Verification of the Core side Pressure Drop Calculation Sub-routine

Jeong-hun Cha, Kyong-Won Seo, Hyuk Kwon, Teawoo Kim, Dae-Hyun Hwang

Korea Atomic Energy Research Institute, 1045, Daedeok-daero, Yuseong, Daejeon, Korea, 305-353
**Corresponding author: chajh@kaeri.re.kr*

1. Introduction

Minimum design flow rate in core is applied to analyze a core thermal performance. And the maximum bypass flow rate is needed to estimate an actual cooling flow rate. The actual flow rate is the minimum design flow rate except the maximum bypass flow rate. Currently, a code has been developing to calculate the bypass flow rate of System Integrated Modular Advanced Reactor (SMART) in Korea Atomic Energy Research Institute (KAERI). The code solves the continuity, momentum, and energy equations for a flow system consisting of two parallel flow paths. One path is for inside the thimble or instrumentation tube. The other path is for outside the thimble or instrumentation tube, i.e., the core side. In this work, validation of thermal property in the code is checked, and then, results about the pressure drop of the core side are verified.

2. Verification of Subroutines and Results

There are five functions depicted in Table 1 to calculate thermal properties in the code. It is necessary for verification of the functions due to feasibility of results. To verify the results, National Institute of Standard and Technology (NIST) standard reference data is used [1].

NAME	INPUT	RESULT
SVC	Temp., Press.	Specific vol.
SSV	Temp.	Sat. Specific vol.
SSH	Temp., Press	Enthalpy, Specific Entropy
SHC	Temp.	Sat. Specific Enthalpy
SST	Press., Specific Enthalpy	Specific Entropy, Temp.
VCL	Temp., Press	Viscosity

2.1Momentum equation

The code solves the following momentum equation for the core side pressure drop.

$$\triangle P = \sum_{i=1}^{N}\left[\left(K + \frac{fL}{De}\right)_i \frac{\rho_i V_i^2}{2g_c} + \triangle\left(\frac{G_i^2}{\rho_i}\right) + (\rho_i L)\right] \quad \cdots \textbf{(1)}$$

Where, K : Form loss coefficient factor
f : Friction factor
De : Hydraulic Diameter
N : Calculation step

2.2 Verification of thermal property functions

Temperature and pressure are input to the SVC function. And then, The SVC function calculates the specific volume. There is no difference between the result of the SVC function and NIST data. Figure 1 shows the comparison result of SVC function and NIST data.

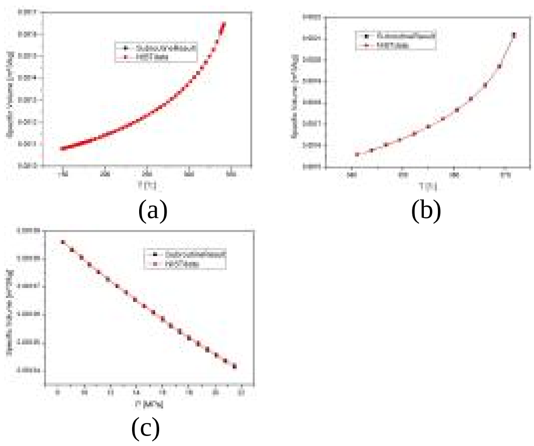

Figure 1. Comparison of specific volume

Temperature is input to the SSV function. The SSV function then calculates the saturated specific volume. At the temperature condition between 3°C and 373°C, the maximum difference of specific volume is calculated in error of 0.48 %. Figure 2 offers the comparison result [3].

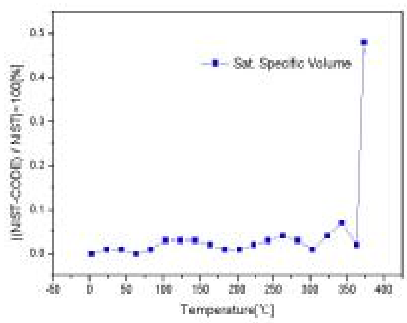

Figure 2. Comparison of saturated specific volume

Temperature is input to the SHC function. The SHC function and SHC function then calculates the saturated specific enthalpy. At the pressure condition between 0.1 MPa and 20.1 MPa, the maximum difference of the saturated specific enthalpy is calculated in error of 0.158% [4]. Figure 3 suggests the comparison of saturated specific enthalpy.

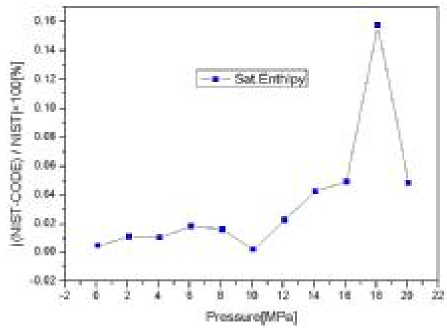

Figure 3. Comparison of saturated specific enthalpy

Pressure and specific enthalpy are input to the SST function. The SST function then calculates the temperature and the specific entropy. At the pressure condition between 0.1 MPa and 20.1 MPa, the maximum difference of the temperature and the specific entropy are calculated in error of 0.18% and 0.01%, respectively. Figure 4 proposes the comparison of the temperature [3].

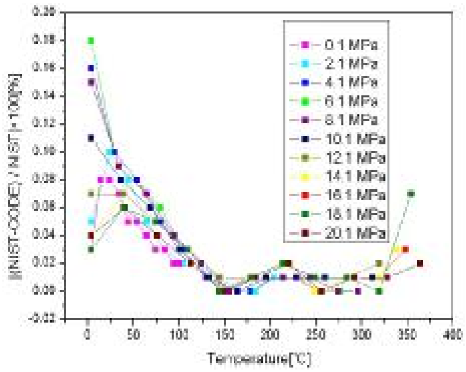

Figure 4. Comparison of Temperature

Temperature and pressure are input to the VCL function. The VCL function then calculates the viscosity. At the pressure condition between 0.1 MPa and 20.1 MPa, the maximum difference is calculated in error of 0.48 %. Figure 5 shows the comparison of the viscosity [3].

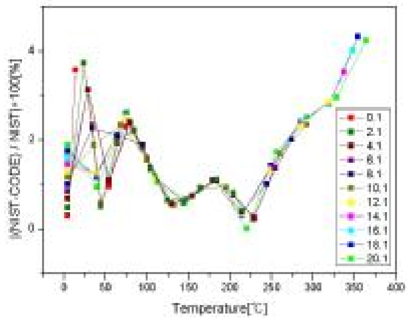

Figure 5. Comparison of Viscosity

2.3 Verification of pressure drop calculation

The comparison of results between the pressure drop calculated by using NIST data and the pressure drop computed by using the code is performed. At pressure condition between 0.1 MPa and 20.1 MPa and temperature condition between 3 °C and 364 °C, the maximum difference was calculated as 0.31%. Figure 6 presents the comparison of the pressure drop result.

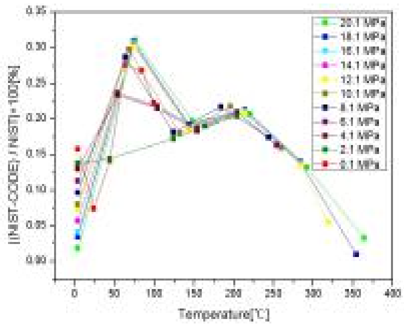

Figure 6. Comparison of Pressure Drop Result

3. Conclusions

The subroutine of pressure drop and the thermal property functions are verified. According to the results, the thermal property difference and the pressure drop difference between the code result and NIST data can be negligible. Consequently, these results support validity of the development of the code for the calculation of the core bypass flow rate in SMART.

REFERENCES

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