Process design of solar-fossil power plant integration including control aspects

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Abstract

Current trends in energy production suggest that renewable energy will play an important role in future electricity generation. Among renewable sources, solar power is considered to be one of the most promising alternatives which is well supported by the rapid increase of Solar Thermal Power Plant installations worldwide. Solar energy (so as renewables) however is plagued by the intermittent nature of the source causing power shut-downs in power generation due to the lack of primary resource. To overcome this difficulty one of the possible alternatives is the hybridization of the solar plants with supplement fossil-fuel fired power plants. Besides that integration solves the intermittency problem it allows an efficient use of fossil as well as solar resources. Integrated plants can achieve lower fossil fuel consumption and lower CO_2 emissions than conventional fossil plants allowing a rational use of local and renewable resources.

Having some overview on the key benefits, on the other hand, it must be emphasized that although the related individual fields are mature enough technologically, solar-fossil plant integration is not "plug and play" it does involve numerous challenges related to (process) design and control highlighting only the most significant disciplines which are involved. To handle such projects in industry currently the governing perspective is the so called sequential process and control design. Explaining briefly, this means that the process is commonly designed first (plant configurations and hybridization topology is picked based on engineering traditions, experience and rules of thumb), and then the control system is synthesized to satisfy dynamic performance and closed-loop stability criteria. In this sequential approach, the control structure is thus selected for a ready-made process. Needless to detail the features (disadvantages), as a new emerging paradigm referred to as *integrated process and control design* grabs the attention of researchers, scientists and industrial practitioners. As its name suggests here the process and control design stages are not separated anymore rather these are executed in synergy.

This paper addresses the problem of solar and fossil power plant integration. The aim is to develop a general mathematical framework which provides some guidelines for process design including control aspects utilizing the dynamics of the underlying process. Correspondingly, the presented approach is dynamic model based, heavily relies on the mathematical model of the process(es). The key idea of the approach is as follows: integrated process (plant) configurations are parametrized via a mathematical model such that for each parameter setting the dynamic behavior of the corresponding integrated process can be examined by simulations. Assuming that the integrated process is in a steady state equilibrium, we are interested to identify configurations where the "effort" required to compensate a power-loss disturbance (caused by the change of power output of the solar plant) with the fossil plant is minimal such that the total output power of the integrated plant remains unchanged. The effort is defined by the L_2 gain between the disturbance and compensator signals. This can be interpreted as a search for an integrated plant configuration which has the best disturbance rejection performance with respect to L_2 gain. An application of the proposed approach is presented for a simple model of once through boiler and concentrated solar power plant integration.