ARS-TSControl 210 MW

System for regulation and protection of the thermal block steam turbine

institute MIHAILO PUPIN
AUTOMATION & CONTROL SYSTEMS

Investor: Electric Power Industry of Serbia,
EA Thermal Power Plants "Nikola Tesla A" plc,
Obrenovac, Serbia
Object: TPPNT A, Obrenovac, Units 1 and 2
Year of project termination: 2010. A2; 2011. A1

PROJECT DESCRIPTION

Thermal Power Plant „Nikola Tesla" A is the largest thermal power plant in Serbia, with 6 blocks with a total installed capacity of 1.650MW. It was built on the right bank of the river Sava, near the town Obrenovac. It is the biggest independent electric power producer in the Serbian electric power system. The first block with capacity of 210MW – A1 was put in operation on 7th March, 1970. Six months later, another block i.e. A2, of the same capacity, was added.
The basic characteristics of the electric power generation technologies of the blocks A1 and A2 are as following:

- nominal steam flow 650 t/h, pressure 140 bar and temperature 540°C ,
- single-axel steam turbine K-200-130-1, manufactured by the LMZ-Sankt Petersburg, with the function of the steam intersuperheating and three cylinders (Figure 1), nominal synchronous speed 3000rpm and nominal power 210MW,
- the ability to work in district heating mode (for district heating of the town Obrenovac).

Figure1 - Steam turbine of the block TPPNT A2, 210MW

Due to very complex requirements, including a high level of multidisciplinary knowledge in the field of turbines, as well as strict requirements for system reliability, for a long time the domestic technological solutions could not be implemented in the system in which the turbine regulator was replaced during the modernization process. The new turbine regulators were supplied by the world reputable manufacturers, and the old ones, which had not been replaced, were integrated in the new control system on the block with certain adaptations. Due to the long period of exploitation of the power plant, as well as cooperation between the Electric Power Industry and the Institute "Mihailo Pupin", the experience and knowledge gained in these projects created conditions for the development of the system for the steam turbines control, regulation and protection - turbine control system. The new turbine regulator and turbine protection system were developed according to the established program which consisted of more phases, units and areas:

- Development of the microprocessor controller based on the proven Atlas-Max® system of the Institute "Mihailo Pupin", with improvement of the system hardware and software I/O modules, as well as components for analogue and digital signal processing. Logic execution time is reduced to 30ms, and for critical functionalities to 10ms,
- Within the system development, two-level redundancy is achieved, accelerating the IPC communication and increasing its capacity, enabling monitoring of a large number of values between supporting and leading controller,
- Development of the new library of functional blocks which include possibility of monitoring all internal statuses from the leading controller,
- Development of the turbine speed measurement, as one of the most important components in the turbine regulation system, as well as other components important for the functioning of the turbine control system.,
- Development of the algorithm for the turbine control, regulation and protection,
- Development of the steam turbine simulator with auxiliary systems. There are two prepared versions: the software version, which is used in the phase of the development of the turbine control algorithm and the version of the device with independent hardware and software which is used in the phase of testing all functions of the completed turbine control system cabinet,
- Reconstruction and adjustment of the old system of the hydraulic-mechanical turbine regulation and protection to the modern control-regulation system,
- Project of integration of modernized turbine regulation and protection system into the existing control, regulation, monitoring and protection systems,
- Design of new control sequences for starting and stopping turbine, adaptation and design of new algorithms for controlling turbine technological subsystems by the principle of the functional groups,
- Testing, putting into operation and setting of the complete turbine control and protection system integrated in the control system of the turbine and the block as a whole.

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Besides facilitating the maintenance process, modernization of the turbine control system also increases reliability, availability and security of the turbine generator sets as a whole, since the advanced system enables the following:

- precise, secure and simplified process of starting, loading and shutting down the turbine (*Figure 2*),
- more precise position control, better dynamic characteristics of the control valves and consequently better performance of the system as a whole,
- introduction of advanced functions in the turbine control and monitoring system,
- use of three-channel electronic overspeed protection,
- better control and monitoring system, and three-channel turbine protection system - greater safety of the turbine in operation.

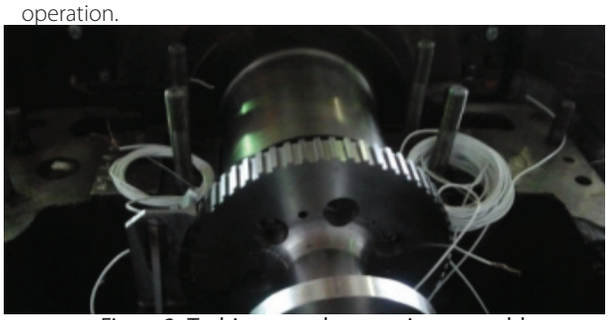

Figure 2- Turbine speed measuring assembly

Modernization of mechanical assembly for turbine speed measuring was performed by the Institute "Mihailo Pupin". Turbine speed measuring is a multi-channel device, which has been developed by using inductive proximity probes that detect rotation of the gear firmly bound to the turbine rotor, generating impulse trains.

APPLIED TECHNOLOGY

ARS-TSControl is a steam turbine protection and regulation system based on Atlas Max-RTL® controllers and VIEW6000 SCADA system, produced by the Institute "Mihailo Pupin". The system consists of the following (*Figure 4*):

- **Protection part of the system**, which is designed by using 2oo3 principle in a complete protection loop (from sensors in the drive unit, through I/O modules, controllers, to the executive protective hydraulic block). Thus the requirements of the SIL3 reliability are fulfilled completely;
- **Regulation and control part of the system**, which controls turbine control valves. The automatic turbine speed, power and fresh steam regulators are installed in front of the turbine. Then the limiter features, which reduce the plant load in the case of impermissible values of vacuum in the condenser, a sudden drop of the fresh steam pressure in front of the turbine or unallowable increase of the steam pressure in the action chamber of the high-pressure cylinder. In this part of the system the regulation and control function is realised through the system of the turbine heating extraction. The principle 2oo2 is applied in the design of the regulation and control part of the system.

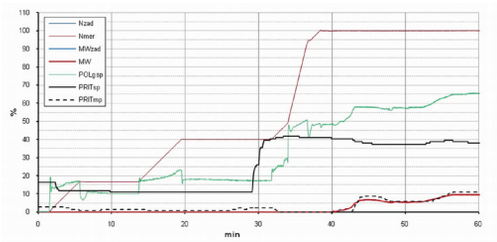

Figure 3 - Turbine performance at nominal parameters

A special requirement for the control logic is applied in terms of the realization of capturing turbine at the nominal revolution number after generator outage. In fact, regarding the turbines with strong compound between the high and low pressure valves, there is a transient regime, after the network outage, in which the trapped steam is injected in the turbine from the inter-superheater, before the high pressure valve is opened. Special control logic is developed with the aim to reduce the transient effects caused by the existence of the transient phase.

Figure 4 - ARS-TSControl

RESULTS

Implemented new solution of integrated turbine control and protection system has all functions, features and performances of a modern steam turbine control, regulation and protection system. With appropriate adjustments it can be implemented on the condensing steam turbines of any capacity and it can be integrated into any master control system.

The operation is successfully adjusted with the existing master and slave control systems. Development and implementation of the turbine model enabled further operation improvement through the application of the advanced control algorithms, such as Predictive Control Model.

It is important to note that development of the turbine hardware-software simulator has enabled that the turbine control system operation can be tested even in conditions and scenarios in which tests could not be performed due to safety or other reasons. Thus, a significant increase in the system reliability is achieved.

ARS-TSControl system designed for turbines with a nominal capacity of 210MW has already been implemented at two power plants in Serbia, and it can be said that it entered the line production.

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