**Reuse of coke oven and flue gases into methanol: a techno-economic assessment.**

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**Highlights**

* Methanol synthesis process is simulated using a computer aided design software.
* A techno-economic assessment is performed to evaluate the process viability.
* A preliminary carbon balance is performed.

**1. Introduction**

The iron and steel industry is one of the main energy intensive industrial sectors in the world. The associated CO2 emissions are then very large representing, in 2006, 30% of the 7.2 Gt of direct CO2 industrial emissions 1. To mitigate these Greenhouse Gases (GHG) emissions, the development of Carbon Capture and Utilization (CCU) processes to reuse wasted gases is a crucial point to succeed in the energetic transition. These gases can be converted into Added Value Products (AVP). Various studies 2 have shown that methanol is a serious candidate as an AVP because it represents an interesting intermediate in chemical industry and offers the possibility to recycle a large quantity of carbon. Moreover, the methanol synthesis process from syngas is available at a commercial stage.

Three main off-gases are generated in the steelwork sector: the Blast Furnace Gas (BFG), the Basic Oxygen Furnace Gas (BOFG) and the Coke Oven Gas (COG). These gases, produced transiently, are classically used for energy integration in the steel mills or even burnt in flares without any profit. The development of transient processes able to convert these gases could be an interesting solution. This work focuses on the thermochemical reuse of COG that can be produced either in a steelwork or in an isolated coking plant. Interesting ways of COG reuse could be considered such as hydrogen recovery, syngas production or chemical looping 3. Different process structures are investigated and assessed to produce methanol by COG conversion and by CO2 reuse from flue gases.

**2. Methods**

COG contains mainly H2 and CH4 leading to two main case studies considered in this work to produce almost pure H2: (i) the direct recovery of H2 in the COG, and (ii) the reforming of CH4 contained in the COG into H2. Besides, the required quantity of CO2 is extracted from flue gases to be hydrogenated into methanol. Both solutions are modelled, simulated and assessed from economic, energetic and environmental point of view. The process structure is divided into four main building block: H2 separation, CO2 capture, COG reforming and methanol conversion/purification. For each block, the available technologies are compared based on heuristic criteria 1,4. Then, the selected technologies are modeled considering some hypothesis and simulated on a Computer Aided Design (CAD) software (Aspen Hysys) enabling to determine mass flow rates, utility needs and the equipment size. A pinch analysis is performed to improve the heat integration among the different process units. The *levelized cost of methanol* is then calculated using a factorial method. A preliminary carbon footprint analysis was also performed in order to evaluate the potential savings in terms of GHG. The main calculated criteria was the *avoided CO2*which corresponds to the CO2 that is not emitted in the atmosphere with respect to a reference system (methanol from natural gas) of methanol production and takes into account the quantity of CO2 entering in the reuse process.

**3. Results and discussion**

The *levelized cost of methanol* is equal to 228 €/ton (+/- 30 %) for the case study (i) and to 268 €/ton (+/- 30 %) for the case study (ii). At current conditions (fossil fuels price, methanol price on the market and level of carbon tax), the cost of methanol from COG is slightly higher than the one produced from fossil fuels. Nevertheless, for a price of Natural Gas (NG) of approximately 3 €/GJ, the methanol production cost of the fossil fuels route will be comparable to the one of the reuse route. Concerning the *avoided CO2* criterion, the results obtained for case study (ii) are in good agreement with those obtained in the literature 5.

**4. Conclusions**

Two process structures describing the reuse of COG and flue gases into methanol are studied. The techno-economic evaluation has enabled to evaluate the CAPEX, the OPEX and finally the *levelized cost of methanol*. This cost is slightly higher than the current production cost of methanol from NG. Nevertheless, the evolution of the NG price on the market together with the evolution of the carbon price may offer some interesting perspectives.

**References**

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