RESEARCH ARTICLE OPEN ACCESS

ULTRAFINE HOLLOW FIBER MEMBRANE FOR DRINKING WATER PURIFICATION

Dr.D.V.Srikanth[1], D.Bhaskar[2], G.Hema[3], N.Mounika[4], P.Arun Kumar[5]

Department of Mechanical Engineering, St Martin's Engineering College, Secunderabad, India

----------**********----------

Abstract:

The sustainable utilization of water resources is the support for the sustainable development of the economy and society. In recent years, with the increasing shortage of water resources in the process of economic development, various kinds of new, improved and highly efficient water treatment technologies have emerged as with most conventional filtration methods, sand filters and media filtration require consistent raw water quality to deliver quality effluent, which is not always possible. They also don't provide an absolute barrier. So as to improve quality of This project aims to design and manufacture a portable and multi functional ultra fine hollow fiber membrane filter for drinking water purification using ultra fine hollow fiber of pore size 0.01 microns, powdered activated carbon , silicon rubber gasket, nylon sheet for activated carbon shell and PVC plastic.

Keywords **— filtration, portable, multifunctional, hollow fiber membrane, activated carbon.**

----------**********----------

I INTRODUCTION

Filtration is a procedure that expels particles from suspension in water. Expulsion happens by various systems that incorporate stressing, flocculation, sedimentation and surface catch. Channels can be arranged by the primary strategy for catch, for example prohibition of particles at the outside of the channel media for example stressing, or affidavit inside the media for example inside and out filtration

Membrane filtration through an extremely dainty channel medium is otherwise called 'surface filtration'. The strong particles to be isolated are normally enormous contrasted with the pore size quality of the film. The pores on a superficial level are of unpredictable shapes. The dismissal of particles is reliant on a few components influencing the vehicle through these pores into the convoluted channels. The division depends on rejection separation by physical size, charge or partiality or a blend of these properties. Huge particles are dismissed on a superficial level and don't collect on a superficial level and don't get an opportunity to go into the inside of the channel.

TYPES OF MEMBRANE FILTERS:

1. Microfiltration (MF)
2. Nanofiltration (NF)
3. Reverse osmosis (RO)
4. Ultrafiltration (UF)

1. MICROFILTRATION:

Microfiltration is inexactly characterized as a membrane division process utilizing layers with a pore size of roughly 0.03 to 10 micronas (1 micron = 0.0001 millimeter), a sub-atomic weight cut-off (MWCO) of more prominent than 1000,000 daltons and a moderately low feed water working weight of around 100 to 400 kPa (15 to 60psi) Materials expelled by MF incorporate sand, residue, muds, Giardia lamblia and Crypotosporidium sores, green growth, and some bacterial species. MF isn't an outright hindrance to infections. Be that as it may, when utilized in blend with purification, MF seems to control these microorganisms in water.

2. NANOFILTRATION:

Nanofiltration membranes have an ostensible pore size of around 0.001 microns and a MWCO of 1,000 to 100,000 daltons. Pushing water through these littler film pores requires a higher activity pressure than either MF or UF. Working weights are as a rule close to 600 kPa (90psi) and can be as high as 1,000 kPa (150psi). These frameworks can expel for all intents and purposes all blisters, microscopic organisms, infections, and humic materials. They give astounding insurance from DBP arrangement if the disinfectant remaining is included after the layer filtration step.

3. REVERSE OSMOSIS:

Reverse osmosis can successfully expel almost all inorganic contaminants from water. RO can likewise successfully expel radium, characteristic natural substances, pesticides, blisters, microbes and infections. RO is especially viable when utilized in arrangement with various units. Sterilization is likewise prescribed to guarantee the wellbeing of water.

4. ULTRAFILTRATION:

Ultrafiltration has a pore size of roughly 0.002 to 0.1 microns, a MWCO of around 10,000 to 100,000 daltons, and a working weight of around 200 to 700 kPa (30 to 100 psi). UF will evacuate all microbiological species expelled by MF (fractional expulsion of microscopic organisms), just as some infections (however not a flat out obstruction to infections) and humic materials.

Hollow fiber:

This structure is reasonably like the turbular module with a shell and cylinder game plan. A solitary module can comprise of 50 to thousands of empty strands and in this manner are self-supporting not at all like the cylindrical plan. The distance across of every fiber ranges from 0.2 – 3 mm with the feed streaming in the cylinder and the item pervade gathered radially outwardly. The benefits of making them bolster membranes similar to the tranperency at which it tends to be cleaned because of its capacity to be backflushed. Substitution costs anyway are high, as one flawed fiber will require the entire pack to be supplanted. Considering the cylinders are of little measurement, utilizing this plan likewise makes the framework inclined to blockage.

II LITERATURE REVIEW

Boller, (1993) built up a Roughing filtration innovation, this filtration strategy through a coarse medium utilizing low filtration rates. It's in the fundamental utilized as pretreatment in order to hold strong issue before moderate filtration. This strategy has been utilized effectively as pretreatment to evacuate turbidity, being along these lines followed by moder

Chaturvedi (2012) considered the evacuation of iron for safe consumable water. He utilized the techniques for iron expulsion from drinking water, for example, electro coagulation; oxidation filtration, particle trade, lime mellowing, adsorption by enacted carbon, BIRM media, Anthracite , green sand, rock and sand blend, ultra filtration and so on are referenced. ate sand filtration.

Simonis(2012) considered the assembling a moderate artistic water channel and channel framework for the end of regular pathogenic microscopic organisms and suspended solids. A smaller scale permeable fired water channel during which dirt was blended in with rice husk in a proportion 2:1 by weight and a round and hollow shaped channel was made by convention stove drying and afterward consuming in furnace at indicated sintering temperature. In the wake of being covered with silver nitrate answer for forestalling the extension of microorganisms, the channel was tried for expulsion of suspended solids and pathogens.

III PRESENT STUDY

INTRODUCTION:

As the traditional process cannot give effective result i.e they filter the water but cannot remove bacteria and virus completely. The modern filters remove bacteria but also purify water to an extend that water eventually losses its quality that is useful minerals present in it are lost. So to avoid such problem ultrafiltration process is used in this work. An ultrafiltration filter has a pore size around 0.01 micron. A microfiltration filter has a pore size

around 0.1 micron, so when water undergoes microfiltration, many microorganisms are removed, but viruses remain in the water. Ultrafiltration would remove these larger particles, and may remove some viruses. Neither microfiltration nor ultrafiltration can remove dissolved substances unless they are first adsorbed (with activated carbon) or coagulated (with alum or iron salts).

MATERIAL REQUIRED:

ULTRAFINE HOLLOW FIBRE MEMBRANE:

Hollow fiber modules for ultrafiltration are accessible with a scope of non-cellulosic polymeric membranes, commonly polysulfone and polyacrylonitrile. These membranes can be inside pressurized and in this manner during activity the feed can stream down within the cylinders. A run of the mill module utilizes membranes as self supporting cylinders with the skin within. Each hollow fiber has a genuinely uniform bore; a few distinctive measurement strands are accessible, extending from around 0.19 to 1.25mm in width. Filaments have a thickness of around 200 µm. For UF applications, the feed is siphoned through the internal center of the cylinder, dissimilar to hollow 'fine' strands utilized for RO.

- Low fouling membrane modules.
- Excellent filtration execution with high motion.
- Very fine ostensible pore measurement (0.02 µm).
- High evacuation effectiveness of microscopic organisms and infections
- Dead-end or concentrate drain stream capacities.

Fig 1: Bounded ultra fine hollow fibers

ACTIVATED CARBON:

The adaptability of enacted carbon is unending, with more than 1,000 realized applications being used. From gold-mining to water sanitization, the creation of food materials and that's only the tip of the iceberg, initiated carbon can be altered to meet a huge range of explicit needs.

Actuated carbons are produced using an assortment of carbonaceous source materials - including coconut shells, peat, hard and delicate wood, lignite coal and olive pit to name yet only a couple. Notwithstanding, any natural material with a high carbon substance can viably be utilized to make enacted carbons through physical change and warm disintegration.

Fig 2: Powdered Activated Carbon

MILD STEEL:

Mild steel is a sort of low carbon steel. Carbon prepares are metals that contain a little level of carbon (max 2.1%) which upgrades the properties of unadulterated iron. The carbon content shifts relying upon the prerequisites for the steel. Low carbon prepares contain carbon in the scope of 0.05 to 0.25 percent.

- More flexible, machinable and weldable than high carbon and different prepares.
- Nearly difficult to solidify and fortify during warming and extinguishing.
- Very little carbon and other alloying components to square disengagements in precious stone structure, which implies less rigidity.
- High measures of iron and ferrite, making it attractive.
- Subject to oxidation if not appropriately covered.

- Relatively reasonable contrasted with different prepares.

PVC PLASTIC:

Polyvinyl chloride (PVC) is a well known thermoplastic that is unscented, strong, fragile, and for the most part white in shading. It's right now positioned as the third most broadly utilized plastic on the planet (behind polyethylene and polypropylene). PVC is most generally utilized in plumbing and waste applications, in spite of the fact that it's likewise sold as pellets or as pitch in its powder structure.

- Biocompatibility.
- Clarity
- Resistance to concoction stress breaking.
- Low warm conductivity.
- Requires next to zero support.

As a thermoplastic, PVC can be reused and changed over into new items for various enterprises, albeit because of the a wide range of details used to make PVC, it's not generally a simple procedure

IV DESIGN

We have designed a outer cartridge to hold the filter and connect it to the bottle or tap as per the requirement using CATIA software. The cartridge is multifunctional design which can be used for tap and bottle as well. The bottom is designed such that it can be carried by anywhere and everywhere without any effort. The design of the cartridge is tested by the manufacturer for material flow, temperature ect .

The design consists of three parts they are

1. Cap
2. Bush
3. Bottom

V CONSTRUCTION

CONSTRUCTION OF FILTER:

The hollow fibers are bonded together by using epoxy resin and hardener as polyurethane. Epoxy and polyurethane mixture acts as glue to bind fibers together and gives an air tight bond. Here powdered activated carbon is used and it is made to surround the fiber which is kept in a nylon cloth which acts as a mesh shell type structure for water coming from fibers. The powdered activated is filled in this mesh shell type structure made by nylon cloth. These powdered activated carbons help to remove the chemical which cannot be removed by the fibers. Then this whole setup is provided with a silicone rubber ring to avid water leakages between outer cartridge and filter.

CONSTRUCTION OF CARTRIDGE:

The construction of cartridge involves two steps they are

1. Preparation of die
2. Moulding

PREPARATION OF DIE:

A sample design of the die of cap, bush and bottom of the cartridge is designed as per requirements using CATIA. The design is then analysed for flow of material during molding and temperature using ANASYS. This design is then sent to manufacturer where the general design of cartridge is then converted into die design and manufactured of mild steel as per design.

Fig 3: Mild steel Die for manufacturing Cap

MOLDING:

Using die the cartridge is molded using PVC food graded plastic and PVC plastic using hand operated injection molding machine.

HAND OPERATED INJECTION MOLDING MACHINE:

Injection molding is a manufacturing process for producing parts by injecting molten material into the die or mould, commonly used for thermoplastic and thermosetting plastic.

The injection system consists of a hopper, a reciprocating screw and barrel assembly, and an injection nozzle, This system confines and transports the plastic as it progresses through the feeding, compressing, degassing, melting, injection, and packing stages.

VI RESULT AND DISCUSSION

RESULT:

Final output is a portable ,multi propose and cost friendly ultra fine hollow fiber membrane with activated carbon sheld with total diameter 28mm and total length 60mm.

Fig 4: Filter

DISCUSSION:

Due to the present situation that is lockdown we couldn't complete the testing of the water quality. The below table represents the water quality determined by taking reference for few source they are

- Bench-scale study of ultrafiltration membranes for evaluating membrane performance in surface water treatment by Dillon A. Waterman; Steven Walker; Bingjie Xu; Roberto M. Narbaitz
- Water quality in Kentucky using activated carbon filters to treat home drinking water by Joseph L. Taraba, Agricultural Engineering Department; Linda M. Heaton, Dept. of Human Environment: Design and Textiles Thomas W. Ilvento, Department of Rural Sociology
- https://tappwater.co/en/what-activated-carbon-filters-remove/by Magnus.

TABLE 1:Table showing water quality

PARAMETERS	FILTERED WATER
pH	6.23 ± 0.1
Turbidity (NTU)	0.706 ± 0.1
Alkalinity (mg/L as $CaCO_3$)	10
TOC (mg/L)	2.81 ± 0.05
UV_{254} absorbance (cm^{-1})	0.062 ± 0.015
SUVA $(L/mg\text{-}m)^{-1}$	2.21
Arsenic	30-70%
Nitrate	30-50%
Chlorine	5-10%
Phosphate	10-30%
Silver	50%

VII CONCLUSION:

The present work gives an effective result as the hollow fiber removes the bacteria and virus effectively and the activated carbon helps in removing the chemicals but still water does not loss its quality as it does not remove useful minerals like magnesium and calcium. As it is a portable and multipurpose filter it is very comfortable to

understand and carry around. Other advantages of this work are:

1. It is cost friendly.
2. It does not require any kind of energy like electricity
3. It is user friendly i.e, its working can be understood easily.
4. It can remove harmful bacteria and virus efficiently while keeping the useful dissolved mineral undisturbed
5. It is easy to carry as it is of less dimensions
6. As it is multi functional it costs less and is time saving.

VIII FUTURE SCOPE

In order to increase the life-cycle of membrane filtration systems, vitality proficient membranes are being created in membrane bioreactor systems. Innovation has been presented which permits the force required to circulate air through the membrane for cleaning to be diminished while as yet keeping up a high transition level. Mechanical cleaning forms have additionally been embraced utilizing crushes as an option in contrast to traditional types of cleaning; this diminishes vitality utilization and furthermore decreases the region required for filtration tanks.

IX ACKNOWLEDGEMENT

We express our sincere gratitude to Prof. Dr.D.V.SRIKANTH, for his stimulating guidance, continuous encouragement and supervision throughout the course of present work.

X REFERENCE

[1] Bench-scale study of ultrafiltration membranes for evaluating membrane performance in surface water treatment by Dillon A. Waterman; Steven Walker; Bingjie Xu; Roberto M. Narbaitz.

[2] Water quality in Kentucky using activated carbon filters to treat home drinking water by Joseph L. Taraba, Agricultural Engineering Department; Linda M. Heaton, Dept. of Human Environment: Design and Textiles Thomas W. Ilvento, Department of Rural Sociology

[3] https://tappwater.co/en/what-activated-carbon-filters-remove/by Magnus

[4] BoltonG.LaCasse,D.KuriyelR.2006Combined models of membrane fouling: development and application to microfiltration and ultrafiltration of biological fluids. J. Membr. Sci.277, 75–84.

[5] ChellamS.Jacangelo,J.BonacquistiT.1998 Modeling and experimental verification of pilot-plant scale hollow fiber, direct flow microfiltration with periodic backwashing . Environ. Sci. Technol.32, 75–81.

[6] CheryanM.1998Ultrafiltration and Microfiltration Handbook. Technomic Publishing Co., Lancaster, PA, USA.

[7] CroueJ.-P.Korshin, G. V.Benjamin, M.1999Characterization of Natural Organic Matter in Drinking Water.AWWA Research Foundation, Denver, C, USA.

[8] DangH. T.Rana, D.Narbaitz, R. M.MatsuuraT.2010aKey factors affecting the manufacture of hydrophobic ultrafiltration membranes for surface water treatment. J. App. Poly. Sci.116, 2626–2637.

[9] DangH.T.Narbaitz,R. M.MatsuuraT.2010bEvaluation of apparatus for membrane cleaning tests .J. Environ. Eng.136, 1161–1170.

