Solar thermal dissociation of methane: research into reaction kinetics

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According to the Intergovernmental Panel on Climate Change emissions of carbon dioxide and other greenhouse gases have to be reduced drastically in order to mitigate the climate change. The usage of hydrogen does not cause any release of carbon dioxide and thus hydrogen is a promising energy carrier for the future. However, the clean – particularly the CO_2-free production of hydrogen – still poses a challenge.

The solar thermal dissociation of methane is considered as a possibility to generate hydrogen without releasing harmful substances, since the reaction enthalpy is provided by renewable energy.

For the design of industrial applications it is necessary to have reliable knowledge about the reaction kinetics. A great number of relevant works can be found in literature, but the published results show extensive variations. Main aims of the doctoral work are the clarification of kinetic dependencies and the determination of kinetic parameters of the thermal decomposition of methane. Therefore experiments are carried out at DLR covering numerous reaction conditions, which differ for example in reaction temperature, initial concentration of methane and residence time of the gas mixture in the reactor.

The first period of the doctoral work mostly dealt with the preparation of the experiments comprising specification, design, acquisition, adjustment and assembly of needed units. A tube reactor, which is heated by a tube furnace, was chosen as the basic element of the installation representing a reactor with a simple geometry. Very important for the evaluation of the tests is the accurate determination of temperature profiles in the reactor, which show maximum temperatures between 1200 °C and 1800 °C. For these measurements thermocouples (type B and C) with a tantalum coating are used. Mass flow controllers generate defined inlet and calibration gases containing argon, methane and hydrogen. The outlet gas of the reactor is analyzed by gas chromatography. Employing the measured data the conversion of methane and finally kinetic parameters are calculated.

The experimental setup will be shown and explained. In this context several characteristics of controlling and measuring devices, which lead to troubles in practice, and the need to question declared accuracies will be discussed. First results will be presented along with possibilities of evaluation refinement and an outlook regarding the next steps of the doctoral work.