Development of CANDU Core Operation Support System Based on Core Monitoring System

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1. Introduction

The efficient core management and operation has been important targets to increase safety and performance as well as to decrease operational cost. Due to the on-power refueling, the operator of CANDU core needs to process large number of data from the detectors of core and output of several core calculation codes. In order to reduce the task and support reactor operation, the CANDU Core On-line Monitoring System (COMOS) was developed as an on-line core surveillance system based on the standard in-core instrumentation and the numerical analysis codes such as RFSP (Reactor Fueling Simulation Program).

The major monitoring items of COMOS are core power distribution, burnup distribution, LZC statistics, and the position of control devices and detectors.

Since the system handles huge data in the real time, the response time and reliability of the system are critical performance issues that should be solved. Therefore, the latest informational technology is applied to COMOS as client & server system using 3-tier architecture which has user-friendly GUI, data base, and application server.

Based on the automatic real time monitoring system, core operation support system was developed to maximize utilization of COMOS and enlarge estimation accuracy and operational safety margin [1].

2. CANDU Core On-line Monitoring System

The COMOS is composed of three major components to process core data from DCC through gateway. The first component of them is the application server module that makes RFSP input file from gateway data and uploads the input to run RFSP in the remote workstation. When the execution of RFSP is finished, the outputs are transferred to the server again. After getting output data from the workstation, the paring module in the server processes and calculates the data and inserts them into the database for storing and then the information are retrieved by the client module in the next time.

The second component is the database as mentioned above and the role of database is storing process data from the output of RFSP. Since DCC data from gateway increase by geometric series, the stored data also have time stamp as that of gateway and user can query the data using the time stamp.

Final component of the COMOS is the client module that retrieves data from database and make them visualized through GUI and navigated historical data using implemented date tree.

. To make it more user-friendly, users' opinions were considered and applied to the display design.

2.1 System architecture of COMOS

Implementation of the system is the integration task of the three components via TCP/IP network as follows. In the Figure 1., system architecture of COMOS that shows integration of the gateway from DCC, workstation for execution the RFSP, application and database server and a few clients.

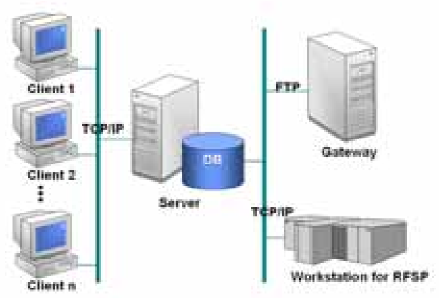

Figure 1. 3-tier architecture of COMOS and network connection diagram.

The application server executes procedures that repeat following cycle.

1. Get the latest uploaded gateway binary files
2. Parse the gateway binary file and make RFSP input
3. Execute RFSP
4. Process RFSP output and insert the results into the database

2.2 Data Visualization by COMOS

The client of COMOS shows data of current or past status of CANDU core in the various points of view. It also has several functional abilities as Table 1.

Table 1. COMOS functional abilities.

Monitoring Item	Displayed contents
Core power distributions, Core status and historical data	- Channel & bundle power(2-g and mapped) - Channel & bundle overpower(2-g and mapped) - *k* increase on refueling - Time of last refueling

	- Average exit burnup - Burnup over time averaged burnup - Zone statistics
control rods	- Adjustor position - MCA position
detectors	- Vddet reading value - ZonePt reading value - Sds1det reading value - Sds2det reading value

Users can show and refer the current and past data in the graphical display that are typically shown as Figure 2.

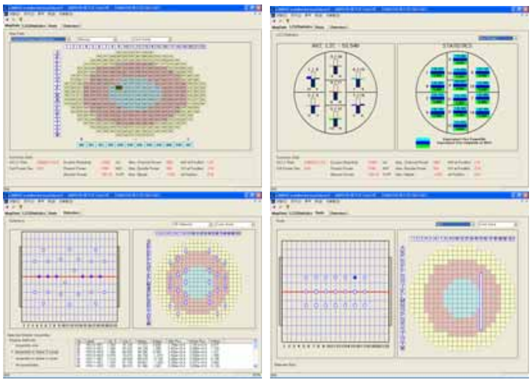

Figure 2. Client graphical user interface: Core map, Zone map, Detectors, and Control rods.

On the contrary current status data as shown in the Figure 2., historical trends are displayed by the time series of the specific channel. When user wants to get status report, it can be exported as HTML-style report pages as shown in Figure 3.

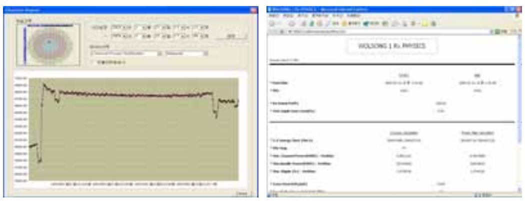

Figure 3. Historical view of core status and HTML report.

3. Reactor Operation Support System

After implementation of monitoring system, adding operational functionality into the system is very desirable and required task. The core operation support system is composed of refueling channel selection & pre-simulation, and reactor re-startup simulation modules.

Figure 4 shows the step of selection for refueling channel, whose procedure is performed by the algorithm called "*rule-based optimization methodology*." It selects refueling candidate channels based on the rule function while observes if the determined refueling scheme violates criteria or not [2].

As a part of developing strategy during re-startup, several experiments were performed and combined in the operation support system. It determined constraints for certain circumstance if the reactor conditions are under pre-defined set point. These criteria are allowable maximum power with respect to the poison density in the coolant and adjuster positions. The other is maximum overpower channel limit must be observed during re-startup and normal operation.

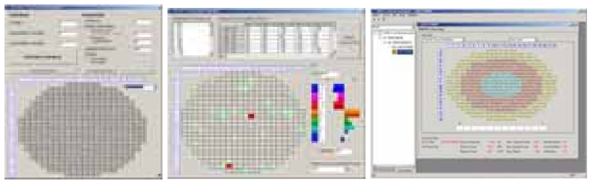

Figure 4. Refueling channel selection and pre-simulation modules.

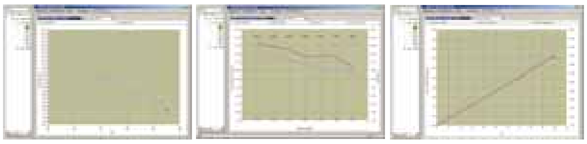

Figure 5. Reactor re-stratup simulations: Boron density, Adjuster positions, Maximum overpower channel limit.

4. Conclusion

The CANDU core on-line monitoring system and operation support system was developed for increasing safety, operational margin, and the efficiency of core management.

To ensure high performance and utilization, adapting the latest informational technology to integrate each component and implementing user-friendly graphical interface that enhanced availability of reactor operator.

REFERENCES

[1] Choongsub Yeom, Moonyoung Yoon, Ohwan Kim, Kyunghwa Kim, Development Monitoring/Operation Modules for CANDU Core, IAE Tech. Report, 2004

[2] Choongsub Yeom, Ohwan Kim, Eunggon Kim, Daeyu Park, A Study on the Prediction Model for Level Variations of LZCs in Refueling of a Existing PHWR Core, IAE Tech. Report, 2004