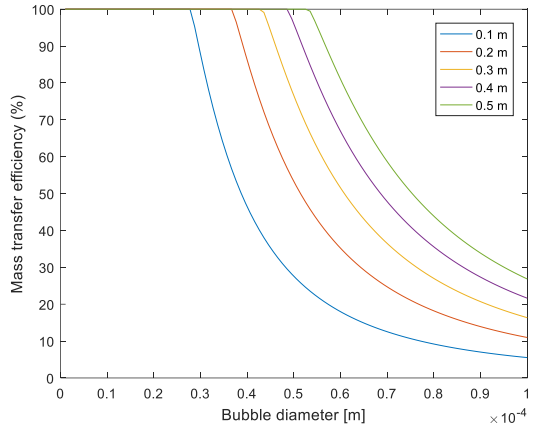

Fig. 7. Mass transfer efficiency as a function of bubble size

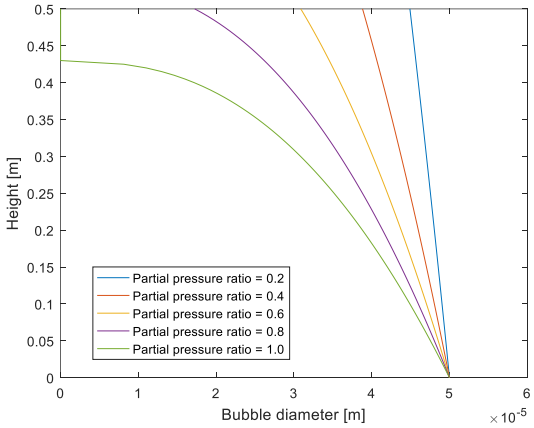

Fig. 8. Bubble diameter as a function of partial pressure

4. Summary and Conclusions

The experimental facility and numerical method for simulating and analyzing the case of PWR coupled with the S-CO_2 power system are introduced in this paper.

The purpose of the experiment is identifying the phenomenon of supercritical CO_2 leaking into high pressure water. Using the measured pressure and temperature data, the dissolved mass of CO_2 is calculated.

The numerical method is based on the mass transfer from the bubble and it is used to calculate the dissolution according to the bubble size. The bubble size is thought as a key parameter because it is judged appropriate to be used as a model for safety analysis code later.

5. Further works

Eq. 3 does not consider the transient situation. Thus, the model is being developed by considering the variation with time. The model is a combination of the developed models by other researchers. Thus, the results could vary significantly depending on the models. The sensitivity of the model should be studied.

The process of bubble break up is dependent on many conditions such as physical properties, geometry, mass flow rate and so on. However, the authors only considered the physical properties as parameters for estimating the bubble size. It is challenging to consider the geometry effect such as interaction between wall and jet. Flow rate of CO_2 can be considered as a factor and can be studied further with more experiments.

ACKNOWLEDGEMENT

This research was supported by the KUSTAR-KAIST Institute, KAIST, Korea.

REFERENCES

[1] Yoonhan Ahn, Seong Jun Bae, Minseok Kim, Seong Kuk Cho, Seungjoon Baik, Jeong Ik Lee, et al., "Review of supercritical CO_2 power cycle technology and current status of research and development", Nuclear Engineering and Technology, 47, 647-661,2015.

[2] Wu, P., Ma, Y., Gao, C., Liu, W., Shan, J., Huang, Y., Wang, J., Zhang, D., Ran, X., "A review of research and development of supercritical carbon dioxide Brayton cycle technology in nuclear engineering applications", Nuclear Engineering and Design, 368, 110767,2020.

[3] J.J. Lee, J.I. Lee., "Experimental Facility for Supercritical CO2 Leakage to High Pressure Water", Transactions of the Korean Nuclear Society Autumn Meeting, July 9-10, 2020, Korea.

[4] Hu, Q., Guo, H., Lü, X., Lu, W., Chen, Y., Zhu, Y., Geng, L., "Determination of P-V-T-x properties of the CO_2-H_2O system up to 573.15 K and 120 MPa-Experiments and model". Chemical Geology, 424, 60–72, 2016.

[5] Duan, Z., Sun, R., "An improved model calculating CO_2 solubility in pure water and aqueous NaCl solutions from 273 to 533 K and from 0 to 2000 bar", Chemical Geology, 193, 257–271, 2003.

[6] Vivaldi, D., Gruy, F., Simon, N., Perrais, C., "Modelling of a CO2-gas jet into liquid-sodium following a heat exchanger leakage scenario in Sodium Fast Reactors", Chemical Engineering Research and Design, 91, 640–648, 2013.

[7] Li, P., Ma, Y., Zhu, D.Z., "Mass Transfer of Gas Bubbles Rising in Stagnant Water", Journal of Environmental Engineering, 146, 2020.

[8] Sam, A., Gomez, C.O., Finch, J.A., "Axial velocity profiles of single bubbles in water/frother solutions" International Journal of Mineral Processing, 47, 177–196, 1996.

[9] Tomiyama, A."Struggle with computational bubble dynamics", Multiphase Science and Technology, 10 (4): 369–405, 1998.

[10] Higbie, R. "The rate of absorption of a pure gas into a still liquid during short periods of exposure", Transactions of the American Institute of Chemical Engineers, 31, 365–389, 1935.

[11] Calderbank, P. H., and M. B. Moo-Young. "The continuous phase heat and mass-transfer properties of dispersions", Chemical Engineering Science. 16 (1–2): 39–54, 1961.

[12] Nock, W. J. "An investigation into gas transfer from bubbles into water." Ph.D. thesis, Faculty of Engineering and the Environment, Univ. of Southampton. 2015.