# Hydrodynamic Experiments for a Flow Distribution of a 61-pin Wire-wrapped Rod Bundle

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## 1. Introduction

Fuel assembly of the SFR (Sodium-cooled Fast breeder Reactor) type reactor generally has wire spacers which are wrapped around each fuel pin helically in axial direction. The configuration of a helical wire spacer guarantees the fuel rods integrity by providing the bundle rigidity, proper spacing between rods and promoting coolant mixing between subchannels. It is important to understand the flow characteristics in such a triangular array wire wrapped rod bundle in a hexagonal duct. Many studies have been conducted related to the thermal-hydraulics of the SFR type reactor in terms of the pressure drop, the friction factors and the flow mixing between subchannels. [1,2,3] .

The experimental work has been undertaken to quantify the friction and mixing parameters which characterize the flow distribution in subchannels for the KAERI's own bundle geometric configuration. This work presents the hydrodynamic experimental results for the flow distribution and the pressure drop in subchannels of a 61-pin wire wrapped rod bundle which has been fabricated considering the hydraulic similarity of the reference reactor.

## 2. Experimental Works

### *2.1 Test Assembly*

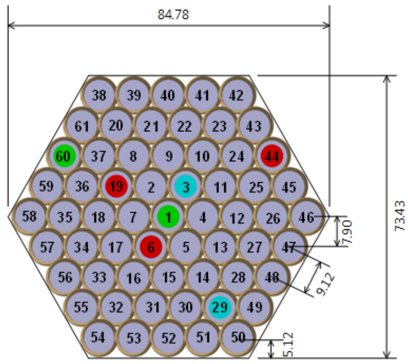
The number of pins in a test fuel assembly has been chosen as 61 in this work. Nominal operating flow conditions in a test fuel assembly are 15.02 kg/s at 60 ℃ which is equivalent to *Re*~60,750. Table I summarizes the geometric specifications and the hydraulic conditions of the test fuel assembly.

Table I: Specifications of 61-pin Test Assembly

| Geometric Specifications | | Hydraulic Conditions | |
|---|---|---|---|
| Rod Dia., D (mm) | 8.0 | Inlet Press. (MPa) | 0.8 |
| Rod Length, L (mm) | 1,500 | Inlet Temp. (℃) | 60 |
| Wire Dia., DW (mm) | 1.0 | Fluid Density (kg/m$^3$) | 983.4 |
| Lead Length, H (mm) | 238.9 | Dynamic Viscosity (Ns/m$^2$) | 4.67 x 10$^{-4}$ |
| P/D | 1.14 | Re number | 6.07 x 10$^4$ |
| H/D | 29.86 | | |

Configuration of the 61-pin test assembly is illustrated in Fig. 1. Three special pins i.e., #6, 19 and 44 are for the measurement of the pressure drop through the three-lead distance (716.7 mm) in subchannels.

### *2.2 Test Facility*




- ΔP Measurements : 6, 19, 44
- Exit Pressure : 3, 29
- Salt Injection : 1, 60

Fig. 1. Configuration of 61-pin Test Assembly.

Hydrodynamic tests for the flow distribution and the pressure drop in subchannels of a 61-pin wire wrapped rod bundle have been performed at the experimental facility called the name of CTL-II (Cold Test Loop – II) in KAERI site. This facility is used for hydrodynamic experiments of various fluidic components such as any type of rod bundle and flow inventories at near ambient conditions. It consists of a test rig, a water storage tank and a circulation pump. Figure 2 illustrates a schematic of the experimental facility.

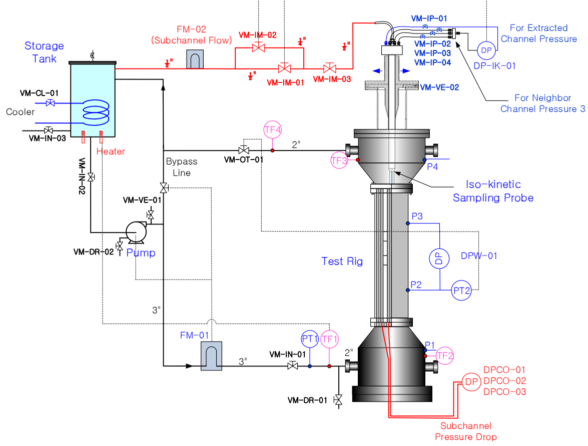



Fig. 2. Schematic of the Test Facility.

The test rig contains a 1,500 mm long 61-pin rod bundle in a hexagonal housing. Four inlets are attached at the lower part of the test rig and the honey comb is placed at the inside to straighten the inlet flow. Four outlets are formed at the upper part of the test rig as the same of the lower part.

### *2.3 Iso-kinetic Sampling*

The sampling probe was designed in a way that the cross section of the entrance of the sampling probe coincides with the shape of the measuring subchannel. Therefore, three kinds of sampling probe were fabricated for each three types of subchannel as shown in Fig. 3.

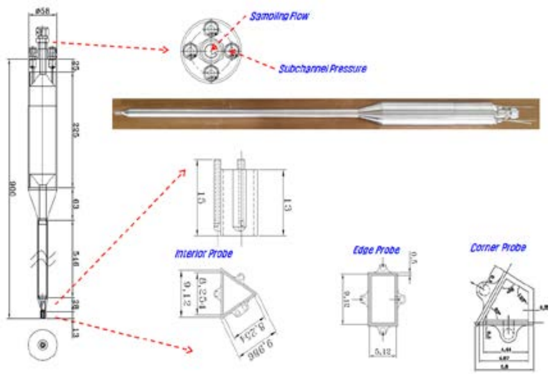



Fig. 3. Iso-kinetic Sampling Probes.

## 3. Experimental Results

### *3.1 Flow Distribution in Subchannels*

Figure 4 shows the sampling flow rates at a nominal flow rate for all subchannels at 126 locations in a 61-pin rod bundle. The flow rates at the edge subchannels were higher than those at the interior subchannels because of the larger flow area and lower friction loss due to the smooth wall. The lowest flow rates were occurred at the corner subchannels and it was caused by the smallest flow area. Flow fluctuations are least in a case of 'All Fix' which presents the fixation of all rods with the support grid for right positions.

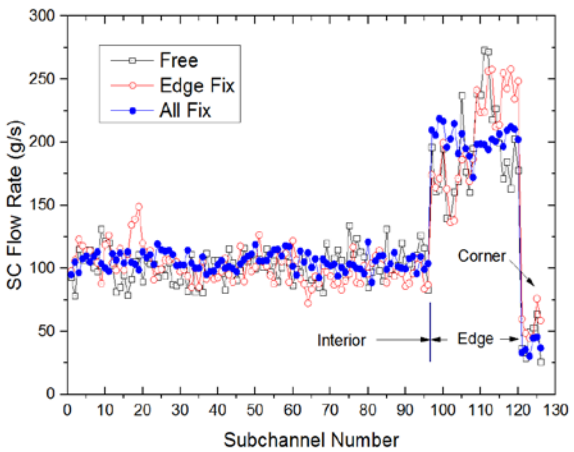



Fig. 4. Subchannel Flow Distribution in a 61-pin Rod Bundle at a Nominal Flow Condition.

### *3.2 Pressure Loss in Subchannels*

The pressure loss in subchannels have been measured for three-lead flow distance at subchannel #5(DP-02), #53(DP-03), #102(DP-01) and #110(DP-W) as shown in Fig. 5. The pressure losses in all measured subchannels were almost identical whatever the subchannel locations are under the same flow condition as shown in Fig. 5.

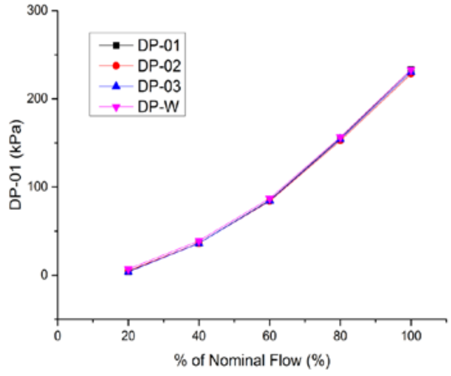



Fig. 5. Pressure Losses in Subchannels (100% = 15.02 kg/s).

## 4. Conclusions

Hydrodynamic experiments for a 61-pin wire wrapped test assembly has been performed to provide the data of a flow distribution and pressure losses in subchannels for verifying the analysis capability of subchannel analysis codes for a KAERI's own prototype SFR reactor. Iso-kinetic flow sampling technique has been adopted to measure the flow rate at each subchannels. Three type of sampling probes have been specially designed to conserve the shape of the flow area for each type of subchannels. All 126 subchannels have been measured to identify the characteristics of the flow distribution in a 37-pin rod assembly. Pressure drops at the interior and the edge subchannels have been also measured to recognize the friction losses of each type of subchannels.

## ACKNOWLEDGMENTS

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## REFERENCES

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