Integration of mixed conducting membranes in an oxygen–steam biomass gasification process

Oxygen–steam biomass gasification produces a high quality syngas with a high H2/CO ratio that is suitable for upgrading to liquid fuels. Such a gas is also well suited for use in conjunction with solid oxide fuel cells giving rise to a system yielding high electrical efficiency based on biomass. However, high costs for both oxygen supply equipment and operation are significant challenges for the commercial implementation of this technology. Mixed ionic and electronic conducting (MIEC) membranes can be used for oxygen separation from air at a lower energy consumption compared to cryogenic distillation, especially for small to medium scale plants. This paper examines different configurations for oxygen production using MIEC membranes where the oxygen partial pressure difference is achieved by creating a vacuum on the permeate side, compressing the air on the feed side or a combination of the two. The two configurations demonstrating the highest efficiency are then thermally integrated into an oxygen–steam biomass gasification plant. The energy demand for oxygen production and the membrane area required for a 6 MWth biomass plant are calculated for different operating conditions. Increasing the air feed pressure increases the energy consumption but decreases the membrane area. As an example, for the highest efficiency configuration working at a membrane temperature of 850 °C, 6 bar of air feed pressure and 0.3 bar of permeate side pressure, 150 m² are needed to generate the oxygen for the 6 MWth plant at an energy consumption of 100 kW h per tO2.

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