# Development of a Valve Actuation Simulator by using the Interactive Control Features of the MARS Code

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## 1. Introduction

A joint development project involving KAERI and KHNP Kori Nuclear Power Division has been launched at October 2009. Based on the case study of the occasional system trip, it is revealed that major reason of the trip of the reactor system comes from the inadequate operation at the emergency situation of the BOP part. Up to now, it is not easy to perform a proper action within an adequate time. Due to the lack of the exercise involving a combined situation of real valve actuator and hydraulic system, it is hard for the field operator to access the valve actuator in manual mode.

In this project, the real valve actuator action is combined to the system analysis code MARS via LabVIEW. A valve actuator signal is detected and transferred to the MARS boundary condition as a valve junction flow rate. With the combined capability of the real valve operation and accurate system analysis, it is successful to provide a field operator instruction environment for the better understanding of the hydraulic behavior of the nuclear system.

In this paper, the hardware configuration and software combination of valve control simulation system are introduced. Most important thing is that the real field signal is conjugated with the system analysis code. In addition to the cooling system of the generator stator, the $H_2$ cooling system and MS drain tank level control system are prepared for the valve control simulation scenarios.

## 2. Simulator Program

The LabVIEW code behaves as the utmost top level program. MARS code has been modified to dynamic link library form. As a DLL, MARS can accept and put out any kind of data selected by user input with the exterior environment program. The interactive control provides the gate action for the data in and out.

### 2.1 Interactive Control Feature

The interactive control is a new capability of MARS or RELAP5 developed by Kim *et. al.*[1] Later, Kim makes the interactive control features more useful by adding the broadcast capability[2]. The interactive control capability is a feature for the Visual System Analyzer. This feature is enabling the data in and out with the environment program which is connected to the MARS code. The trip attributes, heater power, valve area, and flow rates *et. al.* can be transferred under the interactive control. Figure 1 shows the MARS DLL schematics. Argument 1 and 2 are array data. Argument 1 is the hydraulic value data calculated by the MARS DLL with the real boundary condition obtained by sensors. Argument 2 points the junctions or trip locations which are interrupted by the exterior data in the argument 1 array. It also contains the real sensor data which will be used as a boundary condition of MARS DLL. Location of interruption position of argument 2 can be assigned as a text wise MARS input.
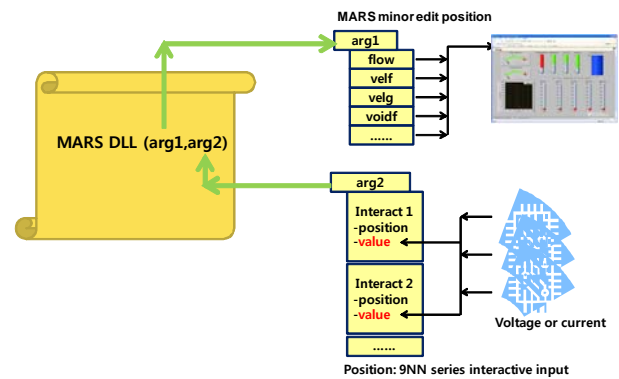


Figure 1. Schematic of MARS DLL

### 2.2 LabVIEW and Monitoring

LabVIEW program behaves as a top master handling both MARS and signal acquisition drives. As a operation master, LabVIEW synchronizes the time advancement of MARS DLL and A/D converter signal incomings.

## 3. Simulator Hardware

Simulator hardware is designed to compact movable type lack shape for portability. In order to use the operator instruction, instructor and student monitors are divided. FOXBORO field controller and level controller are installed as a real valve actuating machine. Manual/automatic switch device is installed to provide both instruction modes. An air compressor is installed to provide the air pressure actuating the valve. A P/I sensor is installed at front of the valve to detect the final valve opening in the automatic or manual valve operation.

A step motor control system is installed to replace the water level gauge floater. A slider attached to the step motor moves up and down manner like a floater. This movement gives the artificial level of drain or storage water tank. The level controller gibes feedback the in and out flow valve opening signal regarding the current water level.

## 4. Operation of Simulator

The instructor screen for the generator stator cooling system is shown in figure 2. The student identity input window and mimic diagram of the simulation system is appeared. At the right upside, the error temperature signal input window is shown. This error temperature input window is not shown in student screen. Instructor may vary the target temperature level and variation duration since the transient start.

## 5. Conclusion

A valve control simulation system is developed by combining the real instrument operation data and system analysis code MARS. Turbine generator stator cooling system, H2 cooling system, MS drain tank level control system are selected for the instruction and education scenario. MARS DLL and LabVIEW program work successfully.

## Acknowledgement

## REFERENCES

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[2] K.D. Kim and Rizwan-uddin, "A web-based nuclear simulator using RELAP5 and LaVIEW", Nuclear Engineering and Design, Vol. 237, pp.1185-1194, 2007.
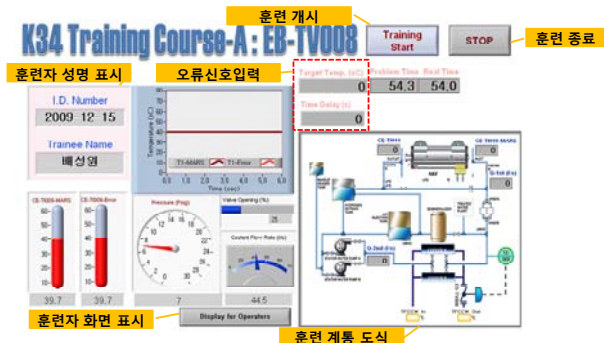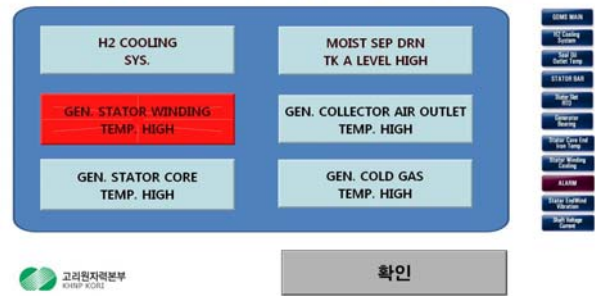


Figure 2. Start instructor screen



Figure 3. Student screen with the alarm of generator stator cooling system temperature 'HIGH'
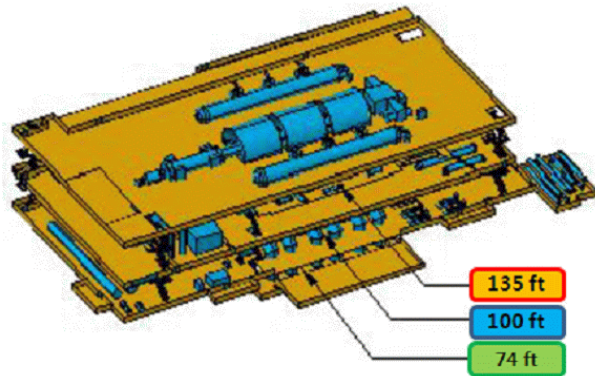


Figure 4. Student screen for floor finding



Figure 5. Graph screen for the instruction result



Figure 6. Photograph of the valve control simulator