Theoretical and experimental investigation of effective solar mixed reforming for a less carbon intensive production of methanol

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Mixed reforming of methane, i.e. replacing a fraction of the reactant steam by CO_2 has become a widely discussed option for the conversion of CO_2 into a useful product. However, this can only be beneficial, if the heat of reaction is provided by a heat source that does not produce CO_2 itself. For instance, concentrated solar irradiation is a suitable non CO_2 emitting heat source. Within the framework of the INDIREF project (Indirectly solar heated reforming for methanol production), the possibility of solar assisted mixed reforming for methanol production is investigated.

A theoretical study solely based on thermodynamic data was carried out to assess possible inlet ratios of $H_2O/CO_2/CH_4$ into the solar heated reforming reactor in dependence on reforming temperature and pressure. Several metrics where used to evaluate the results for the different configurations: (1) Absence of carbon formation, (2) sufficiently high methane (>85%) and CO_2 (>50%) conversion as well as a (3) suitable composition of the product syngas for methanol and Fischer-Tropsch synthesis. The results indicate that the criteria are only met within a very narrow range of $H_2O/CO_2/CH_4$ ratios. Furthermore it is shown that the maximum achievable CO_2/CH_4 ratio is 0.35, of which only 50 % are converted in the reactor. This shows the very limited capability of the mixed reforming reaction to convert CO_2 into a useful product. At the same time the study showed that low temperatures at the reformer inlet cause a regime that favors carbon formation in the reforming reactor. A new concept for later injection of the reactant CO_2 is proposed. The concept is validated by carrying out lab scale experiments in an electrically heated furnace on which results are presented.

In the next step, process for indirectly heated solar reforming with air as heat transfer medium is developed. The central innovation is the air heated reforming reactor, which allows for efficient utilization of the solar heat as well as effective reaction control based on the above mentioned findings. The developed process will be demonstrated in the large scale solar simulator (*synlight)* in Jülich, Germany in the end of 2018.

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