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Voltage Sag Compensator for CAR and SOR of HANARO

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1. Introduction

HANARO is designed so as to be tripped automatically by insertion of control absorber rods(CAR) and shut-off rods(SOR) and the process systems, such as primary cooling system, secondary cooling system and reflector cooling system, etc., stop whenever the off-site power failure occurs, the reactor trips automatically. When voltage sag or momentary interruption occurs, the process systems are in operation but the reactor has an unwanted trip by insertion of CARs and SORs. We installed the voltage sag compensator on the power supply for CARs and SORs so as to prevent a nuisance trip. The compensated time is decided not to exceed 1 sec in consideration of reactor safety. This paper is concerned with the impact of the momentary interruption on the reactor and the effect of the voltage sag compensator.

2. Impact of Momentary Interruption

Present power quality standards define the voltage sag and momentary interruptions as a short duration variation of the voltage in the electrical system. Although there are slight differences between the various standards, the voltage sag and momentary interruption are always expressed and referred to as a rms voltage event. According to IEEE Std 1159, the magnitude of the voltage sag ranges from 10% to 90% of a nominal voltage and sag durations from one half cycle to 1 min. The momentary interruption is the complete loss of the voltage (<10% of nominal voltage) for a time period between half cycle and 3secs[1]. This section describes the impact of momentary interruption for 1 sec on HANARO.

2.1 Process system

When the off-site power fails, the primary and secondary cooling pumps stop after 2.4secs by under voltage relay actuating. Therefore in case of the momentary interruption for 1 sec, the pumps are still running.

We studied the mismatch, which leads to reactor trip, between the neutron power and the thermal power. The magnitude of the N/T mismatch is set at 3MW. The flow of the secondary cooling system at normal operation is 950kg/sec. At the momentary interruption for 1 sec, the flow of SCS is 925.5kg/sec, a decrease of 2.6% compared with the normal flow. The figure 1 shows the variation of flow when the electric power fails. On the assumption that the temperature of coolant is constant during 1 sec and the reactor power is 30MW, the thermal power decreases only 0.78MW[2].

The reactor trips if the flow of the reflector coolant reduces to 60% of the normal flow and lasts more than 60secs. The momentary interruption does not impact on the variation of the reflector coolant flow. As above, we found that the momentary interruption for 1sec did not impact on the process systems.

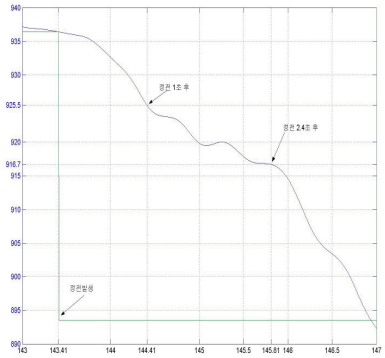

Figure 1. Variation of coolant of SCS when electric power fails

2.2 SOR and CAR

If momentary interruption occurs, the magnetic switch on circuit of power supply of SOR pump is open and the hydraulic circuit of SOR system loses the pressure in the hydraulic circuit. Consequently, the reactor is tripped by dropping SORs. We carried out the test for impact of momentary interruption. Figure 2 and 3 shows the test setup and test result[3].

Figure 2. Test setup for impact of momentary interruption on SOR

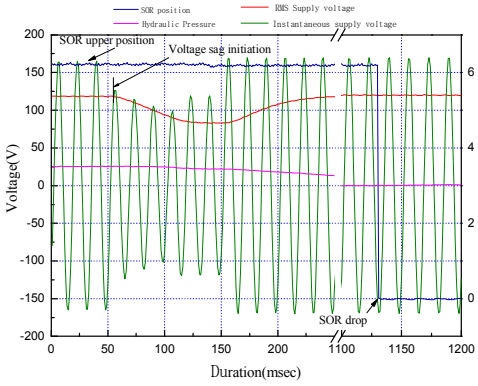

Figure 3. Test result for impact of momentary interruption on SOR

CARs are connected to the driver through a magnetic clutch and driven by four independent stepping motors. If momentary interruption occurs, the magnetic clutch loses the electromagnetic force and the reactor is tripped by dropping CARs.

As above, we found that the momentary interruption impacted on SOR and CAR system, and the reactor is tripped by insertion of SORs and CARs.

3. Implementation of Sag compensator

When voltage sag or momentary interruption occurs, the process systems are still in operation but the reactor has an unwanted trip by insertion of CARs and SORs. We installed the voltage sag compensator on the power supply for CARs and SORs so as to prevent a nuisance trip.

To implement the sag compensator, we carried out the accident analysis for the case of the momentary interruption being exceed 1sec. Even though the reactor trip is delayed 1 sec by sag compensator, the fuel temperature and MCHFR do not come up to safety limits. We confirm that the sag compensation for 1sec does not impact on the safety.

Figure 4. Installed sag compensator

Figure 4 shows the installed sag compensators. The sag compensator consists of a Dip-Free manufactured by NTC and bypass switch. The Dip-Free consists of the static switch connected to load and inverter. The energy using for compensating is stored in capacitor bank[4]. The performance test was carried out. Figure 5 is the performance test results of the sag compensator after installation the SOR power supply unit. The supplied voltage is reduced to 0 V (short interruption), and the duration is 1sec. The sag compensator compensates the interruption for 1sec successfully.

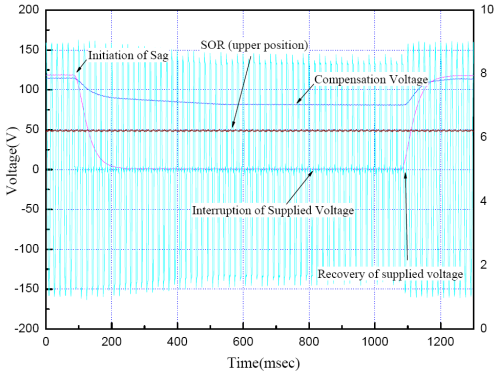

Figure 5. Performance test result of sag compensator

4. Conclusion

The voltage sag compensator is installed to operate HANARO without nuisance trip by momentary interruption or voltage sag. The performance of the compensator was established by test. The reactor safety is proved by the accident analysis. The unwanted trip by electric fail of HANARO can be reduced.

REFERENCES

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[3] H. K. Kim, H. S. Jung, J. S. Wu, "Voltage Sag Analysis and Compensation of the RPS of HANARO", APAP2004, Jeju, 2004

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