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A novel combination of methane fermentation and MBR — Kubota Submerged Anaerobic Membrane Bioreactor process ☆,☆☆,☆☆☆

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ABSTRACT

Methane fermentation is considered one of the best placed biological processes to reduce volume of organic waste while keeping small sludge production and recovering energy. One of the disadvantages of early anaerobic digestion technologies was the long hydraulic retention time thus large capacity tanks were required to hold slow growing methanogenic bacteria. New technological attempts such as upflow anaerobic sludge blanket (UASB), fixed or fluidised bed and membrane bioreactor (MBR) appeared as counter-measures.

Kubota's submerged anaerobic membrane biological reactor (KSAMBR) process has been developed in the last decade and successfully applied in a number of full-scale food and beverage industries. It consists of a solubilization tank and a thermophilic digestion tank, the latter incorporating submerged membranes. The biogas generated can be utilized for water heating via boilers. Both permeate and waste anaerobic sludge are further treated in wastewater treatment facilities.

One of the main advantages of KSAMBR is that membranes retain the methanogenic bacteria while dissolved methane fermentation inhibitors such as ammonia are filtered out with the permeate. This makes the KSAMBR process very stable. Furthermore, the digester volumes can be scaled down to 1/3 to 1/5 of the conventional digesters provided that biomass is 3 to 5 times as concentrated.

Applications include stillage treatment plants for Shouchu (Japanese spirits made from sweet potato, rice or other grains), potato processing sites, sludge liquor and food factory treatment plants.

In summary, it is believed that KSAMBR offers the best possible solution combining the benefits of methane fermentation process with the performance of membrane technology. More details will be presented in the proceedings paper and in the presentation.

1. Introduction

Methane fermentation is considered one of the best placed biological processes to reduce volume of organic waste whilst reducing sludge production and recovering energy. One of the disadvantages of early anaerobic digestion technologies was the long hydraulic retention time with large capacity tanks required to hold slow growing methanogenic bacteria. New technological attempts such as upflow anaerobic sludge blanket (UASB), fixed or fluidised bed and membrane bioreactor (MBR) appeared as countermeasures.

In Japan, Food Recycling Law (FRL) came into force in 2001 and Biomass Nippon Strategy was proposed in 2002, respectively. FRL forces 20% reduction of food waste mass for the company which discharges food waste over 100 tons annually. As a company who started business in field machinery and then developed into environmental sector, KUBOTA aimed to a society where sustainable development is possible. KUBOTA regarded food waste as valuable "energy source", and has developed a new system realising both recovering energy from food waste and reducing the volume of final disposals.

☆ Additional information on Kubota Membrane Technology Kubota started its Membrane Business in the 80s and developed Submerged Membrane Unit® (Kubota SMU) housing MF flat sheet membrane cartridges. In 1998, the first European (and the first overseas Kubota SMU) aerobic MBR municipal sewage treatment plant was accomplished in Porlock, Dorset, UK. Porlock WWTP is in its 11th continuous operation this year. There are more than 270 in Europe and more than 2200 (as of August 2008) applications employing Kubota SMU worldwide treating both municipal and industrial wastewaters. Kubota produces ceramic membrane modules as well as polymeric flat sheet membrane modules.

☆☆ Acclaimed quality: certifications awarded to Kubota SMU Kubota SMU system meets the filtration performance and disinfection requirements for compliance with the California Water Recycle Criteria (Title 22) in USA, maintaining log-5 virus inactivation and daily average turbidity no more than 0.5 NTU. In addition, Kubota SMU system complies with the World Health Organization Criteria, the EU Bathing Water Directive and the International Maritime Organization (IMO) criteria. Most recently, the new IMO resolution MEPC.159(55) certification was given to EVAC MBR 8 employing Kubota SMU.

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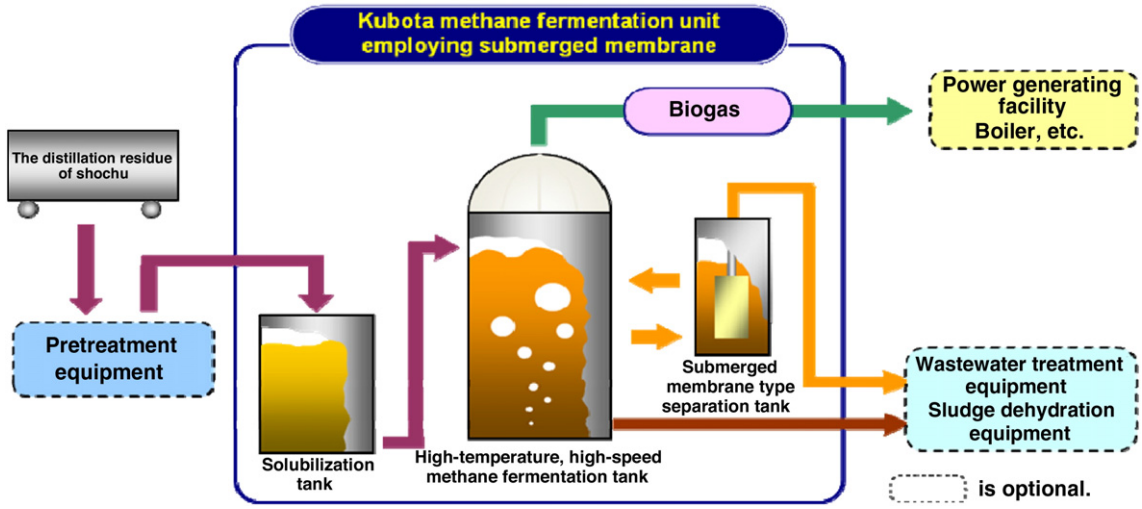

Fig. 1. KSAMBR process.

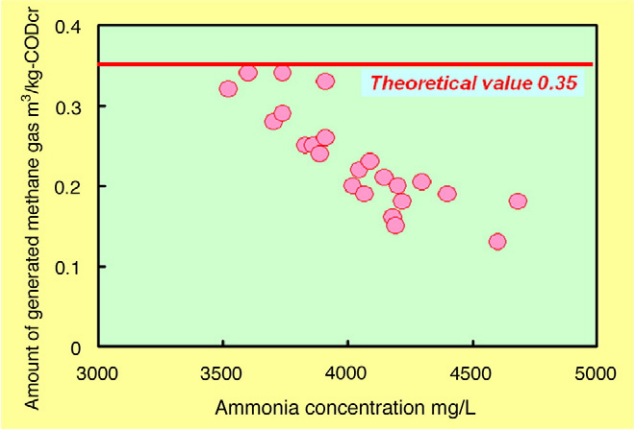

Fig. 2. Correlations between amount of generated methane gas and ammonia concentration.

Kubota's Submerged Anaerobic Membrane Biological Reactor (KSAMBR) process has been developed in the last decade and a patented technology which has been successfully applied in 15 full-scale plants (14 in Japan, 1 in North America as of August 2008). It consists of a solubilisation and a thermophilic or mesophyllic digestion tanks, the latter incorporating submerged membranes. The generated biogas can be utilised for water heating via boilers. Both permeate and waste anaerobic sludge are further treated in aerobic wastewater treatment facilities where membranes can play a role to obtain high-quality effluent.

One of the main features of KSAMBR is that membranes retain the methanogenic bacteria whereas dissolved methane fermentation inhibitors such as ammonia are filtered out with the permeate. This makes the KSAMBR process very stable. Furthermore, the digester volumes can be scaled down to around 1/3 or 1/5 of the conventional digesters provided that biomass is 3 to 5 times as concentrated.

Table 1
Characteristics of Shochu stillage.

Item	Unit	Min.	Max	Ave.
pH	–	3.60	4.76	4.11
TS	%	3.62	9.63	6.00
VTS	%/TS	96.6	99.7	97.8
COD_{Cr}	mg/kg	57,000	182,400	101,275
T–N	mg/kg	1530	5130	3720

Applications include Shochu (Japanese spirit made from sweet potato, rice or other kind of starchy vegetables) stillage treatment plants [1–2], garbage bio-gasification facilities [3], food processing factories. In this paper, a Shochu spillage treatment plant case study operational data is presented since its commission in 2005.

2. KSAMBR process

Raw materials such as distillation residue or food waste are fed to this system. If required, firstly residues are induced to pretreatment equipment such as crushers or screens. Then, residues are stocked in a solubilisation tank for a few days. The solubilisation tank has two roles; equalization of nutrients and storage of the raw feed. After solubilisation, liquors are introduced into the methane fermentation (MF) tank where thermophilic digestion takes place. The MF tank has a sub-compartment called submerged membrane separation (SMS) tank where the submerged membrane units are installed. The anaerobic sludge is concentrated at the SMS tank then recirculated to the MF or pumped to the sludge treatment line. The biogas generated consists of ca. 60% methane, 40% carbon dioxide and a few minor components such as hydrogen sulfide. After collected, biogas is utilised either at a power generation facility or boiler, thus recovering energy for the factory or neighbourhood. Fig. 1 shows the KUBOTA methane fermentation system.

Fig. 3. The appearance of the MF and SMS reactors.