

Progress in Fiber Filtration Technology

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Abstract. This paper introduces the research progress of fiber filtration technology in water treatment, mainly introduces several different types of fiber filters and their roles in the water treatment process. By searching and analyzing in the patent database, it analyzes the trends of domestic and foreign applications, the geographical distribution of related technology patents, the distribution and types of domestic and foreign main applicants, and the development of related technology patents. The technical application of fiber filtration provides a reference.

Keywords: Fiber Filtration; Water Treatment; Backwash; Filter Media.

1. Introduction

An overview of the technical application of fiber filtration in the water treatment process.

The main research purposes of the water treatment filtration process include increasing the filtration rate, increasing the interception capacity, improving the filtration efficiency and improving the backwashing efficiency. Due to the limitation of particle size of granular filter material, the above problems cannot be effectively solved. Fiber filter material has entered people's field of vision with the advantages of small diameter, large specific surface area, small water flow resistance and high filtration accuracy, and has become an important material to replace granular filter material. In recent years, fiber filtration technology has developed rapidly and has been widely used in water treatment.

The diameter of the fiber filter material is in the order of microns and has a large specific surface area, which enables the filter material to absorb and retain more suspended solids and obtain a larger retention rate; at the same time, the fiber material is soft in texture and low in density. The layer has a large porosity and a small resistance, which makes the filtration rate in the filter very large; the core of the fiber filtration technology is the two processes of compression filtration and loosening backwashing. During backwashing, the fiber filter material is not easy to occur. The strength control is better than the granular filter material filter tank, which makes the backwashing more thorough. Based on the above characteristics, fiber filtration technology has been rapidly developed and applied in recent years. Here, several common fiber filters are introduced.

1.1 Comet Fiber Filter

The comet fiber filter material with asymmetric configuration is used as the filter layer. There are three types of comet fiber filter materials: single-tail type, double-tail type and multi-tail type. One end of the single-tailed comet fiber filter material is a loose fiber tow, also known as "comet tail", and the other end is a denser "comer core". During filtration, the lower layer of the fiber filter material has a high degree of compaction and a small porosity, forming an approximately ideal filter layer with a gradually decreasing porosity along the filtration direction, ensuring the filtration accuracy. At the same time, the compaction effect of "wisdom core" makes the cross-section porosity distribution of the filter bed uniform. During backwashing, due to the high density of the "wisdom core", the "wisdom tail" fiber bundles will generate a strong drag force under the action of air-water backwashing, and the collision between the fiber bundles will increase the friction and strengthen the backwashing. Effect.

1.2 Fiber Ball Filter

The fiber ball is a fiber filter material made of fiber filaments. The fiber ball is used as the filter material to form the bed layer. The fiber ball is loose so that the fiber filaments between the fiber

balls in the bed can be interspersed with each other. At this time, the fiber ball bed The layers form a whole. During the filtration process, the voids of the filter layer gradually become smaller along the direction of water flow, forming an approximate ideal filter layer, which has the characteristics of fast filtration speed, large capacity for intercepting dirt, good filtration effect and easy cleaning.

1.3 Capsule Extrusion Fiber Filter

The soft capsule is used to extrude fibers to form a filter layer, the fiber bundle is axially installed in the filter, and a weight is placed on the lower part. When using, fill the capsule with water first, and the long fiber bundles will be squeezed by the capsule in the axial direction. Through this operation, the porosity and filter pore size of the fiber layer will be gradually distributed from large to small, forming an approximate ideal filter layer. During backwashing, the liquid in the capsule needs to be discharged to loosen the fiber bundle filter layer, so that the subsequent air-water combined backwashing can achieve better results. The soft capsule needs to be filled with water before filtration, and needs to be discharged before rinsing. Through the flushing and drainage process, the problem of fiber compaction during filtration and the problem of fiber loss during backwashing can be effectively solved. However, this kind of filter has the following problems: firstly, the manufacturing cost is high; secondly, the soft capsule has a low lifespan and is easily damaged; thirdly, the device design is complicated.

1.4 Pressure Plate Fiber Filter

The long fiber bundles are installed on the water outlet orifice plate, and then the other end of the long fiber bundles is installed on the pressure plate, and the pressure plate has dense pores. In order to make the density of the filter reach the density of water, the pressure plate is generally made into a double-layer structure. At the beginning of operation, in the state of sewage flow, there is a certain pressure on the pressure plate, which will bend the long fiber bundle at the end connected to the pressure plate, increase the head resistance, and cause downward pressure. The lower part of the lower fiber bundle is squeezed. Once the position of the pressure plate pressing down exceeds the setting of the limit device, the pressure plate can no longer be pressed down. During pressure backwashing, since the filter density and water flow density are almost the same, the pressure plate will float under the action of the reverse force, the fiber layer will be stretched, and the backwashing effect will be improved.

1.5 Self-pressing Fiber Filter

The compression of the fiber layer is achieved only by the force of the water flow. Due to the easy bending properties of fibers, when a suitable structure is adopted, under the action of hydraulic force, the fiber filter layer will form an approximate ideal filter layer with a pore size from large to small along the filtering direction. The advantages of this filter are: simple manufacture, high filtration capacity, and relatively easy maintenance. Due to the large resistance of the water outlet, it has a better compaction effect on the filter layer, can better adhere to the solid suspended matter, and has better filtration efficiency and higher filtration speed.

2. Analysis of Patent Application Situation of Fiber Filtration Technology

In order to fully understand the application of fiber filtration technology-related patents, including domestic and foreign application trends and the distribution of major applicants at home and abroad, a search was conducted in CNABS and VEN databases. The classification number involved in the search is B01D, and the search keywords are mainly There are fibers, filtration, compression, compaction, recoil, water resistance head, fiber, filter, etc., which are searched by a combination of classification numbers and search keywords. The search date ends on December 31, 2020. A detailed analysis of the patent applications involving related technologies is now carried out.

2.1 Global and Domestic Patent Application Volume Trend Analysis

In order to facilitate the systematic analysis of the number of patent applications for fiber filtration technology, the change trend of patent applications was analyzed with 2003-2020 as the time interval. Figure 1 is a trend chart of global patent applications; Figure 2 is a trend chart of patent applications in various countries.

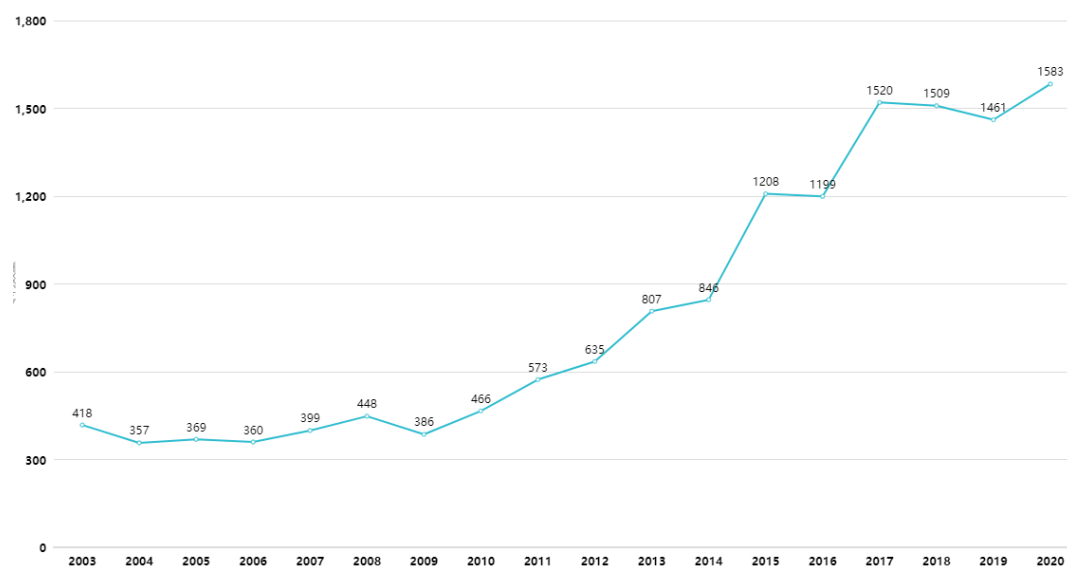


Figure 1. Trend of global patent application volume

As can be seen from Figure 1, from 2003 to 2020, the number of patent applications for fiber filtration technology in the world has been fluctuating within a certain range, but it has generally shown an upward trend. The number of applications has stabilized at around 400. Since then, there has been an explosive growth in global applications. As of 2017, the annual patent application volume has increased by 226% compared with 2010, and the annual number of applications has reached 1,500 and continues to this day. The steady growth of global patent applications in the past ten years shows that people are paying more and more attention to the fields of environmental protection and water purification.

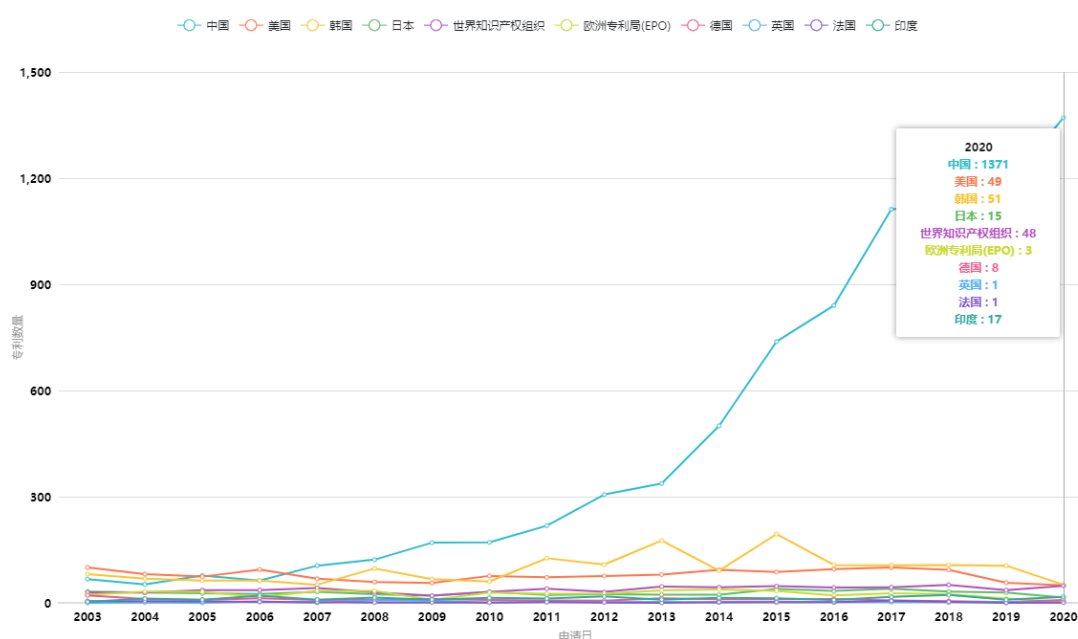


Figure 2. Trend of patent application volume by country

Figure 2 shows the trend of fiber filtration-related patent filings by country from 2003 to 2020. It can be clearly seen that my country's patent application trend in the field of air purifiers is basically consistent with the global application trend, which is the main driving force for the rapid development of fiber filtration technology in the world. As can be seen from the figure, before 2006, South Korea and the United States had dominant positions in fiber filtration technology. Afterwards, the number of applications in this field in my country increased rapidly, surpassing South Korea and the United States to become the largest country in the number of applications, and accounting for the largest number of applications in the world. The percentage of the number of applications has been increasing year by year, showing a strong momentum of development. It can be seen that with the continuous improvement of people's living quality in my country in recent years, people's urgent needs for environmental protection and water purification have promoted the vigorous development of relevant patented technologies in my country. On the other hand, the large investment of funds has stimulated the application of patents in my country.

2.2 Geographical Distribution of Global Patent Applications

In order to analyze the proportion of each country in the patent application volume of fiber filtration technology, the patent application volume of each country is now drawn into a pie chart. Figure 3 is a geographical distribution map of patent applications.

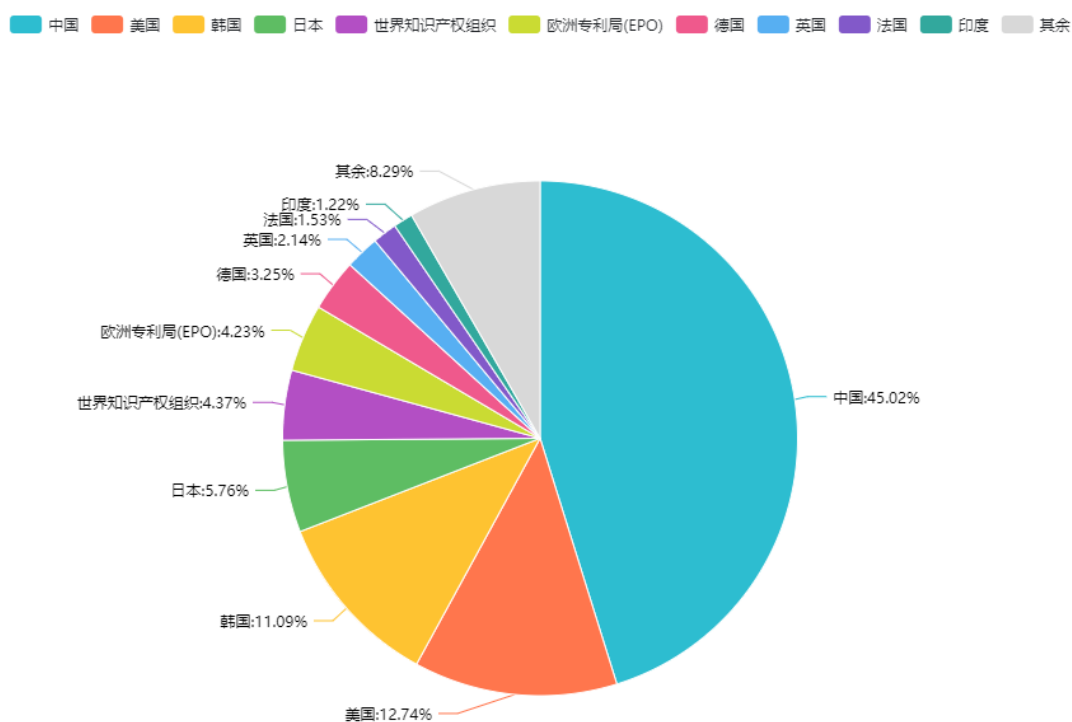


Figure 3. Geographical distribution of patent applications

The data on the geographical distribution of patent applications in Figure 3 shows that although China's fiber filtration application technology started late, it has developed rapidly in the later period. In the past 20 years, the number of patent applications has been the most, ranking first, followed by the United States, South Korea and Japan. The top four countries accounted for more than 70% of the total number of patent applications. It can be seen that the research and development and innovation of the leading countries and enterprises in the field of fiber filtration technology are dominant, indicating that this technology has certain technical barriers in traditional developed countries, and the number of applications in my country can account for nearly half of the total number of applications in the world. , and increase year by year, indicating that my country attaches great importance to high-performance filters and water treatment technology. The reason for this phenomenon may be that with the development of people's economic level, people begin to pursue

high-quality and high-quality life. With the improvement of people's health awareness, people put forward higher requirements for environmental protection and water purification, and the rise of fiber filtration technology is in the background of this era, and has received extensive support in terms of policy, market, technology, etc. Innovation abounds.

2.3 Global and Domestic Main Applicant Distribution

In order to better understand the development of fiber filtration application patent technology, according to the distribution of main applicants and the types of main applicants, the distribution of applicants in related technology patent applications is studied, and the global and domestic main applicants are now counted separately. Analyzed and plotted the top ten applicants for patent applications in Figure 4.

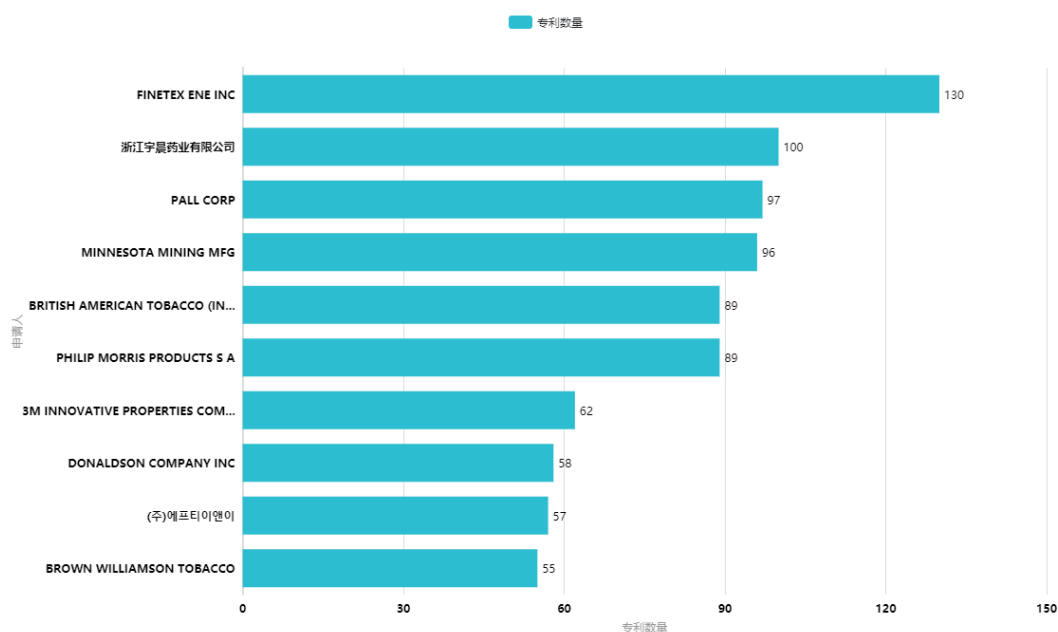


Figure 4. Distribution of major applicants worldwide

As can be seen from Figure 4, the top three patents in the world for the application of electric field in liquid-liquid heterogeneous separation are FINETEX ENE INC (Korea Fantes), Zhejiang Yuchen Pharmaceutical Co., Ltd., PALL CORP (United States). Pall, of which Fantes and Pall filter elements are both old and classic filter element brands in the field of filtration. They have been operating in the field of filtration for many years and have a solid foundation. The only Chinese company on the list, Zhejiang Yuchen Pharmaceutical, has a strong reputation in the field of fiber filtration. The number of applications is as high as 100, and it has developed rapidly in recent years. It can be seen that the top ten main applicants are still mainly concentrated in South Korea and the United States, and there is a certain degree of technological exclusivity. Although the number of applications in my country is high, the applications are relatively scattered, and they are still in their infancy. There is a broad space for transformation and innovation.

Figure 5 shows the composition of domestic application types for fiber filtration application technology patents. It can be seen from the figure that related technology patent applications are mainly in enterprises, accounting for 71%, while individual applications can also account for about 20%. It shows that the market has a strong demand for this technology, and demand-oriented companies have invested a lot of money and talents in R&D in related technologies. Although there is still a gap with the level of the world's leading companies and products, the R&D threshold is low and the participation is extensive. Enterprises, individuals, and universities can all become the main force in fiber filtration R&D and innovation.

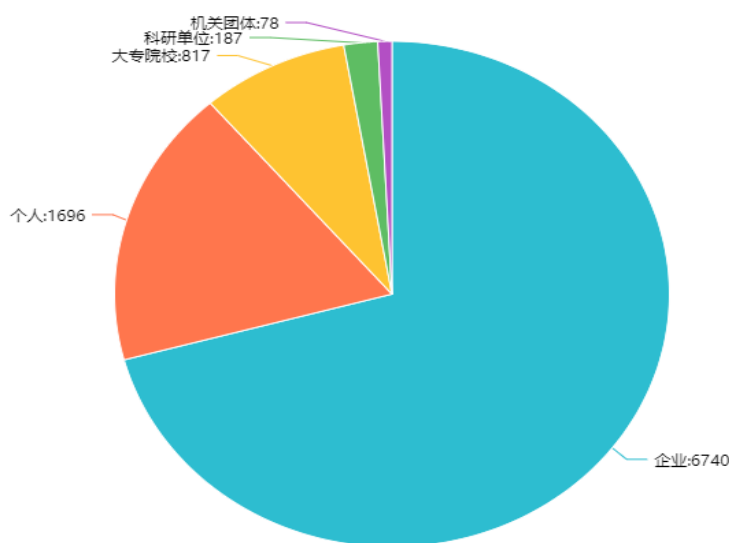


Figure 5. Types of domestic applicants

three. Development and Analysis of Fiber Filtration Technology Patents

3. Development Analysis of Fiber Filtration Technology Patent

Combined with the above analysis of the application situation, our country's patents in the field of fiber filtration show a trend of rapid growth, and by 2020, my country's patent applications will top the list. However, because my country started later than other countries, it needs to be Discover technical hotspots in time, keep up with technological development, and at the same time be able to achieve innovation on this basis, and pay attention to the layout of patent applications, thereby enhancing the status of my country's fiber filtration technology. The development of the patent application of fiber filter is also divided into five directions according to its filter material and filter structure: comet fiber filter, fiber ball filter, capsule extrusion fiber filter, pressure plate fiber filter, self-pressure type fiber filter Fiber filters are briefly analyzed from the development of the above-mentioned aspects.

3.1 Comet Fiber Filter

CN200942314Y discloses a comet-type fiber filter element composed of several comet-type fiber filters, which is characterized in that a plurality of comet-type fiber filters are connected in series with ropes to form a comet-type fiber filter element. The main purpose is to make The degree of compaction of the filter layer of the comet-type fiber filter can be controlled and adjusted, and the filter material is not easily lost during backwashing.

CN110947212A discloses a reverse flow fiber filter, including a tank body and a communication pipe; a partition plate is arranged inside the tank body, and the partition plate divides the inside of the tank body into a filter cavity and a water inlet cavity arranged up and down, and the tank body is provided with a filter cavity and an inlet cavity. The water inlet pipe communicated with the water cavity and the water outlet pipe communicated with the filter cavity; a plurality of filter elements are arranged in the filter cavity, the bottom end of the filter element is installed on the partition, the filter element is provided with a water conduit, and the water conduit passes through the filter element, the partition plate and the inlet. The water cavity is connected, the surface of the aqueduct is distributed with water holes, the filter element is provided with a layer of sand and gravel stacked around the aqueduct, and the sand and gravel layer and the inner wall of the filter element are filled with comet-type fiber filter material; one end of the connecting pipe is provided with an exhaust gas The other end of the valve extends into the filter cavity, and the communication pipe communicates with the

communication ports at the top of the filter element through a plurality of connection pipes respectively. The invention adopts bottom water inlet and top water outlet, and uses a filter element with spherical structure, which can be filled with low-density comet-type fiber filter material, and the filter material can quickly form a filter bed in the filter element with high filtering accuracy.

CN211561970U discloses a compact fiber filter, comprising a tank body, a plurality of water inlet pipes and water outlet pipes; a cylinder body is arranged inside the tank body, the central axis of the cylinder body is arranged vertically and the cylinder body is installed at the bottom of the tank body, and the cylinder body A plurality of filter elements are arranged inside, and a fiber filter body is arranged inside the filter element; one end of the plurality of water inlet pipes extends into the tank body and is respectively connected with the inside of the plurality of filter elements; the water outlet pipe extends into the tank body and communicates with the inside of the cylinder body. The utility model introduces the raw water to be filtered into the plurality of filter elements through a plurality of water inlet pipes respectively. The raw water is filtered by the fiber filter body and then enters the inside of the cylinder body and is discharged from the water outlet pipe. The structure is simple, the use is convenient, the filtering effect is good, and the washing is thorough.

CN210331788U discloses a comet-type fiber filter, which relates to the technical field of comet-type fiber filters. The inner part of the comet-type fiber filter housing is equipped with a cross-sectional uniform mixing device main body, and the bottom end of the cross-sectional uniform mixing device main body is installed A second conveying pipeline is provided, the other end of the second conveying pipeline is provided with a backwash water inlet and a water outlet, and a first remote differential pressure gauge is installed between the backwash water inlet and the water outlet, and the first remote pressure differential gauge is installed. One side of the two conveying pipes is provided with a positive outlet, one side of the main body of the cross-sectional mixing uniform device is provided with an air inlet pipe, and the other end of the air inlet pipe is provided with a backwash air inlet. The invention solves the problems of low filtration efficiency and backwashing efficiency of the existing fiber filter, which easily leads to low suspended solids removal rate and unstable filtration treatment water quality.

3.2 Fiber Ball Filter

CN213049543U discloses a fiber filter for sewage treatment system, comprising a tank body, the top and bottom ends of the tank body are respectively provided with a water inlet and a water outlet, and an upper splint and a lower splint are fixedly installed in the tank body. The space is filled with a plurality of fiber balls, and the upper and lower plywood are both provided with through holes for fluid to pass through; the lower plywood is provided with an air intake pipe inserted from the outside of the tank, and an air pump is connected to the outer end of the air intake pipe. The fiber filter of the utility model uses the fiber ball as the filter medium, and utilizes the change of the pressure and direction of the filtered water flow and the cleaning water flow, so that the fibers can be automatically compressed during filtration and automatically loosened during cleaning, thereby solving the problem of difficulty in cleaning in the past.

KR101789429B1 discloses a multi-stage fiber filtration device capable of selectively filtering raw water according to the turbidity of raw water, wherein a first filtration mode in which raw water passes through a fiber ball medium and a second filtration mode in which raw water passes through a fiber yarn medium can be selectively operated. Filtration mode, or a third filtration mode in which raw water passes through both the fiber yarn media and the fiber ball media. With this device, the use of each fiber filter medium can be reduced and the replacement cycle is long, so that maintenance costs can be reduced. In addition, due to the change of the filtration mode, the amount of backwash water can be reduced, so that the burden of wastewater treatment in the backwash water treatment device, which is a subsequent process, can be reduced, and the consumption of drugs and the amount of sludge can be reduced.

US2015182884A1 discloses a hybrid fiber filter device, which includes a housing, a filter, a first filter layer and a second filter layer. The housing has an upper case and a lower case coupled to the

upper case. The filter is installed in the upper housing in the longitudinal direction. The first filter layer includes a plurality of fiber filters fixed between the upper fixing unit and the lower fixing unit and surrounding the outer peripheral surface of the filters. The second filter layer includes a plurality of fiber ball filters disposed within the lower housing. The raw water introduced into the upper shell through the raw water inflow pipe passes through the first filter layer, flows into the filter, drips down from the inside of the filter, is introduced into the lower shell, passes through the second filter layer, and is then discharged through the filtered water discharge pipe. The hybrid fiber filter device is formed in a duplex type in order to reduce the space it occupies. Raw water can be filtered through the upper fiber filter and the lower fiber ball filter to enhance the filtration performance.

3.3 Capsule Extrusion Fiber Filter

CN101249337A discloses a twisted fiber filter, comprising a shell, a fiber bundle inside the shell, and a fiber bundle support body, a water inlet pipe and a water outlet pipe are opened on the shell, and at least one porous filter cartridge is installed inside the shell, each One end of each porous filter cartridge is connected with a transmission shaft, which penetrates out of the casing and is connected with a torsion driving device through a transmission mechanism. The outer surfaces of the transmission shaft and the outlet end of the porous filter cartridge are each surrounded by a circle of fiber bundle supports. The fiber bundle supports include wire hanging rods that are evenly arranged in a horizontal radial shape. The fiber bundle filter layer on the outer wall of the filter cartridge. The filtering area of the invention is the outer surface area of the porous filter cartridge, which gets rid of the limitation of the diameter on the filtering area, can greatly improve the filtering speed and reduce the floor space.

CN206081789U discloses a fiber filter with adjustable fiber density. The adjustable fiber filter mainly includes a filter cylinder body, a floating orifice plate and a fixed orifice plate are arranged in the filter cylinder body, and a filter material density adjustment device, and the filter material density adjustment device includes a chain and a lock hole, The floating orifice plate and the fixed orifice plate are provided with upper and lower corresponding lock holes, and a chain connects the floating orifice plate and the fixed orifice plate through the lock holes. By adjusting the length of the chain, the moving distance of the floating orifice plate can be adjusted, the floating orifice plate squeezes the fiber filter element, and the water in the fiber filter element is squeezed out, which improves the cleaning speed of the filter material, saves the water consumption for flushing, and saves flushing energy.

TW201943446A discloses a filter device to solve the problem that the existing filter device cannot adjust the pore density of the filter element. Including: a base with a shaft tube, the shaft tube is combined with the base by a closed end, the other end of the shaft tube forms an open end, the open end has an opening, the shaft tube is connected with the open end at the open end There are a plurality of through holes between the closed ends, and each through hole penetrates the tube wall of the shaft tube; a filter element has a plurality of filter units, the filter element has a first end and a second end opposite, and the filter element is formed by the first end and the second end. The two ends are fixed on a surface of the base; and a cover plate has a through hole, the cover plate is ringed by the through hole on the outer surface of the shaft tube and can be rotated relative to the shaft tube, a surface of the cover plate combined with the first end of the filter element.

TW200528171A discloses an automatic cleaning type fiber rapid filter device, which includes a hollow filter cartridge, a first orifice plate, a second orifice plate, a plurality of fiber bundles, and a spin-lock unit. The filter cartridge includes a bottom wall with a water outlet hole, a surrounding wall extending upward from the periphery of the bottom wall, and a top wall provided on the top surface of the surrounding wall and having a water inlet hole. The first and second orifice plates are both disposed in the filter cartridge and adjacent to the water inlet hole and the water outlet hole, respectively. The first and second orifice plates respectively include a plate body and a plurality of guides passing through the plate body. Orifice. The fiber bundles are respectively connected between the first and second orifice plates. When backwashing is performed, the rotary switch unit can make

the first orifice plate rotate radially, and the fiber bundles are twisted and rubbed together with each other, so as to achieve the effect of accelerated regeneration of the fiber bundles.

3.4 Self-pressing Fiber Filter

CN2253242Y discloses a self-pressing fiber filter device, comprising a layer of two layers of fiber filter layers fixed to a container, a horizontal connection net is connected between the upper fiber filter layer and the lower fiber filter layer, and one end of the two layers of fiber filter layers A fixed grille fixedly connected with the container is arranged, and the other end is connected with a horizontal connection net. The fibrous filter layer has two types of arrangement in which the fiber bundles are arranged in the vertical direction or the fiber bundles are arranged in the horizontal direction. In the filter layer where the fiber bundles are installed horizontally, vertical connecting nets with one end connecting with the fixed grid and the other end connecting with the horizontal connecting net are arranged at intervals. During filtration, the water head resistance is small, the filtration efficiency is high, the structure is simple, the failure is less, and the maintenance is easy.

CN2495354Y discloses a hydraulic self-pressing fiber filter, which comprises a container, a water inlet and a water outlet are arranged on the container, a gas distribution device, a perforated plate and a filter layer composed of fiber bundles are arranged in the container, and the filter layer fiber bundles are provided with a filter layer. One end is connected with the perforated plate fixed in the container, and the characteristic is that the other end of the fiber bundle of the filter layer is connected with the mesh member. When filtering, the filter has low resistance, no external force device is needed, and only the water head resistance of the water or aqueous solution flowing through the fiber bundle of the filter layer can filter the suspended matter impurities in the water or the aqueous solution, and has the advantages of simple structure and low cost. , high filtration efficiency, strong interception ability, low failure rate, long life, easy maintenance and so on.

CN2495355Y discloses a dual-flow self-pressure fiber filter, which belongs to a filter device for water and aqueous solutions. It includes a container, with water inlet and outlet on the container, water distribution, air distribution device, fixed orifice plate and a fiber filter layer composed of fiber bundles in the container. Water outlet, a water distribution device connected with the water inlet is arranged in the container, upper and lower fixed orifice plates are arranged in the container, a water outlet is arranged between the upper and lower fixed orifice plates, upper and lower fiber filter layers are arranged, and the upper fiber filter layer is arranged One end of the fiber bundle is connected with the upper fixed orifice plate, the other end is connected with the upper moving net, one end of the fiber bundle of the lower fiber filter layer is connected with the lower fixed orifice plate, and the other end is connected with the lower moving net. It has the advantages of high filtration efficiency, large equipment output, easy cleaning, and low compressed air consumption.

4. Conclusion

In recent years, through the continuous efforts of researchers, fiber filtration has been widely used in industrial sewage, municipal sewage, drinking water and seawater desalination pretreatment. Special pollutants cannot achieve a good removal effect, so researchers focus on modifying the fiber filter material with other substances, which will further expand the processing range of the fiber filter material and get a wider range of applications. In general, fiber filtration technology is an economical and effective filtration technology with the advantages of large specific surface area, fast filtration speed, high filtration accuracy, and convenient cleaning. In addition, fiber filtration technology also has the advantages of low self-consumption, small footprint, and investment saving, which makes it show a good application prospect in the field of water treatment. However, the current fiber filter still has the problem of incomplete cleaning, which needs further research.

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