Study on the Automation Level and Configuration Plan for ISMR MMIS

Sung Kon Kang*
KHNP, Central Research Institute, Instrumentation & Electrical Design Group, 70 Yuseong-daero 1312 Yuseong-gu Daejeon, 34101

***** ***Keywords:*** ISMR, MMIS, Automation, Turbine Control System, NSSS Control System, Flexible Operation

1. Introduction

It is necessary to apply automation technology as much as possible to improve operability and maintainability for electric output in ISMR (Innovative Small Modular Reactor) in order to increase economics and efficiency based on safety. Therefore, in this paper, we would like to present ways to apply automation technology and introduce an analysis of the pros and cons of each method in the ISMR Man Machine Interface System (MMIS).

2. Definition of Automation Level and Large NPP Automation

Table 1 shows the definition of the automation level of Billings [1]. Currently, level 2&3 automatic control technology is mainly applied in large nuclear power plants. Level 2 is the concept of shared control, which is a method to achieve the goals of the system or plant by simultaneously applying the operator's manual control and the system's automatic control. Level 3 is automation, which is mostly applied in safety-level control systems or protection systems. The system is automated and the operator acts as a supervisor. Thus, automation technology was already being applied to some extent in large Nuclear Power Plants (NPPs). However, multiple reactor modules and turbine controls must be performed in one main control room in ISMR, therefore, we would like to increase automation even more than large NPPs, raising the level of automation to level 4 or 5.

Table 1: Definition of Automation Level

Automation Level		Automatic Functions	Human Functions
6	Autonomous Operations	Fully autonomous operation. Human not usually informed. System may or be capable of being disabled.	Human generally has no role in operation and monitoring is limited.
5	Operation by execution	Essentially autonomous operation unless specific situation or circumstances are encountered.	Human must approve of critical decisions and may intervene.
4	Operation by concept	Full automatic control under close monitoring and supervision.	Human monitors closely, approves actions, and may intervene.
3	Operation by delegation	A automatic control when directed by human to do so.	Human provides supervisory commands that automation follows.
2	Shared control	A automatic control of some functional tasks.	Manual control of functions/tasks.
1	A ssisted manual control	Primarily manual control with some automation support.	Human manually controls with assistance from partial automation.
0	Direct manual control	No automation.	Human manually controls all functions and tasks.

3. ISMR MMIS Automation Application Plan

In order to determine the level and method of automation to be applied to ISMR, the parts requiring automation must be derived through system design to be applied to ISMR. When selecting parts that require automation, automation is applied in cases where automation can increase the safety and reliability of output operation of the power plant rather than having operators do it manually to achieve the goals of the system or power plant. In addition, due to the nature of ISMR, it is necessary to actively apply automation technology to increase the reliability of operability and reduce operator errors by performing simple tasks automatically rather than manually. Therefore, it is necessary to apply automation technology to the following jobs [2][3].

Table 2: ISMR Automation Area and Automation Level

Automation Area	Method	Auto Level
(1) Automation of power plant startup and shutdown - Turbine control automation - Process control automation - Driver automation	① Turbine Control System	Level 5
	② NSSS Control System	Level 4
	③ MMI operation	Level 3
(2) Flexible operation - Grid Automation of	① Turbine Control System	Level 5

Automation Area	Method	Auto Level
frequency control according to situation - Automatic daily load following operation - Operation automation	② NSSS Control System	Level 4
	③ MMI operation	Level 3
(3) Procedure operation automation	① Computerized procedure ② MMI operation	Level 3 or Level 4

As shown in Table 2, the automation level (Auto Level) was determined based on the importance aspects of safety, equipment protection, and power plant operation. This design will be decided after careful review with system designers and consideration of operation strategies as it enters into standard design in the future. Please keep in mind that we are currently introducing a conceptual review in terms of increasing automation and efficiently controlling, monitoring, and operating multiple reactor modules and turbine generators from one main control room.

4. ISMR MMIS Automation System Configuration Plan

There are many ways to configure the MMIS system for automation, but we first reviewed them in terms of operational efficiency and minimizing the impact of failure in the event of a system failure. Table 3 shows MMIS system configuration methods and their pros and cons.

Table 3: ISMR MMIS Configuration Plan and Analysis

MMIS System Configuration Plan	Advantages	Disadvantage
(1) Implementation of MMIS automation function in I&C Controller (2) MMI display and operation automation display based on computerized procedures	1. Reduction of operation workload. 2. Operators mainly perform their duties focusing on supervision. 3. I&C Controller fails, only the relevant module is affected.	1. I&C Controller control logic is complicated. 2. Operator must always be aware of the control logic execution status.
(1) Implementation of MMIS automation in Information Processing System (2) A plan to implement automation logic as simply as possible in I &C Controller	I&C Controller logic is simplified.	1. Information processing becomes more complex. 2. Difficulty writing procedures. 3. operation duty of automation through only MMI. 4. If the information processing system breaks down, the entire power plant will be affected.

As a result of reviewing the plan presented in Table 3, the MMIS automation function is implemented as much as possible in the I&C Controller and implemented as simply as possible in the information processing system, so that operators can simplify their monitoring and control duties as much as possible. This type of MMIS configuration make it possible to easily recognize and diagnose the status of the diverse MMIS and plant situation.

5. Conclusions

In this paper, in order to apply automation methods in ISMR MMIS, applicable methods and automation levels in the control system and MMI operation system were reviewed. In the near future, we will perform MMIS design based on the standard design of turbine control system and NSSS process control system referencing more advanced automatic turbine control system of coal-fired power plant than NPP. In order to increase the competitiveness of ISMR, we hope to contribute to increasing overseas export competitiveness in the future by forming an MMIS Architecture to increase operation reliability based on safety based on the latest technology and to cope with various power plant operation situations.

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