

# Pressure build-up due to dissociating natural gas hydrates in pipelines

September 2010

## Problem

Hydrate remediation constitutes a substantial part of flow-assurance efforts in the oil & gas industry

Hydrates will become an increasing problem as deepwater projects become more common and existing fields enter tail end production.

Need for:

- cheap
- efficient
- environmentally friendly remediation techniques!

Can heat tracing / electrical heating be used as remediation technique ?

## Model Goal

Gain insight into the dissociation dynamics in an electrically heated pipeline blocked by hydrates.

Develop model to give conservative estimates of local pressure build-up in such pipelines.

Allow for a spatial and temporal variation of the heat flux applied to the pipe.

## Model Assumptions

### Geometry

- Two sided depressurization => symmetry in longitudinal direction
- Neglect gravitational effects => axial symmetry

### Mass

- Dissociated hydrate enters annular gap => no flow inside plug

### Energy

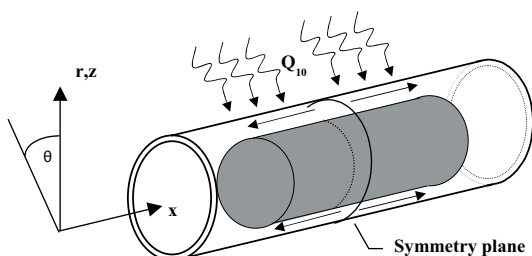
- Heat loss to surroundings described by heat transfer coefficient.
- Stationary heat conduction in pipe wall
- Heat transfer to annular control volume treated using heat transfer coefficients from both sides.
- Heat conduction inside plug according to Fouriers Law.
- External heat flux is applied to outer pipe surface, and is uniform in circumferential direction.

### Momentum

- One dimensional flow in annulus => Single control volume needed for annulus in radial direction

### Mechanical Energy / Elasticity

- Kinetic energy included in energy equation
- Pipe responds to pressure and thermal expansion
- Plug exhibits pressure expansion only
- Composition of hydrate plug is uniform



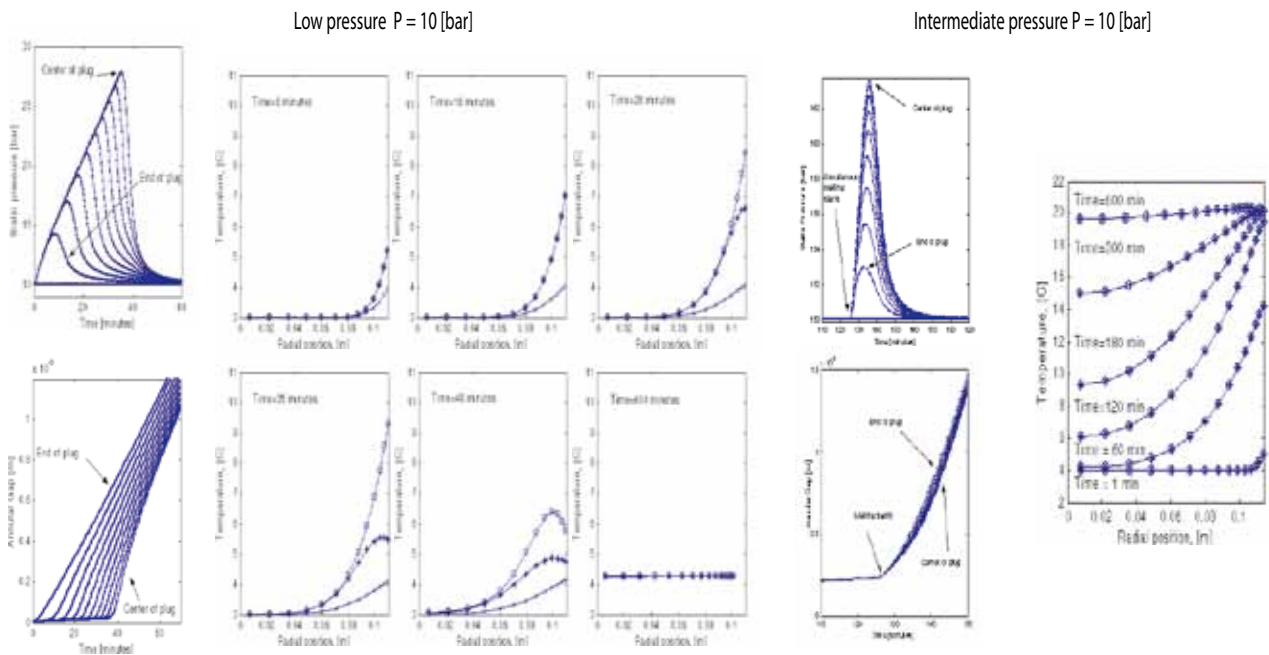
## Solution Strategy

- Simplify differential equations for mass, momentum and energy
- Use homogenous two-phase model in annular gap
- Adapt moving grid to plug surface
- Use table interpolation for thermodynamic properties (r, H, Td).
- Use algebraic equations for flux relations, mass balance at plug surface, conduction in pipe wall and elastic expansion of pipe and plug.
- The set of differential and algebraic equations were solved using the DAE-solver DDASPK.

## Conclusions

- Plug length important for maximum pressure build-up independent of ambient pressure
- Gap needed for annular flow smaller at high ambient pressure
- Time between start of dissociation to maximum pressure build-up shorter at high ambient pressure
- Radial temperature profile inside plug depends on ambient pressure.

## Simulation Results



This research has been conducted on behalf of Statoil ASA



SINTEF Materials and Chemistry  
 box 4760 Sluppen, NO-7465 Trondheim, Norway  
 Phone: + 47 40 00 37 30, www.sintef.no/materials\_chem

## CONTACT

Paal Skjetne  
 Phone: +47 93 42 34 24  
 E-mail: paal.skjetne@sintef.no