FILTRATION INDUSTRY -*An Overview*

Introduction

The term filtration, as applied to water treatment, refers to the removal of suspended solids from water. In most cases it is the last stage in the pre treatment of water for removal of undissolved impurities prior to treatment by Ion Exchange or by Reverse Osmosis . Coagulation, flocculation and clarification precede filtration.

Suspended solids are made of silica, clay, silt, oxides of iron or manganese and degraded organic matter. Suspended solids tend to clog equipment and impair the efficiency of downstream units like Ion Exchange or Reverse Osmosis. Removal of suspended solids is therefore the first step in water treatment.

Suspended solids also include very finely divided particles of colloidal dimensions (of size less than 1 micron. These particles result in haziness and make the water turbid. While large particles would settle down easily, the finely divided particles do not settle .Finely divided particles carry a negative charge on their surface and as like charges repel each other, the particles do not collide with each other and therefore do not settle.

There are at least three stages of treatment involved in removal of suspended solids including colloidal particles from water.

- Coagulation in which a coagulant like Alum is added to the water in a tank fitted with a high speed agitator with a retention time of 1-2 minutes.to allow the coagulant to mix with the entire volume of water. A coagulant like Alum neutralises the surface charge present on the particle and allows the particles to collide with each other and form a bigger particle. Alum reacts with the alkalinity present in water and forms a gelatinous precipitate aluminium hydroxide to which the particles get adhered.

- Flocculation in which a poly electrolyte is added in a flocculator fitted with a low speed agitator to provide the gentle agitation required for agglomeration of the flocs. Polyelectrolytes are water soluble high molecular weight long chain compounds based on Polyacrylamide and its derivatives and these are added to aid the coagulation process. They may include cationic or anionic groups. Charges on these polyelecrolytes serve two purposes; they provide means of adsorption onto the particle surfaces by electrostatic attraction and they cause the polymer molecule to extend and uncoil due to charge repulsion along the polymer chain.

The selection of the coagulant, flocculant and their dosages are best determined by Jar Tests.

- Clarification & settling in which the flocs are allowed to settle to the bottom of the clarifier to be collected and disposed off

- Clarified water would still contain a low level of suspended solids(upto10-15 mg/l) and will have a turbidity less than 2 Nephelometric Turbidity Unit(NTU).The process of filtration removes the residual suspended solids present in clarified water and also reduces the turbidity to less than 1 NTU.

Filtration for removal of suspended solids

Filters are also employed to remove the hardness salts that are precipitated when the process of softening of water by the lime or lime-soda process is used. Filters with special media are also used to remove iron and or manganese that may be present in some borewell waters.

Filters used in water treatment are either pressure or gravity filters depending upon the flow of water-Water is pumped through a pressure filter while water flows by gravity in a gravity filter .They employ granular media like sand, anthracite or activated carbon either alone or in combination as the filter media.

Granular Media filters

Granular media filters remove suspended solids that are visible to the naked eye-these are particles typically greater than20 micron in size.

Pressure Sand filters

A typical pressure sand filter consists of a pressure vessel-this could be either vertical or horizontal-fitted with a set of frontal pipe work and valves, graded sand supported by layers of graded under bed consisting of pebbles and silex, a top distributor to distribute the incoming water uniformly throughout the cross section of the filter, and an under drain system to collect filtered water.

Raw water flows down wards through the filter bed and as the suspended matter- which has usually been treated by addition of a coagulant like alum- is retained on the sand surface ands between the sand grains immediately below the surface. There is steady rise in the loss of head as the filtration process continues and the flow reduces once the pressure drop across the filter is excessive.

The filter is now taken out of service and cleaning of the filter is effected by flow reversal. To assist in cleaning the bed, the backwash operation is often preceded by air agitation through the under drain system. The process of air scouring agitates the sand with a scrubbing action, which loosens the intercepted particles. The filter is now ready to be put back into service.

Gravity Sand filters

Conventional Gravity Filters are units, which are used for filtering gravity flows of water, and which incorporate a nest of valves for the operation of the different functions of filtering, backwashing and rinsing. These units may be made of concrete, steel, or wood, but concrete is the material that is almost universally employed. Also, the rectangular form is the one that is most widely used, because, in that way, the walls of the inner units in any one battery can be made common to one another. Their application is generally limited to the municipal treatment field where high flow rates of water must be treated. The filter effluent water in such a case is usually pretreated in a coagulation and/ or settling basin. Their size and number in any one plant is governed by the size of the valves that would be required, as well as by the shape of the area available for the installation. In other words the maximum design area for any one conventional filter is almost limitless, but they are usually kept within 1000 sq.ft so as not to require excessively sized valves and controls. Filter media is generally sand or anthracite, with a bed depth of 24”. Fig 2 & 3 show the constructional feature of a typical Rapid Gravity sand filter.

Multigrade filters

Multigrade filter is a depth filter that makes use of coarse and fine media mixed together in a fixed proportion. This arrangement produces a filter bed with adequate pore dimensions for retaining both large and small suspended particles. This filter performs at a substantially higher specific flow rate than conventional filters. Specific flow rates of 15 – 30 m/h have been successfully obtained for treating waters containing 25 – 50 ppm suspended solids respectively to produce filtrate with less than 5 ppm.

Advantages :

- Higher specific flow rate than conventional down flow filters thereby saving on space and cost.
- Very little maintenance required.
- Lower backwash water requirement
- In most cases, raw water can be used for backwash.

Applications

Multigrade filters is an ideal choice for all applications where a conventional sand filter is used. It is extensively used in side stream filtration of cooling water and in potable water treatment. It is ideal for filtration of clarified water. In addition it finds application in sea water filtration and in filtration of chemical solutions. For these types of filtrations rubber lined or epoxy painted filters are used.

Dual Media filters

Anthracite can be used as a stand alone filter medium or it can be used in combination with sand in what are called dual media filters. Used in this way higher filtration rates in excess of 10m/h are achieved in typical dual media filter consists of a layer of anthracite (1.25-2.5mm) resting on a a layer of fine sand(1-1.5mm)Anthracite is coarse and has more dirt holding capacity as compared to sand.

If it is desired to remove particles less than 15-20 microns, Micron cartridge filters can be used. Feed to Reverse osmosis units always incorporate these filters to produce clear water, free from micron size particles and with a low silt density index.

Automatic valveless gravity filters (AVGF)

AVGF operates automatically on the head loss principle. This is generally accepted as being the most accurate control besides eliminating the need for continuous analysis of filtrate turbidity which is seldom practical. The head loss at which the AVGF initiates backwashing is determined by the height of the inverted U turn of the top of the backwash pipe. The level of water in this pipe is proportional to the head loss across the filter.

Working : Filtering : Raw water enters the filter chamber, flows down through the filter media into the collection chamber and up through the ducts to the backwash storage chamber and to service.

As the filter bed collects dirt during the filter run, head loss increases and the water level rises in both the inlet and backwash pipes. When the water starts flowing over and into the downward section of the backwash pipe, a siphon action occurs and backwash begins.

Backwashing : Flow through the backwash pipe reduces pressure immediately above filter bed. This draws water from the backwash storage compartment down through the ducts and up through the strainers expanding the filter bed and cleaning it, and then discharging it to waste. Backwashing continues until the backwash water level drops below the end of the siphon breaker. This admits air to the top of the backwash pipe, terminating the siphon action and backwash.

Rinsing : At this point inlet water resumes its flow down through the filter chamber, automatically rinsing, settling and levelling the bed. The rinse water then flows up into backwash storage chamber where it is held for the next backwash. When water rises to the filtered water outlet level, all filtered water then flows to service.

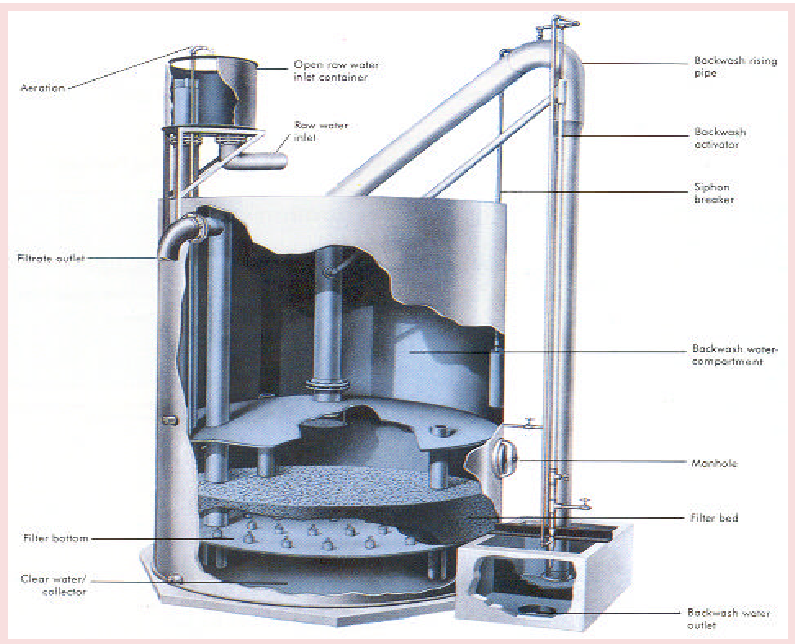
Features & Advantages

Features	**Advantages**
Automatic backwash	Reliable. No manpower required for monitoring
No valves, instrumentation and backwash pumps	Cost effective
No moving parts	Low maintenance
Compact and modular design	Low installation and expansion costs
Backwash can be initiated manually	Flexibility in operation
Handles inlet suspended solids load upto 25 ppm while giving consistent high quality treated water of less than 2 ppm	Best suited downstream of clarifiers
Rinse water through a freshly backwashed AVGF is not discarded but stored and used for next backwash cycle.	Saves water

Applications :

- Pretreatment of process water for the paper and pulp, metallurgical, refinery, food processing, automobile, fertilizer and petrochemical industries.
- Ideal for side stream filtration. It is widely used to reduce suspended solids in recirculating cooling water to improve the efficiency of the cooling system as a whole and reduce maintenance and cleaning costs.
- Treatment of potable water supplies. Internationally, AVGFs are approved and used by the majority of municipal corporations for treatment of potable water.
- Polishing filter for domestic sewage as well as industrial effluent.

Figure given below shows the cross sectional view of the AVGF.



Activated carbon filters

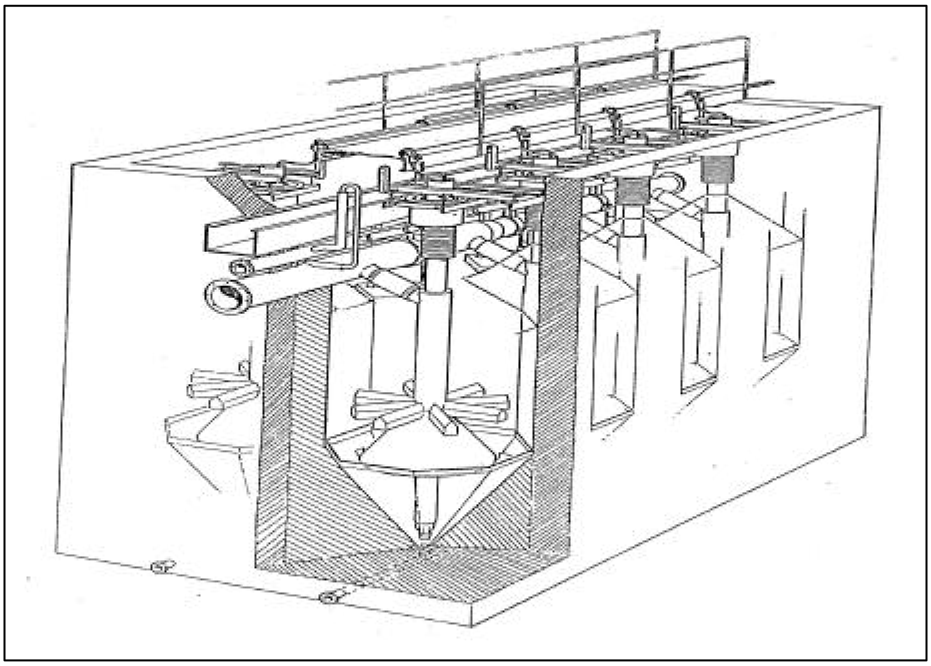
Activated carbon filters are normally used to remove free chlorine and organic molecules that cause taste or odour problem. It is often necessary to filter water going to an activated carbon filter to ensure that influent turbidity is less than 5 NTU

DynaSand (Continuous) Filters

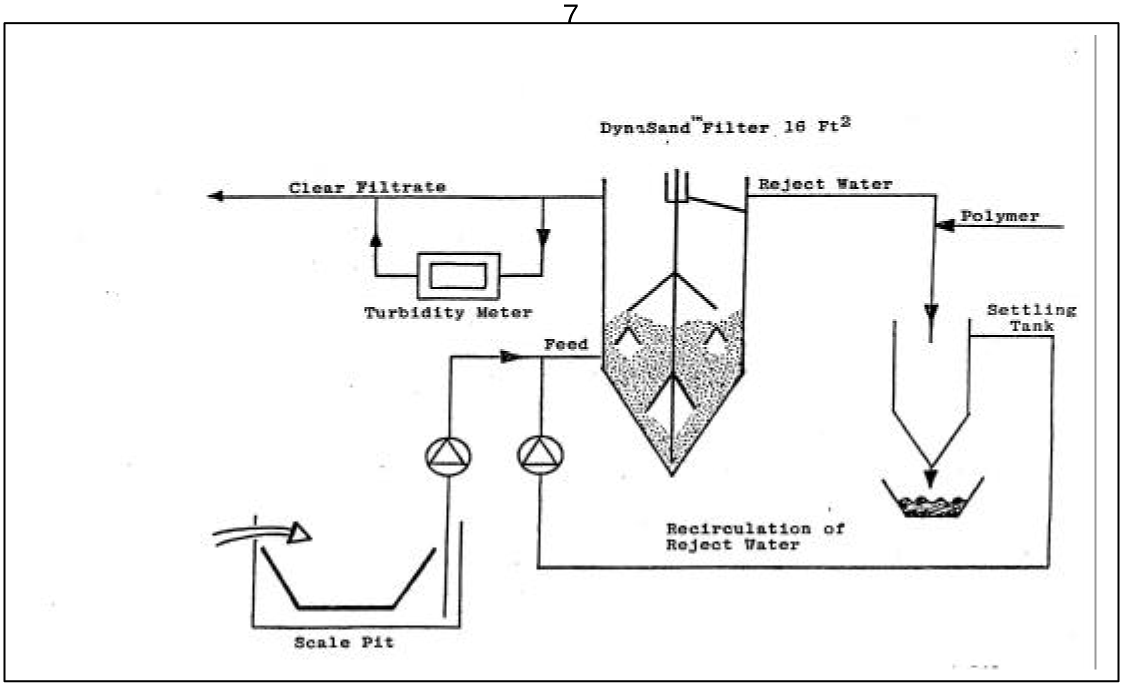
The filters described above operates on a batch mode. Contrasted with this, a DynaSand filter operates continuously and does not require to be stopped for backwash. Recycling the sand internally continuously cleans the filter media. Water to be filtered enters at the bottom, flows upward through a set of riser tubes and is evenly distributed into the sand bed through a distribution hood. The influent moves upward through the downward moving sand with the solids getting trapped in the sand. Filtered water exits from the sand bed, overflows a weir and is discharged from the filter.

Simultaneously, the sand is drawn downward into the suction of an air lift pump. The sand, dirt and water are transported upward through the pipe to the collection vessel in the upper part of the filter. Sand gets washed ,is rinsed and clean sand falls back to the surface of the filter bed The dirty liquid is discharged through the wash water outlet

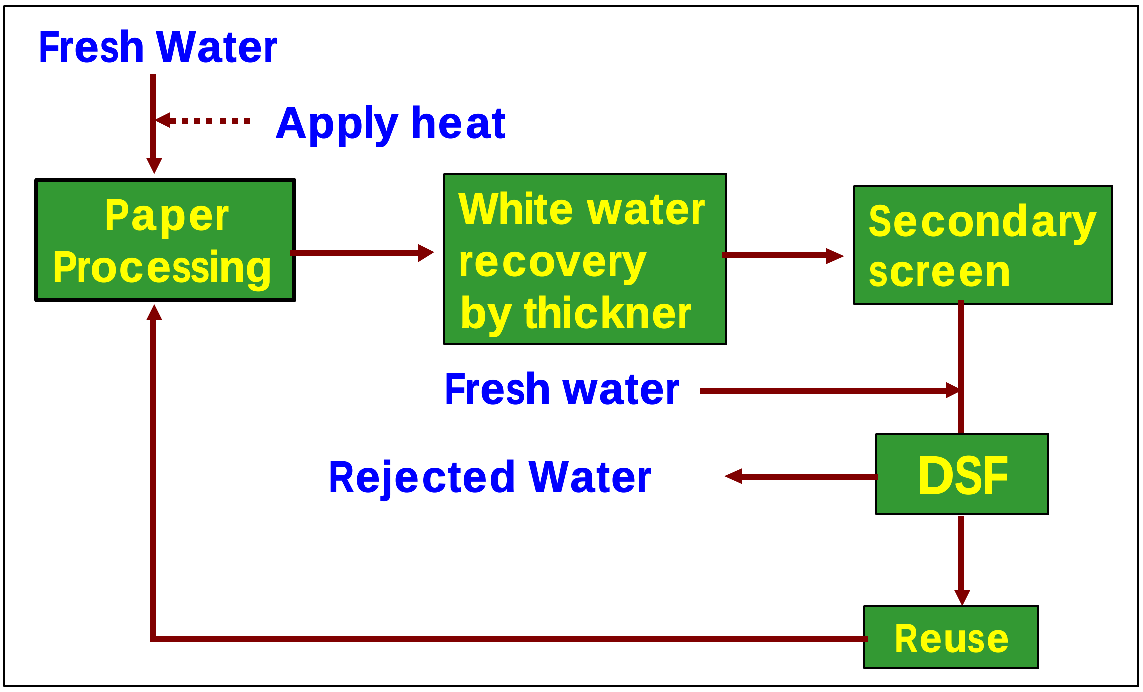
The DynaSand filter is thus a continuous, upflow, deep bed granular media filter and can handle water containing high turbidity without coagulation. Continuous operation means elimination of peripheral equipment like backwash pumps, air blowers, backwash storage tank etc. Figure given below shows the arrangement of a battery of filters in honeycomb design in concrete



The DynaSand continuous filter was originally developed for use in steel mills for mill scale filtration. Water used for quenching the hot metal contains very fine mill scale and oil. DynaSand filters have been found to be ideal for these applications. Conventional filters get clogged very quickly because of presence of oil. Figure given below shows the schematic arrangement for mill scale filtration.

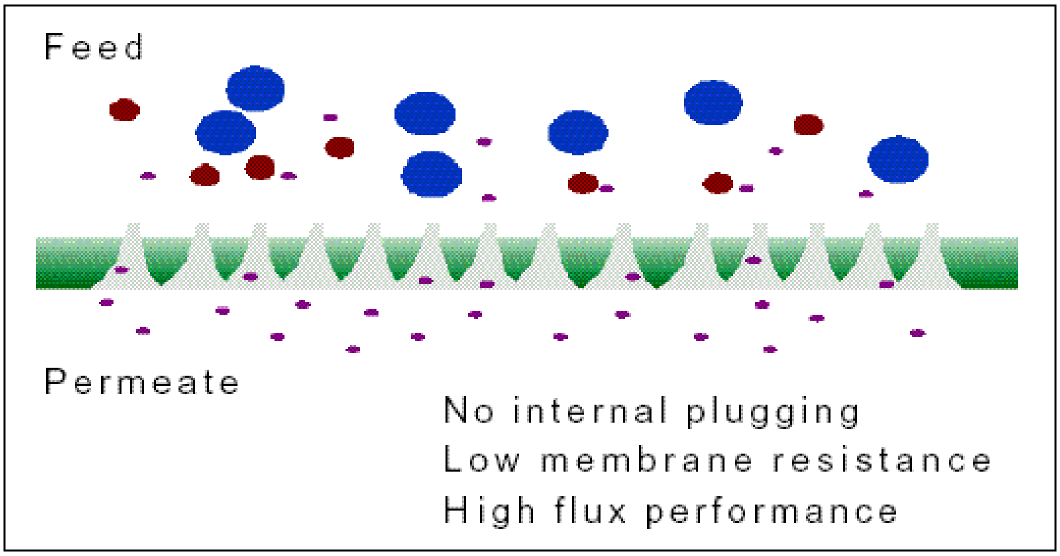


Yet another application is in recovery of white water from paper mills. White water contains very fine fibres apart from other suspended solids and needs to be filtered before reuse. The DynaSand filter has been found to be ideally suited for recovery of white water. Figure given below shows the schematic arrangement for white water recovery from paper mills.



Crossflow filtration

The filtration processes described above involve what is called “Dead end “ filtration- a process in which water flows in a direction perpendicular to the media and the dirt gets accumulated on the media and needs to be removed by backwash.In contrast, in crossflow filtration water flows tangentially along the surface. Figure given below shows the schematic for crossflow filtration.



Membrane processes almost always involve the “cross-flow” filtration, a process in which water flows in a direction tangential to the filtration surface and filtrate permeates through the membrane. The dirt is not allowed to accumulate on the surface in as much as the flowing water continuously sweeps away the solids. Ultrafiltration is a membrane process that typically runs on this mode.Ultrafiltration not only removes suspended solids and colloidal particles but also bacteria and pyrogens and dissolved organic matter depending upon the molecular weight cut off(MWCO) of the membrane.For example a membrane with a 5000 MWCO will typically remove organic molecules whose molecular weight is in excess of 5000.One of the applications of UF membrane is removal of colloidal silica from boiler feed water.It is also emerging as the most optimal way of pretreating RO feed water to ensure trouble free operation of RO systems. Figure given below shows the general arrangement of an ultrafiltration system.

The suggested specifications for various filter media are given in Annexure –1. It is hoped the reader will find it useful and informative.

Summary

We have covered in the above article the various types of filters in use in water treatment .We have also attempted to touch upon the recent developments in this important field.

Annexure-1

Specifications for filter media

Sr. No.	Parameters	Unit	Value	Remarks
1	**Anthracite**			For use in Dual Media filters
	Density	kg/m^3	800	
	Bed Depth	m	0.610 – 0.194	
	Service Flow	$m^3/hr/m^2$	12.22	
	Backwash flow	$m^3/hr/m^2$	29.32 – 43.97	
2	**Activate Alumina**			For removal of fluoride, arsenic and humic acid
	Density	kg/m^3	688	
	Bed Depth	m	0.914+	
	Service Flow	$m^3/hr/m^2$	2.44 – 4.88	
	Backwash flow	$m^3/hr/m^2$	19.54 – 24.43	
3	**Crushed Marble (Calcite)**			For correction of pH of RO treated water
	Density	kg/m^3	1600	
	Bed Depth	m	0.610 – 0.762	
	Service Flow	$m^3/hr/m^2$	4.88 – 14.66	
	Backwash flow	$m^3/hr/m^2$	24.43 – 29.32	
4	**Granular Activated Carbon**			For removal of free chlorine, odour and taste
	Density	kg/m^3	400	
	Bed Depth	m	0.610 – 0.914	
	Chlorine removal service flow	$m^3/hr/m^2$	7.33 – 12.22	
	Organic removal service flow	$m^3/hr/m^2$	2.44 – 7.33	
	Backwash flow	$m^3/hr/m^2$	19.54 – 24.43	
5	**KDF 85**			For removal of Iron, Manganese and H_2S
	Density	kg/m^3	1200	
	Bed Depth	m	0.254+	
	Service Flow	$m^3/hr/m^2$	36.65	
	Backwash flow	$m^3/hr/m^2$	73.29	
6	**Manganese Greensand**			For removal of iron, manganese and H_2S
	Density	kg/m^3	1361	
	Bed Depth	M	0.762 – 0.914	
	Service Flow	$m^3/hr/m^2$	4.88 – 12.22	
	Backwash flow	$m^3/hr/m^2$	29.32 – 36.65	
7	**Multi-media (Anthracite, sand and garnet)**			For use as depth filter and reduce SDI.
	Density	kg/m^3	1463	
	Bed Depth	M	0.914	
	Service Flow	$m^3/hr/m^2$	24.43	
	Backwash flow	$m^3/hr/m^2$	36.65	
8	**Sand**			For removal of suspended solids.
	Density	kg/m^3	1600	
	Bed Depth	m	0.457 – 0.914	
	Service Flow	$m^3/hr/m^2$	7.33 – 12.22	
	Backwash flow	$m^3/hr/m^2$	36.65 – 48.86	