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A study on duplexing of HP TBN Throttle Valve Control System in Yeonggwang Unit #1, 2

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1. Introduction

In the nuclear power plant, the large scale of turbine is inevitable because of its characteristics using the saturated steam at the secondary side. The facility which surely controls the speed and the load of this large turbine and stops it safely in case of emergency is the DEH(Digital Electro-Hydraulic) control system. DEH for Yeonggwang unit #1 & 2 controls of TV(Throttle Valve), GV(Governor valve), IV (Intercept Valve), and RV(Reheat Stop Valve) along with an amount of steam supplied to a high pressure turbine and a low pressure turbine in order to control the number of rotation of a turbine along with the output of a generator. Among them, TV(Throttle Valve) blocks steam incoming to a high pressure turbine in a condition which requires the operation of the turbine to be stopped, and control the speed of turbine when a power plant operates. In addition, TV (Throttle Valve) deactivates a nuclear reactor when 4 valves are all shut down due to valve control signal errors arisen during normal operation.

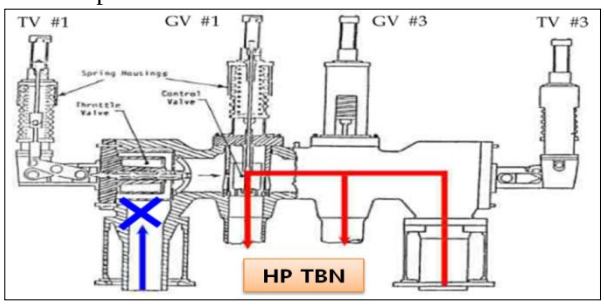

Fig. 1 Steam Path Generated when TV #1 is closed

This paper is to analyze current status and classification of failures of a throttle valve controller of Yeonggwang unit #1 & 2 and to improve a throttle valve control loop which is composed a single control loop in order to increase the reliability of an equipment and to promote the convenience of an equipment to enhance the stability of turbine output control

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2. Methods and Results

2.1 Composition of Control Loop of TV

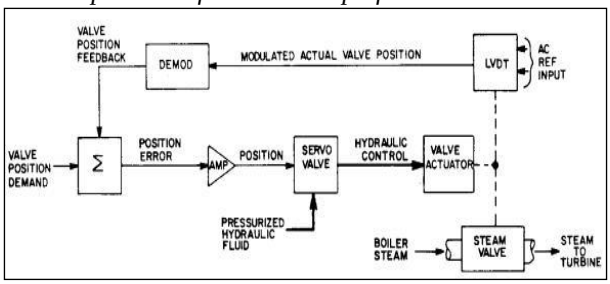

Fig. 2 Block Diagram of a Control Loop

In general, a control loop of TV is composed a RVP (R-Line valve positioner) which is in charge of the control of a valve location at a site upon signals of a controller (controller requested signals), a servo valve which generates a path for a hydraulic system along control signals, LVDT (Linear variable Differential Transformer) which is used for the detection of valve divergence, etc.

2.2 Analysis of Failures of Control Loop

Failures of compositions of a control loop of TV arisen from January '06 till the time of writing have been analyzed and it shows that out of 17 failure cases, 8 cases were related with RVP (of 47%) and there were 4 cases of the reduction in output.

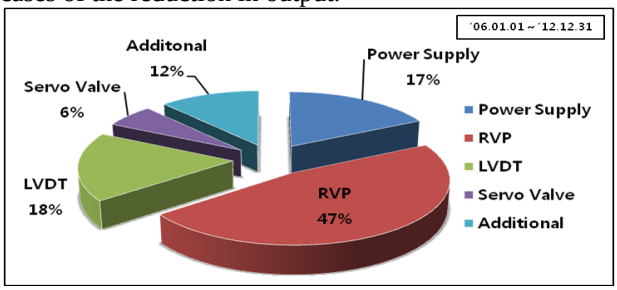

Fig. 3 Status of Failures of a Control Components

There was one case of RVP failure during the full power operation at Yeonggwang unit #1 on the date of '06.07.30(Sunday) as shown in the figure 4. As the valve control value was changed from 100%→0%, the valve got closed and there was about 20MW of output reduction. At the same time, pressure at an impulse stage of a turbine was decreased and Tavg and Tref were differentiated, and these conditions resulted in the auto insertion of a control road (D-Bank) to 231→211 Step and the decrease in the output level of a nuclear reactor by 98.7%, consequently.

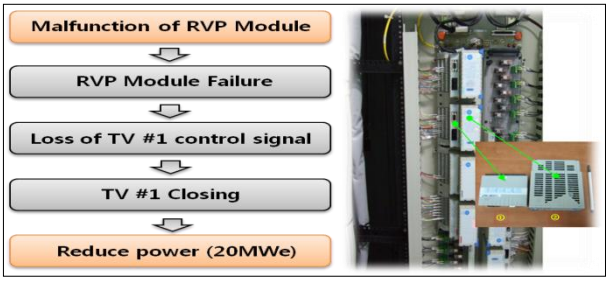

Fig. 4 Fault tree for RVP Module (Example)

2.3 Dualization of Control Loop of TV

The analysis of failure cases reveals that a single control loop has a negative side. When individual control equipment is failed, a signal processing process gets stopped and then, TV gets shut down as well. Dualization can be divided into RVP dualization, servo valve dualization and LVDT dualization, and if dualization is applied concurrently, it could be

considered as a system with fault tolerance against a failure of a single controller.

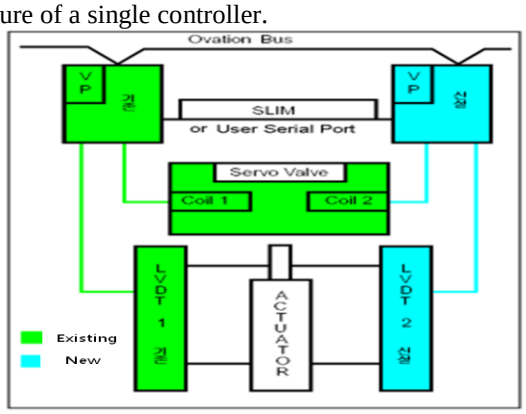

Fig. 5 Dualization Method for Control Loop

2.4 Simulation for Field Application

In order to verify control features of overall valve control loop, a dualized control loop was composed as the figure 5 for conducting the comprehensive fail-over test which includes a primary/secondary position control module failure test, a servo valve coil opening/short-circuit test, a LVCT secondary coil-1/2 failure test, a serial link failure test, etc.

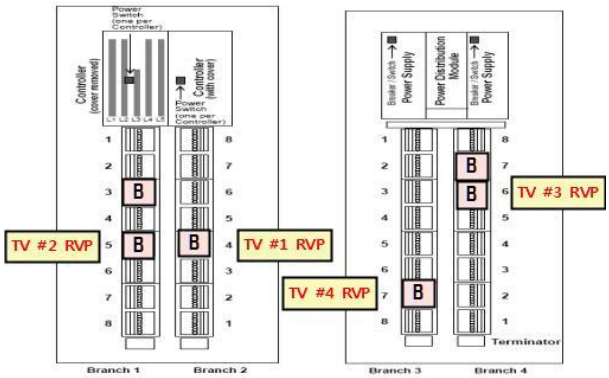

Fig. 5 Layout of Dualization Module

2.5 Analysis of Improved Effects of Control Loop

If a control loop of TV is improved, the consistent effect is generated throughout a lifespan of a power plant without any additional investment, which results in the cost reduction effect with the worth of 3.2 billion won.

Moreover, since an organic diagnosis method would be applied, maintenance efficiency would be enhanced significantly.

Fig. 7 Economy Effect of control Loop Duplexing

3. Conclusions

In order for one control system to execute control actions in a proper manner, an operation part, which is the end-point, should respond quickly. Also, it becomes very important to have the system to be multiplexed so it could operate normally even in occurrence of failure. Recently, it has become a trend for a control system for nuclear power generation/thermal power generation to be dualized/triplized, and such trends lead to the multiplexing of the steam valve control. Therefore, in order to improve a TV control system of Yeonggwang unit #1 & 2, a control loop was dualized in the same way as the field to understand proper features of the valve control. It is anticipated that the aforementioned study results would be used as reference data for improving the reliability of DEH of an actual power plant.

REFERENCES

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