Modeling and techno-economic evaluation of a CSP/ Fischer-Tropsch fuel production plant

Fakultät III - Prozesswissenschaften
der Technischen Universität Berlin
Institut für Energietechnik
Fachgebiet: Energieverfahrenstechnik und
Umwandlungstechniken regenerativer Energien

von

Tubagus Aryandi Gunawan

Masterthesis

Supervisors

Prof. Dr. rer. nat. Frank Behrendt
Friedemann G. Albrecht M.Sc

Berlin, den September 26, 2016

Ich erkläre hiermit, dass ich die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

Berlin, den September 26, 2016

to my mother, Yennie Gunawan

Abstract

Liquid fuels are still the backbone of world transportation nowadays. Therefore, the development of carbon neutral liquid fuels is being crucial. Solar energy has the largest technical potential of all renewable energy sources available and is therefore considered as an appropriate energy resource for the liquid fuels production.

The proposed thermochemical concept to convert solar energy to liquid fuels is the combination of concentrated solar power (CSP), reverse water gas shift reaction (RWGS) and Fischer-Tropsch synthesis (FTS). Two concepts were proposed differing on the heat supply to the RWGS reactor. The first concept applies burner to supply heat to the RWGS reactor, on the other hand, the second concept places RWGS reactor to the top of solar tower as solar reactor to cover the heat demand by concentrated solar irradiance.

Both concepts were modeled and simulated in Aspen plus™. By using the base case capacity of 20 MW solar heat in the first concept, 1,865 tons of liquid fuels per year can be generated by feeds of 10,092 tons of water per year and 6,720 tons of carbon dioxide per year. In comparison, using 21 MW solar heat in the second concept, 2,029 tons of liquid fuels per year can be produced from 10,092 tons of water per year and 6,887 tons of carbon dioxide per year. Solar-to-liquid efficiency in the first concept and second concept are respectively 42% and 42.5% for the base case scenario.

With the scale factor of 10 from the base case scenario, the total capital investment (TCI) for the first and second concepts are 1,190 M€and 1,220 M€, respectively. The net production cost (NPC) are 10.59 €/l in the first concept and 9.95 €/l in the second concept. If the economic evaluation considers the learning curve for CSP, the NPC of the first and second concepts drop to 9.29 €/l and 8.59 €/l, respectively.