Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 12-13, 2016

Study on Pressure drop for Ion Exchanger in Jordan Research and Training Reactor

Ki-jung Park*, Jungwoon Choi, Seong-Hoon Kim, Dae-Young Chi, and Cheol Park
KAERI, Research Reactor System Design Div., #111, 989 St., Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea
**Corresponding author: pkijung@kaeri.re.kr*

1. Introduction

The Jordan Research and Training Reactor (JRTR) is currently being constructed and commissioned in the JUST (Jordan University of Science and Technology) site. The main fluid systems relevant to the JRTR have been proceeding at the Korea Atomic Energy Research Institute. The main fluid systems are composed of a primary cooling system (PCS), a pool water management system (PWMS), a hot water layer system (HWLS), a heavy water system (HWS), and emergency water supply system (EWSS). The PWMS is in charge of the purification and cooling of the pool water. In order to achieve the purpose of the pool water purification, two filters and two ion exchangers which can be to remove suspended solids and ionic impurities in the in-taken pool water have been designed. For the reliable design of this system pump, it is important to predict the pressure drop of the system equipment including the ion exchanger.

In this study, the pressure drop in the ion exchanger of PWMS is predicted by using the well-known model and the results provided from manufacturing company. And, the calculated results are compared to the actual data which is measured from the ion exchanger during the PWMS commissioning.

2. Methods and Results

2.1 Ion exchanger on PWMS

Fig. 1 shows a schematic of the ion exchanger which is designed for the PWMS in the JRTR.

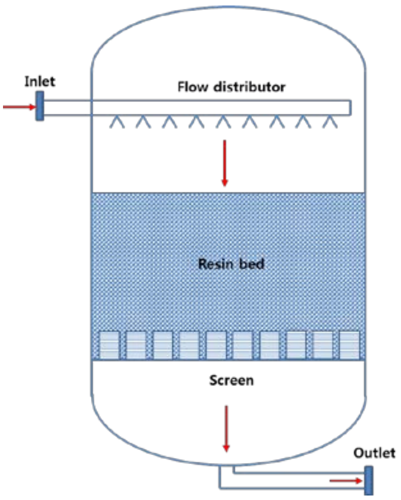

Fig. 1. Schematic of the ion exchanger

As shown in Fig. 1, flow distributor connected the inlet pipe is installed at the upside in the ion exchanger. The inlet flow can be uniformly distributed to the horizontal section of the ion exchanger through this flow distributor which has flow holes. So, the flow can be uniformly going across the resin bed. The resin of 0.6 mm to 0.7 mm size is piled high the resin bed depth of 1.2 m in the ion exchanger. Radioactive products such as corrosion, fission or activated product, will be eliminated from the system flow through the ion exchange reaction of the resin bed. The nozzle type a resin retention screens are installed at below the resin bed to hold mixed anion and cation exchange resins. This screen have 0.15 mm (0.006 inch) nominal opening.

The pressure drop of ion exchange will be formed through the flow distributer, resin bed, and retention screens.

2.2 Pressure drop prediction of ion exchanger

The pressure drop of ion exchanger was calculated from 5 parts of the flow distributor, resin bed, screen, screen & resin interface, and outlet of the ion exchanger. The pressure drop of each part was calculated as the variation of flow rate from 0 to 10 kg/s.

- Flow distributor

Flow distributor was shaped the thin-walled distributor with perforated lateral outlet referred from Handbook of Hydraulic Resistance. To calculate the pressure drop of the flow distributor, the following equation (1) was used.

$$\zeta = \frac{\Delta P}{\rho v^2/2} \approx \frac{1.8}{\overline{f_0}^2} + \left(\frac{l_0}{D_h}\right)^{0.15} \qquad (1)$$

$$\overline{f_0} = \frac{A_{or}}{A_o} \qquad (2)$$

where ζ, ΔP, ρ, v, $\overline{f_0}$, A_{or}, A_o, l_o, and D_h are the pressure loss coefficient, pressure drop, density, water velocity, area ratio, total cross section area of perforated holes, total cross section area of the pipe, distance of perforated plated, and hydraulic diameter, respectively.

- Resin bed

The pressure drop from the resin bed was used the data provided from the manufacture company of resin.

This data from the company is reliable due to the experimental result itself.

- Screen

The pressure drop of the screen was calculated by the following equation (3) from the reference. [2]

$$Q = 21.07 \cdot d_1^2 C \sqrt{\frac{\Delta P}{\rho}} \quad (3)$$

where Q, d, and C are the flow rate per one screen, diameter of nozzle, and flow, respectively. However, because the result of calculation shows that the pressure drop was very small, this portion of the pressure drop was negligible.

- Screen & resin interface

The pressure drop of the screen & resin interface is function of the water slot velocity. The data provided from the manufacture company of screen was used.

- Ion exchanger outlet

For the calculation of the pressure drop of the ion exchanger outlet, the following equation (4) was used.[2]

$$K_{EQ} = \frac{0.5\sqrt{\sin\frac{\theta}{2}}\,(1-\beta^2)}{\beta^4} \quad (4)$$

$$\beta = d_1/d_2 \; (d_1 < d_2)$$

$$(45^{\circ} < \theta \leq 180^{\circ})$$

where K_{EQ}, θ, d_1, and d_2 are the resistance coefficient, angle of divergence, diameter of smaller pipe, and f diameter of larger pipe, respectively.

Table I shows the results of pressure drop calculation at the mass flow rate 5 kg/s and 10 kg/s. Additionally, Table I have the calculated portion for total pressure drop at the mass flow rate 10 kg/s. As shown the Table I, the predicted pressure drop was dominated by the resin bed as a portion of about 85% for total pressure drop.

Table I: Portion of total pressure drop (kPa)

	Mass flow rate 5 kg/s	Mass flow rate 10 kg/s	Portion for total pressure drop at 10 kg/s (%)
Flow distributor	0.223	0.895	2.2
Resin bed	17.311	34.622	84.4
screen & resin interface	2.077	4.154	10.1
Ion exchange outlet	0.337	1.347	3.3
Total predicted pressure drop	19.948	41.018	100

Fig. 2 shows the results of accumulated pressure drop at the variation of mass flow rate 0 kg/s to 10 kg/s. The result shows the trend is proportional trend because the pressure drop of resin bed provided from the manufacture company presented to be mostly proportional trend.

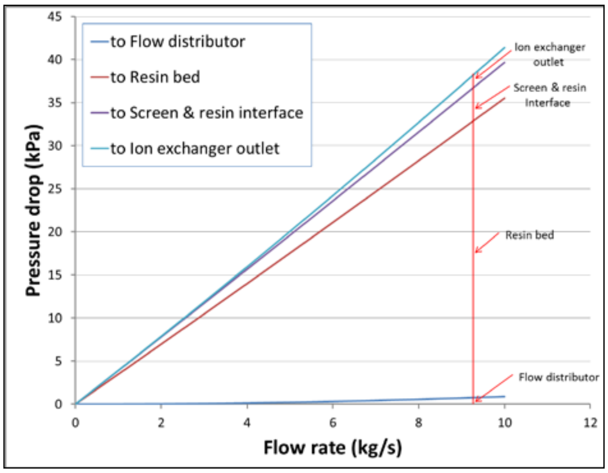

Fig. 2. Accumulated pressure drop at the variation of mass flow rate 0 kg/s to 10 kg/s.

2.3 Comparison of measured data with prediction

After predicting the total pressure drop of ion exchanger, the measured data at the JRTR site during the commissioning are compared with the prediction to confirm the reliability of the calculation. Fig. 3 shows the comparison of measured pressure drop with predicted pressure drop. Even though there is a deviation in measured pressure drop below 5 kg/s, the data above 5 kg/s agree within 5% in the entire range. From this comparison, the reliability of the prediction and calculation method was confirmed.

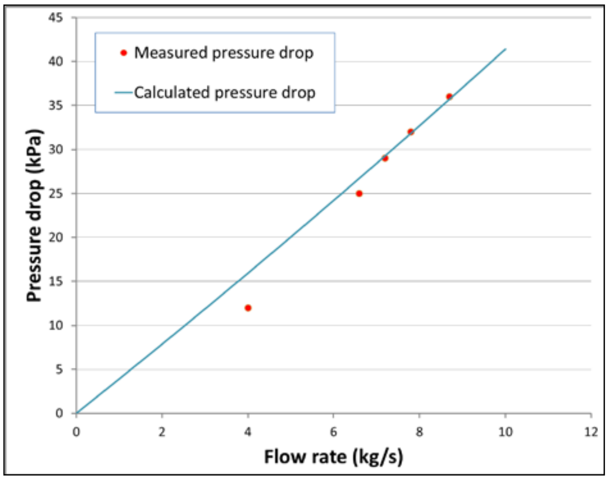

Fig. 3. Comparison of measured pressure drop with predicted pressure drop.

3. Conclusions

The pressure drop of the ion exchanger was calculated with well-known equations and by using the results provided from manufacturing company. The predicted pressure drop is dominated by the resin bed as a portion of about 85% for total pressure drop. The predicted pressure drop is compared to the measured pressure drop of the ion exchanger which is installed in the JRTR, the data above 5 kg/s agree within 5% in the entire range. From this comparison, the reliability of the prediction and calculation method was confirmed.

REFERENCES

[1] I.E. Idelchik, Handbook of Hydraulic Resistance, 3rd Ed., 1996.
[2] Crane Technical Paper No. 410, Flow of Fluids through Valves, Fittings and Pipe, 1988.