Promoting Further Energy-saving of Membrane Bioreactor (MBR)

(Research of FY 2017-2021)

1. Purpose

This study aims to:

- Develop a next-generation MBR which is operatable with equivalent or less power consumption to the conventional nutrients removal process
- Establish the evaluation scheme of MBR performance, including energy efficiency, required performance levels, and cost estimation procedures

In this report, the next-generation MBR means MBR with higher energy efficiency than the energy-saving goal of 0.4kWh/m^3 set at the fourth public proposal joint research of MBR.

2. Outcomes of This Year

(1) Demonstration of energy-saving MBR: Research groups conducted pilot-scale demonstrations for the following four different MBRs, including the continued study from the previous year (table 1)

- **Demonstration of MBR using energy-saving PVDF flat membrane units for Medium to large-scale WWTPs:**
  Joint research with SUIDO KIKO KAISHA, LTD. and Toray Industries, Inc.: The study tried to save the energy of immersed MBR by combining a new membrane unit and automatic air volume control for membrane surface washing. The demonstration also included the immersed MBR's adaptability to inflow fluctuations for daily or rain.

- **Demonstration of highly efficient denitrification MBR with cost-saving, energy-saving, and space-saving:**

Joint research with KUBOTA Corporation:
The study dealt with the immersed MBR with a new treatment flow combining a multi-staged anoxic-aerobic tank and a step-feed system. The demonstration achieved a high nitrogen removal rate of 90% and over. The demonstration included the process of combining biological phosphorus removal, too.

- **Energy-saving MBR applying membrane washing technology with ozone water**:
  Joint research with Mitsubishi Electric Corporation:
  The demonstrated MBR combines high flux with automatic aeration control. A new chemical membrane washing procedure with ozone water achieves high flux, and automatic aeration control is for membrane surface and biological treatment. The demonstration tried to save the energy of the immersed MBR with the combination of these two technologies.

- **Demonstration of energy-saving MBR with a new membrane washing system**:
  Joint research with JFE Engineering Corporation and FUSO Corporation:
  The study tried to save energy from immersed MBR with a new biological membrane washing by water flow. The demonstration, a small-scale experiment in joint research from 2012-2018, is reconducted over a full-scale and long period.

(2) Study on the evaluation scheme of the economic efficiency of MBR: We studied the evaluation scheme of standard conditions and approaches to effectively evaluate different MBR processes' economic efficiency, including construction costs, O&M costs, and total costs.

Table1. Overview of joint research related to MBR

Joint researcher, (Year of demonstration)	Membrane/ System	Purpose	Technology
SUIDO KIKO KAISHA, LTD., Toray Industries, Inc., (2018-20)	Organic flat membrane (PVDF)/Immerged MLE	Energy saving Adapting to the inflow fluctuation	・New membrane unit (enhancing filling rate, multi-stage) ・Airflow volume control for membrane surface washing ・Improvement of chemical washing
KUBOTA Corporation, (2020-21)	Organic flat membrane (Chlorinated PE)/Immersed multi-stage MLE	Improvement of nitrogen removal rate	・New treatment process (multi-stage circulation MBR) ・Combination of the above technology and biological phosphorus removal (UCT)
Mitsubishi Electric Corporation, (2019-21)	Hollow fiber membrane (unspecified; ozone resistance required) /immersed MLE	Energy saving	・New chemical washing (ozone water washing) ・Airflow volume control for membrane surface washing ・Aeration airflow volume control for biological treatment
JFE Engineering Corporation, FUSO Corporation (2019-21)	Organic hollow fiber membrane (PTFE) /Immersed MLE	Energy saving	・New physical washing system (water flow washing) *scale-up demonstration of the research completed in 2018

*PVDF: Polyvinylidene fluoride, PE: polyethylene, PTFE: polytetrafluoroethylene, MLE: Modified Ludzack-Ettinger, UCT: University of Cape Town

3. Future Schedule

Joint research will continue new MBR's development and demonstration with enhanced energy-saving and establish the evaluation scheme for MBR's costs, energy-saving performance, etc.

Keywords: **Membrane bioreactor, MBR, Energy-saving**