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Introductory Chapter: Review of Current Research Trends in the Field of Power Plants

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1. Introduction

Since first AC current high-power hydropower plant was put in operation, built by Nikola Tesla and George Westinghouse in 1895 on Niagara Falls, electrification of the world is dramatically changed. The growing power demand and energy consumption in the last decades require fundamental changes in the process, power production and services. These requirements tend to use both conventional and nonconventional energy generation in order to have power plants useful both economically and environmental friendly to the society. Although new trends in this field focus on producing clean energy from renewable sources, the world's most used fuel in power plants is still coal with 41% of produced global electricity [1]. Coal, oil, nuclear and gas power plants are still dominant for supplying base load in all power grids. Also, energy consumed at power plants for generating electricity is still high. Based on OECD data [2], the amount of electricity supplied to the final consumers was 33% of the total energy consumed at power plants.

In Europe, the largest share of budget spent on research, development and demonstration (RD&D) on energy technology was in energy efficiency and renewable sources [3]. On the other side, in Japan, 39% share of total energy RD&D in 2015 remains in the field of nuclear energy [3]. Regarding nuclear power plant (NPP), more attention is spent on improving safety, especially after accident in Fukushima NPP in March 2011.

2. Energy efficiency and reliability

Improving energy efficiency and reliability goes in several ways. Some of the solutions are to continuously monitor and supervise vital equipment in power plants, like generator transformers, in order to improve maintenance and reduce costs. Additional advantage is decision support, where results taken from online monitoring systems are analyzed by external experts that help plant staff and management to make decision about plant operation when

some of the possible malfunction of transformers is detected or expected [4]. This also could yield to proper time schedule of transformer replacement [5].

Modern control systems in power plants cannot be realized without the modern system of monitoring of process parameters or parameters of machines and systems. Continuous monitoring includes continuous monitoring of machine operation (online), automatic storage of information and the possibility of automatic or subsequent processing and analysis. It also includes the generation of specific alarms and their submission to the operator and control system, according to a certain procedure [6]. Diagnostics of the generator are based on a wide range of data from off-line and online testing generators and data analysis. All test data, operating data and data of the machine are stored in a database for generators. Thus, all test data from any laboratory, repairs, unexpected events and failures are available for analysis. The data in the database with each successive inspection and testing are updated. The database is very flexible and has the ability to expand for all possible new types of tests, acquisition of photo records of visual inspections and so on [7].

3. Operation improvement and stability

In virtually all coal preparation operations, mill systems are a critical part of the process to provide economical, reliable and energy-efficient grinding. Operating mills at a slightly lower speed or even a slightly higher speed than line frequency give process engineers the advantage of the mills being optimized for the grade of material and desired throughput of the final process [8]. To get the target boiler power increase in order for 5–10% of rated power, it is necessary to increase the fuel intake and one of the possibilities for that is the coal grinding mill capacity increase [9]. Proposed solution in Ref. [9] is based on enhanced motor voltage supply by increasing frequency, what is possible by medium voltage (MV) inverter. The main goal is to supply motor with rated voltage and frequency in range between 50 and 55 Hz to obtain increase of plant power for 10% by increasing grinding mill capacity. Additional benefits are reduced mechanical stress during start-up and the additional possibility of mill slow running for inspection purposes.

In order to improve power plant stability while operating close to its capability limits, as a requirement of a deregulated electricity market, one solution could be to optimally coordinate the synchronous generators' reactive power outputs in order to maintain the total reactive power delivered by a steam power plant (SPP) or the voltage at a steam power plant high voltage (HV) busbar [10]. In such way, it is possible to aggregate the multimachine power plant into single virtual generator, thus enabling more sophisticated zonal voltage control across power transmission network.

4. Environmental impacts

Environmental impacts of power plants are mainly reflected in emissions of pollutants and greenhouse gases from fossil fuel-based electricity generation. For instance, electricity generation

is the fourth highest combined source of NO_x , carbon monoxide and particulate matter in the United States [11]. The combustion of coal for power generation produces fly ash, which must be collected prior to discharge to the atmosphere. Electrostatic precipitators are devices used for collecting of fly ash from smoke gases in power plants that use coal as a combustion fuel. The precipitator collection efficiency can be expected to exceed 99.5%. Most existing electrical precipitators are developed with classical continual power supply that provides DC voltage at the end of electrodes. Improvement of this power supply type that has better purification and overall energy efficiency is obtained by the usage of intermittent supply [12].

5. Renewables and clean fuels

But, not only fossil fuel power plants affect on the environment. Renewable sources like small hydropower plants and wind farms could have significant influence on fish and bird habitats and migrations. The strategic environmental assessment can be considered as the most important, the most general and the most comprehensive instrument for directing the strategic planning process toward the principles and objectives of environmental protection, as well as for making optimum decisions on future sustainable spatial development, especially in energy sector [13].

Hydrogen is the most abundant element and cleanest fuel in the universe. Unlike hydrocarbon fuels that produce harmful emissions, hydrogen fuel produces pure water as the only by-product. Low-cost photoelectrochemical process efficiently uses sunlight to separate hydrogen from any source of water to produce clean and environmental friendly renewable hydrogen. Innovative solar hydrogen generator eliminates the need for conventional electrolyzers, which are expensive and energy intensive.

6. Conclusion

All of the above takes the attention of researchers to continuously work on solutions for better fuel usage and energy efficiency improvement, while producing more electricity with higher reliability and safety and lower impact to the environment. The aim of this book is to assist researches involved in power plant design and development, as well industrial engineers involved in plant's maintenance with recent techniques taken from different technologies and disciplines.

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