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# Numerical Evaluation of Averaging BDFT(bidirectional flow tube) Flow Meter on Applicability in the Fouling Condition

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## 1. Introduction

Most of the NPPs adopt pressure difference type flow meters such as venturi and orifice meters for the measurement of feedwater flow rates to calculate reactor thermal power. However, corrosion products in the feedwater deposits on the flow meter as operating time goes. These effects lead to severe errors in the flow indication and then determination of reactor thermal power. The averaging BDFT has a potentiality to minimize this problem [1,2]. Therefore, it is expected that the averaging BDFT can replace the type venturi meters for the feedwater pipe of steam generator of NPPs. The present work compares the amplification factor, K, based on CFD calculation against the K obtained from experiments in order to confirm whether a CFD code can be applicable to the evaluation of characteristic for the averaging BDFT. In addition to this, the simulations to take into account of fouling effect are also carried out by rough wall option. The results show that the averaging BDFT is a promising flow meter for the accurate measurement of flow rates in the fouling condition of the NPPs.

## 2. Characteristics of averaging BDFT

Fig. 1 shows a schematic diagram of averaging BDFT. The pressure measured at the front of the averaging BDFT is equal to the total pressure while the one measured at the rear tube is less than the static pressure of the flow field. The lower pressure at the rear tube is caused by the suction effect induced by the flow velocity at the downstream. Thus, the differential pressure measured by the flow tube is larger than the dynamic pressure in the flow stream and its magnitude is changed to a flow velocity.

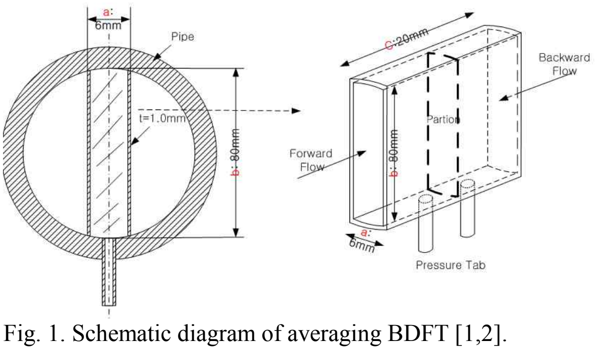


Fig. 1. Schematic diagram of averaging BDFT [1,2].

## 3. Numerical simulation

### *3.1. Numerical model*

Fig. 2 shows a schematic diagram of 3D numerical model for averaging BDFT with a diameter of 80 mm. In total, 2 million structured meshes were used in the analysis, of which the average size is about 4 mm. Furthermore, the meshes are clustered densely around the flow tube based on a preliminary mesh dependency study.

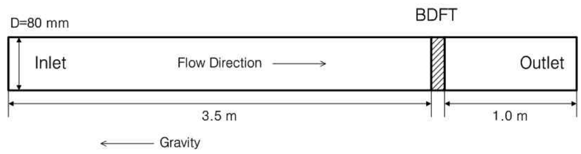


Fig. 2. Schematic diagram of numerical model for BDFT.

### *3.2. Numerical method*

In this study, steady-state RANS equation was solved using a commercial CFD code STAR-CCM 8.04. Also, the standard k-ε model and SST model were used for simulation of the turbulence. The SIMPLE algorithm is used to ensure coupling between velocity and pressure. The convection terms in the governing equations are discretised using 2nd order upwind scheme. An Dirichlet and pressure boundary conditions were applied to "inlet" and "outlet" as shown in Fig. 2, respectively. The inlet velocity ranged from 0.02 m/s to 8.0 m/s. In verification calculation for analysis capability of CFD code (non-fouling), roughness option of all the wall including BDFT was selected as smooth wall. While, in case of evaluation for fouling effects, the height of the surface roughness around BDFT was assumed to be 0.2 mm, 0.5 mm [3].

## 4. Analyses results

### *4.1. Amplification factor*

As a first step, simulations were performed to validate the applicability of a CFD code by comparing the calculation results with the calibration test results. Fig. 3 shows the dependencies of K values on the Reynolds number for calibration test results and analysis results. The K values based on CFD analyses show good agreement with the K values based experiments.

However, low Reynolds number region (below 1,000), the discrepancy in the K values between calculations and experiments are relatively large. The discrepancy might be attributed to the inherent limitation in the performance of the turbulence models at the region of very low Reynolds number. These results except for low Reynolds number region show that a CFD code can be used as a tool evaluating characteristics for averaging BDFT.

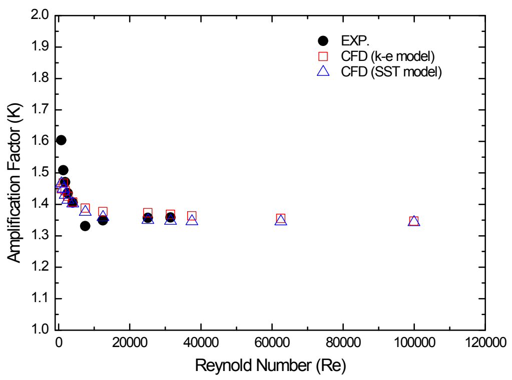


Fig. 3. Dependencies of the K values on Reynolds number based on experiments and CFD analyses.

### *4.2. Fouling effects*

In terms of application in the feedwater piping system of steam generator of NPPs, the performance of the averaging BDFT under the corrosion environment is important issue. The CFD analyses were carried out to examine the performance of the averaging BDFT under the corrosion environment. In this case, the SST model were used for simulation of the turbulence. Also, the height of the surface roughness around the BDFT was assumed to be 0.2 mm, 0.5 mm. Fig. 4 and 5 show the comparison of the K values between the two cases of non-fouling and fouling. According to Fig. 4 and 5, the averaging BDFT does not lose the measuring performance even under the corrosion environment.

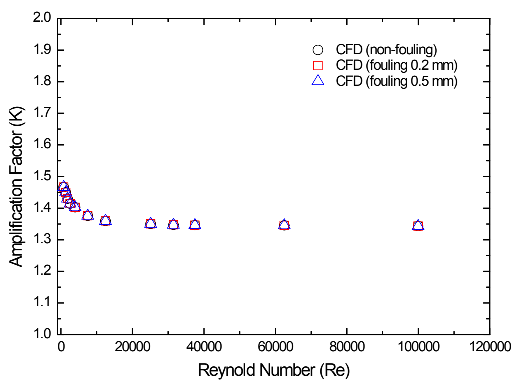


Fig. 4. Dependencies of the K values on Reynolds number for the non-fouling and fouling around BDFT

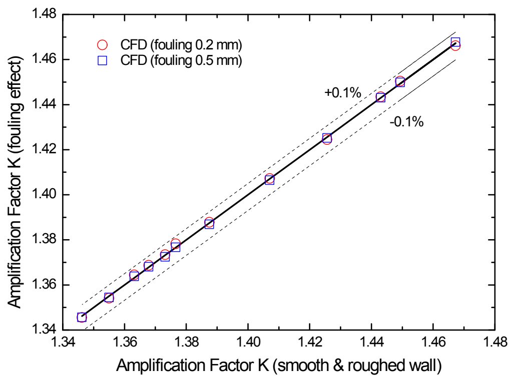


Fig. 5. Comparison of the K values according to the fouling effect

## 5. Conclusions

A new instrumentation, an averaging BDFT, was proposed to measure the accurate flow rate under corrosion environment. In this study, to validate the applicability of the averaging BDFT on the fouling conditions, flow analyses using the CFD code were performed. Analyses results show that this averaging BDFT does not lose the measuring performance even under the corrosion environment. Therefore, it is expected that the averaging BDFT can replace the type flow meters for the feedwater pipe of steam generator of NPPs.

## ACKNOWLEDGMENT

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http://www.spray.com/calculators/Pressure_Drop_Calc/rauh.html