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Heat production in depth up to 2500m via in situ combustion of methane using a counter-current heat-exchange reactor

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In situ combustion is a well-known method used for exploitation of unconventional oil deposits such as heavy oil/bitumen reservoirs where the required heat is produced directly within the oil reservoir by combustion of a small percentage of the oil. A new application of *in situ* combustion for the production of methane from hydrate-bearing sediments was tested at pilot plant scale within the first phase of the German national gas hydrate project SUGAR. The applied method of *in situ* combustion was a flameless, catalytic oxidation of CH_4 in a counter-current heat-exchange reactor with no direct contact between the catalytic reaction zone and the reservoir. The catalyst permitted a flameless combustion of CH_4 with air to CO_2 and H_2O below the auto-ignition temperature of CH_4 in air (868 K) and outside the flammability limits. This led to a double secured application of the reactor. The relatively low reaction temperature allowed the use of cost-effective standard materials for the reactor and prevented NO_x formation. Preliminary results were promising and showed that only 15% of the produced CH_4 was needed to be catalytically burned to provide enough heat to dissociate the hydrates in the environment and release CH_4.

The location of the heat source right within the hydrate-bearing sediment is a major advantage for the gas production from natural gas hydrates as the heat is generated where it is needed without loss of energy due to transportation. As part of the second period of the SUGAR project the reactor prototype of the first project phase was developed further to a borehole tool. The dimensions of this counter-current heat-exchange reactor are about 540 cm in length and 9 cm in diameter. It is designed for applications up to depths of 2500 m. A functionality test and a pressure test of the reactor were successfully carried out in October 2013 at the continental deep drilling site (KTB) in Windischeschenbach, Germany, in 600 m depth and 2000 m depth, respectively.

In this study we present technical details of the reactor, the catalyst and potential fields of application beside the production of natural gas from hydrate bearing sediments.