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Problems in the Textile and Light Industry in the Context of Integration of Science and Industry and Ways to Solve Them (PTLICISIWS-2022)

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Production of Nonwoven Fabrics by Impregnating Fibrous Canvases with a Binder

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Abstract. In this article we are talking about the physico-chemical technology of production of nonwovens, which is based on the effect of binders on fibrous material and strengthening it during subsequent drying and heat treatment. According to physico-chemical technology, non-woven materials are produced by impregnation, molding from melt or polymer solutions, by hot pressing, by papermaking. The main technological processes for the production of non-woven glued materials by the impregnation method are impregnation, drying and heat treatment. An important process here is the introduction of a liquid binder into the fibrous canvas, i.e. impregnation. The liquid binder is distributed in the canvas over its entire thickness or in its surface layers. The binder not only binds the fibers together, but also affects the final properties of the non-woven material, such as strength, rigidity, softness, water resistance, breathability and flammability. The choice of binder also affects the ability of the fabric to be further processed after its useful life. The impregnation method is characterized by the simplicity of the technology and the equipment used in the textile industry.

Keywords. Nonwovens, base element, canvas, fibers, liquid, effectively, latexes, rolexes, crosslinking, wetting agents, emulsifiers, technological, physico-mechanical, decorative and finishing, dispersion

INTRODUCTION

Currently, the use in the production of nonwoven fabrics as binders of aqueous dispersions of polymers (synthetic and natural latexes, dispersions of polymers obtained by rolling or solvent replacement, etc.) has become widespread. This is due to the cheaper production of these products and the appearance of high-quality synthetic latexes.

Nonwovens consist of two elements, one of them serves as a base, the other as a binder. The basic element is the basis of nonwoven fabric. As a basic element, a fibrous canvas, a system of threads, a polymer film having a fibrous structure, fabrics or combinations of these materials are used. As a binder, which is used to fasten the base element, threads, fibers from the base, fibrous canvas, polymeric substances (polyethylene, rubbers), chemical fibers with a low melting point can be used. [1,14].

The advantage of polymer dispersions over solutions is determined by their incombustibility, excluding fire hazard, lower toxicity, low viscosity and a number of other positive properties.[2]

When impregnating fibrous canvases with polymer dispersions, coagulation of dispersions, drying of impregnated canvases, complex physico-chemical processes occur, which depend both on the colloidal-chemical nature of the dispersions used, and on the composition and structure of fibrous canvases and the conditions for the use of dispersions of the application of dispersions in relation to specific technological equipment.

The main physico-chemical processes in the production of nonwoven fabrics by the impregnation method are wetting, impregnation, fiber sorption of dispersion particles (heterocoagulation), drying, accompanied by the migration of the dispersed phase. [3]

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The main factors affecting the wetting of fibrous canvases, which is one of the main conditions of impregnation, are the surface tension of the wetted fibers and the surface tension of the aqueous dispersion of the polymer.

Since the surface tension of specific types of fibers is a constant value, it is usually necessary to use dispersions with a lower surface tension to improve wetting. The physical meaning of this lies in the possibility of reducing the free energy of the solid–liquid system. [4] However, in relation to fibrous canvases, such a criterion of impregnation as wetting acts in conjunction with the influence of other factors, in particular with the phenomenon of capillary rise of liquid in the "capillaries" formed by a porous system – a fibrous canvas

Unlike ordinary capillaries, the capillaries formed in a fibrous canvas have different diameters in length, are twisted in the thickness of the canvas, the shape of the capillaries deviates sharply from the usual one.

The diameter of the capillaries of the fibrous canvas has a significant effect on its impregnation. The liquid first fills the wider capillaries, and then moves into the narrower ones.[5]

The presence of capillaries filled with air in the fibrous canvas leads to the fact that when the fibrous canvas is freely wetted with liquid, the wetting operation is associated with the replacement of the fiber–air interface with the liquid–air interface. The liquid wetting the canvas fiber displaces a certain volume of air from it and instead of the fiber–air boundary forms a fiber–liquid boundary. [6] However, air displacement seems to occur only partially under normal conditions, which slows down the impregnation process. In this regard, various methods are used to displace air from porous systems: canvas sealing between shafts, vacuum suction of binder, heat treatment.

The most important factor of the method under consideration is the process of sorption (heterocoagulation) of dispersion particles by fibers.[7] This process is mainly determined by the loss of aggregate stability by dispersion due to sorption by an adsorbent from the dispersion of surfactants or protective colloids, and when electrolytes are introduced into the dispersion, by a decrease in the potential (electrokinetic potential) of dispersion particles.

Drying is a mandatory operation in the production of non-woven fabrics in this way. When drying in the capillaries of the fibrous system, moisture usually moves, dragging with it the dispersed phase contained in it, which can lead to uneven deposition of the polymer along the thickness of the web and thus worsen its properties. The migration of the dispersed phase is therefore an undesirable phenomenon.[8,20]

Practically all methods of eliminating migration are reduced to fixing the dispersed phase, which is achieved, for example, by freezing, using thermosensitized dispersions (coagulating when heated), introducing substances into the dispersion that provide coagulation during drying, etc.

To ensure the production of high-quality nonwoven fabrics, it is necessary to take into account the complex influence of variable and constant process factors, taking into account the characteristics of the technological equipment used.

The production of nonwovens is efficient, because it is based on a new technology that allows eliminating labor-intensive processes such as spinning and weaving, dramatically increasing labor productivity, automating production processes, using cheap raw materials such as textile waste, non-woven fibers, secondary raw materials.

Work is underway to further improve the technology, create physico-chemical methods for producing nonwovens, organize automated production, create production lines and automatic factories. [9,16]

Binders and Excipients

The binders used in the production of nonwoven fabrics by the method of impregnation of fibrous canvases include aqueous dispersions of synthetic and natural rubbers (latexes), aqueous dispersions of some copolymers, aqueous solutions of polymers. In particular, water dispersions of acrylates (rolexes) have found significant use.

Vulcanizing ("crosslinking") chemical reagents, surfactants of various actions (wetting agents, emulsifiers, anti-foaming agents, etc.), acids and acidic salts used as catalysts in the structuring of binders are used as auxiliary substances. The physico-chemical structure of the binders used mainly determines the most important technological, physico-mechanical and operational properties of nonwovens.

Latexes and rolexes. Latexes are used in the manufacture of many types of nonwoven fabrics for various purposes, for example, filter cloths, medical cloths that serve as the basis for artificial leather (decorative and finishing and vinyl leather), cloths for the manufacture of sealing tapes [10,21].

The disadvantage of latex-based rubbers is the presence of double chemical bonds in the high-molecular chain of polymers, which leads to accelerated light and thermal aging of the polymer and necessitates the introduction of appropriate stabilizers in them.

Latex BNK-40/4 (TU 38. 103-81) is a polymerization product in an aqueous emulsion of butadiene, acrylic acid nitrile and methacrylic acid in a ratio of 60:40:4 (in bulk parts) using a biodestructible emulsifier-sulfonal NP-3. Latex is filled with the antioxidant agidol-2. This latex is intended for use in light industry in the manufacture of nonwovens. The code is OKP 22 9492 0805.

RESEARCH METHODS

TABLE 1. Properties of water dispersion (Method 1)

Content	%
dry matter, not less than	40
agidol-2, within	1-2
free nitrile of acrylic acid, no more	0,15
Surface tension, mN/m, no more	40
pH, nevertheless	7,5
Rigidity of the polymer (latex rubber), cH	24,5 44,1

Latex should not contain foreign inclusions. The presence of coagulum in the form of a surface film is not considered a defect[11].

Before use, latex should be filtered through mesh No. 1 (according to GOST 3584-73 or GOST 6613-73). For transportation, latex is poured into metal barrels (GOST 13950-76, type 1) or into specialized railway tanks. The use of an anti-adhesive coating is allowed, it is applied by the manufacturer to the inner surface of barrels and railway tanks.

Latex BNK-40/4 is not explosive, does not spontaneously ignite, does not burn, does not emit hydrocarbons in quantities sufficient for the formation of combustible and explosive mixtures. Latex contains no more than 0.15% unpolymerized acrylic acid nitrile.

Acrylic acid nitrile has a general toxic and sharply irritating effect on the mucous membranes of the eyes and skin, the maximum permissible concentration of acrylic acid nitrile in the air of industrial premises is 0.5 mg/m3.

BSNK latex is intended for use as a binder of pigment paints used in light industry for dyeing fabrics made of cotton and chemical fibers, as a binder for floor coverings based on nonwovens, in adhesive and sealing compounds for construction machinery, in the production of paper-based adhesive tapes, in the manufacture of nonwovens, etc.[11,22]

TABLE 2. Properties of water dispersion (Method 2)

Content	%
dry matter, not less than	38
unpolymerized monomers, no more	0,1
acrylic acid nitrile	0,05
antioxidant agidol-2 (or HT-2246)	0,7-1,5
Surface tension,мН/м, no more	42
Stiffness of polymer (latex rubber), H	20-50

The presence of a surface film of coagulum is not considered a defect. Latex is poured into metal barrels (GOST 13950-76, type 1) or into specialized railway tanks.

BSNA latex is not explosive, explosive, does not spontaneously ignite, does not burn, does not emit hydrocarbons in quantities sufficient for the formation of combustible and explosive mixtures. Latex contains a small amount of free acrylic acid nitrile[12]. The rules for safe work with BSNA latex are similar to the rules for working with BNK-40/4 latex.

Table 3. Properties of water dispersion (Method 3)

Content	%
dry matter, not less than	33
naftam -2	0,5 - 1,5
free nitrile of acrylic acid, no more	0,45
pH, no more	5
Stiffness of polymer (latex rubber), H	35-85

Latex is transported to the cistern in clean, tightly closed cans or tanks. In the cold season, latex should be transported in heated wagons at a temperature of at least 10 ° C; tanks should have thermal insulation.

Synthetic latex DMMA-65GP (GOST 13522-78) is an aqueous dispersion of divinyl and methyl methacrylate copolymer.

TABLE 4. Appearance of the film (Transparent shiny colorless or slightly colored, without inclusions)

Content	**%**
dry matter, not less than	39
free methyl methacrylate, no more	0,1
volatile hydrocarbons C2- Ca, no more	0,02
methyl methacrylate in the copolymer, no more	61-65
pH	6-8
Conditional viscosity, with surface tension, mN/m,	10-15
no more	50

Latex should not contain foreign inclusions of coagulum and antioxidants that can cause a change in its color. Latex is transported in metal barrels with a removable bottom and an internal anticorrosive coating or in clean railway tanks. It is allowed to use clean enameled or iron barrels, cans and drums. In the cold season, latex is transported in heated wagons at a temperature of at least 10 ° C or in tanks with thermal insulation. Store in a closed container at a temperature not lower than 10 and not higher than 75 ° C. The warranty period of storage is 6 months. from the date of manufacture. Latex is not explosive, does not spontaneously ignite, does not burn. The maximum permissible concentration in the air of butadiene is 100 mg/m3, methyl methacrylate is 50 mg/m3.

Synthetic latex SKS-65 and SKS-65GP (GOST 10564 -75) is a product of joint polymerization of butadiene with styrene in a ratio of 35:65 in an aqueous emulsifier with the use of synthetic fatty acids as an emulsifier of nekal and sodium soap. Latex does not contain antioxidants. It is used in light industry to cover fabrics.

TABLE 5. Appearance of the film (Homogeneous transparent, colorless or slightly colored)

Features		
Content	**With the state quality mark**	**Without a state quality mark**
	%	
dry matter, not less than	48	47
Unpolymerized styrene, no more	0,07	0,08
ash, no more	1,4	1,5
volatile hydrocarbons C_2- C_4	0,02	0,02
coagulum, no more than the pH of latex	0,08	0,1
Surface tension, m.N/m	36 -40	36 -40
Conditional viscosity, with	11-13	11-15
Stability in the presence of pigment while stirring for 2 hours	Absence of lumps and grains	

Latex is transported and stored in the same way as latex DMMA-65GP.

The aqueous dispersion of vinyl chloride copolymer with vinyl acetate (TU 6-01- 754-74) is a latex copolymer of vinyl chloride with vinyl acetate, plasticized with dioctyl phthalate. In terms of fire dispersion is safe. Rooms designed to work with dispersion should be equipped with local and general exchange ventilation, When working with dispersed, plasticized dibutyl phthalate, rubber gloves should be worn.

TABLE 6. Properties of water dispersion (Method 4)

Appearance of the variance	**Homogeneous white liquid**
films	**Transparent elastic non-sticky**
Content	**%**
dry matter, not less than	41
residual monomers in terms of vinyl acetate, no more	0,8
Dispersion viscosity (relative), not lower	4
pH	7- 9,5
Surface tension, mN/m, not higher	36

The dispersion is transported to the emulsion in polyethylene cans or flasks with a capacity of 20 and 50 liters, in glass bottles with a capacity of 20 liters in crates, in special or iron barrels covered with enamel paint, special containers with a capacity of 200 liters. It is recommended to store the aqueous dispersion, as well as prepare working solutions from it, in well-ventilated rooms. The warranty period of storage is 2 months, counting from the date of manufacture [13].

Dispersion is a difficult-to-ignite substance. The self-ignition temperature is 650 660°C.

Water dispersion has a toxic effect on the human body. When working with it, it is necessary to wear rubber gloves, and protect your eyes with glasses. In case of contact with the dispersion on the skin and in the eyes, it is necessary to wash it off with soap and water. The maximum permissible concentration of a dust-like copolymer in the air is not higher than 6 mg/m3 for polyvinyl chloride.

Acrylic emulsions of grades II, grades I and A (TU 6-02- 913-79) are emulsions of polymethylacrylate. Grade I emulsion is a plasticized product of emulsion polymerization of methyl acrylate; emulsion A is a non-plasticized low molecular weight product of emulsion polymerization of methyl acrylate.[15] The emulsifier is mixed with water, soluble in solvents.[17]

RESULTS

The main directions of the development of the range of nonwovens are: the development of a rational range of nonwovens in order to replace household and technical fabrics, especially those containing natural fibers; the development of new technological solutions for the creation of nonwovens with specified mechanical, physical and chemical properties; expansion of the production of nonwovens of disposable and short-term use: the growth rate of their output by 10-13% higher than long-term materials.

In the field of technology and metallurgy and equipment: the most progressive and promising are physico-chemical and combined technologies for the production of nonwovens; technologies and equipment for the production of nonwovens that have already been marketed and conquered the world market are undergoing maximum improvement; development of new high-performance methods for the production of nonwovens.

TABLE 7. Properties of acrylic emulsions

Appearance	**Mark I**	**Mark A**
	Milky-white liquid with a slight cream tint without visible delamination	
Content	**%**	
dry matter, not less than	20	20
residual monomer, no more	0,5	0,5
pH	4,5-7	4,5 -7
Relative viscosity, not less than	4	-
Relative viscosity, not less than	Stable	
Resistance to sodium chloride	Withstands the test	
Mechanical properties of films voltage, MPa, not less when elongated by 100%	0,40	-

Appearance	Mark I	Mark A
300 %	0,46	-
tensile strength, MPa, not less	3	-
elongation at break, %	1200- 1700	-
Surface tension, мН/м, not less	33	-

CONCLUSIONS

In the field of raw materials provision: the rapidly growing world market of nonwovens is mainly focused on the raw materials of the chemical fibers and yarns industry; great importance is attached to the creation of new fibers, in particular modified, bicomponent, profiled, hollow, low linear density.

The high cost-effectiveness of the production of nonwovens, a wide range of products and the possibility of using various types of raw materials, including textile waste, contribute to the rapid development of this production.

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