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Development of A Visual Control and Display System for the SMART Plant Analyzer

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Abstract

A Visual Control and Display System (VCDS) for the SMART plant analyzer has been developed using the MMS simulation tools. The SAMRT plant analyzer consists of the VCDS and the MMS SMART model. The MMS SMART model is a numerical simulation model for the SMART plant and is composed of the MMS real-time modules and control blocks. It covers the whole plant including primary, secondary and auxiliary systems. The developed VCDS is Graphical User Interfaces (GUI) that is running in a synchronized way with the SMART model. The VCDS consists of the MMS Simulation tools and seven control and display screens. The VCDS provides easy means for the control and display of the SMART model status. The VCDS allows users to display and change a specified list of model variables and transient scenarios interactively through the MMS simulation tools. The control and display screens are developed with Visual Basic 6.0 and MMI32 ActiveX controls and it can be executed in several TCP/IP networked computers simultaneously. The developed VCDS can be utilized for the engineering simulation of the SMART plant operation, and for control logic and operational procedure developments.

1. Introduction

The development program of SMART (System integrated Modular Advanced ReacTor) was initiated in 1997 at Korea Atomic Energy Institute (KAERI) for co-generation of desalinated fresh water and electricity. The conceptual design of the SMART has been successfully carried out by March 1999. Another three-year development project for the basic design was launched recently. A SMART plant analyzer is developed using the Modular Modeling System (MMS) package, which is a commercial simulation package distributed by Framatome Technologies, Inc. (FTI)[1]. Fast running and flexible features of the MMS package enable us to perform various scooping analyses and to design and test the control logics of the SMART plant. Due to the many unique features of the SMART, several MMS modules are developed for the SMART plant analyzer[2].

Generally, users of plant analyzer can only set initial conditions and control actions in the fixed form. Just after running the analyzer, they can obtain digital or graphical forms of results with manipulating data. Using the results, they can determine following control action or additional scenario to be studied. These processes, which accompany tedious and time-consuming work, can be overcome through an interactive visual control system. The visual control and display system (VCDS) provides easy means for the control and display of model status to users, who view and change a specified list of model variables interactively in the same time. A VCDS for SMART plant analyzer is developed using MMS simulation tools and Visual Basic 6.0 in this study.

2. SMART Plant Analyzer

To test various combinations of each system and to examine control logic for the normal and abnormal operations, a kind of engineering simulation tool is required, which is running fast, covering whole plant and providing easy user-interface. SMART plant analyzer that has above features has been developed using Modular Modeling System (MMS)[3].

The SMART plant analyzer consists of the MMS SMART model and VCDS[4]. The MMS SMART model is a numerical simulation model of SMART plant using MMS real-time modules. The VCDS is collection of graphical interfaces that can communicate with the MMS SMART model through MMS simulation tools. The MMS SMART model interacts with the VCDS through S-MASTER and MMI32 Manager[5]. S-Master's function is to synchronize the simulation execution with any external processes and to coordinate communication between the model and the MMI32 Manager. The MMI32 Manager distributes data and collects control command from each VCDS screens through the MMI32 ActiveX control. Figure 1 and 2 show possible configuration of VCDS. VCDS can be executed in the stand alone PC with the running model. There is no network transfer retardation but some excessive calculation load. Other configuration using TCP/IP protocol is shown in the figure 2, where the model can be connected a few of VCDS through intranet network.

The MMS SMART model is composed of several interacting MMS modules with numerical data, each of which represents the component of SMART plant and control logic. For the simulation of various transient and steady-state operations of the plant with excluding loss of reactor coolant accident cases, following systems are included in the MMS SMART model; Reactor Coolant System (RCS), Main Steam and Feed-water System (MSFS), Residual Heat Removal System (RHRS), Component Cooling System/Makeup System (CCS & MU) and Plant Control/protection System. Figure 3 shows a whole MMS SMART model. The developed model can simulate a whole range of plant operation modes including normal heatup/shutdown, power generation and emergency shutdown operations. To model the unique features of SMART integral reactor system, new modules have been developed and existing MMS modules modified. The analyses results with the MMS SMART model were compared with those from some design computer codes and showed good agreements[6].

3. VCDS Development

The VCDS provides easy means for the control and display of model status to the user of SMART plant analyzer, which consists of graphical screens representing plant systems or control panel and allows users to view and change a specified list of model variables interactively in the same time with model through MMS simulation tools. Up to date, seven screens, which can be executed independently and navigated between each screens have been developed.

3.1 Program Description

The MMS SMART model is partially modified to send input for display and to receive control signal from users. Model variables for the screen display are collected and manipulated into adequate form for network transfer. Information for control actions and safety signals, current pump and valve status, operating mode is represented by as few and simple variables as possible. Some scenarios are included in the model, which can be initiated from GUI screen. MCDS screen has event history display window, which shows past trajectory of plant operation. A subroutine was developed to generate a corresponding message for each event and to manage cumulated information.

The internal codes for the screens include MMI32 OCXs to communicate with the running model. These OCXs were developed using Visual C++ by FTI. When the screen pops up, it is registered by MMI32 Manager and assigned to be a fixed position of monitor. The routine for this action is as following.

```
Private Sub Form_Load()
...
bRet=MMI32.RegisterScreen(MMI32_MAIN_SCREEN,GenericPersonality, nDDN)
bRet = MMI32.GetScreenPosition(nDDN, MMI32_MAIN_SCREEN, nx, ny, nw, nh)
```

Just after MMI32 Manager connects the screen with S-Master, which manages the running model, it calls MMI32_SmasterConnect(). All variables to be updated periodically should be defined here and assigned special indexes.

```
Private Sub MMI32_SMasterConnect()
...
szCorePower = "PNOM_FUEL"
iCorePower = MMI32.AddListVar(szCorePower)
```

S-Master periodically delivers the values of defined variables to MMI32 Manager and call MMI32_NewListData(). These procedure includes a method, *UpdateData*, which actually updates the defined variable. MMI32.Value is used to get data from the model and MMI32.Setvalue to set the value in the model.

```
Private Sub MMI32_NewListData()
...
MMI32.UpdateData
...
power = MMI32.Value(iCorePower)
bRet = MMI32.SetValue(szTarget, dTarget)
```

The values transferred from running model are utilized for the digital display of important parameters, temperature and level animations, display of data trends, control action and signal generation, and management of log-file.

3.2 Graphical Features.

The VCDS communicates with the running model through the MMS simulation tools and consists of seven GUI screens. The seven screens include the SMART, RCS, MS&FS, RHRS, MU/CCS, MCDS and Trends screens. Each screen has different contents depending on the related model system but has common features as following.

- Title of screen
- Screen navigation
- Color and unit keys

- Operating mode display
- Status of key parameters
- Numerical fields
- Input fields
- Model time display

The SMART screen, which is shown in the figure 4, displays the overall SMART plant including the primary, secondary and residual heat removal systems. This screen is assigned for the graphical representation of overall plant state in the simplified form, where users can identify status of major components and temperature distribution of fluid loops. The water levels in the each tank, the phase boundaries of steam generator and the positions of control group clusters are animated. This screen provides text boxes displaying current operation mode, model time and values of important system parameters. Numerical field windows, which show digital values such as flow rate, pressure, temperature and enthalpy of key points in the same time with running model and input field windows, through which a user can change plant state are generated by clicking red points of this screen. Users can turn on/off various pumps by clicking corresponding ones. Additional four screens shown in figure 5,6,7,8 respectively correspond to RCS, MSFS, RHRS, and CCS & MU system, each of which has same features with the screen for the overall plant but show more detail status of the systems. Each screen has various animation features, such as various water level and control valve stem position simulations, boiling boundary tracking within the steam generator tube side, control rod movements, etc. All the pipe connections and components are color-coded by the system temperature. The inactive and active statuses of the subsystems are also indicated by the gray or temperature color codes, respectively.

A main control and display screen has been developed to provide easy plant-wise control to users, which includes various input and output frames. Users can sensibly change power level or set points, turn on/off pumps, open/close valves and begin/finish special scenario through the input frames. He can also access control/event history and graphical power trajectory through the output frames. This screen also generates special sounds for the abnormal operations. Graphical trends of important variable for plant operation are collected and traced in the trends screen. The graphs are updated automatically with the VCDS data-update frequency. Some of components in the each screen such as trend, valve position and tank level were developed using a commercial ActiveX library. The Trends screen displays the real-time trend charts for about 100 system parameters grouped into 10 categories.

The developed VCDS for SMART plant analyzer is confirmed to run faster than real time in case that it is executed in the stand-alone Pentium PC with interchanging a few of state and control variables between each screen and running model. The VCDS can be run in the configuration such as computers connected through TCP/IP network and the introduction of hardware such as touch screen and hard-panel will extend its capability.

4. Conclusion

A Visual Control and Display System (VCDS) for the SMART plant analyzer has been developed using the MMS simulation tools. The data exchanging procedures are setup between the MMS SAMRT model and the VCDS. The SMART plant analyzer consisting of the VCDS and the SMART plant model is confirmed to run much faster than real time in a stand-alone Pentium PC. The VCDS exchanges about 100 system variables with the MMS SAMRT model in a synchronized way. The developed VCDS and the SMART plant analyzer can be utilized for the engineering simulation of the SMART plant operation, and for control logic and operational procedure developments.

Acknowledgement

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5. References

1. *MMS Modeling Primer*, Framatome Technologies MMS Documentation, Framatome Technologies, November 1998.
2. *Documentation for the developed and modified modules*, SMART-MMS-005, KAERI-FTI, 1999.
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4. *SMART NPA User's Manual*, SMART -MMS-010, KAERI-FTI, 1999
5. *Simulation Tools Integration*, SMART-MMS-007, KAERI-FTI, 1999.
6. *Test Results of the MMS SMART Model*, SMART -MMS-009, KAERI-FTI, 1999

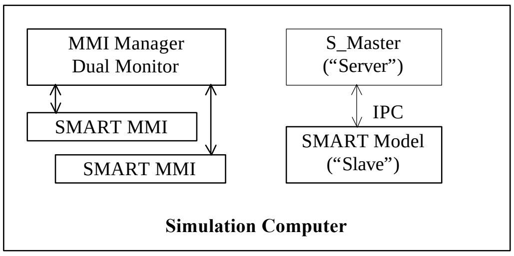

Figure 1. VCDS Configuration with Stand Alone PC

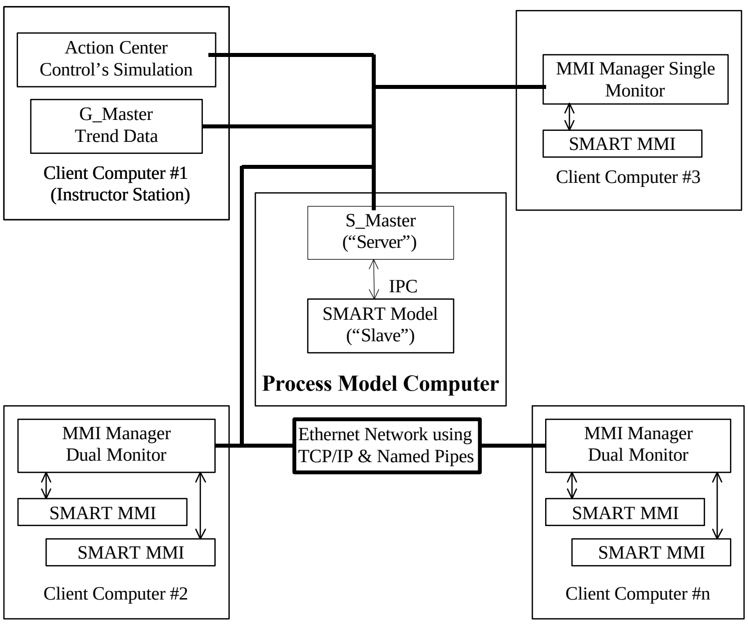

Figure 2. VCDS Configuration with TCP/IP network

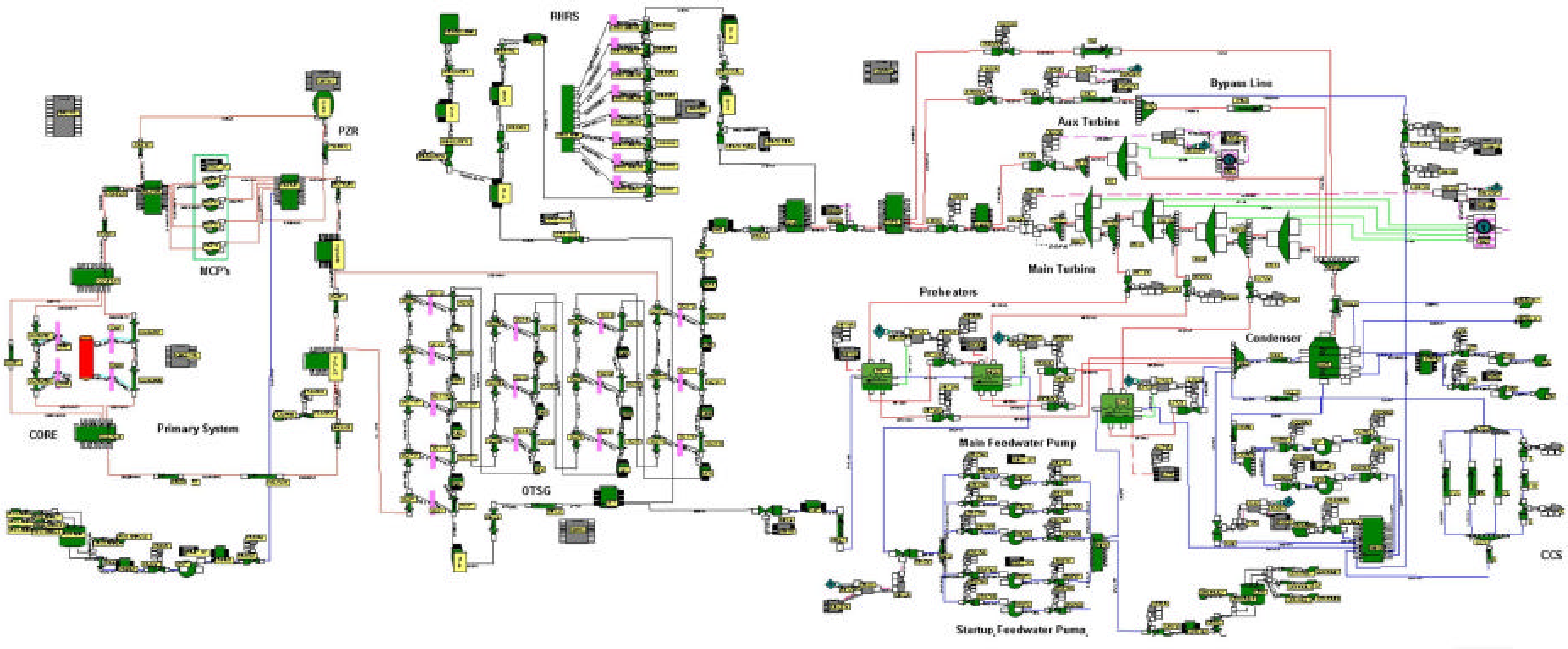

Figure 3. MMS SMART model

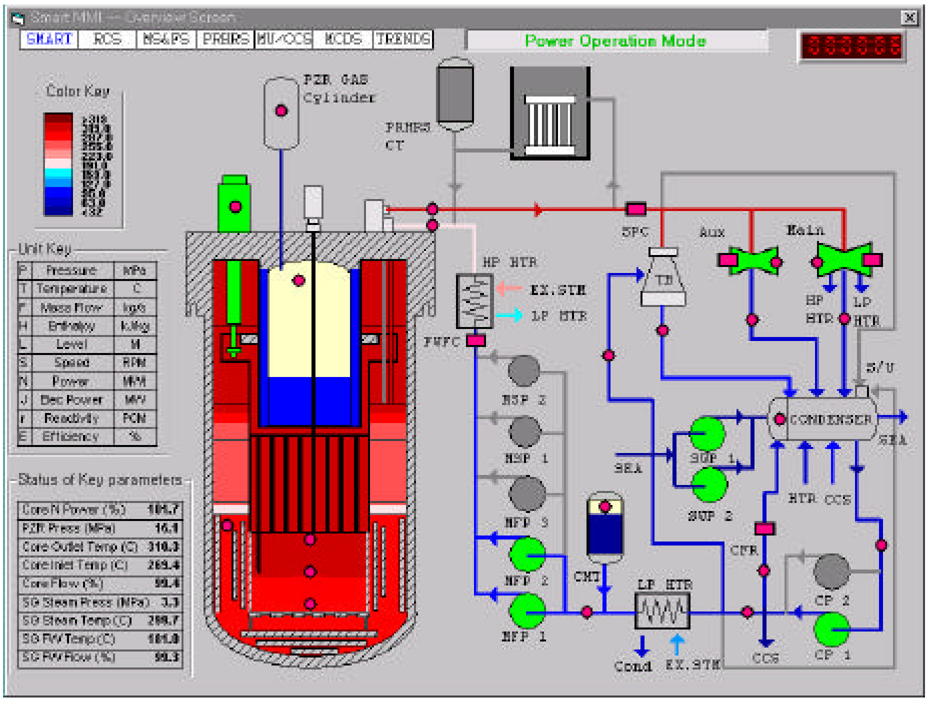

Figure 4. SMART Screen

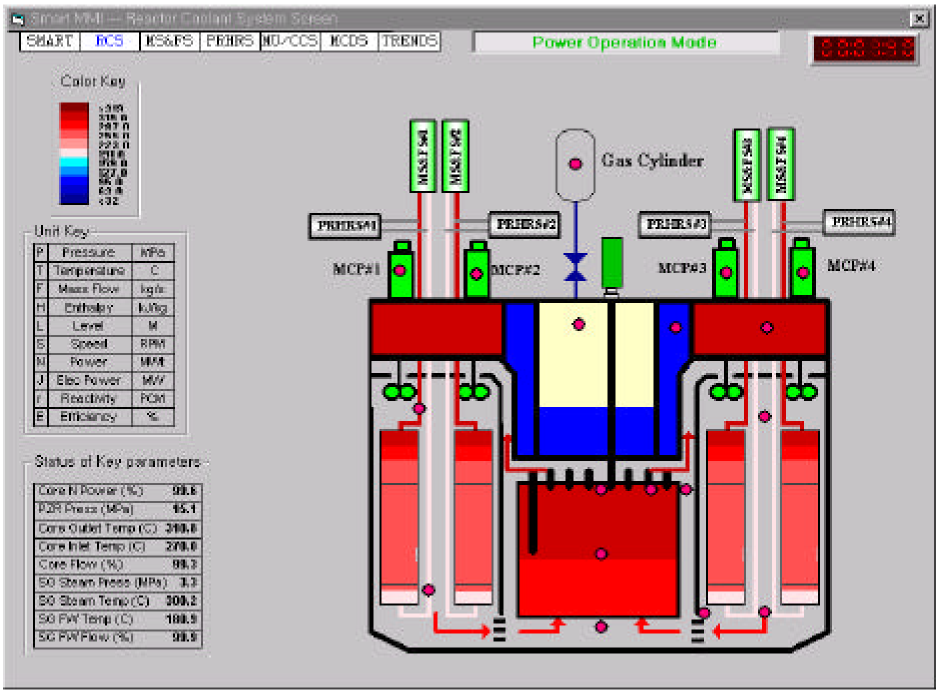

Figure 5. Reactor Coolant System Screen

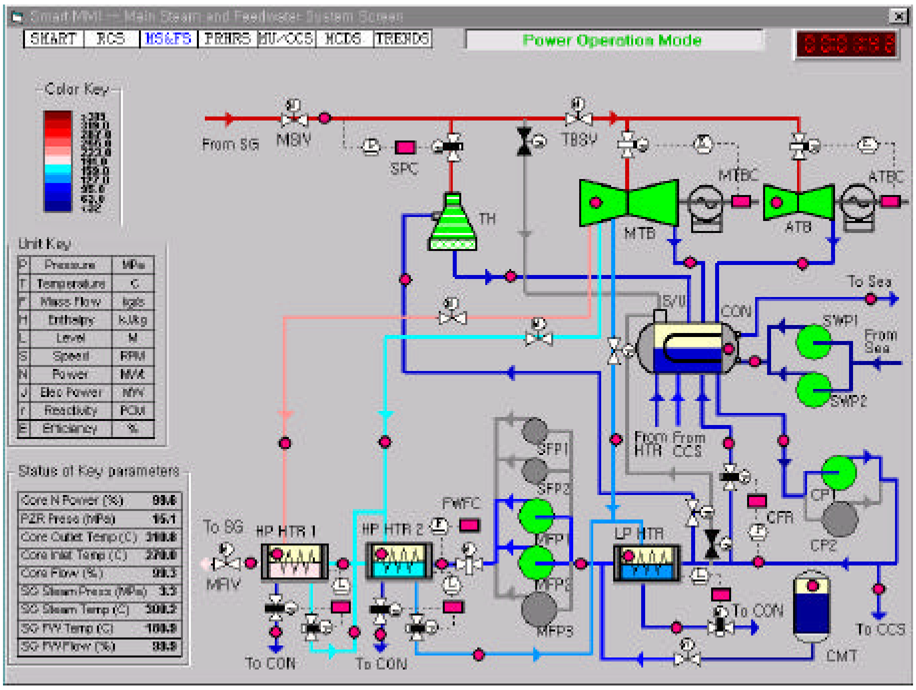

Figure 6. Main Steam and Feedwater Screen

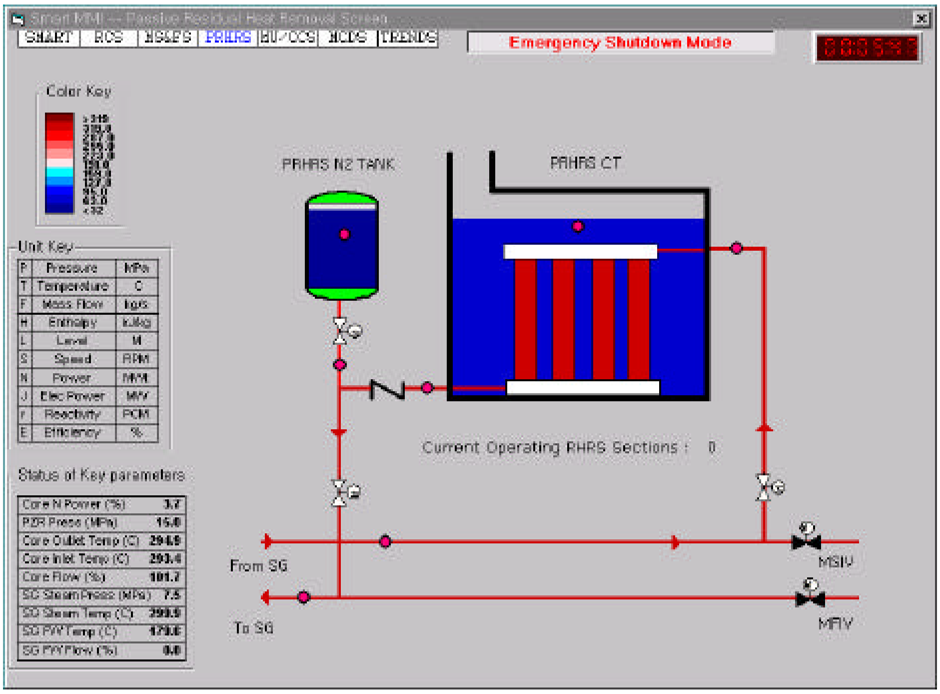

Figure 7. Residual Heat Removal System Screen

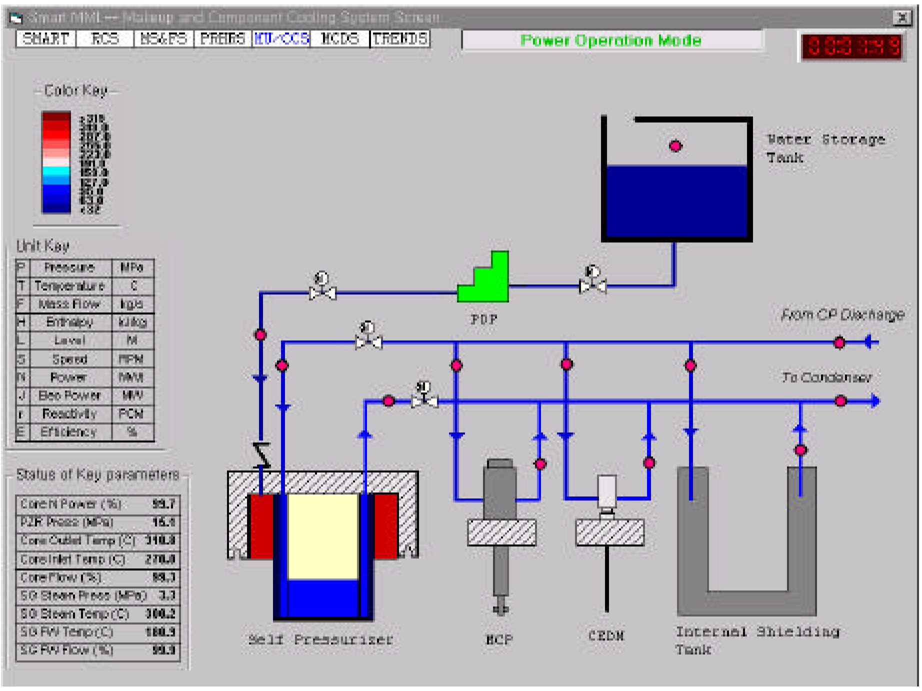

Figure 8. Component Cooling System/Makeup System Screen

Figure 9. Main Control and Display System Screen

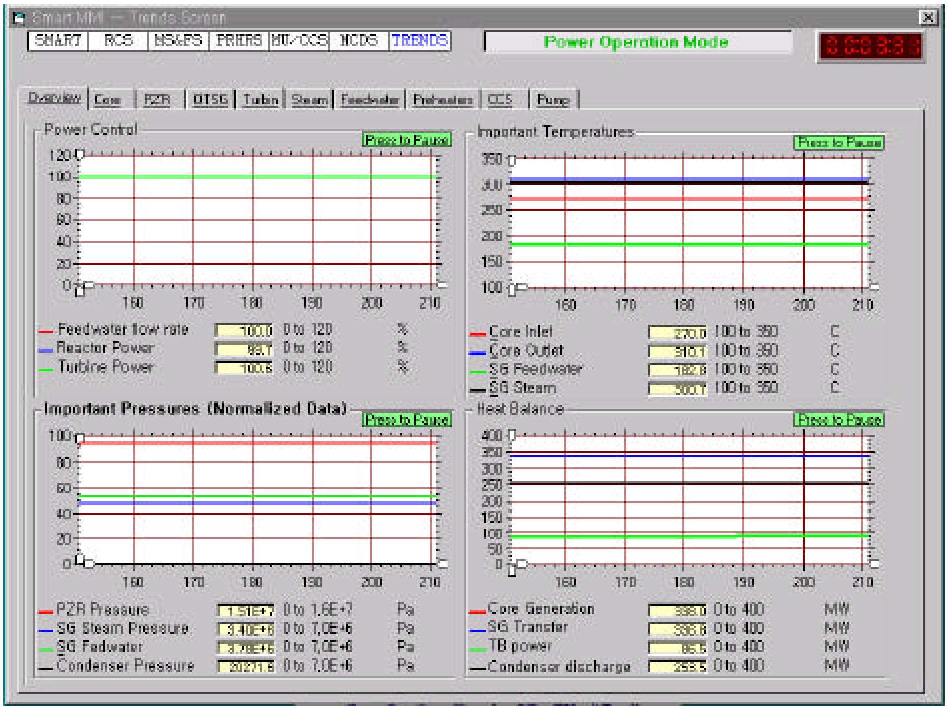

Figure 10. Trends Screen