World Academy of Science, Engineering and Technology
International Journal of Chemical and Molecular Engineering
Vol:12, No:06, 2018

Advanced Exergetic Analysis: Decomposition Method Applied to a Membrane-Based Hard Coal Oxyfuel Power Plant

Authors : Renzo Castillo, George Tsatsaronis

Abstract : High-temperature ceramic membranes for air separation represents an important option to reduce the significant efficiency drops incurred in state-of-the-art cryogenic air separation for high tonnage oxygen production required in oxyfuel power stations. This study is focused on the thermodynamic analysis of two power plant model designs: the state-of-the-art supercritical 600°C hard coal plant (reference power plant Nordrhein-Westfalen) and the membrane-based oxyfuel concept implemented in this reference plant. In the latter case, the oxygen is separated through a mixed-conducting hollow fiber perovskite membrane unit in the three-end operation mode, which has been simulated under vacuum conditions on the permeate side and at high-pressure conditions on the feed side. The thermodynamic performance of each plant concept is assessed by conventional exergetic analysis, which determines location, magnitude and sources of efficiency losses, and advanced exergetic analysis, where endogenous/exogenous and avoidable/unavoidable parts of exergy destruction are calculated at the component and full process level. These calculations identify thermodynamic interdependencies among components and reveal the real potential for efficiency improvements. The endogenous and exogenous exergy destruction portions are calculated by the decomposition method, a recently developed straightforward methodology, which is suitable for complex power stations with a large number of process components. Lastly, an improvement priority ranking for relevant components, as well as suggested changes in process layouts are presented for both power stations.

Keywords : exergy, carbon capture and storage, ceramic membranes, perovskite, oxyfuel combustion
Conference Title : ICEESAO 2018 : International Conference on Exergy, Energy Systems Analysis and Optimization
Conference Location : San Francisco, United States
Conference Dates : June 06-07, 2018