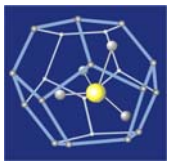
Carbon neutral energy production: CH_4 production from hydrate via in-situ combustion

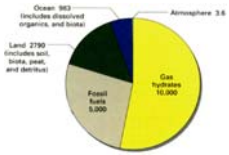
Yue Zhou and Professor M.J. Castaldi ,Earth and Environmental Engineering, HKSM ,Columbia University

Introduction

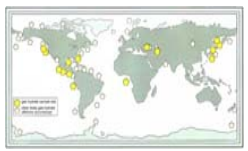


Methane hydrate is formed when water molecules freeze around a molecule of methane gas. l Gas hydrates are solid, non-stoichiometric compounds of small gas molecules and water. They form when methane from organic decomposition comes together with water at low temperatures and high pressures to trap individual gas molecules within crystalline cages of water ice

researchers at Mallik Field, Canada, used a drilling rig (left) to mine methane from buried hydrate crystals

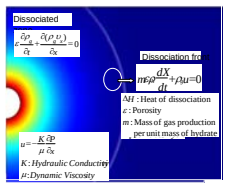


The amount of energy stored in natural gas hydrates is significantly more than that of all the other fossil fuels combined.



The locations of hydrates have been recorded in marine and permafrost environments throughout the world.

Simulation

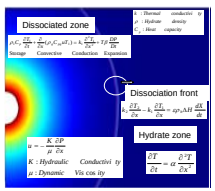


Mass balance equations

A preliminary model was developed using a Finite Element Code (FemLab®) to simulate the temperature distribution that would develop when a heat source is applied locally.

Calculations and simulations using FEMLAB™ show:

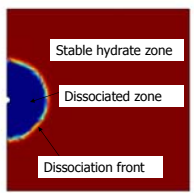
- The in-situ combustion method offers an energy efficient
- Among the heating conditions, constant heat flux has a better efficiency.
- The method can sequestrate a significant amount of carbon dioxide
- System pressure is will sensible to the permeability of the reservoir



Energy balance equations

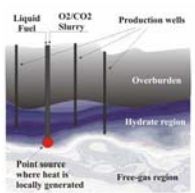
Run	Hydrate loading	Dissociation front (meters)	Center Temp. K	η
T=1000 ºC	0.2	6.45	1273	0.72
T=1000 oC	0.5	4.47	1273	0.52
Qin= 4 KW	0.1	7.8	1303	0.92
Qin= 4 KW	0.2	5.8	1118	0.90
Qin= 4 KW	0.5	4	898	0.74
Qin= 40KW	0.2	7.8	2920	0.42

Summary of simulation results



Heat front movement

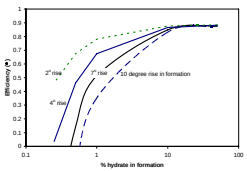
Methods of Production



Conceptual depiction of a point source heat balancing system using vertical

1. Pressure reduction
2. Inhibitor injection
3. Thermal stimulation

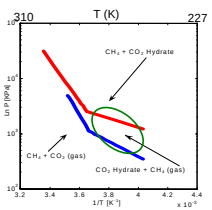
- A point heat source, via in-situ combustion, strategically located in the hydrate deposit
- About 10% of the energy content of the reservoir is used for the process
- This method not only tremendously reduces the energy input, but also has the potential to sequester as much or more CO2



Preliminary energy calculation

	CO_2 release (Tg)	% Reduced
Current Fossil Fuel	5551.6 [1]	
Pure CH4	4648.3[2]	16.3%
Natural gas	5468.6[2]	1.5%

CO2 reduction potential

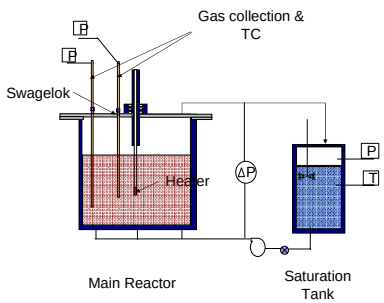


Dissociation temperatures for CH4 and CO2. Based on data and tables from Kamath (1984) and Sloan (1989).

Experiment

Using this experimental apparatus it will be possible to:

- Verify the feasibility of gas hydrates dissociation by down-hole fire flooding.
- Understand important characteristics such as temperature and pressure profiles for methane hydrate formation and dissociation in pure water system as a reference.
- Obtain the relevant data to develop the models for methane hydrate dissociation by combustion method



Experiment system setup

Experiment apparatus

- The apparatus (above) has been built and tested in our lab. The apparatus is a 72 liter, temperature-controlled high-pressure vessel.
- Pressure have tested to 2000 psi which is needed to form the hydrate.