TEXTILE PRODUCTS USED IN FILTER PRODUCTION AND THEIR USAGE AREAS

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ABSTRACT

The necessity of protecting environment is becoming more and more important every passing day. The waste of textile firms causes pollution in water, air and soil. Sources are polluted especially with the chemicals emitted into the air or water. In this respect, the emitting of such textile waste into the environment with minimum harm has become more of an issue. For this reason, it is important to filter wastes before they are emitted.

In general terms, filtration can be defined as the process of filtering something. With this process, it is aimed to increase the purity of the filtered material. In textile industry, filters are generally used in the filtering of solid-gas or solid-fluid mixtures.

This study examines general features of filtration, air and water filtration, types of filtration, raw materials used in the production of filters as well as the usage areas of filters, benefiting from literature review method. According to the findings, it is possible to conclude that nonwoven surfaces are the most suitable and common filter types used in textile filters.

Keywords: Filters, Nonwoven, Water Filtration.

ÖZET

Çevrenin korunması ve tahrip edilmemesi gerekliliği her geçen gün daha da önem kazanmaktadır. Tekstil firmalarının atıkları, toprak su ve havada kirliliğe neden olmaktadır. Özellikle havaya ve suya saldıkları kimyasallar ile kaynaklar kirletilmektedir. Tekstil atıklarının çevreye salınırken en az tahribatı verecek şekilde salınması oldukça önem arz etmektedir. Bu nedenle bu atıklar çevreye salınmadan önce filtre edilmelidir.

Filtrasyonu genel manada ayırma işlemi olarak tanımlayabiliriz. Bu işlemin amacı, filtrelenen malzemenin saflığını arttırmaktır. Tekstil endüstrisinde filtreler genel olarak, katı-gaz veya katı-sıvı karışımların ayrıştırılmasında kullanılır.

Bu çalışmada; filtrasyonun genel özellikleri, hava ve su filtrasyonu, filtre çeşitleri, filtre yapımında kullanılan hammaddeler ve kullanım alanları literatür tarama yöntemiyle incelenmiştir. Elde edilen veriler sonucunda, dokusuz yüzeyler tekstil filtrelerinde en elverişli ve en sık kullanılan filtre çeşididir.

Anahtar Kelimeler: Filtreler, Dokusuz Yüzey, Su Filtrasyonu.

1. INTRODUCTION

Pollutants such as small particles can be found in natural or processed fluid. A filter is basically a mechanism used in order to separate a substance from another. In order to separate solid substances in fluid or water, it is necessary to add a medium of filter through which only fluid can pass [1]. Textile filter materials are often used in order to separate solid-gas or solid-fluid mixtures. Separating solid particles from fluid or gas through textile structures is a process that increases the purity of products for various industrial processes, enables energy saving, increases the efficiency of the process, enables the recovery of valuable materials, ensures a general improvement in pollution and environmental factors. Air purifiers, personal protective equipment (medical mask, apron and gas masks), oil and fuel filters, structures used in waste water purifying and chemical dyestuff recycling facilities including textile firms are among the usage areas of the textile filters [2].

There are four main filtration mechanisms in filtration operation. These are surface straining, depth straining, depth filtration) and cake filtration. The main purpose of producing filter is to increase the volume and air penetration of the filter to the maximum level while decreasing the size of pores to the minimum. However, it is not possible to experience these two scenarios at the same time. For this reason, the usage purpose and the place are important while selecting a filter [3].

Filters can be classified as non-textile-based ones such as foam, water, membrane and sand or textile-based ones such as woven and nonwoven surfaces [4]. In this study, filters obtained from textile products were examined.

2. TEXTİLE PRODUCTS USED İN AİR FİLTRATİON

Because of today's quick industrialization and population increase, the pollutants in the air change and their concentration increase. In addition, people are more exposed to closed places compared to the past. For this reason, air filtration is becoming more important. This filtration is used in order to separate solid particles from air or other gases. These particles include gravitational, impaction, interception, diffusion, and electrostatic methods. In accordance with the sizes of particles, air filters are categorized as roughing, fine and fragile filters. Roughing and fine filters are used in non-fragile areas such as air-conditioning, automobile cabin and motor filters. On the other hand, fragile nonwoven filters are generally composed of nano-fibers within the range of 40-1000 nm, which are produced by means of wet laid or electrospinning method and used to catch very tiny particles. These filters are used in fragile areas and processes such as surgery room, microchip production facilities, nuclear firms and vacuum cleaners [5], [6].

Nonwoven surface filters, one of textile-based filters, is taking huge interest because of their structures. Bulky structures of the nonwoven surfaces used in dry air filters increase the filtering probability of particles. The high amount of filtered particles implies higher filter efficiency. In order to separate thin dust particles from gas stream, fabric filters are commonly used [4], [7].

The accumulation caused by substances that are retained on the surface of dry air filters is called filter cake. This cake layer should be removed from the filter. If this layer is not removed properly, non-homogenous distribution occur in the filter and it becomes exposed to different charges. There are two effects of filter cakes: Firstly, it increases tolerance against cake flow and hence causes decrease in flow rate. Secondly, the cake that has been formed enables filtration, which is called cake filtration [7], [8].

3. TEXTILE PRODUCTS USED IN FLUID FILTRATION

Filter selection is important in the filtration of fluids and the following issues are considered while selecting a filter: thermal and chemical conditions, filtration requirements, filtration equipment considerations, cost [5].

In this filtration, particles of different sizes are filtered. These particle sizes are generally categorized into four groups and these include filtration types, microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

Particle sizes, material types and filtration types of particles in fluids are given in Table 1 [9].

Table 1. Particle sizes, material types and filtration types in fluid filtration

Particle Types	Filtered Material Types	Filtration Types
0,1 - 5 µm	Dye pigment, asbestos, mud, cigarette smoke, bacteria, latex	Microfiltration
20 nm – 0,1 µm	Virus, gelatine, black carbon, albumin protein, cigarette smoke	Ultrafiltration
1 – 10 nm	Plant poison, insect poison, synthetic dye, sugar, salt solution	Nanofiltration
0,1 - 1 nm	Atomic diameter, salt solution, metal ion	Reverse Osmosis

As in all membrane processes, increase in accumulation on membrane surface results in decrease in flow speed. This accumulation known as concentration polarization causes the membrane to get dirty [10].

A significant part of fluid filtration structures are produced from nonwoven surfaces. Most of these filters fulfil separation through cake filtration method that is formed with the accumulation of impurities on the surface. Wastewater treatment and filtering of heavy metal ion from water, food filtration (wine, oil etc.), medical filtration (kidney and blood, medicine production etc.), and swimming pools are the most common areas where fluid filtration is made [2].

4. FIBRE TYPES USED IN FILTRATION

Most of textile fibres are produced with synthetic fibres. Fibres types and structures of filtration materials are closely related to filtration effect. As the diameter of fibre decreases, the quality of filtration increases, but with some decrease in tensile strength. In addition, the pressure to be applied and hence the energy expenses will increase. Cross-section shape of the fibre is one of the features that affect the structure of the fibre. In other words, cross-section shape of natural and synthetic fibres used in the structure of filtration affects filtration efficiency by changing the surface area. Non-round fibre types such as cross-section or ribbon shaped ones decreases flow speed. It is higher in round cross-section fibres. For this reason, the reason and place of filtration is important while choosing a filter. In addition, such parameters as fibre's length, density, linear density, rugosity, endurance against chemicals affect its performance [3], [1].

4.1. Monofilaments

Monofilament refers to a single fibre's infinite length. Monofilaments' diameter ranges between 30 µm and 3 mm. While small-diameter monofilaments are generally used in fibre presses, pressure leaf filters, rotary vacuum discs and rotary vacuum drum filters, bigger ones are preferred in roughing filters. These fibres are often produced in cross-section shapes; they may be flat or round in some special applications (Figure 1,a) [5], [1].

Monofilament fabrics are used in chemical and food processing industries, industrial hydraulic, medical and automotive industries in medical, clean room and aviation applications for practices that require high-level cleanliness. These fabrics are obtained from nylon, polypropylene and fluorocarbon raw materials. As pores of the fabrics are relatively bigger than those made from staple and multifilament fibres, it is easier to clean cake forms [1], [11].

4.2. Multifilaments

Multifilament fabrics have higher endurance and flexibility. They have smaller pore sizes than those of monofilaments (Figure 1,b). In addition, flexibility of monofilaments is higher than that of multifilaments, which provides advantage when filtering fine particles (<1 µm) at high pressure (100 bar) [5].

4.3. Staple-Fibre Yarns

Staple-fibre yarns are obtained from natural fibres and synthetic fibres. First cut linters obtained from raw cotton are used as raw materials in the production of needled felt filter. On the other hand, first and second cut linters are used in wet laid nonwoven filter production [3].

Manila hemp fibre (Abaca) is a kind of nonwoven filter that is generally produced with wet laid nonwoven technology. These fibres are used in fluid filtration areas such as tea bags, coffee filters, industrial filters and vacuum bags. In addition, they are used as reinforced materials in medical gas masks and micro-air filters [3].

Wool fibres have unique properties for filtering applications (Figure 1,c). Filters made from wool are used in air filter applications such as baghouse filtration, residential filters, vacuum cleaner bags and industrial respiration devices. Fluid filtration, on the other hand, is used mostly in aquarium [3].

Diameters of wood pulp fibers are lower than 1 μm and they are often used in the production of wetlaid nonwoven filter. These fibres are environment friendly and provide higher filtration efficiency [11].

Filters can be produced by using both natural wood pulp fibres and staple viscose fibres through wet laid nonwoven production method. The length of these fibres range between 1-12 mm. The cross-section of these fibres can be realized in the forms of traditional round, flat and grooved, trilobal, C-shaped, and V-shaped, hollow and cross-shaped [11].

Glass, metallic, ceramic and high performance fibres are fibres that fulfil filtration function in dangerous places such as high tension, high temperature and abrasive substance or chemicals [11], [12].

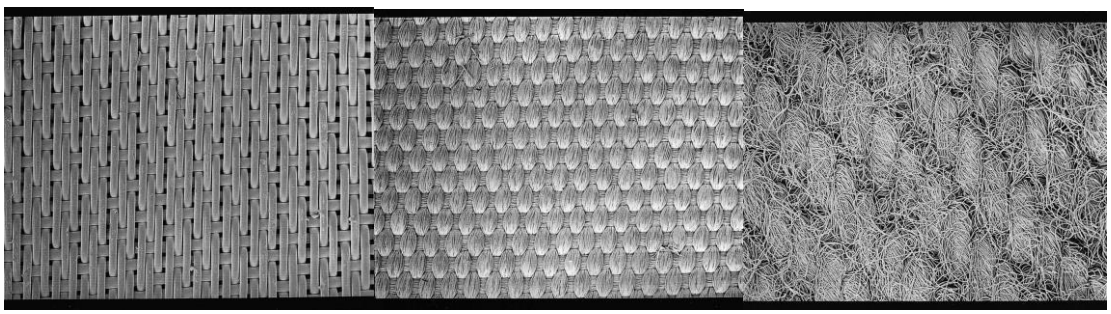

Figure 1. a. Monofilament satin weave fabric, b. Multifilament weave fabric, c. woollen ring-spun fabric [5].

5. FABRIC TYPES USED IN FILTRATION

Three types fabrics are used in filtration process. These include woven fabrics, nonwoven surfaces and knit fabrics.

5.1. Woven fabrics

Weaving design is based on the place where filters will be used to a great extent. In industry, there are three basic types of weaving: plain, twill and satin weaves. The simplest one is plain weave that has the smallest pore sizes in the fabric. Plain weaves catch the particles very quickly and provide the best filtration. However, they are not preferred much because of their high pressure fall.

Twill weaves, on the other hand, (such as 2/1, 2/2 or 3/1) are more flexible compared top lain weaves woven with the same yarns and more suitable for filters. They provide better flow speed than plain weaves, but do not hold as many particles as plain ones.

Satin weaves enable more flexibility, endurance, superior cake emission and surface. However, their particle catching abilities are very low. Briefly, the type of weaving design affects filters' features to a great extent. As the closeness of the weave refers to the distance among the yarns, it affects particle holding.

In order to improve stability, surface features and permeability of the fabric types, they are subject to various finish processes such as calendaring, raising and singeing [1], [5].

5.2. Nonwoven

In filtration, three dimensional nonwoven filters are ideal because of their big surface and multi-pore structures. Nonwoven fabrics are produced within the framework of two main

principles: They include dry formed and wet laid methods. While fibre webs are produced in air in dry formed methods, they are produced in water in wet laid methods [3], [8].

Nonwoven fabrics have been used both in gas and fluid filtration for a long time. Nonwoven surfaces are commonly used as a filtration environment and have the features of perfect filtration efficiency and chemical endurance. However, abrasion endurance of these fabrics falls behind the values required by the filters. These disadvantages of nonwoven filters can be improved and optimized with suitable after treatments. Nonwoven fabrics are filters that are most frequently used in dust collection operations and provide quicker and more efficient filtration compared to woven fabrics (Figure 2) [1], [5].

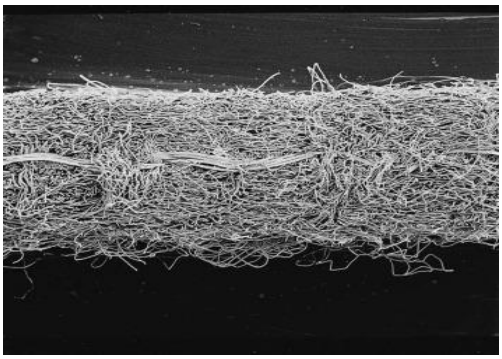

Figure 2. Scanning electron micrograph showing cross-section of needle felt [5].

Fibre diameter is one of the significant parameters in filtration efficiency. With the decrease of fibre diameter in nonwoven fabrics, fibration efficiency will increase. High efficiency air filtration of nanoparticles is generally obtained by using nanofibers having fibre diameter less than 0.5 µm'dan (500 nm) [3].

Cross-section shape of the fibers generally used in forming a nonwoven surface is round. However, Dupont'un Nomex® fibers of peanut shape and Lenzing'in P84® fibers of multilobal shapes are different. As non-woven filters produced with these fibers have higher surface area, they have the capacity to hold higher amount of particles [5].

Sakthivel et. al. [13], examined air filter features of nonwoven fabrics produced with needle method by mixing recycled cotton (60%) and polyester (40%). Air permeability, mechanical features, pore size distribution and filtration efficiency of these fabrics were investigated. Applying calendaring process to these fabrics, filtration efficiency was observed.

It was concluded that filtration efficiency increases in calendared fabrics. Anandjiwala and Boguslavsky carried out a similar study by using waste flax fibres and concluded that calendaring process affects air filtration positively [14].

5.3. Knitted Fabric

Weft knitted textiles are used as alternatives to woven and nonwoven fabrics. In a study, it was shown that the use of single jerseys in dust filters could be an alternative to woven and nonwoven fabrics in physical and economic terms [5], [15].

6. CONCLUSION

The filters that are obtained by means of textile production methods have wide usage areas and significant place in the technical textile market.

Nonwoven surfaces are textile surfaces that are most frequently used in fluid or gas filtration. The reasons why they are frequently used include their good filtration, cheapness and production easiness. Two points are taken into consideration in filter production: filter size and air permeability, and pore size. As pore size increases, permeability decreases. For this reason, usage area and place is important in filter selection.

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