Analysis for Secondary Task in Advanced Main Control Room Using Soft Controls

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1. Introduction

As digital and computer technologies have been adapted in NPPs (nuclear power plants), there have been changes in the design of MCRs (main control rooms) [1, 2]. In adapted designs, soft controls have connections with control and display systems through software and have been adapted to manipulate controls using a mouse, trackball, and so on. The purpose of this study is to analyze operator tasks using soft controls from the simulation data of an advanced MCR.

2. Description of secondary task

The operation actions of operators are divided into primary tasks (e.g., providing control inputs to plant systems) and secondary tasks (e.g., manipulating the user interface to access information or controls or to change control modes) [1]. The primary tasks are operational actions similar to that in conventional MCRs, and the secondary tasks are newly occurring tasks by adapting soft controls in advanced MCRs.

Operators should perform secondary tasks to find appropriate screens or devices by screen navigations and screen selections before they perform the primary task to control a device. That is, whereas there is no secondary task in conventional MCRs, the secondary tasks of soft control take a relatively large portion in advanced MCRs.

Table 1 describes the operational activities included in a secondary task [3].

Table1. Description of a secondary task

Operational action	Description
Switch screen	Switch screen to check plant condition or to operate components
Open control panel	Open screen to operate components
Close control panel	Close screen after finishing operate
Confirm channel	Push channel button to confirm channel before operating systems

3. Analysis of simulator data

3.1 Selection of scenarios and operators for analysis

From an APR1400 simulator, eighteen simulation data, twelve SGTR (steam generator tube rupture) scenarios and six SBO (station black out) scenarios, were analyzed to show the number of primary and secondary tasks.

Also, because most operating tasks are performed by an RO (reactor operator) and TO (turbine operator), only secondary tasks of the RO and TO are analyzed.

3.2 Analysis results on primary and secondary tasks

Fig. 1 shows the number of primary and secondary tasks of RO and TO performing SGTR and SBO scenarios. As shown in Fig. 1, operators need to do secondary tasks more than primary tasks while performing the given scenarios, except in the results of TO performing SBO scenario. When the RO performs given two scenarios, primary and secondary tasks have difference between them. The RO needs more effort to perform about three times more secondary tasks than primary tasks.

In operational actions of a secondary task, a 'switch screen' takes the largest portion of the secondary tasks, as shown in Fig. 2. When RO performs an SBO scenario, the portion of the 'switch screen' is 49.06%.

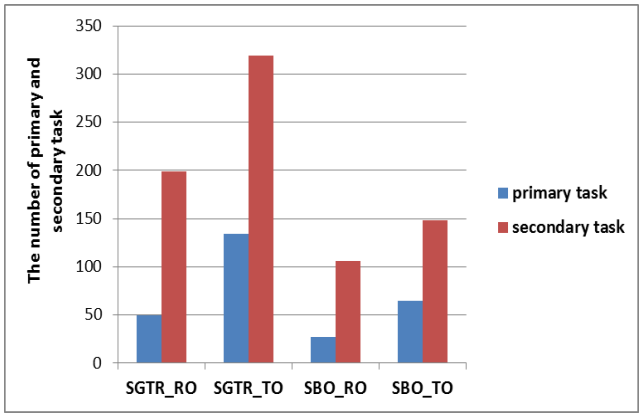

Fig. 1 The number of primary and secondary tasks of RO and TO in SGTR and SBO scenarios

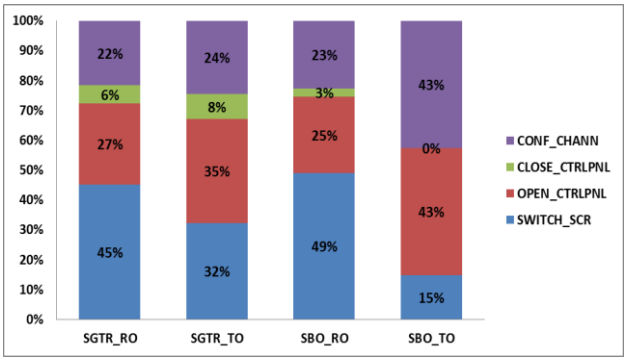

Fig. 2 Percentage of secondary tasks in each operational action of RO and TO in SGTR and SBO scenarios

From these results, the 'switch screen' occupies most of the workload while performing secondary tasks. Moreover, it was observed that operators made mistakes six times when navigating the screen including target systems or components.

To switch screens for the operating devices or observing variables such as pressure or level of reactor, there are a variety of methods of the 'switch screen'; using the screen link buttons, navigating through a main system display such as the primary and secondary side, and navigating from one system display to another system display.

In advanced MCRs of an APR1400, the 'screen link button' is located in the CPS (computer-based procedure system) in each step of the procedure and designed to help operators switch screens including target systems or components. The CPS obtains data on the procedures and is being presented in computer form with functionality to support operator use and management of the procedures [4]. Owing to the support function of the screen link button from the CPS, the secondary tasks are able to be reduced.

3.3 Analysis method and results

The number of operating tasks differs depending on the operator and condition of the NPPs. Since then, the 'ratio of screen alteration' is used to indicate how many tasks are used to switch the screen compared with the number of optimized switching screen. The 'ratio of using the screen link buttons' is used to indicate how many the screen link buttons are used to switch the screen compare with the number of optimized switching screens.

For example, in the SGTR scenario, RO switched screens five times and used the screen link buttons once. In this case, the number of optimized switching screen was two. Therefore, the 'ratio of screen alteration' is 2.5 and the 'ratio of using screen link buttons' is 0.2.

In Fig 3, the 'ratio of screen alteration' is plotted along the Y-axis, and the 'ratio of using the screen link buttons' is plotted along the X-axis during the SBO scenario. This is an example to show 'the ratio of screen alteration' is decreased by increasing the 'ratio of using screen link buttons'. This means that when operators use the screen link buttons, the number of secondary tasks is decreased.

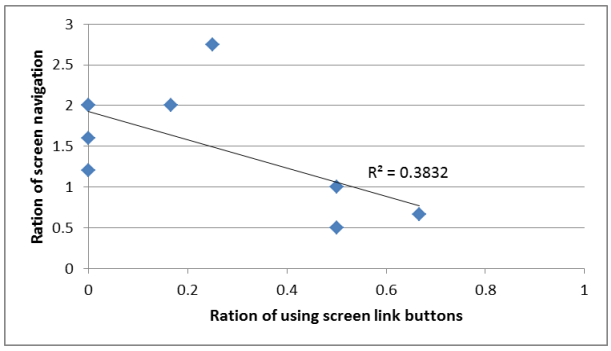

Fig. 3 The 'ratio of screen alteration' to the 'ratio of using the screen buttons' of SBO scenario

4. Conclusions

In this study, the primary and secondary tasks of eighteen simulation data were analyzed. The results showed that secondary tasks were required to perform scenarios more than primary task needs. Among these secondary tasks, the 'switch screen' made up the largest portion. This indicates that operator workload would increase with an increase of the 'switch screen' task. To reduce operator workload, CPS designers put the screen link buttons in the CPS. According to an analysis of secondary tasks using the screen link buttons, it is recognized that using the screen link buttons of the CPS helps reduce the number of secondary tasks and reduce errors of the 'switch screen'.

Therefore, although increased secondary tasks can affect the increase of operator workload according to the adapting soft controls in advanced MCRs, using supporting designs such as the screen link buttons helps to reduce operator workload and errors.

REFERENCES

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