ABSTRACT

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Abstract:

This paper presents the possibility of power plant efficiency improvement when condensing or extraction-condensing turbines is used by interfering with cooling water system. The first step of the research consists of the multiple surface condensers connection configuration impact analysis on the efficiency of the power plant. Large coal power plant unit with turbine power exceeding 800 MW, typically is made up of three double-flow low-pressure (LP) turbine parts. This results in application of three surface condensers. It was checked what is the most advantageous connection on the cooling water side to obtain the highest power plant efficiency. The problem was studied by analyzing the thermodynamic effect, as well as the influence of installations hydraulic resistance on the cooling water pumps load and the power plant net efficiency. Next, to select the most favorable concept of condenser operation, depending on the conditions and limitations, which exist in the industrial factory, the modifications of cooling water installation were tested. The calculations were performed for the full power plant load range.

Sequentially, impact of implementing cooling water flow control on the power plant net efficiency was tested. Because the power plant efficiency significantly decreases when the turbine load drops, it was verified whether it is an economic justification for reducing the amount of cooling water when low load of LP turbine part, and whether such solution is feasible in practical implementation. The cooling water optimal flow, depending on the surface condenser load, has been calculated for condensing and extraction-condensing turbine.

The analysis was conducted based on the calculated heat balances for nominal and not nominal parameters. The tested units were described by energy and mass balances equations. The correct calculation of the turbine exhaust steam pressure is one of key steps to ensure the calculation's correctness. The analysis of three exhaust steam pressure calculation algorithms, comparison of their complexity and the set of the data needed for these calculations were presented. The model of the surface condenser was based on three methods of calculating the heat transfer coefficient: the dimensionless equation with characteristic numbers, the HEI method and the ASME standard. The most advantageous model was indicated after verification with the data from real unit.

Considering the influence of the cooling water system on the net power plant efficiency, hydraulic resistance of two described power plants was calculated. The pumps and installation characteristics allowed an accuracy verification of potential profits. The final part of the work presents the software made in the commercial DCS Valmet DNA tools. It was used for heat balance calculations and indicating the optimal cooling water flow for point or specific power plant operation range. The application was prepared for previously described thermal plant.

Optimalization calculation gives the expected benefits for both tested power plants. Using the HEI algorithm to calculate the condenser's pressure, the serial configuration was found to be the most advantageous configuration, regardless of the possibility of implementing cooling water control. Although this system generates the greatest hydraulic resistance, the final gains are the greatest. Next, for both tested power plants cooling water control system should be implemented. In the condensing power plant, the gains are visible below 80% of the turbine load. However, the cooling water system operating conditions for the individual parts of installation are significant limitation in the pump load control implementation. In the tested thermal plant, the benefits received thanks to optimalization implementation, are also visible below 80% of the condenser load, however, to achieve a real profit, the steam flow through the LP part should not exceed the half of the nominal load.