Study of Head-loss effect for ECCS Strainer Design Variables with Debris Condition

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1. Introduction

LOCA(Loss Of Coolant Accident) due to station damage such as pipe break in NPP generates various debris fragments. Debris moves into recirculation sump at the bottom of NPP with accompanying blow-down, wash-down, pool-fill and recirculation. If strainers at the sump have not enough performance of filtering, it will generate higher pressure drop inside perforated plate of strainer and affect safety issue. Especially as strainers installed do not satisfy design requirements and performance against NPP LOCA, it is necessary to install new strainer with low head-loss, higher safety requirements compared to the existing strainer[1]. In this study, considering the different situations in each NPP station and design parameters of strainers, we study the optimized design of new strainer.

2. Methods and Results

2.1 Strainer debris test and pressure drop

Strainer debris (Nukon) head-loss test was performed by perforated surface area(m^2) of strainer and pocket volume(m^3) with overlapped two lattices(refer to lattice H type and V type). Assumed that debris was filled inside the pocket, we started the test using different amount of debris from 0% to 120% (here 100% means the pockets were covered by debris completely). Fig. 1~2 show that as debris amount is close to the 100% of pocket volume, slope of pressure-drop is higher than that of 100% below.

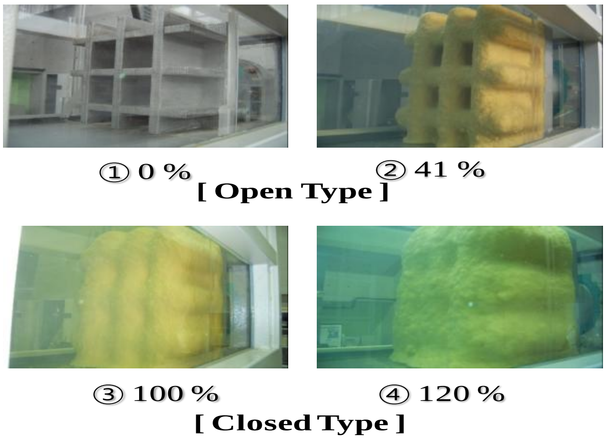

Fig. 1. Debris test figures with debris percentage

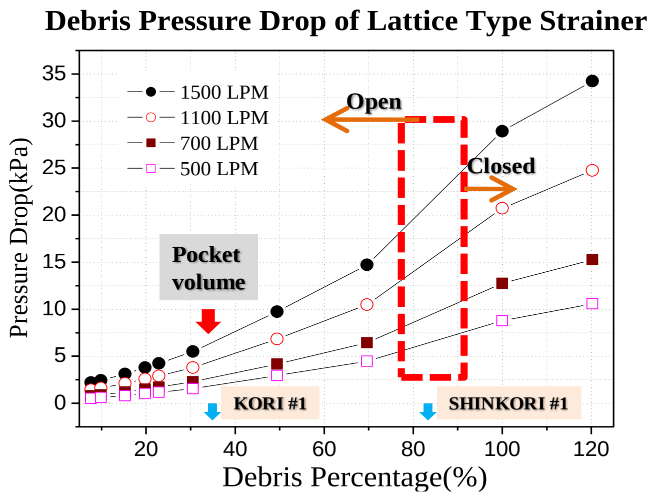

Fig. 2. Pressure drop of debris percentage

2.2 Two types of debris build- up on the strainer surface

When debris is filled until 70% the pockets of strainer (called Open type) or it covered the pocket over 70% (called Closed type), the pressure drop slopes have different behavior. In the case of the Open type, debris is piled on top of each strainer with similar debris thickness, but otherwise Closed type is overcharged in inside of the pocket than outside.

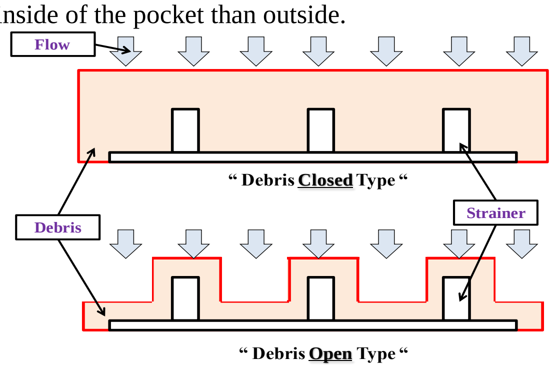

Fig. 3. The debris piling behaviors at the lattice type strainer

2.3 Selection of design parameters for improving strainer with the different debris amount

As the limited space in the sump area of plant, it is important to design the strainer efficiently. Fig 4 shows the design variables for the Lattice type strainer which we consider.

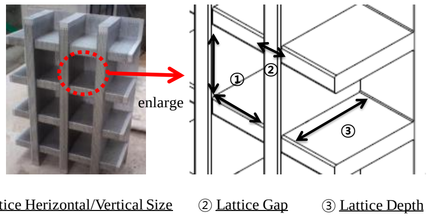

Fig. 4. Design variables at Lattice type strainer

Design variables are lattice size(no.1), gap(here no. 2) and depth(no. 3) for the improvement of strainer design.

2.5 The results of flow analysis for the Open type and the Closed type in the debris Pile-up

For this study firstly, the porosity values which were extracted from the test results apply to the analytical model. And then, boundary conditions were given as like Fig. 5. Numerical simulations performed with different design variables as see in Table 1.

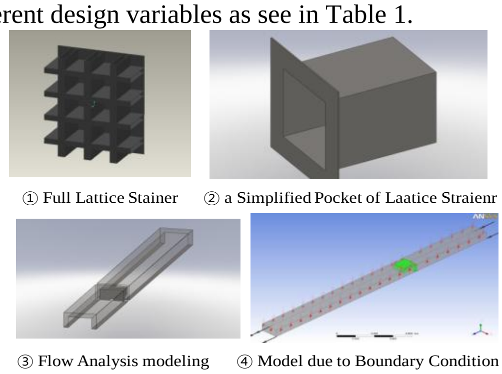

Fig. 5. Numerical modeling for Lattice strainer

Variables (cm)	Experimental Test	CFD Simulation
Size	10	8, 10, 12, 16, 20
Gap	3	1, 2, 3, 4
Depth	20	10, 15, 20, 40

Table 1. Different design variables of Lattice strainer

A state of pressure-drop is moved to another point of higher value at figure 6~7 with design variables. In open type, as increasing the lattice size and depth, pressure-drop is decrease; but the lattice gap case is increase. In closed type, it shows decrease of the pressure drop in according to the increase of the lattice size and depth. But lattice gap case shows in a different way unlike the open type. The pressure drop is decreasing with lattice gap size increase.

2.6 Determination of design key-factors for the lattice type strainer at various debris conditions

It is necessary to apply optimized design to lattice strainer for the debris Open type and Closed type. If we consider the open type with amount of debris, we can have the lowest head-loss by controlling lattice depth and size. At Closed type, lattice gap coupled with lattice size and depth is used to select optimized design. Pressure-drop at each strainer model is likely to be influenced by lattice depth and gap due to the free path inside the pocket with cross-section area at pocket portion. Contrast to lattice depth and size, effect of lattice gap which increase its size is negative value at Open type and positive at Closed type. This major reason will be likely to arise due to cross-section area of pocket and debris thickness at lattice with Fig. 6~7

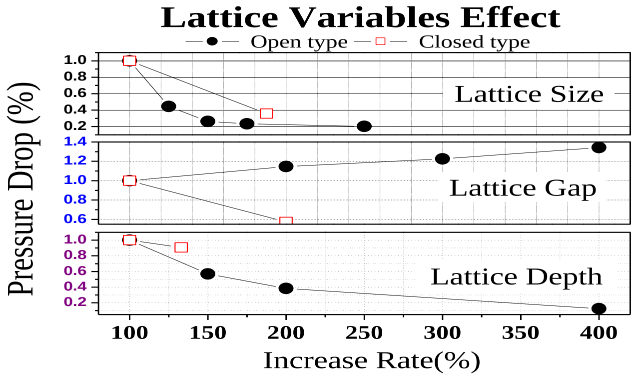

Fig. 6. Design effect of Lattice variables between Open type and Closed type

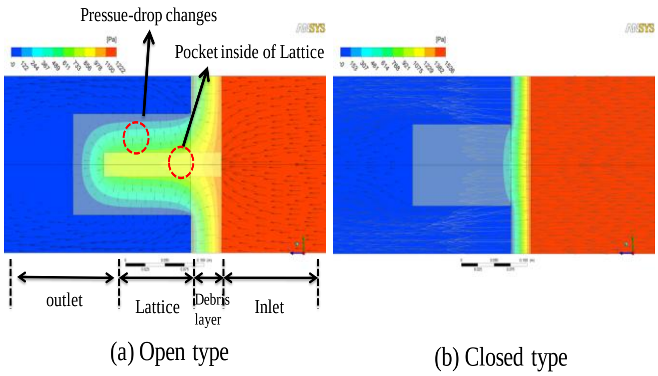

Fig. 7. Pressure-drop changes between Open type and Closed type at same value of lattice gap.

3. Conclusions

It is important to minimize head-loss of strainer against the debris blockage. At each conditions of debris which is covered on the surface of strainer, we studied the optimizing of the Lattice type strainer. Contrast to lattice size and depth with positive effect on pressure-drop, we have different pressure-drop appearance with lattice gap where debris condition are open type and closed type. Different design is determined to plant specification and is mainly optimized due to following the mechanism with flow free path and debris thickness and area ratio.

4. Acknowledge

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REFERENCES

[1] Christian Loetscher, Franc Skrabec, Reactor Building Recirculation Sump Screen Replacement, Nuclear Energy for New Europe 2008, page 1005.1, 2008