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(54) DEVICE FOR INTEGRATEDLY COUPLING MICROBIAL FUEL CELL AND DYNAMIC MEMBRANE BIOREACTOR (MFC-DMBR) .

(57) A device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR). A cation exchange membrane is arranged between an anaerobic anode pond and an aerobic cathode pond of the device. An electricity-producing microorganism, a carbon fiber felt and a stirrer are arranged in the anaerobic anode pond. A stainless steel wire mesh is arranged in the aerobic cathode pond. After the device runs for a set time, a dynamic membrane with solid/liquid separation is formed on the stainless steel wire mesh. An effluent filtered by the dynamic membrane flows out from a water outlet pipe. An aeration head driven by an air pump is arranged in an aeration pond. The device further includes a programmable logic controller (PLC). A positive electrode of the PLC is electrically connected to the stainless steel wire mesh, and a negative electrode of the PLC is electrically connected to the carbon fiber felt.

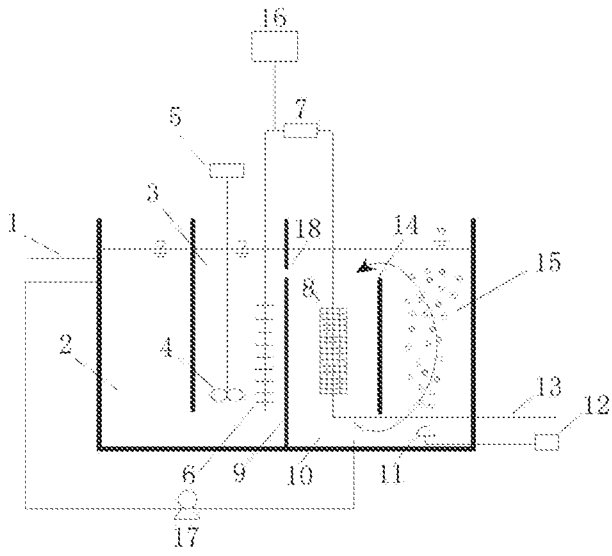

Fig. 1

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DESCRIPTION

DEVICE FOR INTEGRATEDLY COUPLING MICROBIAL FUEL CELL AND DYNAMIC MEMBRANE BIOREACTOR (MFC-DMBR)

TECHNICAL FIELD

This application relates to wastewater treatment, and more specifically to a device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR).

BACKGROUND

A membrane bioreactor (MBR) has a good effluent quality, a small footprint and a low sludge output. A MBR engineering application reached a peak between 2009 and 2012, and once had a tendency to replace an activated sludge process. However, since 2012, the number of MBR engineering applications in the world has declined rapidly, and the number of additional applications in the past two years is only about 10% of the heyday. The reason is that a high energy consumption and a membrane fouling are main factors restricting a development of the MBR. Therefore, there is still an urgent need to effectively control the membrane fouling and greatly reduce the energy consumption in the MBR field.

In recent years, some scholars have tried to introduce a dynamic membrane technology into the MBR, using a cheap macroporous material (such as a non-woven fabric, a filter cloth, a nylon mesh, a stainless steel wire mesh, etc.) to replace an expensive ultrafiltration/microfiltration membrane. A filter cake layer, a dynamic membrane, formed on a surface of the macroporous material is configured to separate a solid and a liquid, thereby developing a dynamic membrane bioreactor (DMBR). The DMBR not only retains most of the advantages of a traditional MBR, but also overcomes a high cost and a high energy consumption of the traditional MBR to a desired extent, which has become a research hotspot. In addition, a microbial fuel cell (MFC) is a device that uses a microorganism as a catalyst to convert a chemical energy in organic matter into an electrical energy. The MFC has been favored in recent years due to an ability to recycle the electrical energy while removing an organic matter.

On the basis, some researchers have tried to couple the MFC with the MBR, which has achieved good results in improving the effluent quality, slowing the membrane fouling and reducing the energy consumption. However, the coupling technology cannot fundamentally solve the problems of the high energy consumption and the membrane fouling caused by the microfiltration/ultrafiltration membrane material.

SUMMARY

On the basis of organically combining microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR), this application provides a device for integratedly coupling MFC-DMBR, which can further reduce an energy consumption and slow down a membrane fouling on a basis of MFC-MBR, and is of great significance to solve the membrane fouling and the high energy consumption and promote an application of the MBR.

The technical solutions of the present disclosure are described as follows.

A device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR), the device comprises a regulating pond, an anaerobic anode pond, an aerobic cathode pond, and an aeration pond; a cation exchange membrane is arranged between the anaerobic anode pond and the aerobic cathode pond; an electricity-producing microorganism, a carbon fiber felt and a stirrer are arranged in the anaerobic anode pond; a stainless steel wire mesh is arranged in the aerobic cathode pond; after the device runs for a set time, a dynamic membrane with a function of solid/liquid separation is formed on the stainless steel wire mesh; an effluent filtered by the dynamic membrane is allowed to flow out from a water outlet pipe; an aeration head driven by an air pump is arranged in the aeration pond;

the device further comprises a programmable logic controller (PLC); a positive electrode of the PLC is electrically connected to the stainless steel wire mesh; a negative electrode of the PLC is electrically connected to the carbon fiber felt;

wherein wastewater flows into the regulating pond and goes down to a bottom of the anaerobic anode pond; the wastewater in the anaerobic anode pond goes up and overflows to the aerobic cathode pond; the wastewater in the aerobic cathode pond goes down to a bottom of the aeration pond; and the wastewater in the aeration pond goes up and is returned to the aerobic cathode pond under an action of an aeration bubble.

In an embodiment, the device further comprises a sludge return pipeline driven by a sludge return pump; an inlet end of the sludge return pipeline is connected to a bottom of the aerobic cathode pond; an outlet end of the sludge return pipeline is connected to an upper part of the regulating pond; wherein a mixed solution formed by the wastewater and a returned sludge is allowed to enter into the regulating pond.

In an embodiment, an external resistor is connected in series with a connection circuit between the PLC and the stainless steel wire mesh.

In an embodiment, a mesh pore size of the stainless steel wire mesh is 25-100 μm.

The present disclosure overcomes deficiencies of the prior art and provides a device for integratedly coupling MFC-DMBR. Raw wastewater enters the regulating pond from the water inlet pipe to be mixed with the returned sludge. The mixed solution enters the bottom of the anaerobic anode pond. An organic matter in the wastewater is degraded by a catalysis of the electricity-generating microorganism in the anaerobic anode pond to generate CO_2, H^+ and e^-, where H^+ diffuses to a surface of a cathode electrode through the cation exchange membrane, and e^- is transmitted to a stainless steel wire mesh cathode through a carbon fiber felt anode and an external circuit. The stainless steel wire mesh is arranged in the aerobic cathode pond, and is also configured as a substrate of the dynamic membrane. After running for a period of time, a filter cake layer, the dynamic membrane, will be formed on a surface of the stainless steel wire mesh, and the filter cake layer plays a role of solid/liquid separation. The effluent in the dynamic membrane flows out from the water outlet pipe, while the untreated wastewater in the aerobic cathode pond goes down to the bottom of the aeration pond. The wastewater in the aeration pond is went up and returned to the aerobic cathode pond under the action of the aeration bubble for a further treatment. The mixed solution in the aerobic cathode pond is returned to the regulating pond through the sludge return pump to participate in a next reaction.

Compared to the prior art, the present disclosure has the following beneficial effects.

(1) The device of the present disclosure has a strong biodegradability and a good effluent quality;

(2) an extracellular polymer substances (EPS) content in the device of the present disclosure is low, which can effectively control the membrane fouling;

(3) a microbial floc and the EPS in the device of the present disclosure are generally negatively charged, and an electric field generated by the MFC can effectively reduce an accumulation of the substances in the filter cake layer and slow down the membrane fouling;

(4) a stainless steel wire mesh is configured as the membrane substrate (many other materials can be configured as the substrate for the dynamic membrane), which reduce the cost;

(5) the mesh pore size of the stainless steel wire mesh is 25-100 μm; a membrane hole resistance is small; and a dynamic membrane module can flow out water by itself, saving a power consumption;

(6) an electric energy generated by the MFC can offset a part of the electric energy during an operation of the device, and an overall energy consumption of the system is low; and

(7) an environment of “aerobic-anoxic-anaerobic” is alternately formed through a return of the wastewater. Therefore, the device of the present disclosure has a good denitrification capability and a dephosphorization capability.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is schematically depicts a structure of a device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR) according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

The disclosure will be described completely and clearly below with reference to the accompanying drawings and embodiments to make the object, technical solutions, and beneficial effects of the present disclosure clearer. The embodiments provided herein are merely illustrative, and are not intended to limit the scope of the present disclosure.

The present disclosure provides a device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR), as shown in Fig. 1, the device includes a regulating pond 2, an anaerobic anode pond 3, an aerobic cathode pond 10, and an aeration pond 15. A cation exchange membrane 9 is arranged between the anaerobic anode pond 3 and the aerobic cathode pond 10. An electricity-producing microorganism, a carbon fiber felt 6 and a stirrer are arranged in the anaerobic anode pond 3. A stainless steel wire mesh 8 is arranged in the aerobic cathode pond 10. After the device runs for a set time, a dynamic membrane with a function of solid/liquid separation is formed on the stainless steel wire mesh 8. An effluent filtered by the dynamic membrane is allowed to flow out from a water outlet pipe 13. An aeration head 11 driven by an air pump 12 is arranged in the aeration pond 15. The device further includes a programmable logic controller (PLC) 16. A positive electrode of the PLC is electrically connected to the stainless steel wire mesh 8, and a negative electrode of the PLC is electrically connected to the carbon fiber felt 6. Wastewater flows into the regulating pond 2 and goes down to a bottom of the anaerobic anode pond 3. The wastewater in the anaerobic anode pond 3 goes up and overflows from an overflow port 18 to the aerobic cathode pond 10. The wastewater in the aerobic cathode pond 10 goes down to a bottom of the aeration pond 15. And the wastewater in the aeration pond 15 goes up and is returned to the aerobic cathode pond 10 under an action of an aeration bubble.

In an embodiment of the present disclosure, a water inlet pipe 1 is connected to the regulating pond 2 to inject the wastewater to be treated. The regulating pond 2 and the anaerobic anode pond 3 are adjacent and a bottom of the regulating pond 2 and the bottom of the anaerobic anode pond 3 are communicated, and the wastewater enters the anaerobic anode pond 3 from a communicated bottom of the regulating pond 2 and the anaerobic anode pond 3. The regulating pond 2 is mainly to regulate the water quality and a water quantity, mainly to maintain the water quality to avoid fluctuating much after mixing with a mixed solution formed by the wastewater and a returned sludge, and the regulating pond 2 can also regulate the pH according to different situations.

In the embodiment, the stirrer is composed of a stirring paddle 4 and a stirring motor 5. The stirring paddle 4 is arranged in the anaerobic anode pond 3 to stir.

In an embodiment, a partition 14 is arranged between the aerobic cathode pond 10 and the aeration pond 15. A bottom of the partition 14 is set to be communicated, and a top level is slightly lower than a liquid level.

In an embodiment, an external resistor 7 is connected in series with a connection circuit between the PLC and the stainless steel wire mesh 8. The external resistor 7 is related to a power generation performance of the MFC.

In an embodiment, the cation exchange membrane 9 has a cation exchange function, which can only allow a cation to pass through, such as H^+, Na^+ and so on, while a water molecule cannot pass through the cation exchange membrane 9, that is, the water molecule overflows from the overflow port 18.

In an embodiment, in order to save more power consumption, the mesh pore size of the stainless steel wire mesh 8 is 25-100 μm. At the moment, a membrane hole resistance is smaller, and a dynamic membrane module can flow out water by itself.

In an embodiment, in order to make the wastewater degrade more completely, the device further includes a sludge return pipeline driven by a sludge return pump 17. An inlet end of the sludge return pipeline is connected to a bottom of the aerobic cathode pond 10; an outlet end of the sludge return pipeline is connected to an upper part of the regulating pond 2. A mixed solution formed by the wastewater and a returned sludge is allowed to enter into the regulating pond 2.

In a practical application process of the present disclosure, Raw wastewater enters the regulating pond 2 from the water inlet pipe 1 to be mixed with the returned sludge. The mixed solution enters the bottom of the anaerobic anode pond 3. An organic matter in the wastewater is degraded by a catalysis of the electricity-generating microorganism in the anaerobic anode pond 3 to generate CO_2, H^+ and e^-, where H^+ diffuses to a surface of a cathode electrode through the cation exchange membrane 9, and e^- is transmitted to a stainless steel wire mesh 8 cathode through a carbon fiber felt 6 anode and an external circuit. The stainless steel wire mesh 8 is arranged in the aerobic cathode pond 10, and is also configured as a substrate of the dynamic membrane. After running for a period of time, a filter cake layer, the dynamic membrane, will be formed on a surface of the stainless steel wire mesh 8, and the filter cake layer plays a role of solid/liquid separation. The effluent in the dynamic membrane flows out from the water outlet pipe 13, while the untreated wastewater in the aerobic cathode pond 10 goes down to the bottom of the aeration pond 15. The wastewater in the aeration pond 15 is went up and returned to the aerobic cathode pond 10 under the action of the aeration bubble for a further treatment. The mixed solution in the aerobic cathode pond 10 is returned to the regulating pond 2 through the sludge return pump to participate in a next reaction.

Described above are only preferred embodiments of the present disclosure and are not intended to limit the present disclosure. It should be understood that any modifications, replacements and improvements made by those skilled in the art without departing from the spirit and scope of the present disclosure should fall within the scope of the present disclosure defined by the appended claims.

CLAIMS

1. A device for integratedly coupling microbial fuel cell and dynamic membrane bioreactor (MFC-DMBR), characterized in that the device comprises a regulating pond, an anaerobic anode pond, an aerobic cathode pond, and an aeration pond; a cation exchange membrane is arranged between the anaerobic anode pond and the aerobic cathode pond; an electricity-producing microorganism, a carbon fiber felt and a stirrer are arranged in the anaerobic anode pond; a stainless steel wire mesh is arranged in the aerobic cathode pond; after the device runs for a set time, a dynamic membrane with a function of solid/liquid separation is formed on the stainless steel wire mesh; an effluent filtered by the dynamic membrane is allowed to flow out from a water outlet pipe; an aeration head driven by an air pump is arranged in the aeration pond;

the device further comprises a programmable logic controller (PLC); a positive electrode of the PLC is electrically connected to the stainless steel wire mesh, and a negative electrode of the PLC is electrically connected to the carbon fiber felt;

wherein wastewater flows into the regulating pond and goes down to a bottom of the anaerobic anode pond; the wastewater in the anaerobic anode pond goes up and overflows to the aerobic cathode pond; the wastewater in the aerobic cathode pond goes down to a bottom of the aeration pond; and the wastewater in the aeration pond goes up and is returned to the aerobic cathode pond under an action of an aeration bubble.

2. The device according to claim 1, characterized in that the device further comprises a sludge return pipeline driven by a sludge return pump; an inlet end of the sludge return pipeline is connected to a bottom of the aerobic cathode pond; an outlet end of the sludge return pipeline is connected to an upper part of the regulating pond; wherein a mixed solution formed by the wastewater and a returned sludge is allowed to enter into the regulating pond.

3. The device according to claim 1, characterized in that an external resistor is connected in series with a connection circuit between the PLC and the stainless steel wire mesh.

4. The device according to claim 1, characterized in that a mesh pore size of the stainless steel wire mesh is 25-100 μm.

Ansprüche

1. Integrierte MFC-DMBR-Kopplungsvorrichtung, dadurch gekennzeichnet, dass die Kopplungsvorrichtung einen Regelstank, einen anaeroben Anodentank, einen aeroben Kathodentank und einen Belüftungstank umfasst, wobei Kationenaustauschmembran zwischen dem anaeroben Anodentank und dem aeroben Kathodentank angeordnet sind, wobei der anaerobe Anodentank mit stromerzeugenden Mikroorganismen, Kohlenstofffilz und einem Rührwerk versehen ist, wobei der aerobe Kathodentank mit einem Edelstahldrahtgeflecht versehen ist, wobei nach der Betriebszeit der Vorrichtung auf dem Edelstahldrahtgeflecht eine dynamischen Membran zum Trennen von Feststoff/Flüssigkeit gebildet wird, wobei das durch die dynamische Membran gefilterte Abwassers aus dem Auslassrohr selbsttätig abfließt, wobei der Belüftungstank mit einem Belüftungskopf versehen ist, der durch eine Luftpumpe betrieben wird,

und dass die Kopplungsvorrichtung ferner eine SPS-Steuerung umfasst, wobei die positiven und negativen Elektroden der SPS-Steuerung jeweils elektrisch mit dem Edelstahldrahtgeflecht und dem Kohlenstofffilz verbunden sind, wobei das Abwasser in das Regelstank eintritt und auf den Boden des anaeroben Anodentanks sinkt , wobei das Abwasser aus dem anaeroben Anodentank nach oben steigt und in das aerobe Anodentank überfließt, wobei das Abwasser aus dem aeroben Kathodentank nach unten sinkt und in den Boden des Belüftungstanks eintritt, wobei das Abwasser aus dem Belüftungstank nach oben steigt und fließt unter der Auftriebswirkung der Belüftungsblasen in das aerobe Kathodentank zurück.

2. Kupplungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die Kupplungsvorrichtung ferner eine Schlammrückführleitung umfasst, die von einer Schlammrückführpumpe angetrieben wird, wobei das Einlassende der Schlammrückführleitung mit dem Boden des aeroben Kathodentanks und das Auslassende mit dem oberen Teil der Wand des Regelstanks verbunden ist; wobei das aus dem Abwasser und dem zurückgeführten Schlamm gebildete Gemisch in den Regelstank eintritt.

3. Kupplungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass ein externer Widerstand

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in Reihe mit der Verbindungsschaltung zwischen der SPS-Steuerung und dem Edelstahldrahtgeflecht geschaltet ist.

4. Kupplungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die Maschenweite des Edelstahldrahtgeflechts 25–100 μm beträgt.

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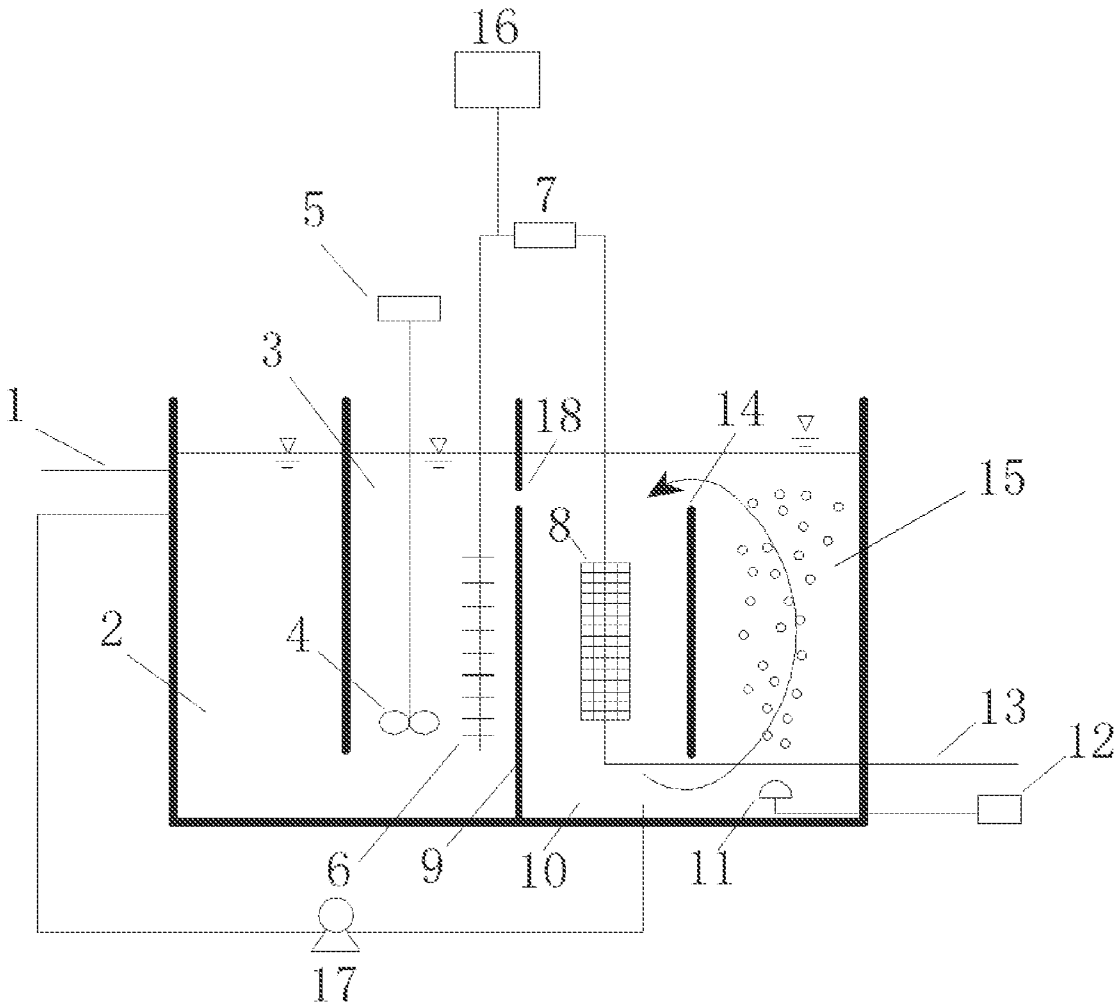

Fig. 1