Energy and exergy analysis of a natural gas fired combined cycle power plant integrated with calcium looping for CO_2 capture in Indian climatic conditions

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Abstract

With the ever growing energy demand in India and the resultant release of enormous amount of greenhouse gas emissions from fossil fuel based power plants has become a major concern for climate change. In the last decade, calcium looping is considered to be among one such CO_2 capture technology for large scale operations that can mitigate this problem at lower cost. The discoveries of shale gas reserves has encouraged India to consider natural gas for clean energy generation. However, being a high CO_2 emitting fuel, integrating calcium looping (CaL) with natural gas fired combined cycle (NGCC) power plant may prove to be a promising option for decarbonisation in India due to its large reserves of lime stones. Hence, this study is intended to simulate and analyse a NGCC power plant integrated with calcium looping system in Indian climatic conditions. An energy and exergy analysis of CaL integrated NGCC power plant was carried out to assess the performance and compared with the conventional NGCC power plant. The study also includes the exergy destruction of major components of the CaL integrated NGCC power plant to identify the location of system inefficiencies for further improvement. The CaL integrated NGCC power plant has a CO_2 capture efficiency of approximately 91%. The energy and exergy efficiencies of the CaL integrated NGCC power plant was found to be 33.90% and 31.85% respectively while its efficiency penalty was 5.6% and 5.1% when compared with conventional NGCC power plant. The analysis also reveals the highest exergy destruction in the combustors, calciner and heat recovery steam exchangers. The combustors although having large exergy destruction but its scope of improvement is restricted due to the limitation on operating temperature. However, the calciner and heat recovery steam generators hold a good and reasonable scope of energy savings.