, 4 – scraping brush, 5 – roller with the material rolled on, 6 – roller onto which the final product is rolled onto, 7 – tub, 8 – spray gun, 9 – spray chamber, 10 – infrared radiator, 11 – drying chamber, 12 – calendar

The powder absorbent is applied onto the engineering carrying material that has the form of a non-woven fabric and is unwrapped from the roller (Fig. 4). The powder is accumulated in the container (2), from which, via the gap formed by the squeegee (3), it is first absorbed by the grooved roller (1) and then scraped from the roller by the brush (4). After that, the binding agent, with the use of the spray gun (8), is sprayed in the chamber (9) onto the non-woven fabric covered in the powder. The excess of the binding agent and the powder is gathered in the tub (7). The binding agent is then dried in the next chamber (11) with the use of the radiators (10). Once that procedure is finished, the entire composite is then pressed in the calendar (12). In the case of the three-layered tape, the non-woven cover is fed in the calendar. The final product is then rolled on the roller (6).

The moisture resistant cable covers need to meet the technical requirements of the recipients (Tab. 1).

Table 1. Technical parameters of the moisture resistant cable laminates

	Parameter		Unit	Requirements
1	Surface mass		g/m^2	100 -130
2	Thickness at the pressure of 0.5 kPa		mm	0.3 - 0.6
3	Resistance to stretching		N/10mm	>40
4	Elongation at the time of tear		%	>10
5	Expansion under the influence of water	minimum	mm	≥8
		average	mm	≥10

The basic functional parameter of the moisture resistant laminates is the level of the expansion the superabsorbent reaches within 10 min from the time of submersion in water [3, 4]. The expansion ability of a given powder depends on the mass of the powder in 1 m^2 of the product and the evenness of its spread. Another very important parameter is the resistance characteristic, such as endurance to delamination, which is influenced by the quality of the non-woven fabric and the proper application of the binding agent.

1. Device for the application of superabsorbent powders

The aim of the modernisation of the device for the application of powders was to improve both the evenness of the spread of the superabsorbent in the moisture resistant cable laminate, and the control over its work. The following assumptions for the construction of the device and its cooperation with the remaining components of the technological line have been taken into consideration [5]:

- The new device will be assembled in the unit with no significant alterations introduced;
- The different compounds of the unit are responsible for the transport of the non-woven fabric throughout the device (i.e. its pull or the speed of the shift);
- The amount of the powder applied will be automatically adjusted to the speed of the base flow; and,
- The supply and control systems of the device will be integrated with the control system of the unit.

A few innovative structural solutions have been used in the device, which allowed the even spread of the powder on the surface of the non-woven fabric. One of them is the superabsorbent powder container presented in Fig. 2. Inside the container (1) the oscillatory element (4) has been installed. The element is mounted on the shaft (6) and makes a move parallel to the longer edge of the container, which is caused by the drive (5) and the eccentric mechanism. The oscillatory element divides the container into the two areas:

– The upper area in which the accidentally distributed stock of the freshly spread powder is located (varied height of the batch); and,
– The bottom area in which the powder pouring through the cracks between the oscillatory element and the walls of the container is spread to the same height along the entire container.

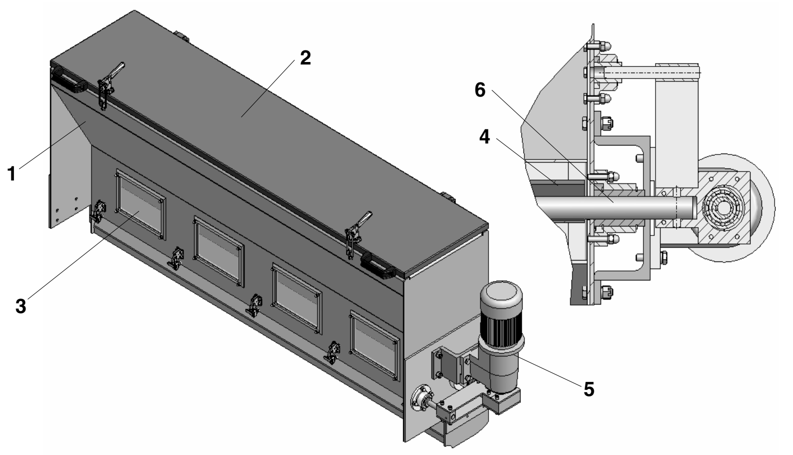

Fig. 2. Superabsorbent powder container: 1 – container, 2 – lid, 3 – control windows, 4 – oscillatory element, 5 – oscillatory element drive, 6 – oscillatory element shaft

The width of the gap and the amplitude and the frequency of the oscillatory movement have been selected in a way ensuring the even spread of the powder in the lower gap and constant in conditions of cooperation with the dosage shaft presented in Fig. 3.

The unit is composed of the shaft (1) mounted in the self-aligning ball bearing located in the frames (2), the squeegee (5), the clamping wedge (7), the squeegee, and bolts (6) for the adjustment of the position of the squeegee in relation to the shaft. On the external surface of the shaft, there are longitudinal notched grooves, whose purpose is to absorb the powder from the container. The powder is scraped from the grooves with the use of a brush and then poured onto the non-woven fabric. The squeegee stops the excess of the powder accumulated above the shaft, whereas the precisely adjusted gap between the squeegee and the shaft enables the even dosage of the powder. The efficiency of the dosage is regulated through the change of the rotation speed of the shaft and is correlated with the speed of the shift of the coated non-woven fabric.

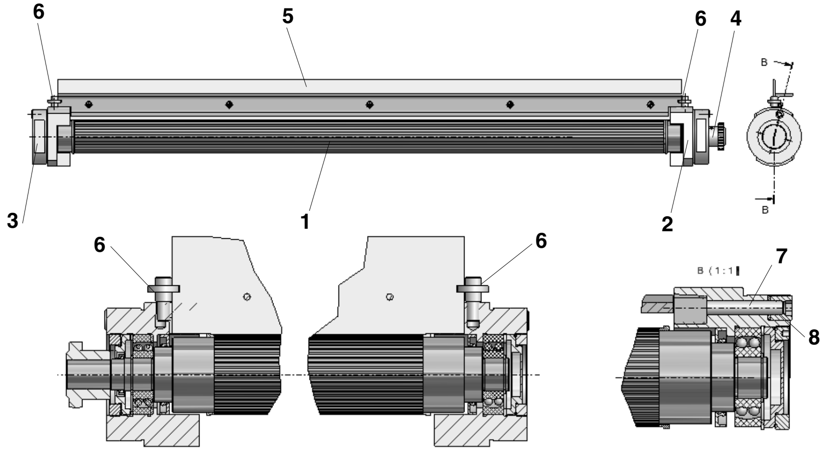

Fig. 3. Dosage shaft unit: 1 – grooved roller, 2 and 3 – bearing, 4 – clutch driver, 5 – squeegee, 6 – bolts for the adjustment of the gaps, 7 – clamping wedge, 8 – lid of the clamping wedge

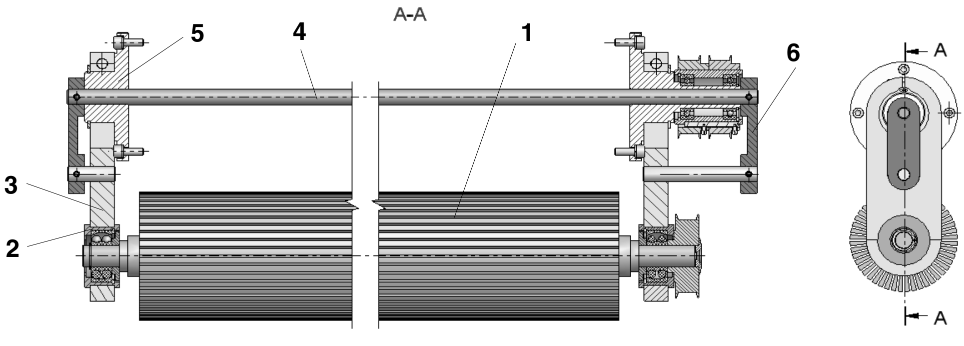

Fig. 4. Rotational brush unit: 1 – rotational brush, 2 – bearings of the brush, 3 – extension arm, 4 – torsion bar, 5 – element joining the unit, 6 – arm of the driver

The purpose of the brush is to scrape the powder from the groove of the dosage shaft. The brush (1) is located in the bearing (2), placed in the extension arm (3) and is propelled by the belt transmission. The torsion bar (4) and the arm of the driver (6) stiffen the system at the time of the changes in the position of the brush in relation to the dosage shaft.

Thanks to the application of the above stated solutions, the even spread of the superabsorbent powder along the width of the non-woven fabric has been obtained. Fig. 5 presents the graph delineating this spread for two typical superabsorbents, which has been obtained with the use of the method of the measurement of the mass of the powder dosed along the sectioned width of the non-woven fabric.

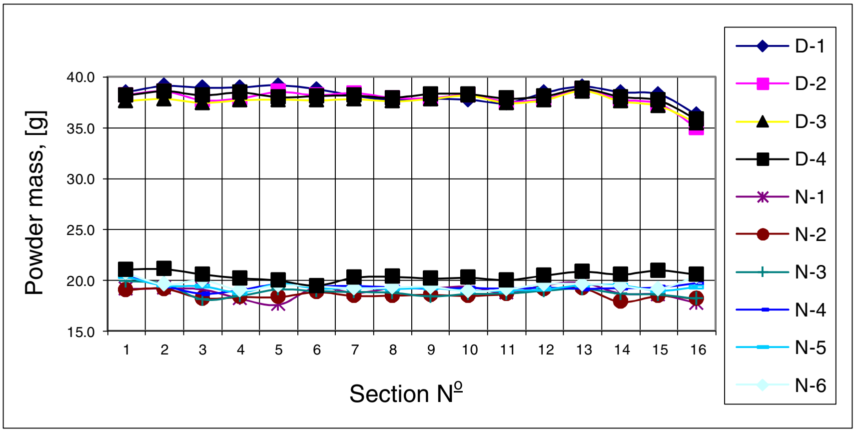

Fig. 5. Powder spread along the width of the non-woven fabric obtained in the developed device D-1..D-4 – DEFOSORB CL-360 superabsorbent spread, N-1..N-6 – NORSOCRYL S-35 superabsorbent spread

2. Device for the spraying of the binding agent

The agent binding the base layer with the cover layer in the unit for the production of coatings has been applied with the use of a pneumatic spray. The spray nozzle moves with the plane-reflexive motion crosswise to the direction of the material flow spreading the liquid glue onto the non-woven fabric with the superabsorbent. The production costs generated by this solution are too high, which has been caused by the excessive consumption of expensive binding agents resulting from the lack of possibilities to precisely control the spraying device and the production loss. Moreover, the drawbacks of the spraying chamber included the lack of the signalling system for the nozzle choke, high dustiness in the chamber, and the blow off of the small particles of the superabsorbent caused by the condensed air used for spraying.

In the latest solution of the device for the adhesive spread, the local spray head with the nozzles is adjusted to the airless spraying [6]. The nozzles can perform a slight swinging motion, which blurs the spraying line between individual stream cones of the binding agent. In order to successfully drain the dustiness, the two-sided water curtains and the open work table with the filters have been applied. The ventilation of the work area of the device ensures that the water filter stops the majority of dustiness, whereas the filters stop the smaller fractions and are installed in the air outlets to the ventilation system. The computer model of the structure of the spraying device is presented in Fig. 6.

The distance from the spray head (1) (Fig. 6) to the adhesive coated non-woven fabric (4) is changeable, depending on the screw gear (6) used, which, together with the possibility to change the number, position and motion of spray nozzles, results in the even spread of the binding agent onto the non-woven fabric. The suitably prepared binding agent diluted in water is fed to the nozzles through the high-pressure hydraulic system equipped with the pressure regulator and the side flow, which allows the efficiency of the spray to be achieved.

The electronic flowmeters are installed on all of the channels feeding the nozzles and diagnose the hydraulic and nozzle choke systems. The electric system integrated with the control system for the entire technological line controls the work of the device.

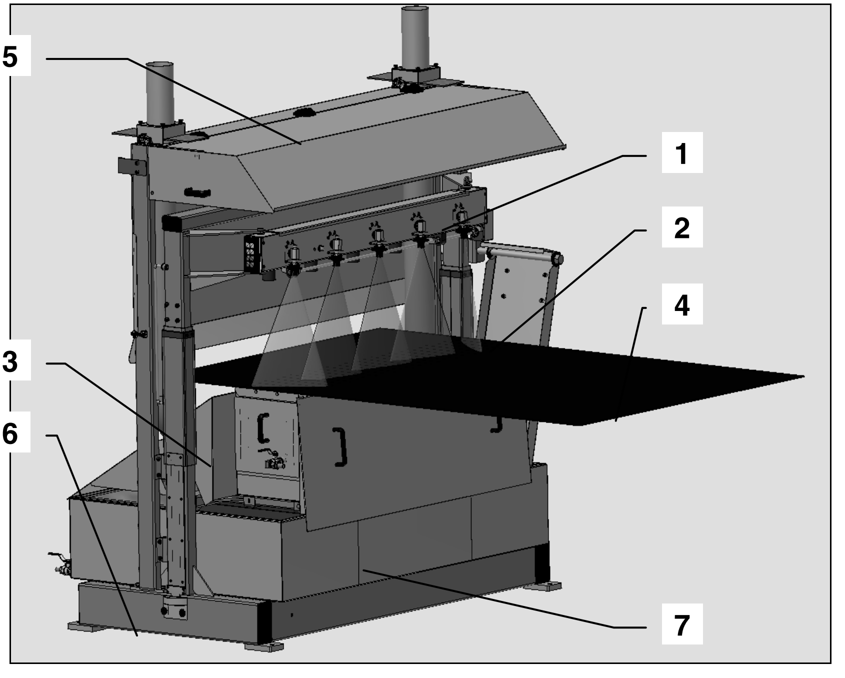

Fig. 6. Model of the spraying device: 1 – spray head, 2 – water curtain, 3 – water filter, 4 – non-woven fabric with superabsorbent, 5 – ventilation system inlet, 6 – adjustment of the position of the spray head, 7 – water container

Water used in the device in the water curtains (2) and the water filter (3) circulates in the closed cycle. In order to increase the speed of the precipitation of the particles of the adhesive, appropriate coagulant has been applied. Water is cleaned by the filters in the container (7) and can be periodically changed with the use of a specially designed installation with the external pump.

The effectiveness of the presented solutions has been verified at the time of testing the evenness of the spread of the binding agent, which has been measured along the width of the non-woven material. Fig. 7 presents the diagram of the spread obtained with the method for the measurement of the mass of the adhesive sprayed along the sectioned width of the non-woven fabric.

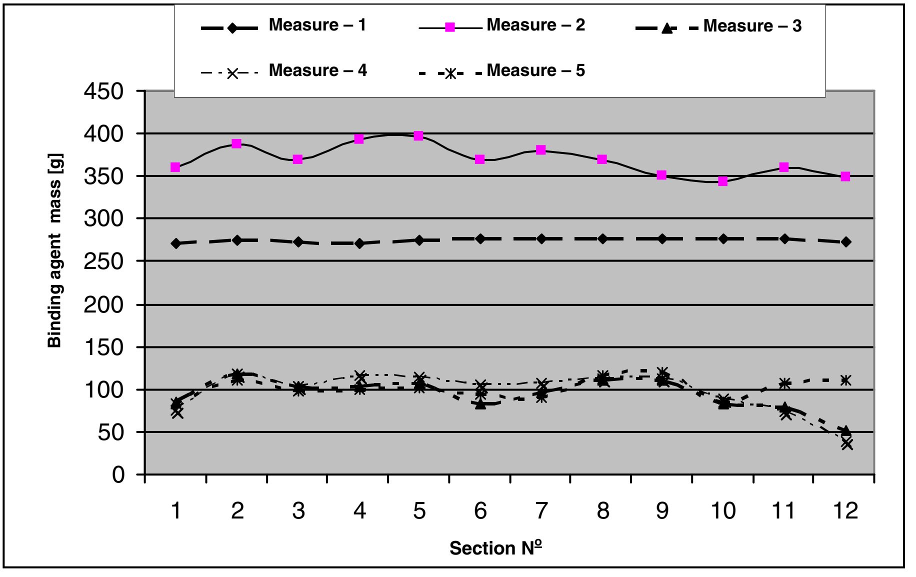

Fig. 7. Spray spread over the width of the non-woven fabric obtained in the developed device: measurement 1 – 10 min, measurement 2 – 15 min, measurements 3, 4 and 5 – 5 min

3. Implementation of developed devices and obtained results

The prototype devices for the spread of the superabsorbent and the spraying of the binding agent have been developed at the Prototype Centre at the Institute for Sustainable Technologies-National Research Institute (ITeE – PIB) Radom, Poland; tested and installed at the technological line for the production of moisture resistant cable laminates at the Textile Research Institute, Lodz, Poland. The moisture resistant coatings for national cable producers have been produced on such a line for more than a year. Fig. 8 presents the fragment of the line with the innovative devices installed.

The standard tests conducted on the moisture resistant laminates manufactured on the modernised line indicated the following changes in comparison to the goods produced before the introduction of modernisation:

– The surface mass of the moisture resistant laminates is between 101.6 g/m^2 and 108.9 g/m^2; whereas, before modernisation, its value was between 107 g/m^2 and 122 g/m^2, which means that the material consumption of the product is lower;
– The level of the expansion of the moisture resistant laminates is lower than before, but it still meets the requirements of the recipient – the average is 10 mm, while the minimum is above 8 mm. Fig. 9 shows the results of the measurement of the level of the expansion of the moisture resistant coatings manufactured in April 2010; and,
– The variability coefficients of all technical parameters of the moisture resistant laminates are lower than those before the modernisation of the line.

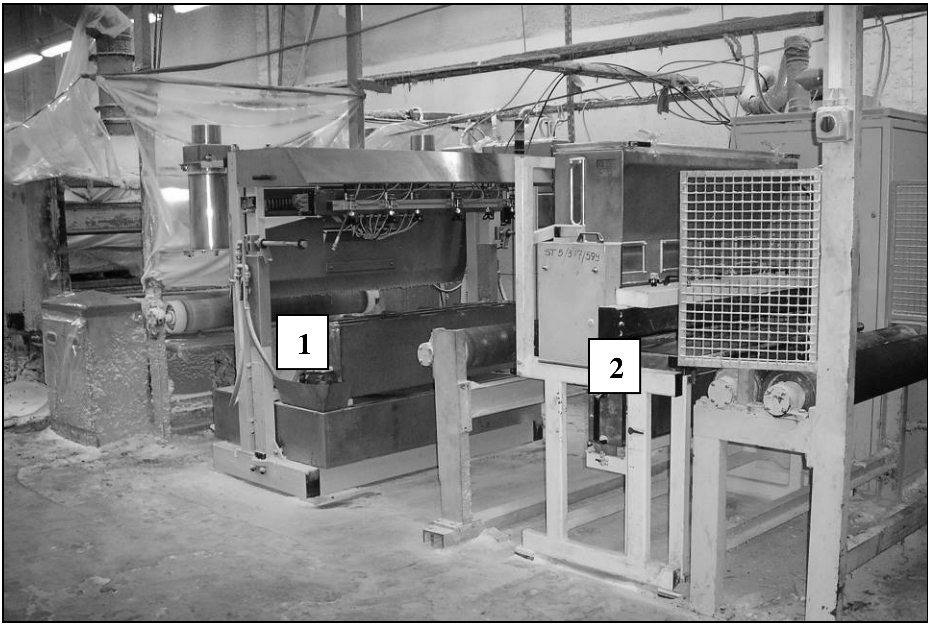

Fig. 8. Fragment of the line for the production of moisture resistant cable laminates with the innovative devices installed: 1 – device for the spray of the binding agent, 2 – device for the application of the superabsorbent

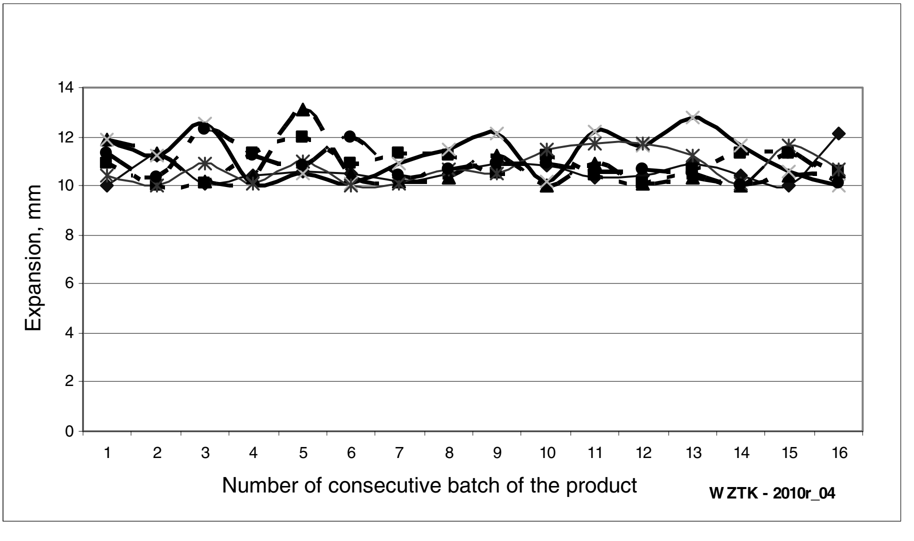

Fig. 9. Level of expansion of the moisture resistant laminates produced in April 2010 with the use of the modernised technological line (diagrams represent consecutive batches of the product)

Summary

Apart from the significant improvement of the production process quality, the introduction of innovative technological devices allowed the following important economic effects to be obtained:

- The economical use of the absorbent powders resulting from the increase in the spread of the powder on the surface of the base non-woven fabric, both along the width of the fabric and along its length. The implementation led to the decrease in the use of the superabsorbent by 11%;
- The decrease in the amount of waste in the form of the cuttings, which are always present at the time of cutting the non-woven fabric into strips. This has been obtained due to the reduced material consumption of the product;
- The decrease in the number of products below the standard (previous devices were difficult to be adjusted and thus some batches of products did not meet the requirements of the recipients which mainly considered the level of the expansion). The number of faulty products has been reduced by 50%;
- The increase in production resulting from the decrease in the amount of shutdowns related to the necessity to adjust and clean the device and its components (i.e. nozzles); and,
- The increase in production resulting from the greater width of the manufactured product, which has grown by 60 mm; and the increase in the working speed of the device by 0.8 m/min, which has been possible due to the application of the new device for the application of powders.

Thanks to their modular structure, the exchangeability of the units and compounds, and the wide scale of working parameters adjustment, the developed innovative solutions, used in the process of modernisation of the technological line for the production of moisture resistant cable laminates, can be applied in the process of powders and binding agents spread over the textile base. The devices with the configuration and parameters adapted to the needs of potential buyers are the commercially available alternative to more expensive machines imported from abroad.

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Reviewer:
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Modernizacja linii technologicznej do wytwarzania kablowych zapór przeciwwilgociowych

Słowa kluczowe

Kablowe zapory przeciwwilgociowe, proszki superabsorpcyjne, nanoszenie proszków, natrysk środka wiążącego.

Streszczenie

W artykule omówiono technologię wytwarzania zapór przeciwwilgociowych do kabli energetycznych i telekomunikacyjnych oraz sposób modernizacji linii technologicznej do ich wytwarzania. Opisano dwa innowacyjne urządzenia do nanoszenia superabsorbenta i środka wiążącego na podłoże włókninowe, opracowane i wdrożone w ramach modernizacji. Rozwiązania techniczne zastosowane w urządzeniach pozwoliły na poprawę jakości wytwarzanych wyrobów oraz wydajności i opłacalności produkcji. Przestawiono wyniki badań weryfikacyjnych opracowanych urządzeń. Rozwiązania wdrożono na linii technologicznej do wytwarzania kablowych zapór przeciwwilgociowych w Zakładzie Doświadczalnym w Instytucie Włókiennictwa w Łodzi.