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Modified Design of Reactor Regulating System for Research Reactor

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1. Introduction

The Reactor Regulating System(RRS) for Research Reactor is being changed into a computer-based fully digitalized system which regulate the reactor power level within the operating limit condition using four Control Absorber Rods(CAR). The power level of the research reactor is required to maintain the parameter related with reactor power within the limit of operating acceptance. The RRS performs the function including reactor startup, changing power levels, maintaining operation at established power level and sustaining the reactor in a shutdown state. The proper design and architecture for the RRS will be introduced by taking account of system reliability and economic feasibility factors.

2. Design Description of the Applied RRS

In this section, a design concept to be modified is described and structure to meet the requirements is proposed. Furthermore, some applied design features are explained in detail.

2.1 Design concept of RRS

The RRS uses the neutron power signal composed by for measuring the power level and cover all operating range with wide range fission chamber. The measuring system is separated independently with three neutron detector channels for redundancy. The measured information is transmitted in timely fashion from local detector to signal processor unit and is used for being calculated the CAR control by control algorithm in the RRS Control Computer. That control information to CRDM is transferred through each CRDM interface module every execution cycle and is taken the feedback information from the devices measuring CAR position. Theses brief procedure are shown as Fig.1.[1]

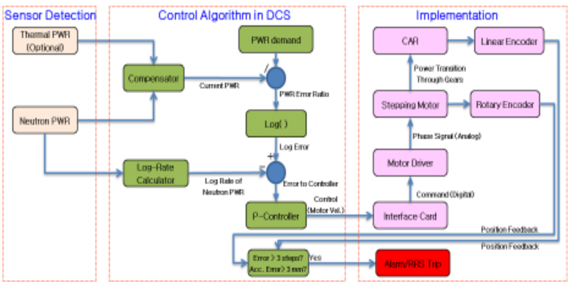

Fig.1. Functional block diagram of the RRS

The RRS is allocated to the non-nuclear safety grade, but its function has very important effects to the reactor operation with high reliability and this has preparatory action such as generating alarms and driving the CARs into the core before the initiation of the RPS trip. This additional safety oriented feature serves as an early suppression in a transient condition.

2.2 The features of the modified RRS

The modified RRS shows some differences from an established research reactor's RRS. This RRS is designed to control the reactor with CARs and to do the protective function by CAR. This means that the Control Rod Driving Mechanism(CRDM) performs both function of power regulating and reactor protecting by moving CARs or drop into the core by gravity. In other words, the RRS regulates the reactor power in normal operation but if the trip happens, the electro magnet will be apart from the magnet clutch of CRDM and all CARs will be dropped at the same time.

Signals (to IPS)	Signals (from MCR)
➢ Process variables for Thermal power ➢ CAR Position by LTI and LS ➢ CAR information for movement ➢ Neutron/Log Power and Log rate ➢ Failure information of Control Computer, CAR and RRS Instrument	➢ Manual / Automatic Operation ➢ Demand set power ➢ Control information for CAR movement ➢ SSR Withdrawal Start
Signals (to PAMS)	**Signals (to RPS)**
➢ CAR/SSR Down status	➢ Operation mode bypass ➢ Non-Trip status

Table 1. Interface signal of the RRS

The part of the RRS interface signal also shows the deviation from an established RRS as shown in Table 1. The information of another shutdown rod including CAR is transferred to Post Accident Monitoring System (PAMS) to verify the status of RPS trip. In addition, the information for another shutdown rod's withdrawal and the bypass signal for converting to the training mode are added in the RRS interface signal.

On the other side, the neutron measurement calibration by thermal power is very no longer needless during a normal operation and the control algorithm of the RRS is very simplified. This means that the calibration is only conducted during the offline inspection and the thermal power is not required to be performed in the real time control algorithm. Thus, only stable thermal power can be still used for comparing with the neutron power as reference power by visual test.

2.3 More user friendly advanced RRS

Training mode is proposed in applied RRS for operating simulation and student's training education. The training mode operation provides opportunity for user to have valuable experiment experiences for reactor control training. In this mode, the user can select auto/manual control mode and try operating CRDM manually or automatically as long as the reactor power is enough low as shown in Table 2.

Operation Modes	Rx Power (%FP)	Reactivity (K_{eff})	Conditions
A. Power	≥ 1%FP (50kW)	≥ 0.99	• Full withdrawal of SSR • Partial withdrawal of control rods • PCS pumps on (Forced convection)
B. Startup	< 1%FP (50kW)	≥ 0.99	• Full withdrawal of SSR • Partial withdrawal of control rods • PCS pumps on
C. Shutdown	0	< 0.95	• Full insertion of SSR • Full insertion of control rods • Natural circulation cooling • Refuelling
D. Training	≤ 1%FP (0~50kW)	≥ 0.99	• Full withdrawal of SSR • Partial withdrawal of control rods • PCS pumps off (Natural circulation)

Table 2. Four types of operation mode

In order to avoid possible danger to reactor, the operators or students are supposed to be noticed that the reactor power should not exceed the specific limit this mode. If the actual reactor power exceeds the specific level then a RPS trip would occur. But, this trip set point is predetermined in the very low power level and for this reason the counting neutron in this level by linear power measurement requires the high technology in dealing with signal fluctuation.

In case of CRDM interface module, the previous one is each implemented separately as shown by Fig. 2.[3] whereas the one of modified RRS is integrated while all functions related with CRDM is well maintained. That indicates that the RRS has the environment with high reliability and more improved maintenance. The interface card is implemented in the RRS by software algorithm and this make the diagnostic function more enhanced. The driver card of step motor also can be installed in the control room as long as the low level signal such as the signal from the encoder is ensured to be transferred without the reduction of fidelity. This is expected that it is capable of easy access and effective maintenance as well as saving more space.

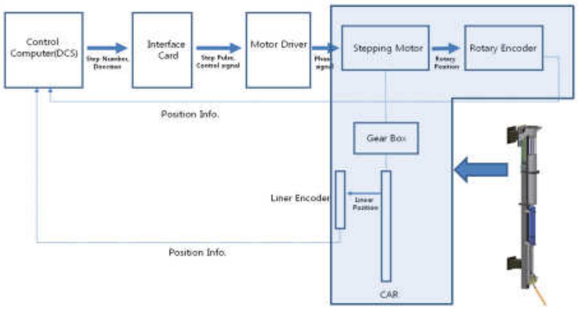

Fig.2. CRDM interface module of the RRS

3. Conclusion

We are trying to design the applied RRS to be optimized and effective in normal operation by controlling the CRDM with high reliability. For this result the strict verification and validation process as well as failure mode effect analysis is accompanied with considerate design procedure.

This paper proposes a system feature and advantage of the developed RRS that make use of the simplified neutron calibration, the training operation mode and integrated interface module and so on.

REFERENCES

[1] Young ki Kim, Design Guide on Instrumentation and Control System for an Advanced Research Reactor, KAERI/TR-2884, 2004.

[2] Young San Choi, The Domestication of Interface Device for HANARO Control Rod, KAERI/TR-4201,2010