Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Validation of Turbulent Momentum Mixing of MATRA-S Code for CNEN 4x4 Single Phase Flow Mixing

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Introduction

- This study has been prepared for validation of the turbulent momentum mixing of MATRA-S code by comparing the results with the CNEN4x4 experiment measurements.
- MATRA-S is a subchannel code which has been developed for thermal hydraulic design and analysis of SMART core.
- The calculation of various turbulent flow mixing coefficients has been done to evaluate the exit velocity distributions for corner, side and central subchannels with the measurement results for each subchannel.
- The effect of the turbulent flow mixing coefficient will be as the main point of this study.

CNEN4x4 Experiment

- This experiment involves velocity and mass flux measurements taken at the exit of a 16-rods test section.
- The configuration of the assembly is shown in Figure.1.
- The test section is fitted with a grid of low form loss coefficient (k=0.3) located at the middle of the fuel assembly.
- The bundle had an unheated length of 1.312 ft, and active length of 3.281 ft. Five average mass velocities of the fluid were imposed, which are 0.5, 1, 2, 3 and 4 (Mlbm/ft^2-hr).
- Table 1 summarizes the measurement results of the velocities at the exit of each subchannel.

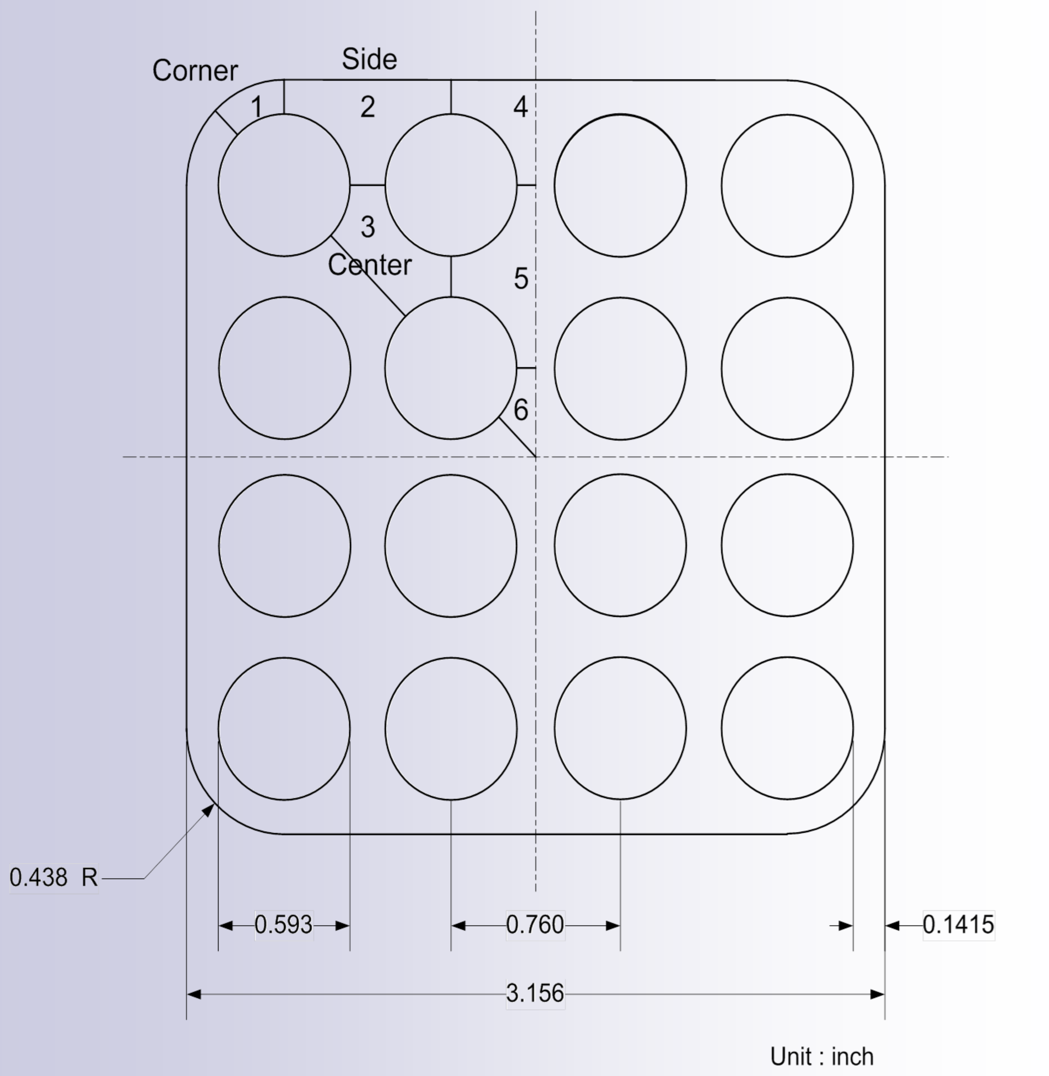

Figure 1. CNEN 4x4 rod bundle assembly and sub-channel analysis model

Table 1. Experiment results of exit velocity.

G_{avg} (Mlbm/ft^2-hr)	Exit Velocity (m/sec)		
	Corner	Side	Center
0.5	0.728	0.641	0.527
1	1.458	1.302	1.039
2	2.873	2.630	2.174
3	4.370	3.887	3.351
4	5.889	5.101	4.444

Methodology

- EM (Equal Mass) model is used as a momentum mixing model that assumes the net mass exchange due to the turbulent flow mixing between the adjacent channels is equal to zero, since the lateral flow rate between subchannels is defined in Equation (1).

$$w'_{IJ} = \beta \cdot s_{IJ} \cdot \bar{G} \qquad (1)$$

- Five different turbulent flow mixing factors were used in order to investigate the turbulent momentum mixing effect with measured velocity at exit plane.
- The axial momentum mixing between the subchannels will affect the results. Thus, the axial momentum factor assumed to be 1 as shows in Equation (2).

$$\tau'_{IJ} = w'_{IJ} \cdot F_{TM}(U_I - U_J) \qquad (2)$$

- The calculations have been done by simulating the geometry as 1/8 symmetric geometry in MATRA-S code.
- In order to have more accurate results along the axial direction of the fuel assembly, sixty uniform nodes were used to evaluate the mixing effect of the TDC (Turbulent Diffusion Coefficient).
- The optimum TDC value will be considered as the minimum percentage error between the measured and predicted values at all corner, side and the center subchannels.

Result

Table 2. Percentage error between the measured and predicted exit velocity with different TDC value.

TDC	Corner	Side	Center
0	19.200	4.104	4.326
0.005	12.398	4.146	3.198
0.02	2.607	2.994	2.206
0.1	18.132	3.609	5.672
0.2	23.387	4.866	6.547

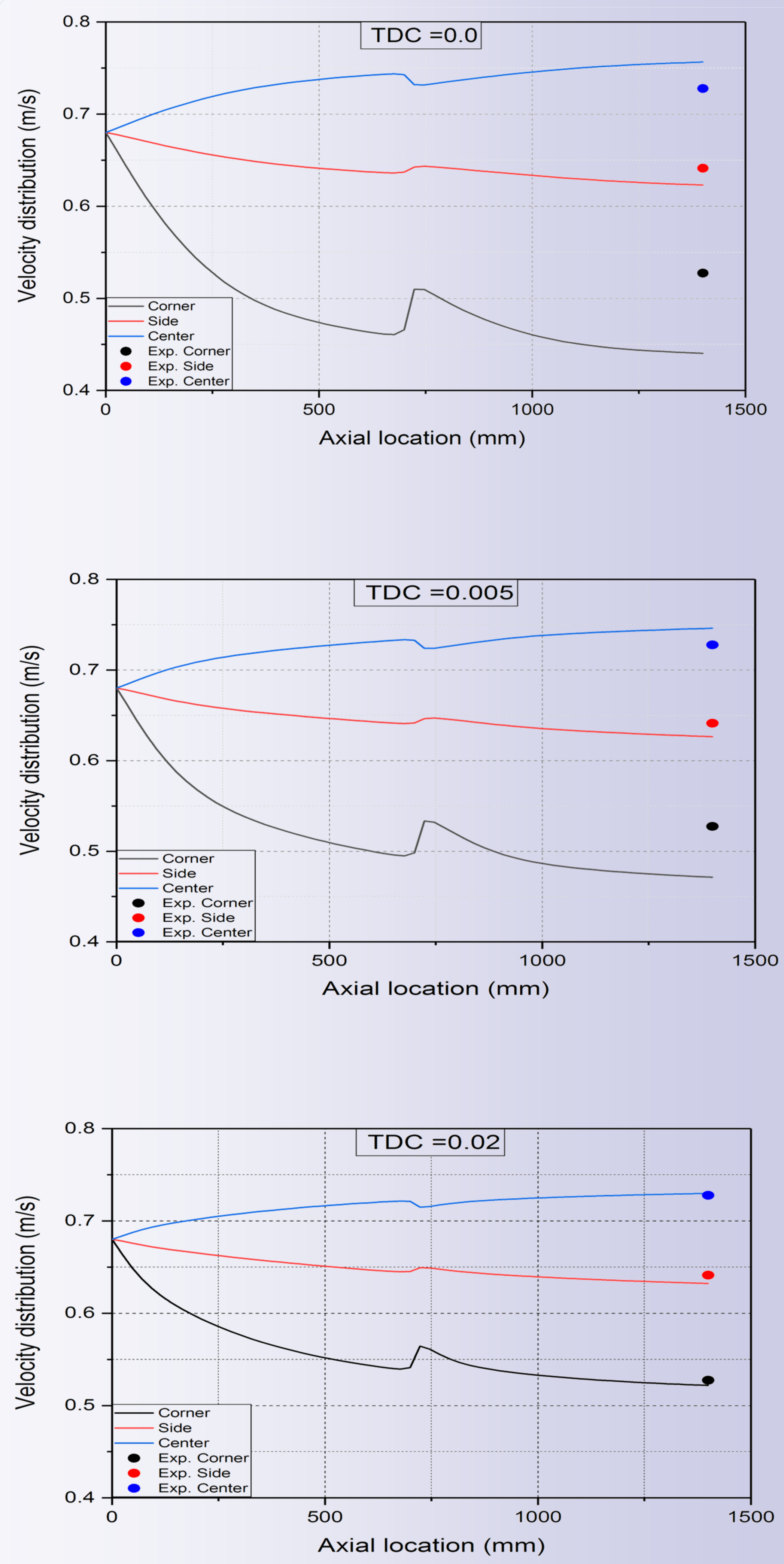

Figure 2. Velocity profile along the axial direction using TDC=0.0, 0.005 and 0.02, respectively.

Conclusion

- Turbulent momentum mixing in MATRA-S code was investigated by analyzing the flow distribution and generate the results as flow velocities with CNEN 4x4 rod bundle test.
- Optimum momentum mixing coefficient was estimated and applied to this analysis.
- MATRA-S predicted accurately the flow velocities profiles along the axial direction, by comparing the measured data using the optimum TDC value with the maximum percentage error which turned to be 3.0 %.
- The comparison with CNEN4x4 measurement was successfully validated by using the appropriate model applied in MATRA-S code which is EM turbulent model and optimizing its coefficient.

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