INVESTIGATION OF THE EFFECT OF HYBRID OF METHANOL AND VINYLACTAMIDE ON HYDRATE FORMATION TEMPERATURE AT DIFFERENT PRESSURES

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ABSTRACT: In this study Hysys software was used to simulate the hydrate formation temperature at different pressure with and without the use of inhibitors, I used the hybrid of thermodynamic Hydrate Inhibitor Methanol (MeOH) and kinetic Hydrate Inhibitors Vinylactamide (VIMA) and a pressure range of 3000 Psi to 5000 Psi to be able to determine the effects of the Hybrid Hydrate Inhibitor to the hydrate formation temperature at different pressures. 10% wt and 40% wt Concentration of Methanol were considered, and a 0.4%wt and 0.8% wt concentration of Vinylactamide were considered. After the simulation it was observed that 40% wt concentration of methanol and 0.8% wt concentration of Vinylactamide gave the least Hydrate formation Temperature and the highest temperature depression. This study makes it easy for a Flow Assurance Engineer to know the right proportion of the weight concentration of methanol and vinylactamide that will give the least hydrate formation temperature at certain pressure.

INTRODUCTION

Flow assurance is the most critical task during deep water energy production because of the high pressures and low temperature (- 4^{o}C) involved. There is a large financial loss from production interruption or damage of properties due to flow assurance issues. Flow assurance task is worsening by the interaction of the solid deposit with one another, resulting to sudden blockage formation in pipelines, and causing flow assurance failure.

Gas Hydrates are formed so fast in marine environment due to relatively high pressure and low temperature. Insulation and heating method which have been used to control hydrate formation in subsea pipelines is however expensive. Based on the above observation, I undertake this study with the intention of using a hybrid of thermodynamic and kinetic inhibitor method which has not been used in deep off-shore Nigeria.

The aim of this study is to prevent hydrate formation in subsea pipeline by investigating the hydrate formation temperatures at different pressures using a hybrid of thermodynamic and kinetic inhibitors.

The objective of this study is to investigate the effect of the hybrid of Methanol and of Vinylacetamide (VIMA) on hydrate Formation temperature at different pressure

This study will prevent further hydrate formation in subsea pipelines and in turn help to increase the flow assurance in deep offshore Nigeria.

The scope of this studies, covers the usage of Thermodynamic and Kinetic Inhibition Method as a tool for Hydrate Prevention, and the study is limited to Subsea Pipelines in Deep Offshore Nigeria.

MATERIALS AND METHODS

In this work, combination of thermodynamic and kinetic inhibitors were used to prevent hydrate formation. Examples of thermodynamic inhibitors are Methanol, Mono-Ethylene Glycol, Di-ethylene Glycol, Tri-Ethylene Glycol and examples of Kinetic inhibitors are polyvinylpyrrolidone(PVP),Vinylcaprolactum(VCAP),Polyvinylcaprolactum(PVCap),PolyvinylValerolactum(PVVam),Poly(acryoylpyrrolidine)(PAPYD), Vinylacetamide (VIMA). But in this study, Methanol and Vinylacetamide inhibitor were considered

Table 1: Composition of the Gas Stream

Component	Mole Fraction (Yi)	Molecular Weight (MW)
CO_2	0.0651	44
Nitrogen	0.0597	28
Methane	0.7662	16
Ethane	0.0688	30.1
Propane	0.0184	44.1
n-Butane	0.0025	58.1
i-butane	0.0075	58.1
i-pentane	0.0018	72.2
n-pentane	0.0021	72.2
Hexane	0.0019	86
Heptanes	0.0061	100
Octane	0	114
Total	1.0000	

Source: Iyowu, (2010).

Table 2: Properties of the Inhibitors Used

Component	Molecular Weight (g/mol)	K-Value	Boiling Point(^{0}C)	Density (g/ml)	Molecular Formular
MeOH	32	2335	64.7	0.7866	CH_3OH
VIMA	85		96	0.959	C_4H_7NO

Theoretical Analysis

Methanol

Methanol is also known as methyl alcohol among others, is a chemical with a molecular formula CH_3OH, Molar mass of 32.04g/mol, density of 0.792g/cm^3, melting point of -97.6^{o}C and Boiling point of 64.7^{o}C. Methanol is produced in the reaction between carbon monoxide and Hydrogen or carbon dioxide and hydrogen. Methanol is the simplest alcohol, being only a methyl group linked to a hydroxyl group. It is a light, volatile, colourless, flammable liquid. It is used as Antifreeze in pipeline, solvent and fuel.

$CO + 2H_2 \rightarrow CH_3OH$

$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$

Vinylacetamide

Vinylacetamide is a non-ionic monomer, it is soluble in water, various organic solvents and liquid vinyl monomers. It has a molar mass of 85g/mol, melting point of 54^{o}C, boiling point of 96^{o}C and a chemical formula C_4H_7NO.

Hydrate Prediction

Hydrate prediction was carried out without the use of inhibitors by using Hysys software, the composition of the gas stream alone was use to determine the hydrate formation temperature at different pressure. Also hydrate prediction was carried out with the use of Inhibitors by the use of Hysys software, the composition of the gas stream and the weight percentages of the various inhibitors were used to predict hydrate formation temperature at different pressure

RESULTS AND DISCUSSION

Results

Table 3 shows the hydrate formation temperature without the use of Inhibitor, 10% wt and 40% wt of methanol and 0.4% wt and 0.8% wt of vinylactamide and a hybrid of 10% wt of methanol with 0.4% wt and 0.8% wt of vinylactamide respectively and a hybrid of 40% wt of methanol with 0.4% wt and 0.8% wt of vinylactamide respectively were used at different pressure.

Table 3: Hydrate Formation Temperature at different pressure

Pressure (Psi)	Without Inhibitor (°F)	10%wt MeOH (°F)	40%wt MeOH (°F)	0.4%wt VIMA (°F)	0.8%wt VIMA (°F)	10%wt MeOH AND 0.4%wt VIMA (°F)	10%wt MeOH AND 0.8%wt VIMA (°F)	40%wt MeOH AND 0.4%wt VIMA (°F)	40%wt MeOH AND 0.8%wt VIMA (°F)
3000	70.9573	70.2044	70.1618	69.2535	66.6409	69.4862	66.035	69.5843	64.7394
3010	70.9967	70.2399	70.1975	69.2903	66.6662	69.5140	66.058	69.6153	64.7575
3276	72.0025	71.1393	71.1027	70.2298	67.3234	70.1483	66.6579	70.3756	65.2422
4000	74.4948	73.2397	73.2151	72.4841	68.9828	71.5604	68.1865	71.1888	66.4995
4500	75.8531	74.4721	74.4531	73.8516	70.0378	72.7982	69.1672	72.1345	67.3211
4867	76.8324	75.2917	75.2758	74.7814	70.7730	73.6478	69.8541	72.4592	67.9028
5000	77.1751	75.5735	75.5585	75.1050	71.0321	73.9450	70.0968	72.9574	68.1095

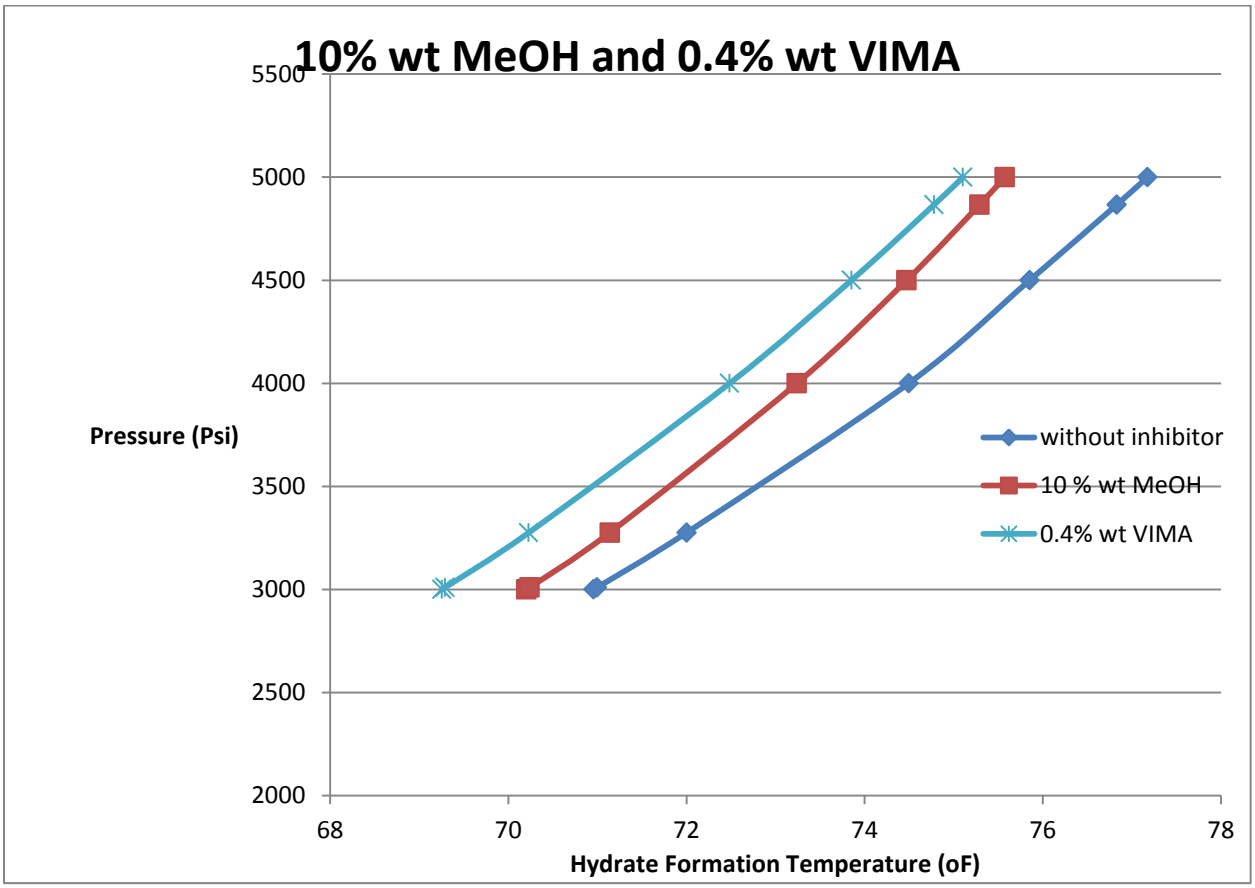

Figure 1: shows the effect of 10% wt of MeOH and 10% wt VIMA on hydrate formation temperature

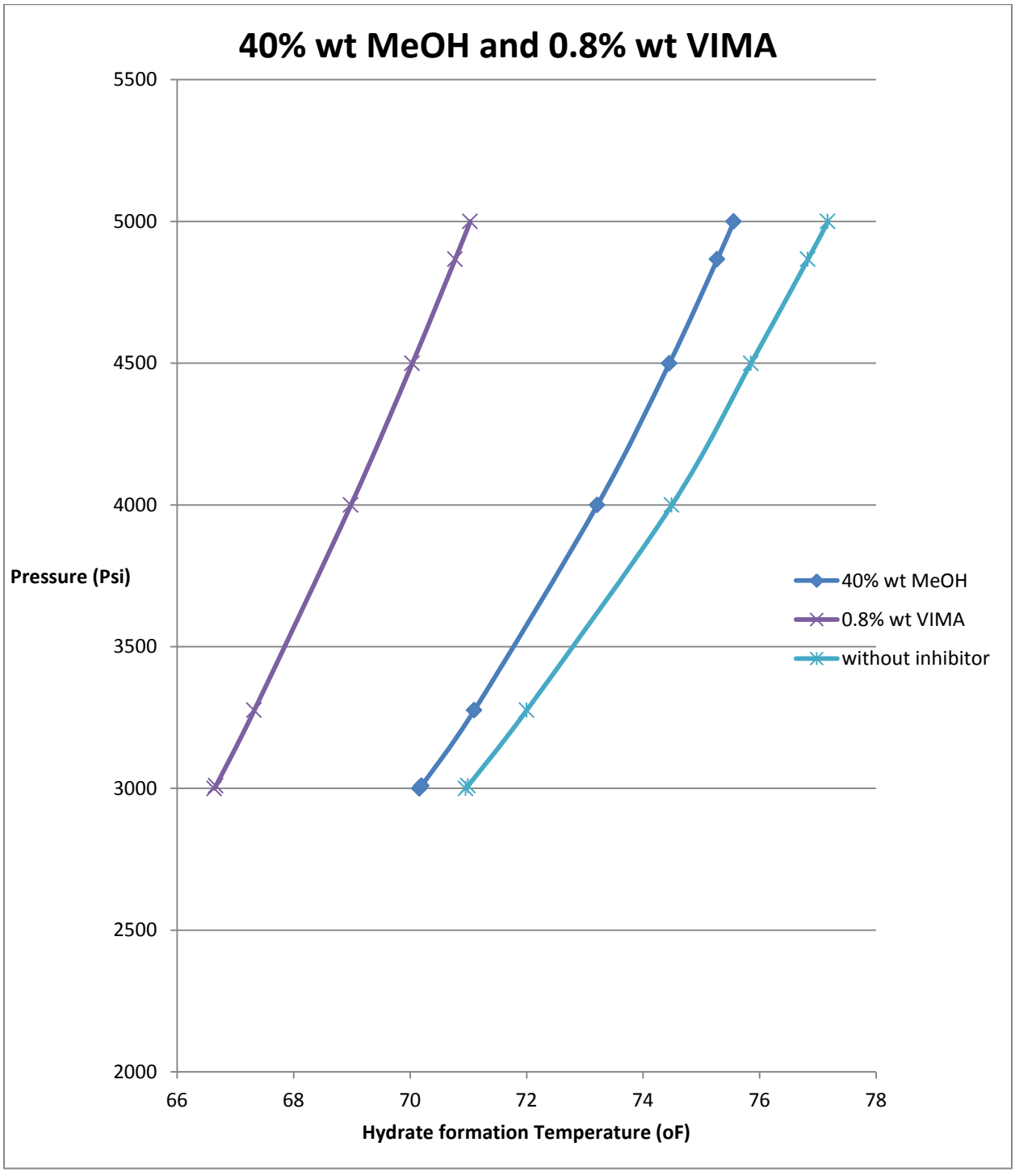

Figure 2: shows the effect of 40% wt of MeOH and 0.8% wt VIMA on hydrate formation temperature.

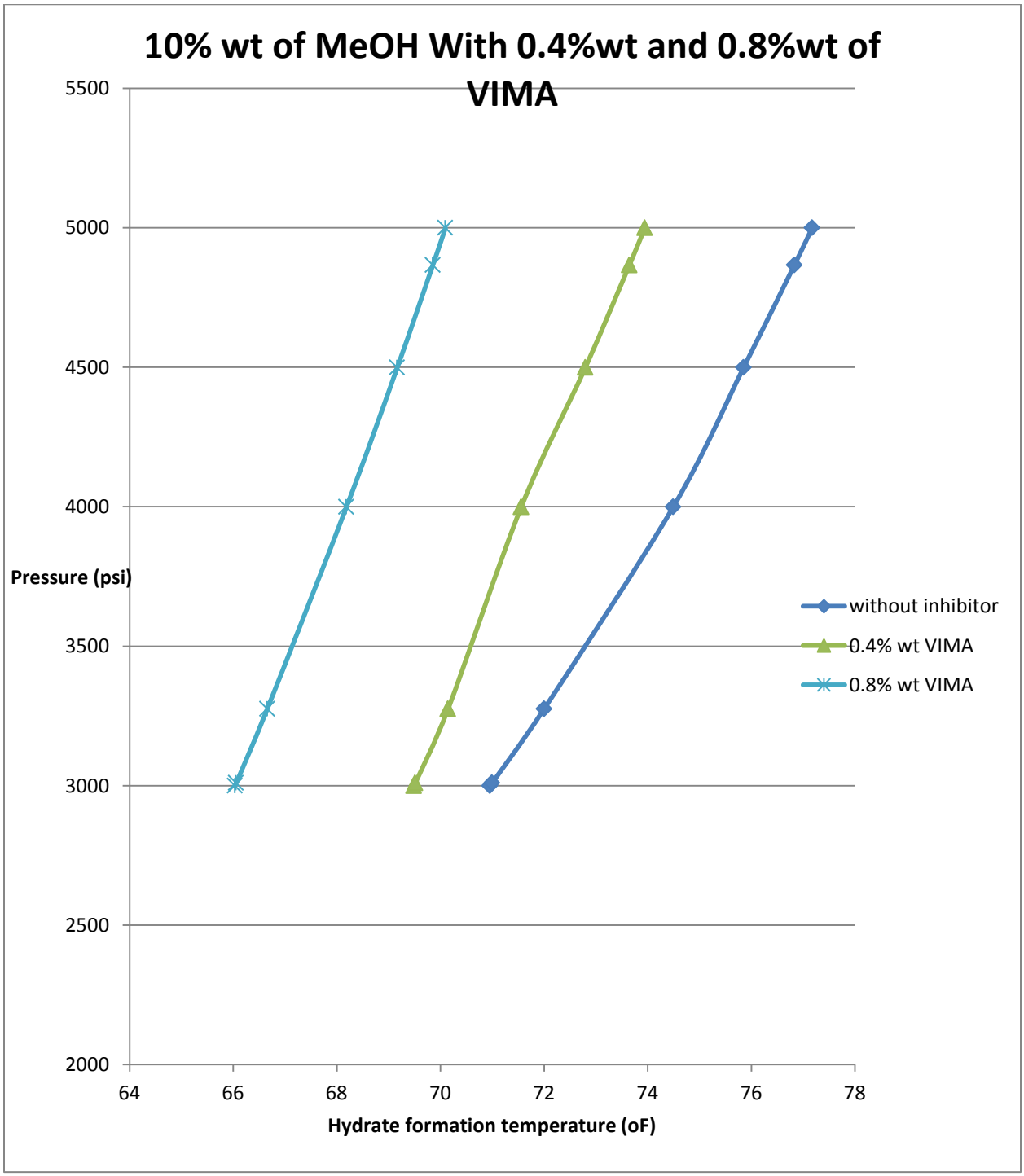

Figure 3: shows the Effect of 10% wt of MeOH with 0.4% wt and 0.8% wt of VIMA on the Hydrate formation Temperature

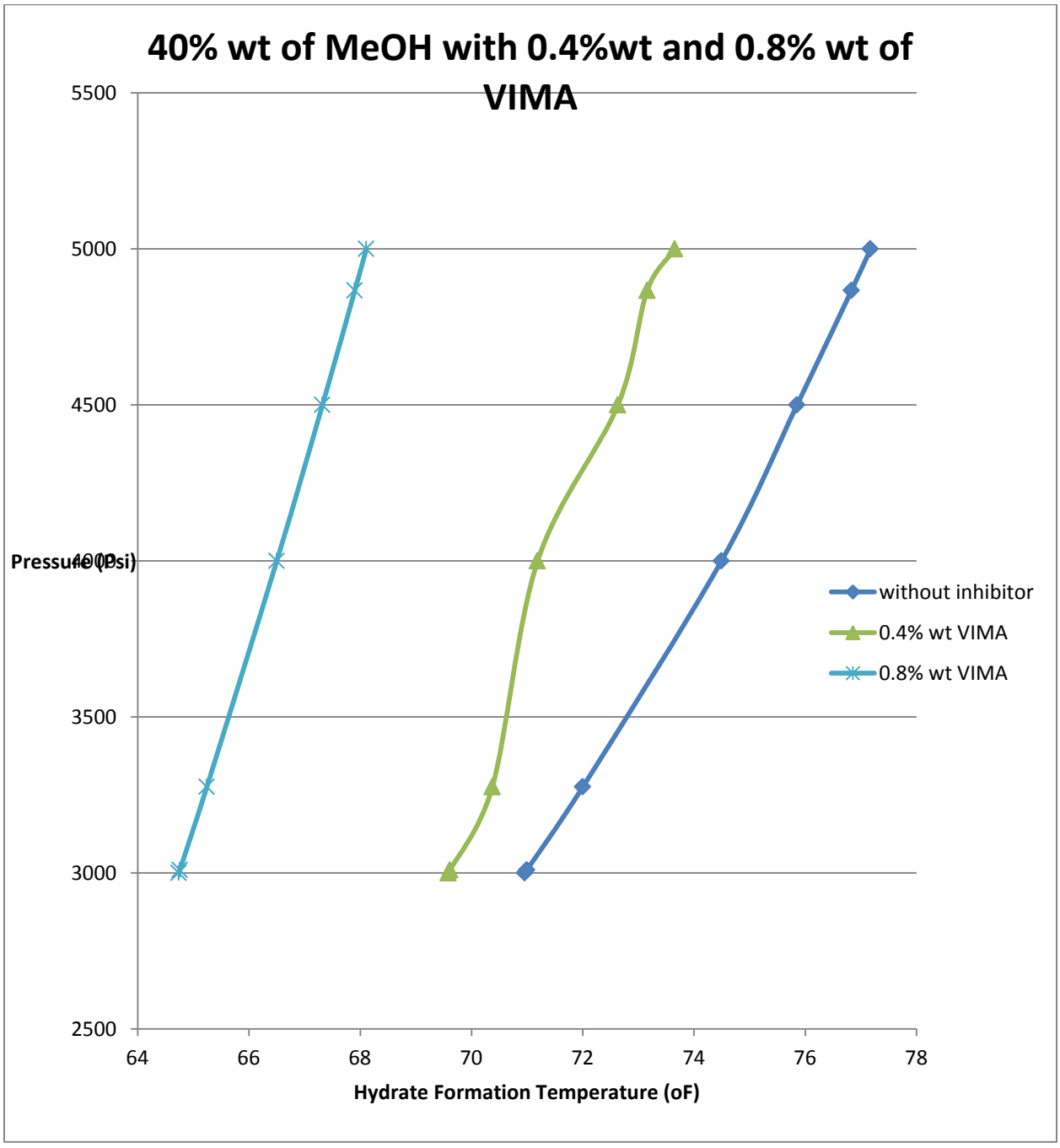

Figure 4: effect of 40% wt of MeOH with 0.4% wt and 0.8% wt of VIMA on hydrate formation temperature.

Discussion

The hydrate formation curve slopes downwards from right to left at high pressure to low pressure, there is relatively high hydrate formation temperature at low pressure. At pressure of 3000psi the hydrate formation temperature without the use of inhibitor is 70.9573^{o}F, at 4000psi the hydrate formation temperature is 74.4948^{o}F, while at 5000psi the hydrate formation temperature is 77.1751^{o}F. It was observed that the hydrate formation temperature increases as the pressure increase.

The hydrate risk zone is the region on the left hand side of the hydrate formation curve while the region on the right hand side of the curve is the hydrate free zone. The hydrate risk zone covers temperature as high as 77.1751^{o}F (5000psi) to temperature of 70.9573^{o}F (3000psi). Without inhibitor the risk of hydrate formation is high, hydrate formation curves with 10% wt and

40% wt of Methanol and 0.4% wt and 0.8% wt Vinylacetamide respectively were obtained by the use of hysys software, the curve shift to the left from the hydrate formation curve obtained without the use of inhibitor thereby reducing the hydrate formation risk region, and increasing the hydrate free zone.

Conclusions

From the results obtained and graphs, it can be concluded that:

- The combination of 40% wt methanol and 0.8% wt vinylacetamide (VIMA) gave the least hydrate formation temperature and a higher temperature depression at different pressures.
- Weight percentages of inhibitors affect the hydrate formation temperature. Increase in the concentration of inhibitors will decrease the hydrate formation temperature but increases the temperature depression.
- It was also observed that increase in pressure result to increase in temperature
- It was also observed that the lower the molecular formula the higher the Temperature Depression and the lower the hydrate formation temperature.

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