Radioactive Particle Tracking Study on a Vertical Motion Mixer

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Background

Wastewater Treatment Plants
- As of 2015, ~500 site are in service in Korea

Anaerobic Digester
- Decompose organic wastes into water and Methane gas, which can be used a fuel for heating the processes

Air bubbling type  Impeller mixing type  Wastewater Treatment Processes
Background

**Vertical Impeller Mixer**

- Developed by a local company with the support from the local environmental cooperation
- Certified by the official test authority: Save energy up to 97%, reduce maintenance cost up to 90%
- Promote marketing for the WWTPs
Background

- Only numerical modeling for fluid dynamics
- Visible difference observed on the flow pattern
- Seemed to be not sufficient to generate good mixing

CFD modeling result

PIV & plastic tracer tests
Objectives

- Visualize the mixing flow pattern of the vertical impeller mixer
- Preparation of Radioactive media (tracer) without a nuclear research reactor (HANARO)
- Radioactive particle tracking technique
Radiation data is converted into Particle trajectories using reconstruction algorithm.

Reference data for reconstruction algorithm is usually obtained by Monte Carlo Method.
Digester

Digester in WWTP

Lab. Scale digester

15 NaI(Tl) (3 layers)

RPT

Detector setup based on optimization study with MCNP6
A typical radioactive particles

**Sc-46 PP ball**
- Produced from a research nuclear reactor
- T1/2 (83.8 days) & Γ-energy (888, 1120 keV) suitable for RPT tech.

\[ \rho_p = 0.999 \text{ (in water)} \]
No reactor-based RI available

**Ga-68 PP ball**
- Radioisotope generator nuclide
- Short half-life (68 min) & low G-energy (511 keV) for the RPT tech.

**Ga-68 solution**
- 0.05 M HCl
- 1.25 mCi in 5 ml

**Ge/Ga generator**
- Internal vol.: ~0.25 ml
- 5 M NaCl
- 1.25 mCi in 0.5 ml
- Higher S.A. (10 times)

Radiation Data Acquisition System

36-port high speed MCA system

- Gamma spectrum from up to 36 probes simultaneously
- HV supply, 2048 channels, 20 msec sampling
- Resolution 7.9% (Cs-137 662 keV)
- User-friendly GUI software
3D coordinates of the radiation source

Linear Regression Method

Correlate radiation intensities with distances between source and prove through Polynomial Fitting
3D coordinates of the radiation source

Linear Regression Method

- Reference data for the reconstruction algorithm is usually obtained by Monte Carlo Method.
- Due to saturation of probes, the relationship equations was experimentally obtained.
Trajectory of the radiation source

Coordinates of the radiation source

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- It was impossible to detect gamma when the particle is close at the wall (detector) because of saturation.
- We could have got over the saturation by using lower activity particle, but it must make blind zone near the center because of digester’s size (r=25 cm).
Conclusion

- As an alternative to a RR, a **RNG** showed a possibility to be a radioactive particle source.

- *High specific radioactivity* from a Ge/Ga generator was prepared by adapting a concentration procedure based on an ion exchange method.

- RPT technique was applied to successfully **visualize flow pattern** in the digester equipped with an allegedly vertically moving mixer.

- *The correlation between motor speed and flow pattern* was not investigated. Only the fact that the vertical motion of the mixer generates flow movement.

- *Data lost both near the wall* where the probes were saturated and *in the center* where the low gamma energy couldn’t penetrate the water.

- *Comparison between RPT / PIV / CFD* to be carried out to confirm the flow movement and for quantitative understanding of the flow.
Thank you.