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Evaluation of the Impact of Monoethylene Glycol and Methanol on Induction Time Performance

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ABSTRACT: This study evaluates the effects of monoethylene glycol (MEG) and methanol on hydrate induction time, focusing on optimizing inhibitor concentrations to mitigate hydrate-related risks. Using Multiflash for fluid characterization and OLGA for multiphase flow simulations, the hydrate induction time was first assessed in an uninhibited system before introducing MEG and methanol at varying concentrations. The results indicate that increasing MEG and methanol concentrations generally reduces induction time, with a 10 mole% concentration of either inhibitor effectively preventing hydrate formation throughout the simulation period. The study concludes that both MEG and methanol at optimal concentrations can significantly enhance flow assurance in hydrocarbon transportation. Further research is recommended to explore the impact of other chemical inhibitors and to investigate the effects of lower MEG and methanol concentrations on hydrate induction time.

KEYWORDS: monoethylene glycol, methanol, induction time, olga.

I. INTRODUCTION

A gas hydrate is a crystalline solid in which gas molecules, such as methane, are encased within a lattice of water molecules, forming a structure similar to ice. These hydrates, also known as clathrate hydrates, naturally occur in environments with high pressure and low temperature, such as deep ocean sediments and permafrost regions. The stability of gas hydrates is influenced by factors like temperature, pressure, and the specific gas composition.

[1]The induction period is defined as the time required to obtain a detectable quantity of hydrates during their natural or artificial production.A study investigated the effect of methanol (MeOH), ethanol (EtOH), and monoethylene glycol (MEG) on kinetic hydrate inhibition when combined with poly-n-vinylcaprolactam (PVCap) in methane systems. While these thermodynamic hydrate inhibitors (THIs) are widely used for hydrate prevention, they require large injection volumes, increasing operational costs. The research explored the synergistic effects of THIs and kinetic hydrate inhibitors (KHIs) to enhance hydrate prevention while reducing the required volume of inhibitors. From the study if was discovered that methanol and ethanol negatively affect PVCap performance, reducing the subcooling extent of hydrate inhibition. MEG, unlike MeOH and EtOH, enhances PVCap's performance, acting as a full "top-up" thermodynamic inhibitor that improves inhibition at concentrations up to 50 mass%. The study suggests that MEG can be an effective complementary inhibitor for KHIs, potentially reducing THI consumption while maintaining hydrate suppression efficiency [2]. However, it did not incorporate induction time of hydrate formation.

The effectiveness of thermodynamic hydrate inhibitors methanol, ethanol, and monoethylene glycol (MEG) in preventing hydrate formation in a controlled flow loop simulating subsea pipeline conditions. Using a 12-meter stainless steel pipe submerged in cold water, different inhibitor concentrations were tested. Results indicate that 2wt% MEG was insufficient to prevent hydrate formation, while 3wt% was effective. A blend of 0.7wt% MEG and 0.3wt% methanol showed optimal performance, reducing

MEG requirements and overall inhibition costs. The study emphasizes the benefits of combining MEG with methanol for enhanced hydrate prevention in offshore operations [3]. The study did not account for induction time. In contrast, this research incorporates the induction time for hydrate formation using OLGA software. This study will evaluate the effects of different monoethylene glycol and methanol concentrations on hydrate induction time and determine the optimum monoethylene glycol and methanol concentrations to elongate induction time.

II. EXPERIMENTATION

The materials used in this study are literature data from the published works and OLGA and Multiflash software for model development and simulation. These data include fluid properties (component and composition, molecular weight, density), pipeline and riser materials (material type, thermal conductivity, density, heat capacity, wall thicknesses), pipeline and riser profile (x- and y-coordinates, internal diameter, wall roughness and thickness), inlet and outlet boundary conditions (volume flow rate, fluid pressure, and fluid temperature), heat transfer (ambient temperature and ambient heat transfer coefficient). Table 1 to 4 presents these data in details.

Table 1: Fluid Composition

Component	**Mole%**
H_20	10
N_2	0.04
CO_2	0.94
C_1	50.22
C_2	3.94
C_3	2.59
IC_4	1.02
NC_4	1.35
IC_5	0.95
NC_5	0.77
C_6	1.5
C_7	2.82
C_8	3.93
C_9	2.98
C_{10}	2.47
C_{11}	2.07
C_{12+}	22.41
C_{12+} MW 284.22	C_{12+} Specific gr. 0.874

Table 2: Pipeline Material Properties

Material	**Density Kg/m^3**	**Specific Heat J/kg/°C**	**Thermal Conductivity W/m/°C**	**Thickness (mm)**
PA-11	1045	2400	0.33	33.9
PVDF	1180	1500	0.19	33.35

Table 3: Tieback distance and water depth

Well	**Flowline (m)**	**Water depth (m)**	**Riser length (m)**
OK-11	3149	129	450

Table 4: Tieback/Riser profile

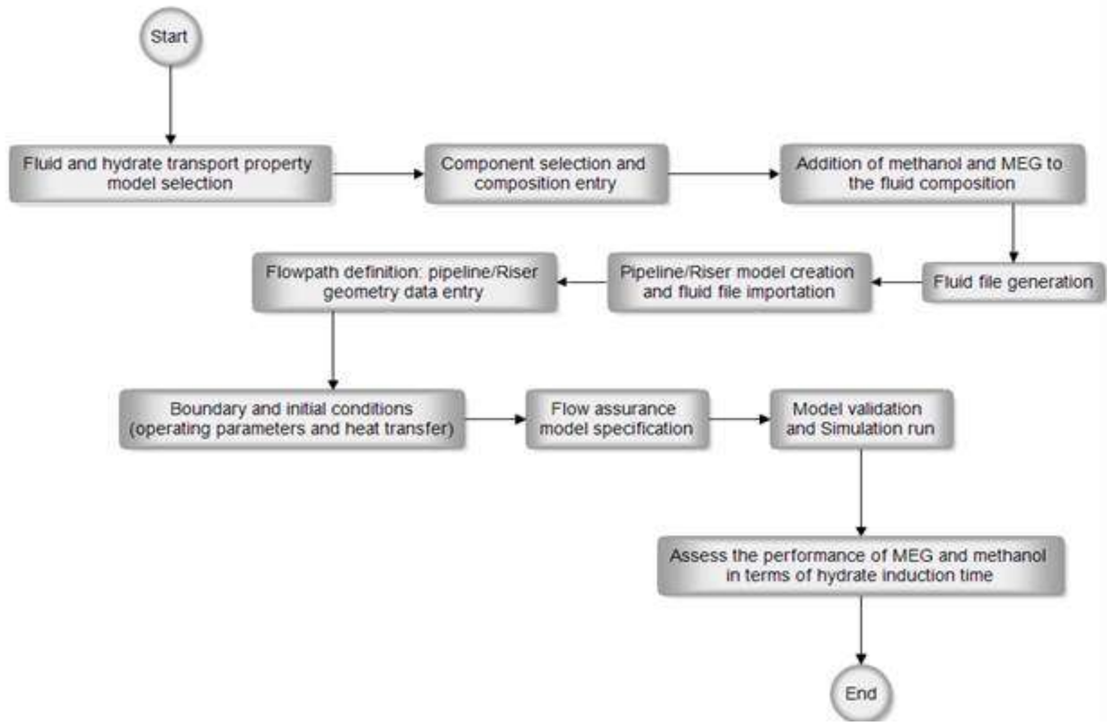
x-coord (m)	**y-cord (m)**	**Section**	**Diameter (m)**
3149	-129	150	0.254
3149	30	15	0.254
3170	30	1	0.254

Table 5: Boundary and initial conditions

Properties	**Value**
Minimum FPSO arrival pressure	150psig
Ambient Seabed temperature	16℃
Ambient Air temperature	25℃
Flexible Pipe Wall roughness	0.00005m
Gas inlet pressure	3000psig
Gas inlet temperature	75℃
Overall heat transfer coefficient	1.1447Btu/ft^2/hr/°F
Gas temperature at Topside	50℃

III. METHOD

The OLGA Hydrate Module, specifically theColorado School of Mines Hydrate Kinetic Model(CSMHyK), was utilized in this study alongside PVTsim, a phase behaviour and fluid property software, for generating the fluid files required by the OLGA model. Table 1 presents the gas composition, which was used as input for Multiflash software to generate the necessary hydrate and PVT files.An OLGA simulation case was developed, incorporating the flowpath and nodes representing the inlet and outlet of the system within the OLGA graphical user interface (GUI). The system configuration included a closed node at the upstream end of the pipeline, a mass source at the inlet, a flowpath representing the pipeline/riser, and a pressure node at the outlet. The material properties and geometric parameters of the pipeline/riser, as detailed inTables 2, 3, and 4, were used to define the system. Additionally, the operating conditions and heat transfer parameters, provided in Table 5, were incorporated to account for thermal interactions between the system and its surroundings.The simulation was executed for a total duration of two hours, and a sensitivity analysis was conducted to assess the effect of varying inhibitor concentrations on hydrate formation and suppression.

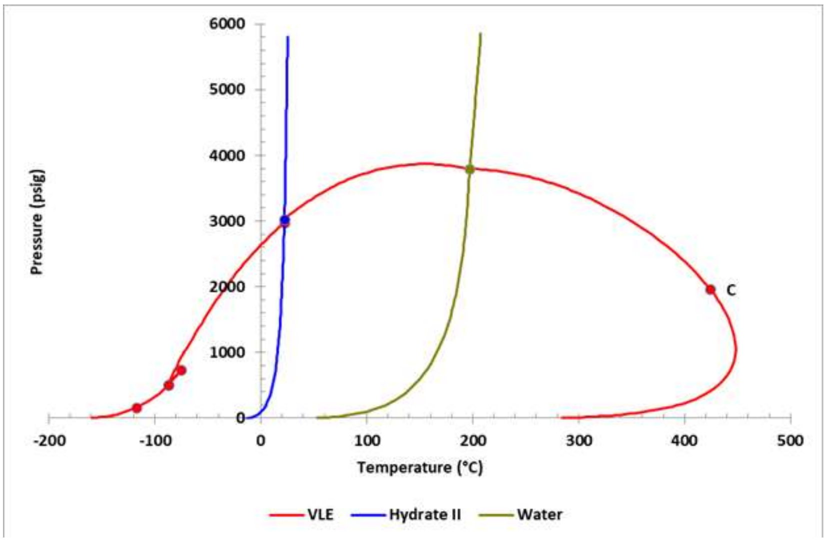


SIMULATION WORKFLOW

IV. OBSERVATIONS FROM THE FROM THE OLGA SIMULATION

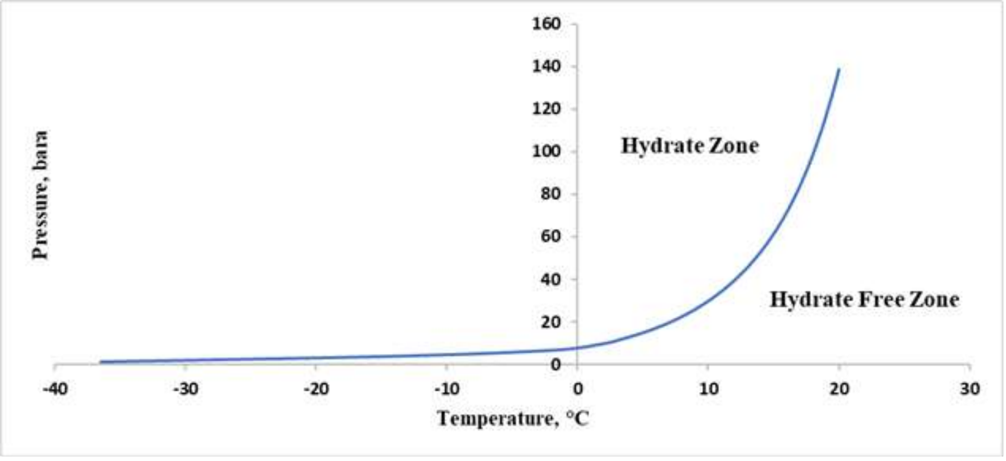
The fluid phase envelope is presented below illustrating the Vapour-Liquid Equilibrium (VLE), which defines the boundary where the liquid and vapor phases coexist in equilibrium within the two-phase region. The critical point is characterized by a critical temperature of 424.16°C and a critical pressure of 1963.42 psig.

The hydrate formation curve indicates a maximum hydrate formation pressure of 5809.43 psig, with a minimum temperature of 25.24°C required for hydrate formation.



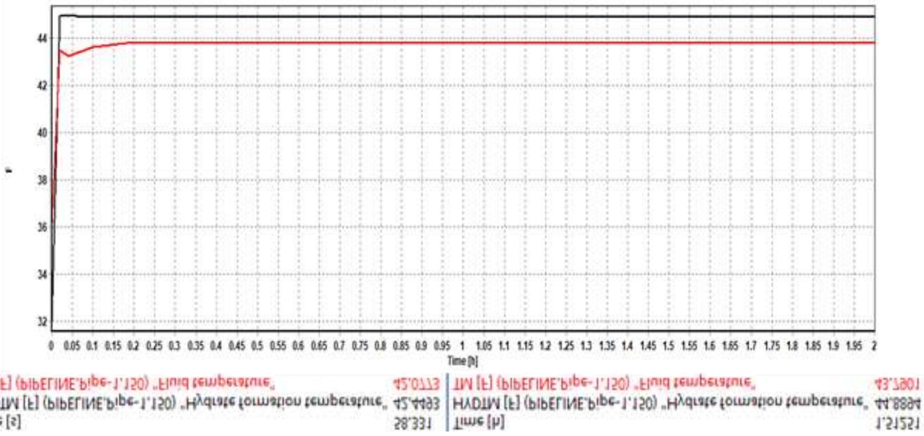
FLUID PRESSURE AGAINSTTEMPERATURE

The hydrate phase boundary results for the fluid systemindicates that operating conditions positioned to the right of the hydrate equilibrium boundary correspond to hydrate-free conditions, whereas those situated to the left indicate a potential risk of hydrate formation. Hydrates remain thermodynamically stable as conditions shift further to the left-hand side of the curve, while they become thermodynamically unstable when moving toward the right-hand side of the curve.



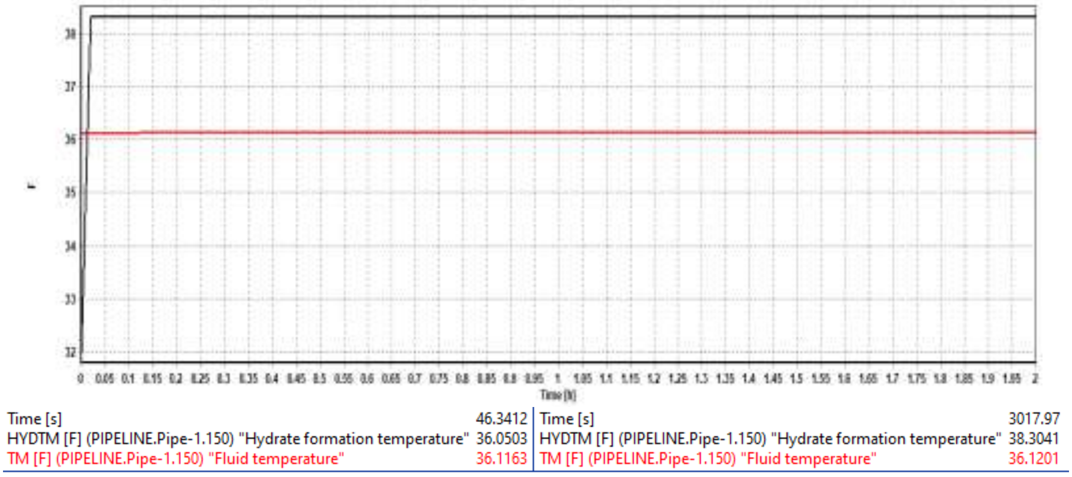
PHASE DIAGRAM

The figure below presents the hydrate formation temperature and fluid temperature as a function of induction time for the base model without methanol or monoethylene glycol (MEG). The results indicate that the fluid temperature drops below the hydrate formation temperature after 58.331 seconds, signifying that, in the absence of methanol or MEG injection, the system exhibits an induction time of 58.331 seconds.



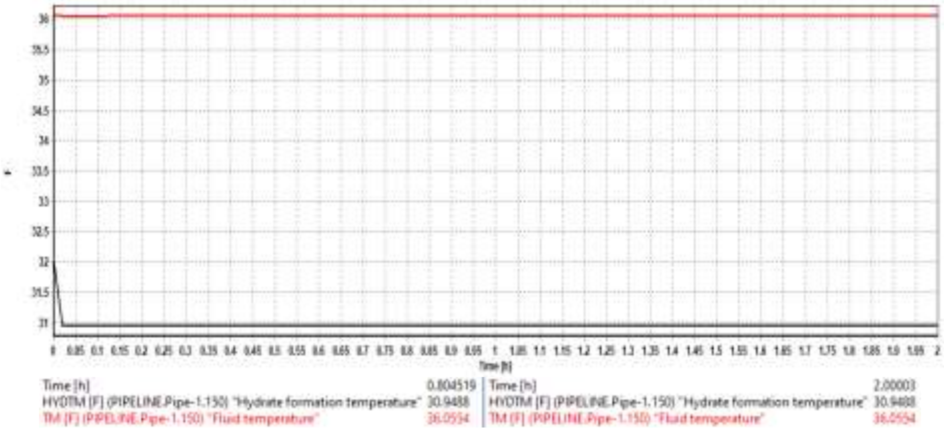
HYDRATE FORMATION AND FLUID TEMPERATURE AGAINST INDUCTION TIME WITHOUT METHANOL/MEG

The illustration of hydrate formation temperature and fluid temperature as a function of induction time for a methanol concentration of 5 mole%. The results indicate that the fluid temperature drops below the hydrate formation temperature after 46.34 seconds, suggesting that the system with 5 mole% methanol exhibits an induction time of 46.34 seconds.

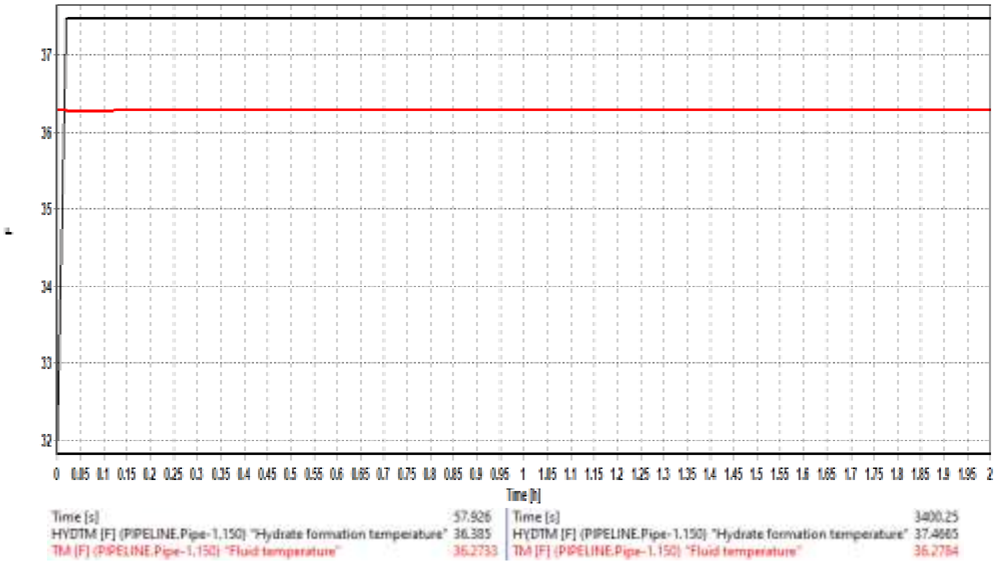


HYDRATE FORMATION AND FLUID TEMPERATURE AGAINST INDUCTION TIME FOR 5MOL% METHANOL

For 10mole%, the result obtained shows that for the injection of 10 mole percent methanol, the fluid temperature was higher than the hydrate formation temperature for a total simulation time of 2hours. Therefore, the system with 10 mole percent methanol, has an induction time of 2hours. See below:

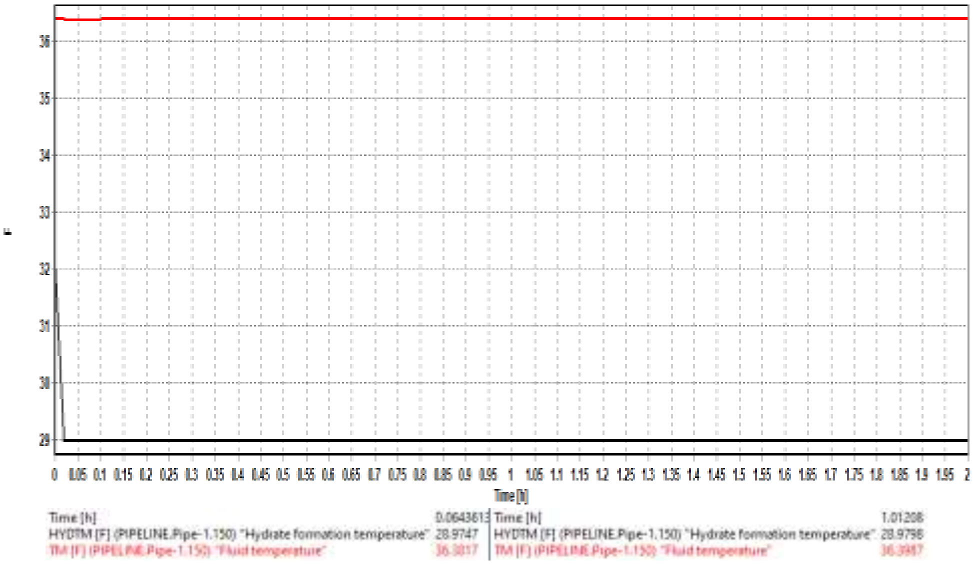


For the hydrate formation temperature and fluid temperature against induction time for a monoethylene glycol concentration of 5mole%. The result obtained shows that the fluid temperature falls below the hydrate formation temperature after 57.926sceonds. This implies that the system with 5mole% monoethylene glycol has an induction time of 57.926seconds.



HYDRATE FORMATION AND FLUID TEMPERATURE AGAINST INDUCTION TIME FOR 5MOLE% MONOETHYLENE GLYCOL.

For the hydrate formation temperature and fluid temperature against induction time for a monoethylene glycol concentration of 10mole%. The result obtained shows that the fluid temperature falls below the hydrate formation temperature after 46.34sceonds. This implies that the system with 5mole% methanol has an induction time of 46.34sceonds.



HYDRATE FORMATION AND FLUID TEMPERATURE AGAINST INDUCTION TIME FOR 10MOL% MONOETHYLENE GLYCOL

V. CONCLUSION

This study evaluated the effects of methanol and monoethylene glycol (MEG) on hydrate induction time using Multiflash for fluid characterization and OLGA for numerical simulation. The results demonstrated that the hydrate induction time decreases as the concentration of methanol and MEG increases. However, at a methanol concentration of 10 mole%, hydrate formation was completely inhibited, extending the induction time throughout the entire simulation period. Similarly, a 10 mole% concentration of both methanol and MEG was found to maximize hydrate induction time, effectively delaying hydrate formation.

SOME OF THE ADVANTAGES FROM THE ABOVE RESULTS

a) Both inhibitors significantly delay hydrate formation, reducing the risk of blockages in pipelines.
b) The study highlights the potential of both inhibitors to be used at varying concentrations depending on operational requirements.
c) By delaying hydrate formation, methanol and MEG enhance the reliability and safety of gas transportation systems.
d) Contributing to knowledge. The ability to optimize inhibitor concentration ensures cost-effective and efficient hydrate management strategies.

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