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CALCULATION OF HYDRAULIC RESISTANCE DURING FILTRATION DRYING OF RAW COTTON

Abstract. Textile, non-woven and other fiber materials have a great importance in the modern world economy. Cotton is one of the most valuable raw materials for the production of various industrial, food and household products. The movement of a gas stream through a porous structure of a material is a mixed problem of hydrodynamics. However, there are no theoretical foundations for the mixed hydrodynamic problem today. In this article, we propose the use of a filtration method for drying raw cotton and calculating the hydraulic resistance. To describe the hydrodynamics of gas movement through the porous structure of the material in scientific articles, the authors use theoretical dependencies of internal or external problems. Given that the intensity of heat and mass transfer determines the speed of movement of the heat agent relative to the elements of the porous layer, this paper presents the results of studies of pressure losses in the layer of cotton fiber from the point of view of the internal problem of hydrodynamics. Experimental studies on filtration of a heat agent through a stationary layer of cotton were conducted. due to the difference in bulk weight and different heights of the layer, they were represented as a functional dependence $\Delta P = f(v_0)$. The results obtained in dimensionless form allow us to predict the energy costs of creating a pressure drop (under the same hydrodynamic conditions) when designing a new drying equipment.

Keywords:cotton fiber, hydrodynamics, filtration drying, hydraulic resistance, porosity, active specific surface of the layer.

Introduction. According to the State program of industrial-innovative development of Kazakhstan for 2020 - 2025, a stable growth and competitiveness of the manufacturing sector will be achieved by creating a technologically advanced industry, the transformation and digitalization of the basic assets of functioning enterprises, focused on the creation of medium-and high-tech products with subsequent access to the global markets [1]. By 2021, the acreage of cotton in South Kazakhstan region is expected to increase by 100 thousand hectares, yield – 3000 kg/ha, and cotton production to 300 thousand tone/year. Therefore, high-quality storage and processing of raw cotton are the main factors. When processing raw cotton to obtain a more efficient and high-quality fiber, its humidity should be in the range of 8-9% [2,3]. In order to boost the cotton and textile industries of Kazakhstan, The law «on the development of the cotton industry» was adopted, and the free economic zone «Ontustik» was created for 2005-2030, which will contribute to the revival and development of the textile industry in Kazakhstan [4] .

At the present, the properties of raw materials deteriorate in cotton processing plants when using drying drums of type 2SB-10, SBT, SBO. As a result of subsequent technological processes, the fiber grade is reduced by 25% through mechanical action, a lot of energy is spent, the color of the fiber is lost, and the fiber twists, and the fiber microstructure deteriorates [5].

In the cotton-growing regions of Central Asia and Kazakhstan, drying drums of type 2SB-10, SBT, and SBO are mainly used for drying raw cotton, and various methods and drying devices are used for drying food and vegetable raw materials [6-8], which are not acceptable for drying raw cotton.

For this reason, experimental and theoretical studies of cotton drying, reducing the cost of technological processes for processing cotton fiber and improving their quality characteristics are of urgent importance for the economy of Kazakhstan. The integration of new highly efficient and resource-saving technologies for processing cotton raw materials into a finished product of high quality will be competitive not only in the domestic but also in foreign markets.

Analysis of literature sources [9-13] allows us to conclude that there is no comprehensive and systematic approach to the intensification of drying processes of wet cotton fiber, given that it contains mainly bound moisture, is a thermolabile material, and the drying process takes place in the second period.

Choosing the drying mode for raw cotton depends on the following parameters: color, fiber length, type of mechanical damage, and so on. During drying of raw cotton, it is important to choose the optimum mode of drying, since inadequate drying parameters, there is a fiber breakage, reducing its length, resulting in reduced fiber quality [2,3].

Experimental part and description of the installation. Theoretical analysis and design of drying systems are complicated by a number of factors, in particular, simultaneous heat and mass transfer to the surface and inside the material, moisture transfer within the material, while there are more than twenty different types of mechanisms for transferring moisture in a solid. Changes in the moisture content and temperature of the material are determined by heat and mass transfer between the surface of the body, the environment and the interior of the material to be dried.

To realize the process of drying raw cotton, as noted above, the industry uses drum type dryers and fluidized bed dryers, which are energy-consuming and expensive. Therefore, we had the task to develop a new type of dryer that will reduce the energy costs of the drying process.

Generalization of the results of experimental and theoretical studies of hydrodynamics and heat and mass transfer during filtration drying of raw cotton allowed us to propose a design of a drying plant that takes into account the physical and mechanical properties of raw cotton, improve the method for calculating the main structural dimensions of this installation and calculate the optimal technological parameters of the thermal agent.

We suggest using the concept of a drum-type filtration drying device for drying raw cotton (figure 1) [14].

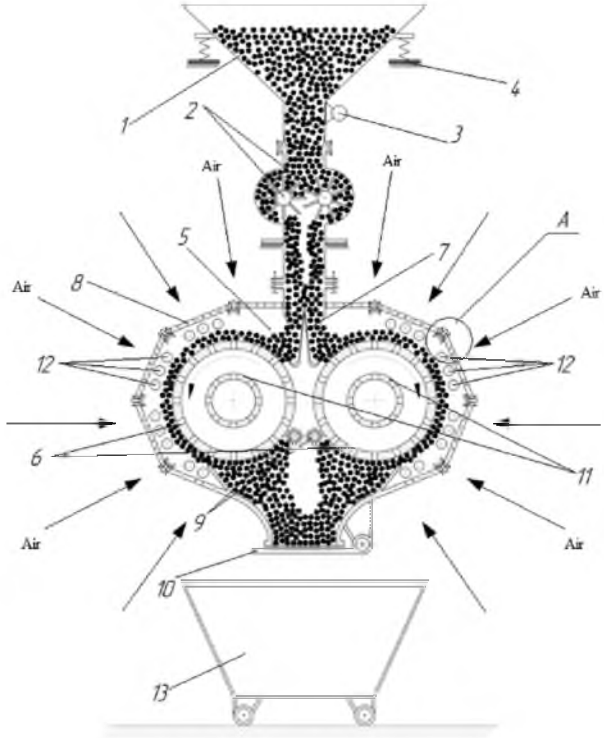

Figure 1 – The installation of the filtration drying of drum-type:
1 – bunker, 2 – proportioner, 3 – vibrator, 4 – springs, 5 – drying chamber, 6 – perforated drums, 7 – partition wall, 8 – perforated sheets, 9 – brushes, 10 – spring-loaded lid, 11 – perforated sleeves, 12 – warming system, 13 – container

Installation for the filtration drying of raw cotton consists of a bunker 1 which serves to feed a raw and in the lower part it includes a proportioner 2 and the vibrator 3, and the bunker 1 is mounted on a spring 4. The lower part of the hopper 1 is attached to the drying chamber 5 in which is placed parallel to the perforated drums 6 with a perforated sleeve 11. The perforated drums 6 with a partition 7. Warming system of heating agent 12 is located inside drying chamber 5. The outside of the perforated drum is equipped with 8 removable perforated sheets. Brushes 9 are installed on the drum 6 in the dry material discharge zone. In the lower part of the drying chamber 5, a spring-loaded lid 10 is installed, which serves for automatic unloading of dry material into the container 13. The Perforated drums are connected to the vacuum line through perforated sleeves 11. Container 13 is intended for dry material.

The installation works as follows. Include a vibrator 3 and a vacuum line, so that the heat agent passes through the perforated sheets 8, which ensure uniform drying of the material and facilitate the changeover of the installation for a different type of material, or for a different humidity. The air is heated directly in the drying chamber 5 by the warming system 12, which is placed directly in the drying chamber, which makes it possible to reduce heat loss to the environment. Due to the fact that the perforated sheets are washed by the ambient air, their temperatures are approximately equal to the ambient temperature.

Turn both the reels 6 and brush 9. The wet material enters the hopper 1 and with a dispenser 2 is fed to the drying chamber 5 into two of the perforated drum 6, between which the partition wall 7 and which rotate in opposite directions. Partition 7 serves to form a uniform layer of dispersed material. Due to the rarefaction, the wet material is firmly pressed against the perforated surface of the drum and rotates along with it in the direction shown in figure 1. 9 Brushes are used to clean the perforated partition from dry material particles. To prevent the hanging of wet material due to caking or compaction, and the formation of a so-called funnel, a vibrator 3 is installed on the hopper 1. The Amplitude and frequency of vibration of the vibrator 3 is set experimentally depending on the humidity and adhesive properties of the material being dried. Container 13 is intended for unloading dry material from the drying zone [14].

Theoretical part and discussion of results. One of the high-intensity methods of removing both free and bound moisture is the method of filtration drying of materials. This is due to the fact that during filtration drying, the heat agent is filtered through the porous structure of the wet material, which is placed on the perforated partition in the direction «wet material – perforated partition». The speed of movement of the heat agent in the pores and channels of a stationary layer of wet material determines the thickness of the boundary layer (hydrodynamic, thermal and diffusion) and, accordingly, the values of the heat and mass transfer coefficients. In addition, the surface of heat and mass transfer is the total surface of the pores and channels through which the heat agent is filtered. The filtration rate of the heat agent is determined based on technical and economic considerations, taking into account that its increase affects the growth of pressure loss. Moreover, the actual speed of movement of the heat agent relative to the layer elements is significantly higher than in the case of drying by any other methods (in the fluidized bed, during drying in pneumatic transport dryers, etc.). The large surface of heat and mass transfer and the speed of the heat agent in the pores and channels of the stationary layer of wet material provide high coefficients of heat and mass transfer and, accordingly, the intensity of the filtration method of drying [15].

At the same time, the total energy consumption for the filtration drying process consists of pressure losses in the stationary layer and heating of the heat agent (air) to a set temperature. Given the above, it is important to establish the dependence of pressure losses in a stationary layer of wet cotton fiber on the fictitious filtration rate of the heat agent, as an important factor determining the intensity and economic efficiency of filtration drying.

The movement of a gas flow through a porous structure of a material is a mixed problem of hydrodynamics. However, there are no theoretical foundations for a mixed problem of hydrodynamics today. to describe the hydrodynamics of gas movement through a porous structure of a material in scientific articles [9-13], the authors use theoretical dependencies of the internal or external problem.Given that the intensity of heat and mass transfer determines the speed of movement of a heat agent relative to the elements of a porous layer, in this paper we present the results of theoretical studies of pressure losses in a layer of cotton fiber from the point of view of the internal problem of hydrodynamics.The movement of a gas stream through a porous structure of a material is a mixed problem of hydrodynamics. However, there are no theoretical foundations for the mixed hydrodynamic problem today. To describe the hydrodynamics of gas movement through the porous structure of the material in scientific articles [9-13], the authors use theoretical dependencies of the internal or external problem.

Given that the intensity of heat and mass transfer determines the speed of movement of the heat agent relative to the elements of the porous layer, in this paper we present the results of theoretical studies of pressure losses in the cotton fiber layer from the point of view of the internal problem of hydrodynamics.

As shown by the researches, the stationary layer of cotton fiber during the application of a pressure drop, to ensure the appropriate filtration rate of the heat agent, due to the slight stiffness of individual randomly placed fibers in the experimental container, changes its height. This leads to a change in the equivalent diameter of the channels through which the heat agent moves, the porosity of the layer and, accordingly, the actual speed.Changing the actual filtration speed of the gas flow leads to an increase in the pressure loss in the layer ΔP and the height of the cotton fiber layer H-to an increase in the volume densityρ_l. Thatis:$H = f(\Delta P)$; $d_e = f(\Delta P)$; $\varepsilon = f(\Delta P)$; $\rho_l = f(\Delta P)$; $\Delta P = f(v)$. At the same time, the only constant values are the weight of the fiber attachment and $G_v = const_v$ and the outer surface of all cotton fibers $F = const$.

The pressure loss in a porous stationary layer is determined based on the well-known Darcy-Weisbach dependence, because it takes into account all possible experimental variables [15,16]:

$$\Delta P = \lambda_l \cdot \frac{H}{d_e} \cdot \frac{\rho \cdot v^2}{2}, \tag{1}$$

where λ_l – is the coefficient of hydraulic resistance of the layer; ΔP – pressure loss in the material layer, Pa; H – layer height, m; d_e – equivalent diameter, m; ρ – the density of the gas flow, kg/m^3; υ – the actual speed of the gas flow, *m/s*.

$$d_e = \frac{4 \cdot \varepsilon_l}{a}, \tag{2}$$

where ε_l – isthe porosity of the layer, m^3/m^3; a – active specific surface of the layer, m^2/m^3; We define the initial specific surface of the fibera$_0$, which depends on the initial height of the stationary layer of cotton fiber and its volume:

$$a_0 = \frac{F}{H_0 \cdot S} \tag{3}$$

where H_o – is starting height of the cotton fiber layer, m; S – cross-sectional area of the experimental container, m^2.

To define the starting specific surface area of all cotton fibersa$_0$assume that there are N identical fibers of length$L_v$in the experimental container. Then the outer surface of all particles can be represent as:

$$F = 2 \cdot (a + b) \cdot L_v \cdot N, \tag{4}$$

where a and b – the middle width and thickness of the cotton lint, respectively,m.

Knowing the specific density of the cotton fiber$\rho_v$and the weight of the hitch $G_v$we find the volume of the cotton fiber:

$$V = \frac{G_v}{\rho_v} = a \cdot b \cdot L_v \cdot N, \tag{5}$$

where we define number of lints *N:*

$$N = \frac{G_v}{\rho_v \cdot a \cdot b \cdot L_v}, \tag{6}$$

so the surface of all the cotton lints:

$$F = 2 \cdot (a + b) \cdot L_v \cdot \frac{G_v}{\rho_v \cdot a \cdot b \cdot L_v} = \frac{2 \cdot (a + b) \cdot G_v}{\rho_v \cdot a \cdot b}. \tag{7}$$

We define the starting and current specific surfaces of a conditionally stationary layer of cotton fiber, which is located in the experimental container, as the ratio of the total surface to the volume:

$$a_0 = \frac{F}{S \cdot H_0} = \frac{2 \cdot (a + b) \cdot G_v}{\rho_v \cdot a \cdot b \cdot S \cdot H_0}, \tag{8}$$

and the active specific surface of the cotton fiber is represented as:

$$a = a_0 \cdot \frac{H_0}{H} \tag{9}$$

where a_o, a – starting and active specific surfaces of the fiber layer, m^2/m^3; H_o – starting height of the fiber layer, m; H – current height of the fiber layer, depending on the pressure loss, m.

So:

$$a = a_0 \cdot \frac{H_0}{H} = \frac{2\cdot(a+b)\cdot G_v}{\rho_v\cdot a\cdot b\cdot S\cdot H_0}\cdot\frac{H_0}{H} = \frac{2\cdot(a+b)\cdot G_v}{\rho_v\cdot a\cdot b\cdot S\cdot H} \qquad (10)$$

Let's express the weight of the cotton fiber attachment in terms of its volume and specific density:

$$G_v = V\cdot\rho_v = H_v\cdot S\cdot\rho_v \qquad (11)$$

where H_v –isthe height of the fiber layer with densityρ_v, m.

Then the active specific surface of a conditionally stationary layer of cotton fiber can be represented as:

$$a = \frac{2\cdot(a+b)\cdot G_v}{\rho_v\cdot a\cdot b\cdot S\cdot H} = \frac{2\cdot(a+b)\cdot H_v\cdot S\cdot\rho_v}{\rho_v\cdot a\cdot b\cdot S\cdot H} = \frac{2\cdot(a+b)}{a\cdot b}\cdot\frac{H_v}{H}, \qquad (12)$$

and then equation (2) can be written as:

$$d_e = \frac{4\cdot\varepsilon_l}{a} = \frac{2\cdot a\cdot b\cdot\varepsilon_l}{(a+b)}\cdot\frac{H}{H_v}, \qquad (13)$$

and equations (1) using (13) can be represented as:

$$\Delta P = \lambda_l\cdot\frac{H}{d_e}\cdot\frac{\rho\cdot v^2}{2} = \lambda_l\cdot\frac{H\cdot(a+b)\cdot H_v}{2\cdot a\cdot b\cdot H\cdot\varepsilon_l}\cdot\frac{\rho\cdot v^2}{2} = \lambda_l\cdot\frac{(a+b)\cdot H_v}{2\cdot a\cdot b\cdot\varepsilon_l}\cdot\frac{\rho\cdot v^2}{2} \qquad (14)$$

It is known that the coefficient of hydraulic resistance of the porous layer ξ is defined as a part of the speed pressure, that is, equation (14) can be represented as [17-20]:

$$\Delta P = \xi\cdot\frac{\rho\cdot v^2}{2} = \xi\cdot\frac{\rho\cdot v_0^2}{2\cdot\varepsilon_l^2} \qquad (15)$$

where ξ – is the coefficient of hydraulic resistance of the porous layer$\xi = \lambda_l\cdot\frac{(a+b)\cdot H_v}{2\cdot a\cdot b\cdot\varepsilon_l}$, v_0– fictitious heat agent filtration rate$v_0 = v\cdot\varepsilon$, *м/с*.

Approximation of experimental information by a power function allowed us to receive the following calculated dependence:

$$\varepsilon = \varepsilon_0\cdot v_0^{-0.025} \qquad (16)$$

The absolute value of the maximum relative error between the experimental data and the theoretically calculated data does not exceed 5.6%.

Generalization of experimental data on the hydrodynamics of filtering a thermal agent through a stationary layer of cotton was carried out in the form of dimensionless complexes$Eu = f(Re_e)$, and dependence of the hydraulic resistance coefficient of the layer $\xi = f(Re_e)$as functions of the Reynolds number:

$$\mathrm{Eu} = 84000\cdot\mathrm{Re}_e^{-1.18}, \qquad (17)$$

where Re_e – is the equivalent value of the Reynolds number.

$$\mathrm{Re}_e = \frac{v\cdot d_e\cdot\rho}{\mu},$$

where μ – is coefficient of dynamic viscosity of the gas flow, $Pa\cdot s$;

The coefficient of hydraulic resistance of the cotton fiber layer was calculated based on experimental data from equation (15). Approximation of experimental information by a power function allowed us to receive the following calculated dependence:

$$\xi = 160000\cdot\mathrm{Re}_e^{-1.16} \qquad (18)$$

Comparing the proportion of experimentally determined values of pressure losses in a conditionally stationary layer of cotton fiber to those theoretically calculated based on the dependence (17) on the Reynolds number, the absolute value of the relative error does not exceed 14.2%, which is explained by the complex structure and spontaneity of the formation of a stationary layer of cotton fiber, as well as the impact of the pressure drop on the height of the layer.

Conclusion. Received in dimensionless form, the calculated dependence (17) makes it possible to predict the energy costs of creating a pressure drop (under the same hydrodynamic conditions) when designing a new drying equipment, and the dependence (18) is convenient to use during the operation of the drying plant when it is necessary to change the technological parameters of the process, that is, to change the height of the cotton fiber layer or the filtration rate of the thermal agent.The Error between the theoretically calculated values and experimental data does not exceed 14.2%, which is quite acceptable for the design calculations of new drying equipment.Obtained in dimensionless form the calculated dependence (17) gives the possibility to predict the energy cost of creating the pressure differential (with the same hydrodynamic conditions) when designing new drying equipment, and the dependence (18) it is convenient to use during operation of the dryer when you need to change the process parameters, that is, change the height of the layer of cotton fibers or the filtration rate of the heat agent.The error between the theoretically calculated values and experimental data does not exceed 14.2%, which is quite acceptable for design calculations of new drying equipment.

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ШИТТІ МАҚТАНЫ СҮЗІП КЕПТІРУ БАРЫСЫНДА ГИДРАВЛИКАЛЫҚ КЕДЕРГІНІ ЕСЕПТЕУ

Аннотация. Қазіргі заманғы әлемдік экономикада тоқыма, тоқылмаған және басқа да талшықты материалдарды үлкен маңызға ие. Мақта – түрлі өнеркәсін, азық-түлік және тұрмыстық өнімдерді өндіру үшін шикізаттың құнды түрінің бірі. Шитті мақтаны кептіру режимін таңдау түсі, талшықтың ұзындығы, механикалық зақымдану түрі және т.б. көрсеткіштерге байланысты болып келеді. Шитті мақтаны кептіру барысында кептірудің оңтайлы режимін таңдаған маңызды, өйткені кептірудің параметріне сәйкес келмесе талшық үзіліп, ұзындығы қысқарады, нәтижесінде талшықтың сапасы төмендейді.

Өнеркәсіпте шитті мақтаны кептіру үдерісін іске асыруда барабан түріндегі кептіргіштер мен энергия шығыны, қайнаган қабаттың қымбат кептіргіші қолданылады. Сондықтан кептіргіштің жаңа түрін әзірлеуді міндет етіп алдық, өйткені ол Кептіру үдерісіне энергетикалық шығындарды азайтуға мүмкіндік береді.

Шитті мақтаны сүзіп кептіру кезінде гидродинамика мен жылу және масса алмасудың эксперименттік және теориялық зерттеулерінің нәтижелерін қорыту шитті мақтаның физикалық-механикалық қасиеттеріне сай кептіру қондырғысының құрылымын ұсынуга, осы қондырғының негізгі конструктивтік өлшемдерін есептеу әдістемесін жетілдіруге және жылу агентінің оңтайлы технологиялық параметрін есептеуге мүмкіндік берді.

Біз шитті мақтаны кептіруге арналған барабан типті Сүзгіш кептіргіш орнатудың принципті схемасын пайдалануды ұсынамыз, ол еркін әрі байланысқан ылғалдың жоғары инсенсивті әдісі болып саналады. Бұл Сүзгіш кептіру кезінде жылу агенті «ылғалды материал-перфорацияланған қалқа «бағытында перфорацияланған қалқа орналасқан ылғалды материалдың кеуекті құрылымы арқылы сүзіледі. Ылғалды материалдың стационарлық қабат тесігі мен каналдарындағы жылу агентінің қозғалыс жылдамдығы шекаралық қабаттың қалыңдығын және тиісінше жылу және масайналым коэффициенттерінің мәнін анықтайды. Сонымен қатар, жылу және масса алмасу беті жылу агенті сүзетін тесіктер мен каналдардың жиынтық беті болып саналады. Жылу агентін сүзу жылдамдығы оның ұлғаюы қысымның жоғалуына әсер ететінін ескере отырып, техникалық-экономикалық пайымдарга сүйене отырып анықталады. Сонымен қатар, қабат элементіне қатысты жылу агентінің нақты қозғалыс жылдамдығы кез келген басқа әдістермен кептіру жағдайына қараганда айтарлықтай жоғары. Жылу және масса алмасудың үлкен беті және ылғалды материалдың стационарлық қабатының поралары мен каналдарындағы жылу агентінің жылдамдығы жылу және масса берудің жоғары коэффициентін және тиісінше кептірудің сүзу тәсілінің қарқындылығын қамтамасыз етеді.

Материалдың кеуекті құрылымы арқылы газ ағынының қозғалысы гидродинамиканың аралас міндеті болып табылады. Алайда гидродинамиканың аралас есебінің теориялық негіздері бүгінде жоқ. Бұл мақалада шитті мақтаны кептірудің сүзгілеу әдісін пайдалану және гидравликалық кедергіні есептеу ұсынылады. Ғылыми мақалаларда материалдың кеуекті құрылымы арқылы газ қозғалысының гидродинамикасын сипаттау үшін авторлар ішкі немесе сыртқы есептің теориялық тәуелділігін пайдаланады. Жылу және масса алмасу қарқындылығы кеуекті қабаттың элементтеріне қатысты жылу агентінің қозғалыс жылдамдығын анықтайтынын ескере отырып, бұл жұмыста гидродинамиканың ішкі міндеті тұрғысынан мақта талшығының қабатындағы қысым шығынын зерттеу нәтижелері ұсынылған. Жылу агентін мақтаның стационарлы қабаты арқылы сүзу үшін эксперименталдық зерттеулер жүргізілді, өйткені үйіндінің салмағы мен қабаттың түрлі биіктігінің әртүрлілігіне байланысты $\Delta P = f(v_0)$ функционалдық тәуелділік түрінде көрсетілді. Алынған нәтижелер өлшемсіз жаңа кептіру жабдығын жобалау кезінде қысымның ауытқуын жасауга (бірдей гидродинамикалық жағдайда) арналган энергетикалық шығындарды болжауга мүмкіндік береді.

Түйін сөздер: мақта талшығы, гидродинамика, сүзіп кептіру, гидравликалық кедергі, кеуектілік, қабаттың белсенді беткі қабаты.

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РАСЧЕТ ГИДРАВЛИЧЕСКОГО СОПРОТИВЛЕНИЯ ПРИ ФИЛЬТРАЦИОННОЙ СУШКЕ ХЛОПКА-СЫРЦА

Аннотация. Текстиль, нетканые и другие волоконные материалы имеют большое значение в современной мировой экономике. Хлопок является одним из наиболее ценных видов сырья для производства различных промышленных, пищевых и бытовых продуктов. Выбор режима сушки хлопка-сырца зависит от следующих показателей: цвет, длина волокна, типа механического повреждения и тому подобное. Во время сушки хлопка-сырца важно выбрать оптимальный режим сушки, поскольку при несоответствующих параметрах сушки наблюдается обрыв волокна, уменьшение его длины, в результате чего снижается качество волокна.

Для реализации процесса сушки хлопка-сырца в промышленности используют сушилки барабанного типа и сушилки кипящего слоя, которые являются энергозатратными и дорогими. Поэтому перед нами стояла задача разработать новый тип сушилки, который позволит снизить энергетические затраты на процесс сушки.

Обобщение результатов экспериментальных и теоретических исследований гидродинамики и тепло - и массообмена при фильтрационной сушке хлопка-сырца позволили предложить конструкцию сушильной установки, которая учитывает физико-механические свойства хлопка-сырца, усовершенствовать методику расчета основных конструктивных размеров данной установки и рассчитать оптимальные технологические параметры теплового агента.

Нами предлагается использование принципиальной схемы установки фильтрационной сушки барабанного типа для сушки хлопка-сырца, которая является одним из высокоинтенсивных методов удаления как свободной, так и связанной влаги. Это обусловлено тем, что во время фильтрационной сушки тепловой агент фильтруется сквозь пористую структуру влажного материала, который размещен на перфорированной перегородке в направлении «влажный материал – перфорированная перегородка». Скорость движения теплового агента в порах и каналах стационарного слоя влажного материала определяет толщину пограничного слоя и соответственно значения коэффициентов тепло- и масоотдачи. Кроме этого, поверхностью тепло- и массообмена является суммарная поверхность пор и каналов, сквозь которые фильтруется тепловой агент. Скорость фильтрации теплового агента определяют исходя из технико-экономических соображений, учитывая то, что ее увеличение влияет на рост потери давления. Причем, действительная скорость движения теплового агента относительно элементов слоя значительно выше, чем в случае сушки любыми другими методами. Большая поверхность тепло- и массообмена и скорость теплового агента в порах и каналах стационарного слоя влажного материала обеспечивают высокие коэффициенты тепло - и массоотдачи и соответственно интенсивность фильтрационного способа сушки.

Движение газового потока сквозь пористую структуру материала представляет собой смешанную задачу гидродинамики. Однако теоретических основ смешанной задачи гидродинамики на сегодня не существует. В этой статье предлагается использование фильтрационного способа сушки хлопка-сырца и расчет гидравлического сопротивления. Для описания гидродинамики движения газа сквозь пористую структуру материала в научных статьях авторы используют теоретические зависимости внутренней или внешней задачи. Учитывая то, что интенсивность тепло- и массообмена определяет скорость движения теплового агента относительно элементов пористого слоя, в данной работе представлены результаты исследований потерь давления в слое волокна хлопка с точки зрения внутренней задачи гидродинамики. Проведены экспериментальные исследования по фильтрации теплового агента сквозь стационарный слой хлопка, из-за разности насыпного веса и различных высот слоя представляли в виде функциональной зависимости $\Delta P = f(v_0)$. Полученные результаты в безразмерной форме позволяют прогнозировать энергетические затраты на создание перепада давлений (при одинаковых гидродинамических условиях) при проектировании нового сушильного оборудования.

Ключевые слова: волокно хлопка, гидродинамика, фильтрационная сушка, гидравлическое сопротивление, пористость, активная удельная поверхность слоя.

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