A Study on the Turbine Rolling operation for Plant Start-up

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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 control system controls TV(Throttle Valve), GV (Governor Valve), IV(Intercept Valve) and RV (Reheat Stop Valve) with the Digital Computer. That is, it controls the amount of steam supplied to the turbine and thus the rotational number of turbine and the output of the generator.

In Yonggwang Nuclear Power Unit 1 and 2, the computer named W2500 supplied by Westinghouse was used in MOD Ⅱ Model the DEH controller, which was replaced in 2002 by MOD Ⅲ Model using the ovation system, a distribution controlling facility of Westinghou -se. With this replacement by a new system, it became necessary to study the possible problems during the operation with the reduced speed after raising the turbine speed. When this study is applied to the real plant, we can expect that it will contribute to the more reliable operation of the nuclear power plant.

2. Methods and Results

When there is a disorder in the turbine or the generator during the initial start-up of the turbine with the DEH control system, it is necessary to reduce the speed of operation swiftly. In this abnormal operation, the characteristics of DEH MOD Ⅲ are studied to prevent the additional generation of transient state. While rolling the turbine, the correlation between the throttle valve and the governor valve used in DEH was examined. As a result, it was found that, when the governor valve was closed by the operation of VPL, there was unexpected open of throttle valve and the excessive increase of turbine speed. This experiment on the supposition were carried out with the simulator of Younggwang Nuclear Power Unit 1 and 2 at Younggwang Training Center, and verified with the DEH simulation equipment (TCAMS : Turbine Control Algorithm Maintenance System).

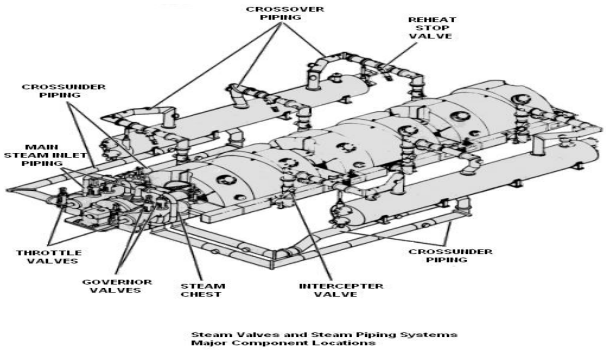

Fig. 1. Steam Valve and Steam Piping System

2.1 Turbine Rolling Operation

Turbine Rolling is carried out in the state that the governor valve is directed to be 100% by using the valve position limit while the turbine is latched. At this time, DEH control mode is set as “OPER AUTO” Mode. In the real plant, the operation in “OPER AUTO” can reduce the internal stress of the machine and the risk of fatigue with more accurate control and smooth output modification. Therefore, it is desirable to make the operation in “Manual” mode only in the case of emergency. So, in this study, the supposition was made only for the operation in “OPER AUTO” Mode.

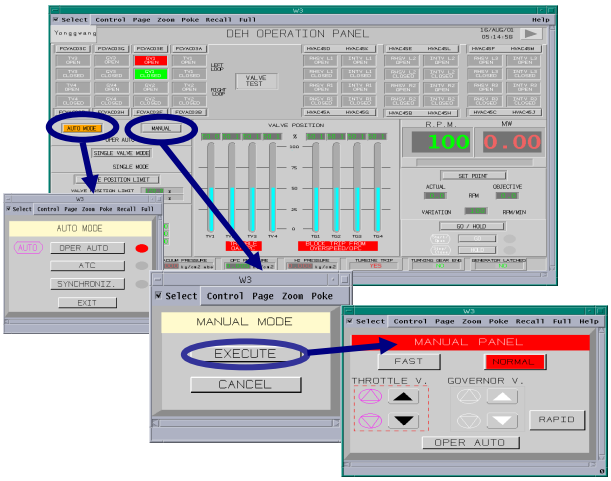

Fig. 2. Younggwang NPP DEH Operation Panel Graphic

22 Increase of Turbine Speed during the reduced-speed Operation of Turbine

When the turbine speed reached about 250rpm after start-up, a strange sound was generated around the turning gear and so operator stopped increasing the speed. To check the cause of strange sound, the operator manipulated the equipment and decreased the turbine speed to 0 rpm.

DEH speed objective reached 0 rpm, TV was completely closed, and the actual turbine speed was being reduced (as the speed reduction of turbine is made with the inertia, it takes enough time to reach 0 rpm). When it reached 122 rpm, the operator decided to close the GV to accelerate the reduction of turbine speed and to minimize the impact on the GV when the turbine tripped. (it was thought that the reduction of the turbine speed was slow due to the internal leakage of TV). With the manipulation of VPL limiter button, the operator reduced the valve position limit and began to close GV. When VPL limiter was decreased from 120% to 100% or less, GV began to be closed. At the moment, TV was suddenly opened by about 11% and the turbine speed began to increase abruptly. To interrupt the speed increase, the operator tripped the turbine.

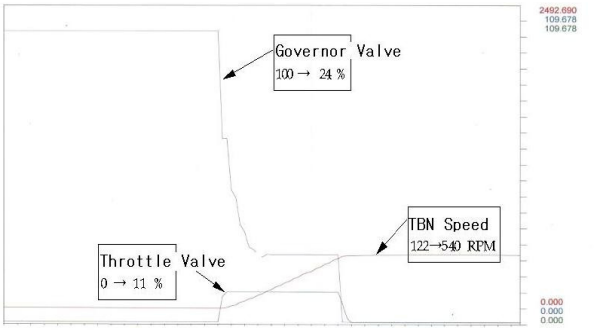

Fig. 3. Trend of Turbine Speed and Opening of GV, TV

2.3 Cause of Turbine Speed Increase

When the foregoing operation condition is analyzed, the cause of the turbine speed increase can be suggested as follows. This analysis of cause was made through the examination of Younggwang DEH MOD Ⅲ Drawing.

When VPL limiter was decreased to 100% or less, the DEHDM338(Valve Position Limiting Is Limiting) Flag was set up, and then DEHDM033(Track Target) was set up, too. At the moment the track target was set up, the set value of DEH speed was changed to 122 rpm, the actual speed of the turbine.

- Track Target : It is the function to match the DEH set value with the actual value. It has the role to minimize the impact on the system when an excessive situation happened.
- Track Target set Condition : TBN Trip, TBN Latch, Generator Synchro, Operation Mode Change (Manual, Operator Auto, ATC), **Valve Position limiting ,** IMP IN/OUT, MW IN/OUT

With the increase of DEH speed set value, the output of PID controller for the TV speed control increased to about 39%. 122rpm corresponds to 4.88% of speed change (total speed range : 2500 rpm).

$$4.88\,\% = \frac{122}{2500} \times 100$$

Due to the instantaneous change of speed set value, the output of PID controller was increased up to 39%.

PID Controller Gain : 6 , Reset time : 5 sec

$$39\% = 4.88 \times 6 + \alpha$$

α : Ouput change by Reset Constant

39% of output signal in PID controller was provided as the input signal into the TV Characteristic Curve, generating about 11% of TV demand output signal to open TV.

Table I: TV Characteristic Curve Data

Input(%)	Output(%)	Remark
0	0	39% input corresponds to 10.6% output.
60	16.4	
100	100	

3. Conclusions

DEH MOD Ⅲ Model is an excellent speed control system, but it can hardly reflect all the cases that can happen in the actual nuclear power plant. Therefore, when rolling the turbine, the operation of DEH must be carried out very carefully, and the non-verified operations must be prohibited. The unexpected opening of TV by the supposition of this study can cause the excessive supply of steam and perhaps the overspeed trip of turbine. In this study, the sudden increase of turbine speed that can be generated in the actual site was examined for its possibility and cause to apply them to the operation procedure in the site. With this, the stability of the DEH control system could be more enhanced.

REFERENCES

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