The Pressure Drop Characteristics of Flow Straighteners for Minimizing Flow Induced Vibration in the Core Channel of the HANARO

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1. Introduction

It is reported that the cause of wear fatigue in fuel assemblies in the HANARO[1] is flow induced vibration occurring rotational flow in the core channel[2]. In order to minimize this vibration, it is investigated that flow straightener (FS) which is substituted for the flow restrictor installed in the low part of the core channel. This paper describes pressure drop characteristics of the FS obtained through experimental test.

2. Flow straightener

To minimize the rotational flow in the core channel, the FS is made in various shapes such as honey, astral and crucial type as show in Fig. 1. Each type has the same outside diameter of the flow restrictor to replace it by the FS and stretched length to induce the directional flow [3], [4].

(a) Honey type (b) Astral type (c) Crucial type

Figure 1 Shapes of flow straighteners

3. Test procedures

Pressure drop test was performed in a single channel test loop installed in the core by pass line of a HANARO Flow Simulation Facility (HFSF) which has a half size of the HANARO core, 13 core channels of hexagonal type and 7 core channels of circular type[5]. As the same HANARO, the core flow rate of HFSF is 90% of total flow and the rest is core bypass flow. The core bypass flow is about 41 kg/s, which is more than the design flow rate of each core channel, 19.7 kg/s for hexagonal type and 12.6 kg/s for circular type. Hence, the flow rate is available to test the pressure drop of the FS in the single channel test loop. A circulating fluid temperature is maintained at 39~40℃ by using the generated heat of a circulating pump installed in the HFSF.

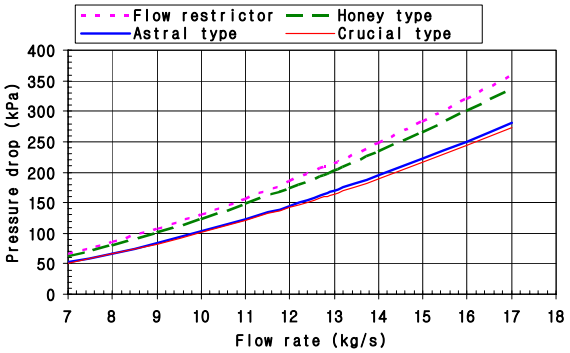
The test method is as followed. Each dummy fuel of hexagonal and circular type is loaded with flow restrictor respectively in the single channel test loop to verify a test method. When the current flow is at 50%, 75%, 100%, 125%, 150% of the design flow, the pressure drop of the dummy fuel is measured and the pressure drop characteristic curve is calculated. When the current flow is the same as the design flow, the pressure drop is calculated by using the characteristic curve. According to this result, it is proved that the reliability of this test loop is allowable as comparing this pressure drop to that of HANARO. After the honey, astral and crucial FS are orderly installed instead of the flow restrictor, each pressure drop is measured as the same previous method.

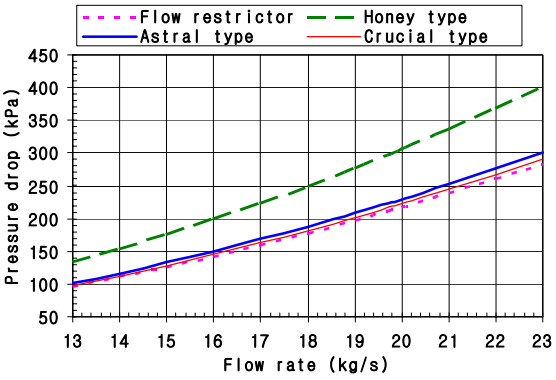
4. Results and consideration

Fig.2-a) shows the pressure drop characteristics expressed in power form ($Y=AX^B$) for the flow restrictor and each FS in circular core channel. In case of the design flow rate at the flow restrictor, the pressure drop is 206.1 kPa. This result is similar to the design pressure drop of the HANARO (209 kPa)[6] and it is proved that test methods are reliable. As shown in the figure, the pressure drop of each FS is lower than that of flow restrictor. The pressure drop characteristics between crucial and astral

FS are similar and a pressure drop is about 45 KPa, which is lower than the pressure drop of flow restrictor.

As the same method in circular flow tube, the pressure drop of flow restrictor and each FS in the hexagonal core channel is measured at the design flow. The results are shown in Fig. 2-b). In case of the design flow rate at the flow restrictor, the pressure drop is 211.1 KPa, which is similar to the design pressure drop of the HANARO. Hence it is estimated that test result is reliable. The test results show that the pressure drop of each FS is higher than that of the flow restrictor. Especially the pressure drop of crucial FS is similar to that of flow restrictor. And the second is the astral type FS and the last is the honey type FS.





a) Circular type

b) Hexagonal type

Figure 2 Pressure drop characteristics curves of flow restrictor and each FS

5. Conclusions

As results, the pressure drop of each FS is measured in order to verify the substitutability for the flow restrictor. At circular core channel, all the FS have the lower pressure drop than that of the flow restrictor but higher pressure drop in the hexagonal core channel. Among the various FS, the pressure drop of the crucial type FS is similar to the flow restrictor among these.

References

[1] Y. C, Park et al., "System Performance Test in HANARO," the Proceeding of the 5th ASRR Vol.1, p. 240~246, 1996.

[2] Cheul, Park et al., "Design of the New Research Reactor," Research Report, KAERI/RR-2289/2002, 2002.

[3] Y.C, Park, "Pressure Drop Measurement of Flow Straightener Loaded in the Circular Core Channel," Technical memo, KAERI, HAN-RS-CR-04-005, 2004.

[4] Y.C, Park, "Pressure Drop Measurement of Flow Straightener Loaded in the Hexagonal Core Channel," Technical memo, KAERI, HAN-RS-CR-04-007, 2004.

[5] Y.C, Park, et al., "Performance Characteristics of the HANARO Flow Simulation Facility," Proceedings of The Third National Congress on Fluids Engineering August 26-28, 2004, Jeju, Korea, pp 895-898, 2004.

[6] KAERI, "Safety Analysis Report of Research Reactor, HANARO, KAERI/TR-710/96, Vol. 2, pp. 5-57 ~ 60, 1996.