TR-PIV Performance Test for a Flow Field Measurement in a Single Rod Test Section

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1. Introduction

For large enhancement of performance of Pressurized Water Reactor(PWR), dual-cooled fuel is being developed in Korea Atomic Energy Research Institute(KAERI)[1]. This nuclear fuel is a ring shape fuel which is different from conventional cylindrical nuclear fuel and cooling water flows both inner and outer channel. For this fuel, it widens the surface area. But it is bigger outer diameter of fuel rods. So, interval between fuel rods narrows. This because of outer channel flow is unstable. So, measurement of turbulence flow and perturbation that influence in heat transfer elevation is important..

To understand heat transfer characteristics by turbulence, measurement of flow perturbation element is necessary. To measure these turbulence characteristics, hot wire anemometer is widely used. However, it has many disadvantages such as low durability of prove, and big probe size.

For these reasons, TR-PIV(Time-Resolved Particle Image Velocimetry) system is employed for better flow measurement in our research institute. TR-PIV system is consisted of laser system and high-speed camera that have high frequency. So, was judged that can measurement complicated turbulence flow and perturbation.

In this paper, introduce TR-PIV system, and with results acquiring in single rod flow through this system, and wish to introduce about after this practical use plan.

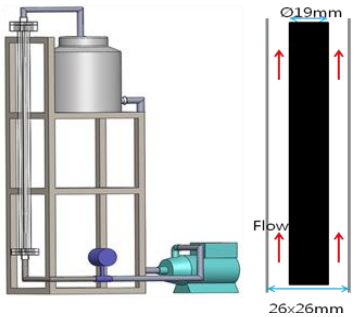

Fig. 1. A schematic of experimental set-up

2. Methods and Results

To judge reliability of new TR-PIV and data processing, we built SOFEL(Small Omni Flow Experimental Loop) which is single rod test section. Width of rectangular channel is 26mm and diameter of pipe is 19mm, so the W/D=1.18. Fig. 1. shows a schematic of experimental set-up.

2.1 Particle Image Velocimetry

PIV system measures velocity and direction with two pictures taken in set time.

Composition of PIV system and measurement location are shown in Fig.2.The PIV system consisted of laser and controller, CCD camera, synchronizing device, and computer. The features of PIV system are followed.

- Measurement system measures velocity of micro particle flows in fluid
- Measurement of velocity vector of velocity field of flow cross section

2.2 TR-PIV

To measure flow perturbation element, we needed laser system with high frequency resolving power and high speed camera.

The specifications of TR-PIV(Dantec Dynamics) are followed.

-Laser System: Nd-Yag Laser, Max. Repetition Rate: 20 kHz, Pulse Energy @ 1kHz: 20 mJ, Wavelength: 527 nm

-High Speed Camera: FPS at Full resolution: 2190 fps, Sensor Resolution: 1280x800, Interframe Time: 700 ns

-Timer Box: Inter clock rate: 80 MHz, Pulse Positioning Accuracy: 12.5 ns

3. Flow Measurement of Fuel rod

3.1Flow Measurement of single rod test section

The mean velocity vector measured by TR-PIV is shown in Fig. 3. As shown in Fig. 3, velocity near pipe and channel wall is low, and velocity in wide flow cross section is high which typical velocity vector shapes are.

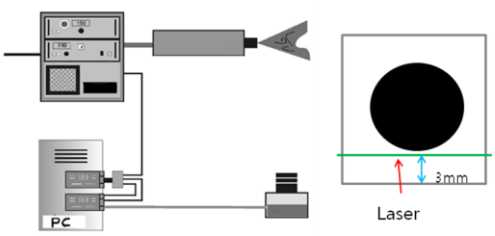

Fig. 2. Compositions of PIV and Location of Laser

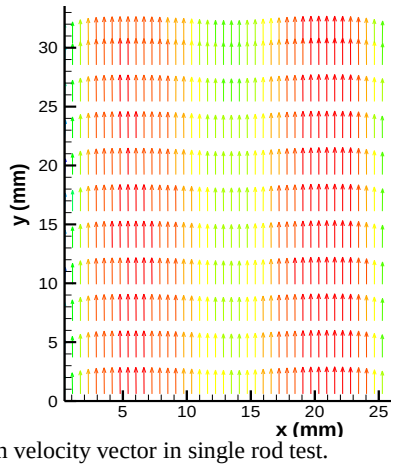

Fig. 3. Mean velocity vector in single rod test.

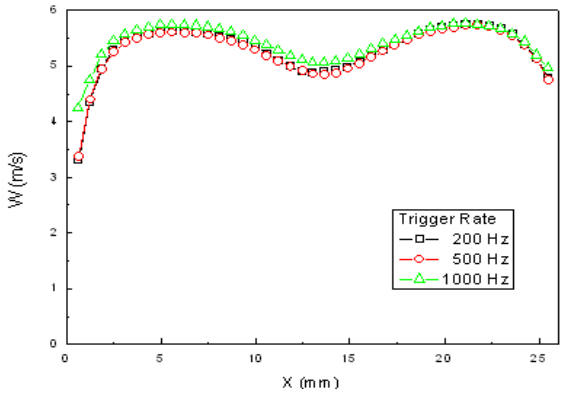

Fig. 4. Axis-direction mean velocity according to measured frequency

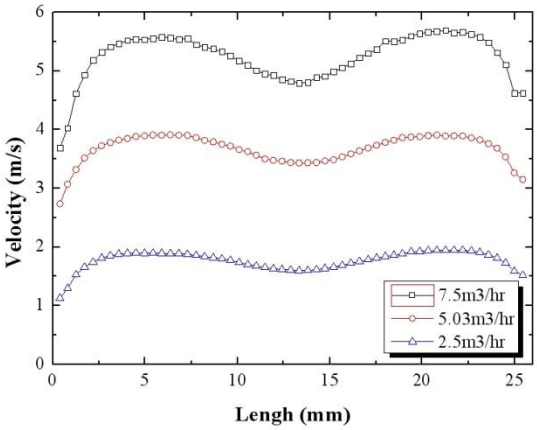

Fig. 5. Axis-direction mean velocity according to flow rate variation.

Fig. 4 shows comparison of mean velocity axis-direction velocity according to frequency(200~1000Hz) with same flow condition.

Mean velocities in simple flow field are almost not relate to frequency change. From this, we confirmed reliability of this system.

In Fig. 5 there are comparisons of axis-direction mean velocity according to flow rate variation. We figured out flow velocity differences in channel were larger with higher flow rate.

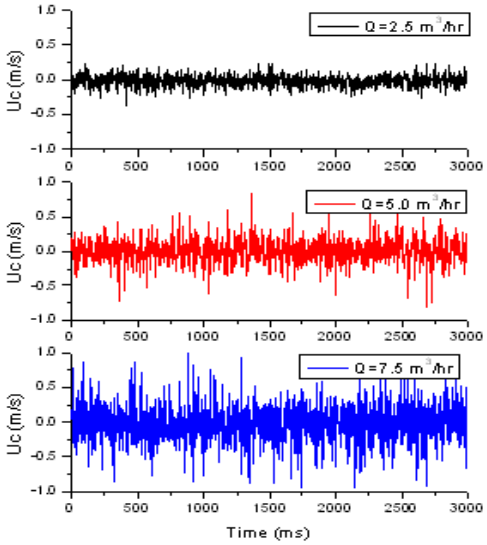

Fig. 6. Transverse velocity perturbation according to flow rate variation

Fig. 6 shows cross-direction perturbation according to flow rate variation. From measurement of these perturbation elements, we can analyze turbulence intensity, period characteristics.

4. Conclusions

This paper is about basic test of TR-PIV for analyzing flow field of fuel assembly. We performed measurement of flow perturbation for single rod and figure out mean velocity is unchanged with frequency variation.

From these experiments, we will measure turbulence characteristics and period characteristics in fuel rod bundle, and perform CFD analysis, so that we can use the result as a fuel assembly for performance evaluation.

후 기

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REFERENCES

[1] Shin, C. H., In, W. K., Oh, D. S. and Chun, T. H., The Design of Annular Fuel Array for a High-Power-Density PWR, *Trans. of the KNS Autumn Meeting*, Gyeongju, Korea, 2009.