Study of the effectiveness of nonwoven filters from textile waste

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Abstract

There are many reasons for recycling of waste from textile products and processes. They include the protection of natural resources, reducing the need of landfills and payment of fees, supply and provide cheap raw materials for new products. In fact, the percentage of recycled textile products is not very high. This is due to the shortage of public willingness to participate in waste collection and recycling. Economy is often the reason for seeking other ways of treating waste. Although the legislation could easily tip the balance in favor of recycling as a forced move, it can only have the opposite effect on the environment. Recycling, apparently an obvious choice is more complicated than it seems.

The increased demand for fibers and their consumption is a result of the world population growth and the overall improvement of the living standard. Regardless the quest for introducing of non-waste technology in textile production, waste remains in the form of textile dust that is usually landfilled.

In the present report are presented results demonstrating the effectiveness of filter screens obtained by wet process for nonwovens production from textile dust from wool production. It is examined the degree of saturation of the filter depending on the concentration of the contaminant in the water (clean and used mineral oil), pressure and flow rate of the fluid and the number of nonwoven layers in the filter.

The results show an increase in the efficiency of the nonwoven filter media by increasing the number of layers of nonwoven incorporated as a filler in the filter body. Filter saturation is determined by passing a different quantity of water contaminated with petroleum products in concentrations of 0,5 g/l. Sorption capacity is determined in the filter in g/in fiber of 1 to 4 cycles of passing.

Keywords: nonwoven filters, textile waste, petroleum products, water purification

Introduction

Oil and petroleum products are currently the main ocean pollutants. In water, they cause different types of pollution: spills, floating on the water surface, dissolved and emulsified petroleum products, precipitation on the basin bottom, such as heavy oil fractions. As a result, the taste, smell, color, surface tension and viscosity of the water change, the oxygen amount reduces, harmful substances form, water becomes toxic and is a threat to the flora and fauna.

Only 0.01 g/l oil in water makes it unusable.

On the other hand textile waste in the contemporary highly developed societies considerably increase in volume and complicate the problem of their disposal.

The aim of the work is to demonstrate the possibility of using adsorption media produced by the wet process for nonwoven textile from waste textile powders with prevailing content of wool and to prove their effectiveness (Fig 1.).

The principle of adsorption purification through bulk or porous layers with a developed surface consists of:

1. Particles of oil or petroleum products come into contact with the surface of the fiber layer and a thin layer / film of the pollutant is formed on the surface due to adhesion interaction.

2. The passing of the water containing petroleum products through the tbarrier, the wetting of the fibers and their adsorption on the surface depends on the pressure of the fluid, the flow rate and the porosity of the barrier. This affects the efficiency of retention and purification.

Materials and methods

Various synthetic and natural porous materials, such as salts, coke pellets, peat, silica aluminogels and active clay are used as sorbents [1]. The most active and effective sorbent is the activated carbon. But the problem is its relatively high price.

The main indicators of the sorbents are: porosity, pore structure, chemical composition. The activity of the sorbent is characterized by the amount of absorbed substance per unit volume or mass of the sorbent ($kg/m^3 kg/kg$).

Sorption process may be carried out under static conditions in which the sorbent is not moved with respect to the particle of the sorbate and under dynamic conditions where fluid moves through the barrier.

The most simple equipment in terms of design are bulk filters which represent a column with a fixed bed, in this case a barrier of non-woven textile of waste fiber, through which the treated wastewater passes.

Fig. 1 Filter body with barriers of nonwovens

Results and discussion

The filtration rate depends on the concentration of dissolved substances in the waste water and fluctuates from 1-2 to 5-6 m/h; the size of fibers in the sorbent is 1.5-2 to 4-5 mm. The optimal direction of passing of the liquid is from the top down as in this case was observed even filling of the entire section of the column and bubbles of air and the gases trapped in the sorbent can be easily removed together with the waste water.

The properties of the sorbent depend on the composition of the multi-component structure of the waste fiber and cellulose pulp, which is formed (Fig. 2.).

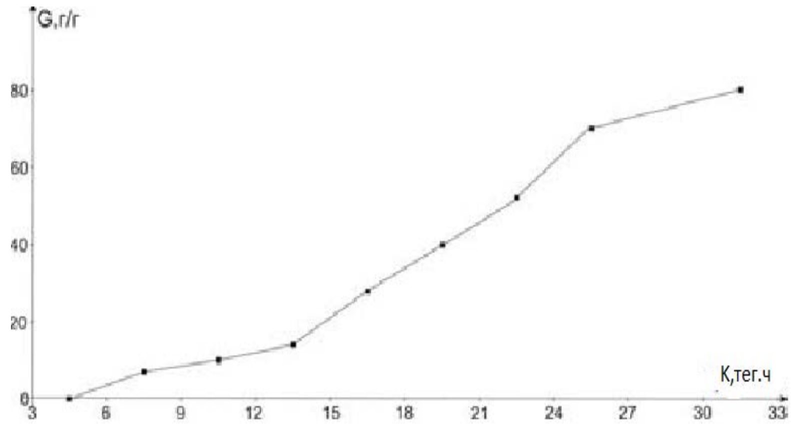

Fig. 2 Influence of wool content in the mixture with polyester on the retention of oil and petroleum products.

The filter barrier of recycled fibers has a stable structure, air permeability coefficient Bp = 0.803-1.22 $m^3/m^2.h$, distribution of pore size of 212- 240 µm, an average pore size of about 226 µm, with an average thickness - 12 to 15 mm and area density 250 g/m^2, with an average dry and wet breakthrough strength respectively 13.15 dN and 10.65 dN (Fig. 3.). Filter media with bulk density 119 kg/m^3, can easily be installed in the filter body and has a hydrodynamic resistance F = 0,153 $kg.m/s^2$ and desired retention capacity of 20 kg/kg of oil; of machine oil- 18 kg/kg and kerosene - 12 kg/kg.

The efficiency of filtration is 88-94% and the fineness of filtration - 20 micrometers.

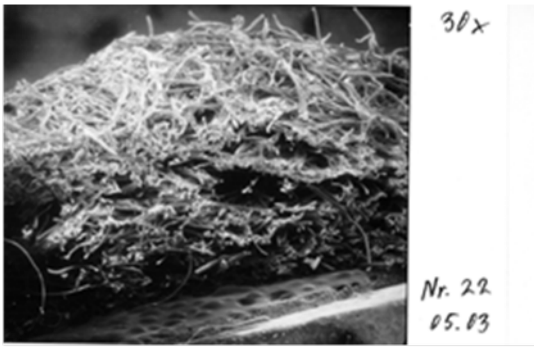

Fig. 3 Cross section of barrier of regenerated waste fibers obtained by the wet process

The filter structure can operate at vacuum pressure and gravity flow of the fluid. It is developed of PVC pipe with diameter 22 cm. It can be used for emulsions based on mineral oil, source and waste oils in the waste water. The purified water can be discharged into the sewage system or can be used in a closed cycle, which drastically reduces water consumption [2]. What radically differs the technology for filter media of nonwovens (FMNW) from ordinary demulsifying chemical treatment plants is the use of physical and mechanical principles for water purification without the need of chemicals (Table 1.). The directions of the inlet and outlet pipe, and their size can be adapted to the local conditions. Water quality at the outlet of the system is not affected by the concentration of oil products in the water at the inlet.

The purification process is easily manageable and the system has high operational reliability.

Table 1. Parameters of filter FMNW

Parameters	**Filter** FMNW 120	**Filter** FMNW 130	**Filter** FMNW 150
Mass per unit area (g/m^2)	220	230	250
Air permeability, 100 Pa (m/s)	0,70	0,50	0,50
Class filter	Adsorption	Adsorption	Adsorption
Diameter (cm)	22	22	22
Thickness, mm	10	15	15
Maximum breakthrough strength (daN/5cm) - dry	13	15	15
Maximum breakthrough strength (daN/5cm), - wet	9	10	12
Operating temperature (^{o}C)	-30 to +140	-30 to+140	-30 to+130

Resistance to: - diluted acids - diluted alkalis - oxidizers - organic solvents	very good good very good very good	very good good very good very good	good good good good
Regeneration (permitted three times)	squeezing	squeezing	squeezing

It is easy to modify the thickness and weight of the barrier, depending on the supplied amount of fiber material, but when there is a change in productivity (Table 3.).

Calculations to determine the effectiveness:

Adsorption using one layer - balance:

$m.a_{max} + Q.C_s = Q.C_n$, where

$m = Q(C_n – C_s)/K_a.C_s$; $C = Q.C_n/(Q + K_a.m) = C_s$

m – mass of the sorbent

Q – amount of wastewater

C_n – sorbate concentration in the treated wastewater

C_0 - initial concentration of water pollution

C_s - amount of the retained oil products on the sorbent

K_a- coefficient dependent on the adsorbent

$m.a + Q.C_s = Q.C_0$, where

$m = Q(C_0 – C_s)/K_a.C_s$; $C = Q.C_0/(Q + K_a.m) = C_s$

Adsorption using n layers:

$m_n = [(C_0/C_n – 1)^{1/n}]Q/ K_a$; $C_n = [Q/(Q + K_a.m_n)]^n.C_0$;

$m_n = n. m$

m_n – mass of the sorbent of the n layer;

C_n - concentration of the sorbate in wastewater.

Table 2. Effectiveness of three variants of the proposed filter media FMNW

Productivity per day, l/m^2	Selectivity, %	Average pore diameter, Å	Porosity, %
600	80	<50	75
350	90	<50	75
250	95	<50	75
150	97.5	<50	75

The change in the bulk density of the material, which can easily be realized, leads to a change of the filter characteristics, efficiency and permeability of the filter media and can be set depending on the requirements of a given workplace [3].

Conclusions

Sorption barrier is created from waste fibers from the textile industry and has proven its effectiveness in the treatment of wastewater from oil and petroleum products.

The developed filter body can be installed in systems at the outlet of the water purification systems in petrol stations and in enterprises of oil industry.

By changing the number of layers used as a filler, water purification from oil products with different dispersity is implemented in a wide range of concentrations.

The total recovery rate can reach 98%.

Acknowledgements

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