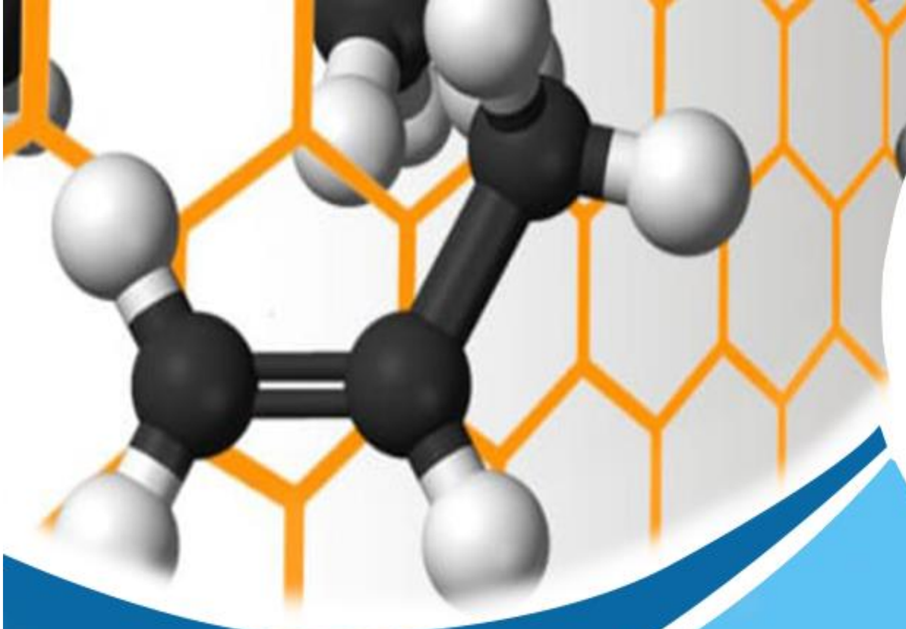

Team Hermetica

Membrane Technology

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INTRODUCTION:

Membrane methods have emerged as the most energy-saving separation techniques. Separation abilities of membranes allow the elimination of many non-effective and energy-consuming methods and their replacement by new, modern and environment friendly technology. The pressure difference across the membrane acts as the driving force for Pressure-driven membrane processes (Reverse Osmosis, Ultrafiltration, Nanofiltration, Microfiltration). Clean water is very important for every living organism to withstand life, but due to the rapid increase in growth in population and industrialization, there is more demand for clean safe and drinkable water. Several techniques have been developed for the treatment of water i.e. adsorption has been widely used to remove water contaminants. Even though adsorption can remove most of water pollutants, it has some limitations such as appropriate adsorbents with high adsorption capacity and low use of these adsorbents commercially. Hence there has been a need for more efficient technique such as Membrane Technology .The membrane technology not only used for water treatment but also use as a processing and separation method in food industry gaining wide applications. Membrane separation can be used either alternatives to conventional techniques or as a novel technology for processing new ingredients and food. Membrane separations are considered green technologies. There are many applications of membrane technology; water treatment; air pollution control; clean fuel; food beverages; bioseparation; biomedical use. About half of the market is in medical applications such as use of artificial kidneys to remove toxic substances by hemodialysis and as artificial lungs for bubble-free supply of oxygen in blood. The importance of membrane technology is growing in the field of environmental protection (NanoMempro IPPC Database). Even in modern energy recovery techniques membranes are increasingly used, for example fuel cells and in osmotic power plants.

In this project, the main aim is to maximize the membrane efficiency. This is done through keeping the membranes in the alternate direction and making them vibrate it. This will make the membranes porous so that the sludge accumulation time delays and the blockage time of ,membranes will increase.

MEMBRANE TECHNOLOGY:

Membrane technology is a generic term for a number of different, very characteristic separation processes . These processes are of the same kind, because in each of them a membrane is used. The main force of a membrane technology is the fact that it works without the addition of chemicals, with a relative low energy use and easy and well –arranged process conduction.

The membrane separation process is based on the presence of semi permeable membranes. Membrane filtration can be used as an alternative for flocculation, sediment purification technique, adsorption, extraction and distillation.

There are two factors that determines the affectivity of membrane filtration process

(1) Selectivity - It is expressed as a parameter called retention or separation factor .
(2) Productivity- Expressed as a parameter called flux.

And both of these are membrane –dependent.

Classification of Membrane processes:

1. Microfiltration (MF)

2. Ultrafiltration (UF)

3. Nanofiltration (NF)

4. Reverse osmosis (RO)

- ## Advantages of using membrane technology

1. The technology is broadly applicable in a lot of industries.

2. The membrane acts as a barrier to components that are rejected. Thus, there is no need to sacrifice the quality of the water that Is being treated. Independent of effluent. The variations may be responsible for the decrease in flux, but it does not affect the quality of water treated.

3. Generally, no extra chemicals are required, which makes the recovery of oil easy.

4. Costs of energy are quite lower as compared to thermal treatments.

5. There is no such need for a highly skilled operator as the plant can be highly automated. The chemical nature of these membranes affects the flux. For example, oils can cover and make a coat around hydrophobic membranes which results in poor flux. Whereas if the membranes will be hydrophilic in nature it attracts water rather than the oil, which results in much higher flux.

- **Typical Problems in Membrane Technology**

Membrane scaling

Scaling is caused primarily by the deposition of colloidal materials near the membrane surface, which may result in fouling due to the introduction of a large number of foulants into the membrane system.

Concentration Polarization

This causes a layer to form near the membrane's surface, depleting the solution's permeate while increasing the concentration of non-permeate across the membrane, resulting in the formation of a concentration gradient across the membrane and reducing the flux through the membrane.

Membrane Fouling

Reduction in the membrane’s performance due to deposition of the unwanted solute particles in the membrane which can result in loss of permeate flow across the membrane. Fouling is a culmination of physical and chemical processes happening when the feed water interacts with the membrane surface.

ANAEROBIC TREATMENT technology has been proven on the long term and offers a number of advantages , including high organic matter removal efficiency , low excess sludge production, stable operation and production of energy in the form of biogas . In combination with membrane separation , high effluent quality is achieved , with no total solids or bacteria is the effluent . Anaerobic membrane bioreactor (AnMBRs) combine the advantages of anaerobic treatment with membrane separation , making it an attractive approach for the treatment of a broad spectrum of wastewaters.

Due to their high operation stability, AnMBRs are suitable for water treatment wastewater under extreme conditions , including high salinity , high suspended solid content or poor biomass granulations . As a result, AnMBRs are currently of great interest both researchers and the industrial community

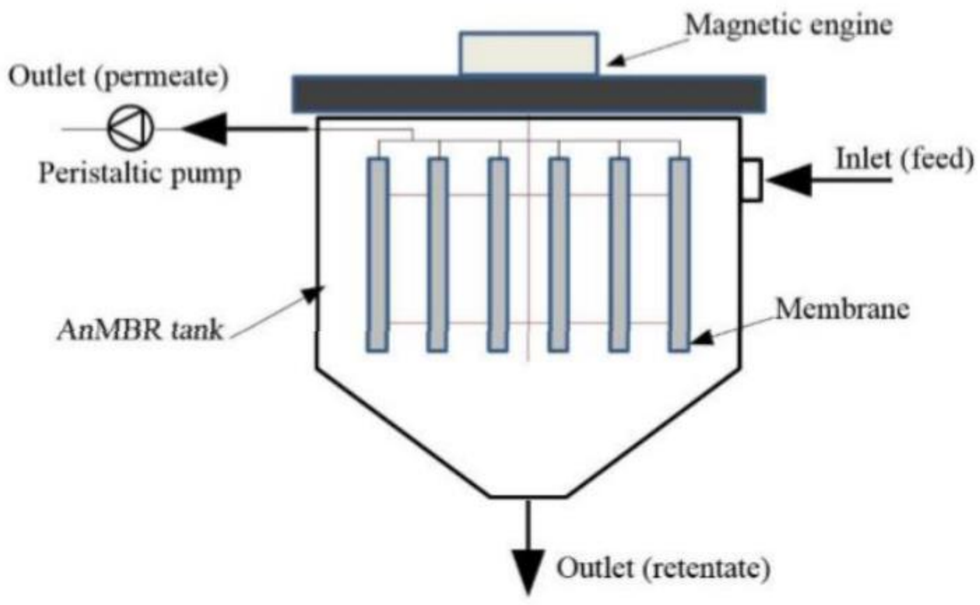
PROJECT DESCRIPTION

The purpose of the project is to increase the membrane efficiency. For that we considered ten membranes which are arranged parallelly and are kept stationary. Then, it is observed that as the sludge is treated, within 5 minutes of time the sludge accumulates and the membrane pores blocks. This decreases the membrane durability and makes it less efficient. To overcome this, the membrane is made to vibrate.

Now, all membranes are kept in the same direction i.e. upright and when it is vibrated, the blockage time for membrane pores delay as the membranes get porous due to vibration. This increases the membrane efficiency. To increase the membrane efficiency even more, the membranes were kept in alternate directions i.e. all the odd membranes in the same direction while the even membranes in the opposite direction. Then, it is made to vibrate and the membranes become even more porous increasing the time for sludge accumulation and blockage of membranes. In this case, the membrane efficiency is maximum.

- **Theoretical study of Hydrodynamic model for anaerobic membrane bioreactor**

The proposed model can be used to simulate the hydrodynamics of the influent in anaerobic membrane bioreactors (AnMBRs) with a magnetically induced membrane vibration (MMV) device. The simulation zone of the model Fig.5 is made up of the AnMBR tank and membrane modules, where the tank media and membrane modules are calculated. For the calculation of mass balances for influential components, the hydrodynamic AnMBRs model could be coupled with the biological AM2b model. To simulate the flow of the influent, the k-epsilon Reynolds averaged Navier-Stokes model is used in AnMBR tank.



Schematic representation of the submerged AnMBR with the MMV system.

Assumptions considered:

The proposed model includes the following assumptions:

1. The influent liquid is incompressible.

2. The gas phase in the influent is neglected.

3. In the model, anaerobic bacteria are represented as dissolved species in the influent.

4. Suspended solids (SS) and SMP are assumed to be the only particles involved in membrane pore fouling.

5. The biological processes described in the AM2b model are assumed to be the only chemical processes occurring within the AnMBR tank.

6. The temperature of the influent is initially defined and does not change significantly throughout the process. As a result, the AnMBR process's heat balance is eliminated.

Momentum Balance

A viscous influential flow interacting with a vibrating membrane module governs the fluid dynamics inside the AnMBR tank coupled with the MMV system. Aside from the liquid phase, the influent contains suspended solids and gases produced during anaerobic digestion. The gases in the AnMBR tank coupled with the MMV system have little effect on hydrodynamics, whereas solids can form a cake at the membrane surface and reduce process efficiency. Thus, the Euler-Euler model with continuous liquid phase and dispersed solid phase is used to model the interactions between the membrane module and the influent.

Magnetically induced membrane vibration system (MMV simulation)

The MMV system regulates the vibration of the membranes immersed in the AnMBR tank. The membrane vibration occurs in the vertical plane at a fixed frequency, with even membranes moving in the opposite direction as odd membranes. The following describes the vibration of the membranes:

dM(□) = AV sin(fM) (even membranes)

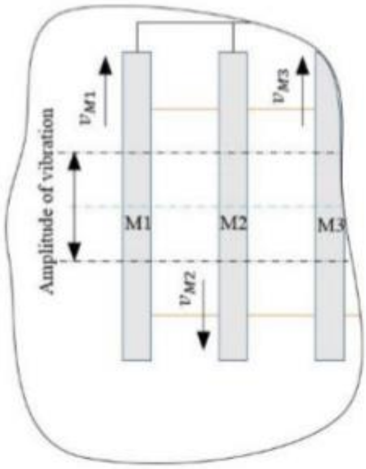
dM(□) = AV sin(fM) (odd membranes)

where dM is the vertical displacement of the membrane in space, AV is the vibration amplitude, and the frequency of vibration is denoted by fM, and the time of vibration is denoted by □.

The velocity of the membrane displacement is estimated by using the following equation:

$\bar{\upsilon}\ M = dy/\ d\tau$

where y is the vertical spatial coordinate.



Schematic representation of the MMV system

- **The influent mass balances**

The mass balance of each component in the influent (including anaerobic bacteria) is described by advection-diffusion equation:

$d\rho i\ d\tau = \sum\nabla\ N\ j=1\ .\ (Dij\nabla\rho j) - \vec{\nu}\ F.\ \nabla\rho i + RRi$

where ρi and ρj are the mass concentrations of the components i and j, respectively, Dij is the diffusion coefficient for the components i and j, RRi is the reaction rate of the component i. The reaction rates of the chemical reactions occurring in the reactor are calculated according to the AM2b model.

Despite the number of assumptions and equations involved, the proposed model has a high potential, experiment planning, optimization, and process design.

Validation study of model

With the use of the COMSOL software, the models needed to be validated at different experimental conditions and parametric studies . Study needed to be done to estimate the effect of the operating parameters and membrane properties (the feed temperature and flow rate, thickness and length of the membrane) not only on the performance of AnMBR but also the velocity, concentration and temperature distributions in the membrane. Parametric study is also required that is not done in previous studies such as the effects of the frequency and amplitude of membrane vibrations inside the AnMBR tank on the hydrodynamics and the distribution of the solids in the tank is discussed. The MMV system affects the fluid velocity at the influent-membrane interface. Indeed, the influent velocity is constantly changing according to the velocity and movement directions of the submerged membranes.

PAST TECHNIQUES:

Various methods and technologies to treat chemical effluent

1. Physicochemical treatment
2. Biological treatment
3. Chemical oxidation

Wastewater, as we all know, can contain particles of varying sizes. As a result, different treatment methods for recycled water are required to make the water safe for consumption, disposal, and compliance with stringent regulatory standards.

- **Physico-chemical treatment**

Physicochemical treatment involves changing the physical state of colloidal particles with chemicals to make them more stable and coagulable for treatment or, more precisely, filtration. In most cases, these treatment methods are used in conjunction with biological treatment methods. These methods are used for industrial water treatment as a part of pre-treatment which leads to higher efficiency and decrease in costs.

- **Biological treatment**

A biological wastewater treatment system that cleans water by using bacteria, protozoa, and a special microbe. This results in a more manageable sludge, which is then dewatered and discharged as solid waste. Aerobic, anaerobic, and anoxic biological water treatment are the three subcategories of biological water treatment.

- **Chemical Oxidation**

Oxidation, by definition, is a process by which electrons are transferred from one substance to another. This leads to a potential expressed in volts referred to a normalized hydrogen electrode. From this, oxidation potentials of the different compounds are obtained.

IMPACT AND LARGE SCALE APPLICATIONS:-

1. The role of membrane technology in sustainable decentralized wastewater systems.

Decentralized wastewater treatment has the potential to provide sanitation that meets criteria for sustainable urban water management in a manner that is less resource intensive and more cost effective than centralized approaches. It can facilitate water reuse and nutrient recovery and can potentially reduce the ecological risks of wastewater system failure and the community health risk in a wastewater reuse scheme. In particular, the role of membranes as a dependable barrier in the wastewater treatment process can increase system reliability as well as lowering the latent risks due to wastewater reuse. The modular nature of membranes will allow plant size to range from single dwellings, through clusters to suburb size. It is concluded that realization of the potential for membrane-based technologies in decentralized wastewater treatment will require some progress both technically and institutionally.

2. Impact of colloidal and soluble organic material on membrane performance in membrane bioreactors for municipal wastewater treatment.

MLSS concentrations, solid retention time, loading rates, and filtration flux were found not to be responsible for the different performance of the submerged modules. These parameters were kept identical in the two pilot plants. Instead, the non-settable fraction of the sludges (soluble and colloidal material, i.e. polysaccharides, proteins and organic colloids) was found to impact fouling and to cause the difference in membrane performance between the two MBR. This fraction was analysed by spectrophotometric and size exclusion chromatography (SEC) methods. In a second step, the origin of these substances was investigated. The results point to microbiologically produced substances such as extracellular polymeric substances (EPS) or soluble microbial products (SMP).

3. Membrane technology for water production in agriculture: Desalination and wastewater reuse.

The two possible alternative sources of water for agriculture are: desalinated water and wastewater. Membrane operations utilized for water production in agriculture advantages:- (i) Their mutual compatibility which offers the possibility of combining different membrane operations to achieve the desired water qualities. (ii) The membrane technology mostly used in desalination is reverse osmosis (RO) whereas membrane bioreactors (MBRs) deal with fresh water reclamation from wastewater streams. Novel membrane technologies are described, such as forward osmosis (FO) and membrane distillation (MD), a promising prospect for agricultural water production, and the possible recovery of nutrients from saline waters and wastewaters.

ADVANTAGES OF MEMBRANE TECHNOLOGY

1. Better removal of contaminants

Smaller, absolute pore sizes offer a 99.9999% (6 log) removal rating for many contaminants Conventional treatment systems typically achieve 99-99.9% (2-3 log reduction).

2. High Efficiency

Water produced water fed ratios to the system reach as high as 98%.

3. Lower overall production costs

One of the advantages of membrane filtration is that Membrane Technology often is less expensive than many other alternative technologies. The installation costs are lower, as are the energy costs. Membrane technology includes fewer processing steps and makes it possible to achieve both a greater degree of purity and higher overall yields. In addition, because membrane technology does not result in a filter cake, there are no costs associated with the removal and disposal of this residue.

4. Integrity Assurance

Automated procedures allow in-place testing to quickly confirm that the membrane is not breached.

5. Variable filtration ratings

Systems employing different classes of membranes ranging from microfiltration to reverse osmosis allow for precise contaminant removal at the lowest total cost.

6. Smaller footprint

Membrane systems typically require 50-70% less space than conventional technologies.

7. High flexibility

Membrane filtration can be used for feed products with a range of different viscosities, including high-viscosity products that can otherwise be difficult to process. A wide range of different membrane filtration products also ensures that the best possible solution is available for each particular application. This also eliminates unnecessary energy costs.

8. Easy to operate

Conventional technologies often require continuous adjustment of conditions via chemical addition to achieve contaminant removal. This means a high level of operator intervention and the risk of contaminants in the effluent automated controls enable consistent trouble free operation, far less operator attention, and automated alarms when attention is required.

9. High end product quality

Membrane filtration is a clean technology. The separation process is carried out solely on the basis of molecular size, making the use of additives unnecessary. This results in an end product with top quality and makes it easier to comply with the many stringent requirements from both consumers and public authorities.

FUTURE ASPECTS:

Membrane technology is gradually revolutionising water and wastewater treatment. Much work has been done in this area over the years. The progress of membrane science and technology leads to the invention of novel and improved membrane processes with lower capital and operational cost.

The state-of-the-art of membrane technology is characterized by a number of mature applications such as sterile filtration, haemodialysis, water purification and gas separation, as well as many more niche applications of successful membrane-based separation and processing of fluid mixtures. The membrane industry is currently employing a portfolio of established materials, mostly standard polymers or inorganic materials (not originally developed for membranes), and easily scalable manufacturing processes such as phase inversion, interfacial polymerization and coating. Innovations in membranes and their manufacturing processes must meet the desired intrinsic properties that determine selectivity and flux, for specific applications.

However, tuneable and stable performance, as well as sustainability over the entire life cycle of membrane products are becoming increasingly important. Membrane manufacturers are progressively required to share the carbon footprint of their membrane modules with their customers. Other examples include increasing the stability of organic membrane polymers and lowering the cost of inorganic membranes.

The coupling of anaerobic biological process and membrane separation could provide excellent suspended solids removal and better biomass retention for wastewater treatment. This coupling improves the biological treatment process while allowing for the recovery of energy through biogas. This review gives a basic description of the anaerobic wastewater treatment process, summarizes the state of the art of anaerobic membrane bioreactors (AnMBRs), and describes the current research trends and needs for the development of AnMBRs. The research interest on AnMBR has grown over the conventional anaerobic processes such as upflow anaerobic sludge blanket (UASB). Studies on AnMBRs have developed different reactor configurations to enhance performances. The AnMBR performances have achieved comparable status to other high rate anaerobic reactors. Overall, it is foreseen that the scope of future membrane applications will become much wider, based on improved existing membrane materials and manufacturing processes.