Pressure Drop of U-shape Bellows at Argon Circulation System

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1. Introduction

Advanced spent fuel conditioning process facility (ACPF) consists of an air cell and an argon cell. In an argon cell, an electrolytic reduction process is performed in which oxygen is separated from the spent fuel by an electrochemical method to reduce it to metal. Therefore, the inside of the cell is filled with argon gas to remove oxygen, and it is a space for handling the radioactive material, so it must be kept at a negative pressure so that the radioactive material can't move to the outside. At this time, the argon circulation system is used to maintain the moisture, oxygen concentration and pressure inside the cell at a constant level. This system consists of a process in which the fluid inside the argon cell is passed through the purification system through the HEPA filter in the air cell and then back to the argon cell. This process is repeated. This system also uses a blower to circulate the working fluid and maintain the design flow rate. In this case, the flow rate is lower than the design value because the pressure loss in the entire circulation system is larger than expected and the differential pressure of the blower is higher than the design pressure. To solve this problem, we investigated the characteristics of the fluid flow from the air cell to the bellows of the HEPA filter system, where pressure drops are large and can easily be improved. In this study, we used flow simulation, a computational fluid dynamics analysis program.

2. Model description

2.1 General Information of U-shape bellwos

In this research facility, a circular bellows of the U-shape type is used, and it is always bent at an angle of 120 degrees or more.

Generally, the bellows are known to have a significant impact on pressure loss due to the pitch value, inner diameter, outer diameter and the corrugate area [1]. Also, there is an experimental result on the occurrence of pressure loss according to the radius of curvature [2]. However, CFD analysis is rarely performed on the fluid flow characteristics of the bellows due to the change of the radius of curvature. Therefore, we analyzed the internal flow characteristics and the pressure drop at a specific flow rate using the bellows standard used in this research facility.

The bellows code is 50A and the detailed dimensions are shown in Table 1.

Table 1. Specifications of U-shape bellows

Material	Product Co.	I.D (mm)	O.D (mm)	Thickness (mm)	Pitch (mm)
SUS 304	50A	49.8	67.5	0.3	5

As shown in Fig. 1, the bellows length of all analytical models is 1000mm and a 50A general piping with a length of 100mm was connected to the inlet and the outlet so that the flow is fully developed.

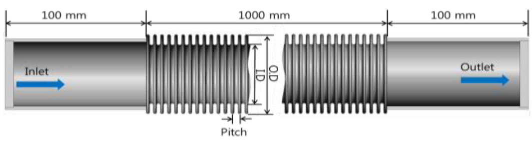

Fig. 1. Shape of bellows.

The analytical model is a total of nine models with 20 degrees interval from 0 to 160 degrees.

2.2 Condition of CFD analysis

In order to compare the experimental results with the analytical results, the pressure and temperature conditions were set to -23.7 mmAq and 24℃, respectively. The initial conditions were -23.7 mmAq of static pressure at the inlet and 98.5 m^3/h of volume flow rate at the outlet.

The analysis used the k-ε model, which is a turbulence analysis model.

Table 2. Boundary condition and Initial condition

Pressure (mmAq)	Tem. (℃)	Inlet (mmAq)	Outlet (m^3/h)
-23.7	24	Static pressure	Volume flow rate
		-23.7	98.5

3. Results and discussion

As shown in Table 3, the pressure drop increase with the bending angle. Also, as shown in Fig. 2, pressure drops are increased more than 25 mmAq at from 0 degree to 60 degree of bending angle, whereas the increase width decreases to 8 mmAq less when the bending angle is 80 degree or more.

Experimental results show a pressure drop of 170 mmAq in the bellows. The cause is two bends, 40 degree and 160 degree. Compared with the analytical results, although the absolute comparison is impossible, it can be seen that the tendency is somewhat consistent.

Table 3. Pressure drop versus bending angle for bellow

B.A (degree)	0	40	80	120	160
P.D (mmAq)	36.8	58	80.8	94	104.6

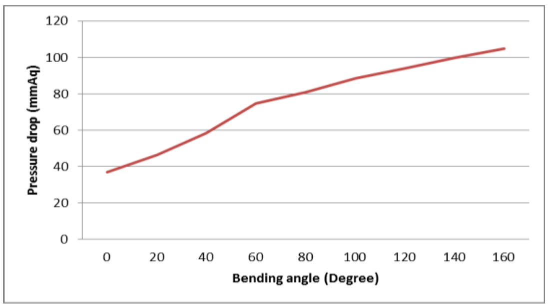

Fig. 2. Pressure drop versus bending angle for bellow.

4. Conclusion

It was found that the bending angle of the bellows significantly influenced the fluid resistance. Also, the pressure drop tendency according to the bending angle was able to be obtained. However, further analysis of the bellows shape and the same model of the experimental facility is needed to make a more accurate comparison.

REFERENCES

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