Development of the CANDU Reactivity Module of COMPAS

Daeyu Park, Sanghoon Lee, Ohwan Kwon, Seongmin Kim*, Hyungbum Suh* , Jinil Kim
Institute for Advanced Engineering, Yongin P.O. Box 25, Gyeonggi-Do 449-863, dypark@iae.re.kr
* Wolsong Nuclear Power Division, Korea Hydro & Nuclear Power

1. Introduction

The purpose of the COMPAS (CANDU cOre Management Procedure Automation System) is to support efficient core management and error-free operation of CANDU core. One of the important functions of the COMPAS is the excess reactivity calculation, which is for predicting core reactivity and maintaining core. The reactivity module of COMPAS gets reactor operation data from DCC through gateway, reactor constants from pre-defined DB and other options from the user. In addition to that, this module can predict the reactivity and manage the history data related with reactivity.

This paper introduced the functionality of the reactivity module of COMPAS and some issues related with the calculation of the reactivity.

2. Functions of the reactivity module of COMPAS

The requirements of the customer were
- The COMPAS shall be able to calculate the current reactivity.
- The COMPAS shall be able to forecast the reactivity.
- The COMPAS shall be able to manage history related with reactivity.

To satisfy these requirements the reactivity module is composed of three major functional modes. The first mode of them is the current reactivity calculation. It calculates real-time excess reactivity of core from DCC trough gateway.

The second mode is the reactivity history management. It saves current reactivity calculation results to DB and adds or removes new dataset to manage the history data.

The final mode is the reactivity forecast. It forecasts the excess reactivity of core from some linear calculation method.

These three modes use common process for calculation of reactivity as shown in Fig. 1.

The COMPAS is operated in the WEB environment and the reactivity calculation module is developed by the *Smart Client* technology of *Microsoft Visual Studio .NET*. It needs graphical data handling using a chart display in WEB environment.
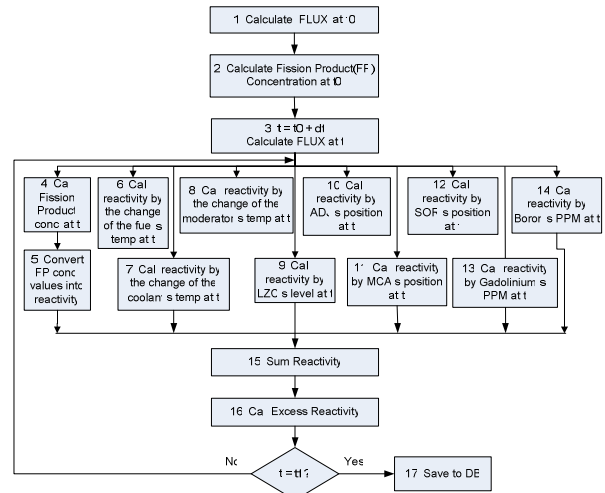

Figure 1. Excess Reactivity Calculation Process [1]

2.1 Current Reactivity calculation

In this mode, current excess reactivity can be obtained. To do it, it is necessary to get DCC data from gateway during the user-selected time interval. To calculate the excess reactivity of core, the selected data from gateway are separated into 5 categories that are composed of Excess Reactivity, Temperature Coefficient, Moderator Poison, Reactivity Device and Fission Product. These 5 categories show current state of CANDU reactor core in various points of view as shown in Table 1.

Table 1. Variables for Excess Reactivity Calculation

Category	Displayed contents	Calculation contents
Excess Reactivity	- AVZL - RxPWR - RRS reactivity	- Excess Reactivity at t
Temperature Coefficient	- Moderator temp. - Coolant temp. - Fuel temp.	- Moderator reactivity at t - Coolant reactivity at t - Fuel reactivity at t
Moderator Coefficient	- Boron Tank Level - Gadolinium Tank Level - Moderator Purification Flow	- Boron PPM & Reactivity at t - Gd PPM & Reactivity at t
Reactivity Device	- ADJ Position - SOR Position - MCA Position - AVZL(From gateway)	- ADJ reactivity sum - MCA reactivity - SOR reactivity - LZC reactivity
Fission Product	PPM of each FP. - I-135, Ru-105, Pm-149, Pm-151, Sm-155, Eu-157, Ag-113, Np-239 - Xe-135, Rh-105, Sm-149, Sm-151, Eu-155, Gd-157, Cd-113, Pu-239	Reactivity of each FP - Xe-135, Rh-105, Sm-149, Sm-151, Eu-155, Gd-157, Cd-113, Pu-239

To obtain excess reactivity, the contents displayed above must be used to calculate input variables. When calculation starts to run, it calculates total reactivity and excess reactivity by time interval. The user also can change AVZL(Average Zone Level) to get the desired excess reactivity value.

Actually, user can carry out this process through just clicking. Figure 2 shows calculation results for each 5 categories.
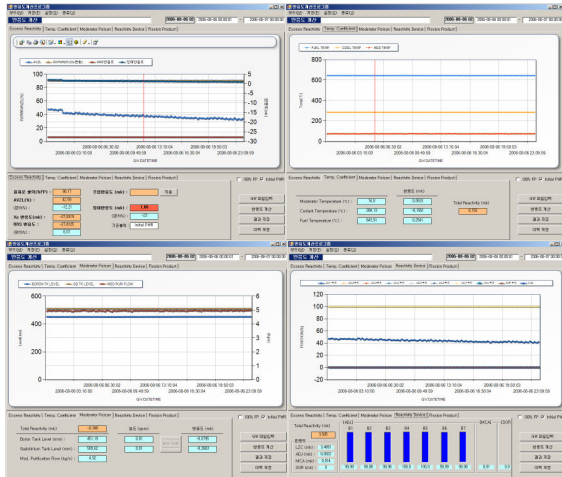

Figure 2. Reactivity module's graphical user interface : Reactivity Calculation Mode.

The calculated current reactivity results are added to the reactivity history DB and can be managed as an accumulated record.

2.2 Reactivity history management

In this mode, users usually manage reactivity and all related data from current reactivity calculation results.

Users can add or remove data on a specific point and save reactivity data from the reactivity calculation mode.

To remove data, users can select the point at which the data should be removed in displayed chart and remove it by clicking.

Users have two options to new data. One is getting data from users and the other is getting data from the 'normal state'. When it is selected 'user input', user must key in data which is required to calculate. When it is 'normal state', it makes a new dataset on user selected point in normal reactor state automatically. Actually, it assumes that excess reactivity is zero.

The GUI is the same as the current reactivity calculation mode.

2.3 Reactivity forecast

Reactivity forecast is the mode to prospect the behavior of the excess reactivity during periods of in the future. This mode has 3 options to make initial input dataset for user-selected time interval.

The first is 'steady'. In this option, initial dataset is created from the state of the normal reactor. Actually, it assumes that the start point of the period which wants to forecast is in normal state.

The second is 'Transient'. In this option, the latest dataset of reactivity history become the initial dataset. It assumes that the start point is from the last point of the past real reactivity calculation data.

The final option is 'Long shut'. In this option, initial dataset values are all constants which were predefined by the reactor operator. It assumes that the reactor state is in the restart mode or overhaul.

Once initial input is created, users can modify reactor power value or moderator purification flow value.

The excess reactivity from above process can be used to manage CANDU core management works like refueling planning. The GUI is also the same with the current reactivity calculation mode.

3. Remaining issues

As the equations related with the calculation of reactivity are not linear, some assumes were made and some factors were neglected. And almost equations are developed using empirical data. But it is expected that the resulting reactivity calculated by this module has no problem for managing safe operation of the CANDU reactor.

The COMPAS project is still on the developing phase, so the effectiveness and efficiency of the reactivity module should be increased by upgrading according to the feed back of the users.

4. Conclusions

The reactivity module of COMPAS can calculate, forecast the reactivity of CANDU and manage reactivity history automatically using integrated database.

These functions of the reactivity module can save the time, effort and potential error of the reactor operators. Furthermore the COMPAS operates on the WEB environment to increase accessibility.

REFERENCES

[1] Choongsub Yeom, Daey Park, Sanghoon Lee, Jinil Kim, Software Requirements Specification for CANDU Core Management Procedures Automation System, IAE Tech. Annual Report, 2005