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Sizing Surface Production Flow line Insulation Thickness for a Desired Output Temperature

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Research Article

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Abstract

Oil and gas is transported from the wellheads to the gathering stations through pipelines called surface production flow-lines. Flow-lines are located at the oil and gas well site and tied to specific wells. Flow-line may be a metallic pipe or a hose. Flow lines may be in a land or subsea well field and may be buried or at grade on the surface of land or seafloor. Most flow lines are very short in length but others may be run for kilometres in larger well fields. Usually, external environment of a surface production flow-line is at lower temperature compared to the flowing fluid temperature in the production flow-line. The interaction of the internal and external temperatures of the oil and gas surface production flow-line is a major cause of temperature drop in flow-line. Undesirable and excessive temperature drops must be prevented in oil and gas production flow-line by suitable and economical sizing of flow-line insulation materials. One of the industry requirements of the oil and gas production flow-line is to ensure the flow-line meets a discharge or an output temperature. This paper focuses on choosing and sizing of an insulation material to meet an output temperature of an oil and gas surface production flow-line. Two well stream flows were developed based on stream compositions from the two oil and gas wells. It is desirable that the discharge or output temperature of the discharge fluid at the discharge end of the flow-line does not fall below 20 degree Celsius. The thermal insulation thickness for the 1 km long production flow-line was designed using Urethane Foam insulation material. The chemical processes were modelled in Aspen Hysys and a case study was developed between flow-line output temperature and the flow-line insulation thickness to correlate the two variables.

Keywords: Flow-line; Gathering station; Corrosion thickness; Output temperature; Aspen Hysys software; Well stream; Stream composition; Heat losses

Introduction

Transportation of petroleum products through pipeline presents considerable risks including wax formation and deposition as a result of heat loss of fluids, which is harmful to the flow due to the reduced inner diameter or totally blocked pipelines in extreme cases [1]. To ensure efficient and economical hydrocarbons transport from wellhead to processing facilities, flow assurance is important in planning and designing of flow transport system [2]. Flow assurance thermal management techniques include insulation, pipe burial, electrical heating, and hot fluid circulation [2].

Apart from conveyance of oil and gas from the wellheads to the gathering stations, surface production flow-lines are also expected to limit heat losses to the external environments. In deepwater oil exploration, wells are located far from platforms, and crude oil often has to be transported over long distances in subsea pipelines [3]. The oil is cooled on its way to the destination due to heat transfer, through the pipelines walls, with the surrounding sea water [3]. Temperature-related transportation problems can take place especially if the production flow-line is not properly and sufficiently insulated against heat losses to the external environment [4]. This may lead to the precipitation of asphaltenes and/or paraffin wax and the formation of hydrates [4].

Thus, during engineering design of subsea production flow-line, it becomes mandatory to have proper insulation type and insulation thickness selection done at the early stages of project, so as to assure the proper flow of the fluids in the flow-line, at desired operating conditions [5]. Thermal insulation design is a key task in oil and gas surface production flow-line. Thermal insulation is one of the most effective energy-conservation measures in hot pipes [6]. Insulation materials are very basic and important requirement in any industry dealing with various heat transfer unit operations [7]. The basic aim of insulation is to retard the rate of heat flow in order to prevent/minimize the change of temperature of the system or the space [7].

The thickness of applied insulation material in any case of oil and gas surface production flow-line usually has a case relationship with the output temperature of the surface flow-line. In optimization of thickness of insulation over a cylindrical pipe and definition of optimum range of thickness for maximum and minimum heat transfer through the insulation at different heat inputs was carried out [8]. It is therefore necessary to build this case to serve as a guide in selecting the suitable thickness of the applied corrosion material.

Study Cases

The methodology adopted involved sizing the minimum required insulation thickness for a 1-km long surface production flow-line with +5 m elevation change. The 1 km long surface production flow-line is expected to collect oil and gas production from two different production wells at the same oilfield. The surface production flow-line is expected to supply a local oil and gas processing unit.

Stream Composition

The Table 1 below shows the stream compositions from the two production wells.

Mol %	Stream Composition 1 From Well 1	Stream Composition 2 From Well 2
Methane	0.8231	0.95
Ethane	0.0589	0.03
Propane	0.0311	0
i-Butane	0.0018	0
n-Butane	0.0021	0
i-Pentane	0.0009	0
n-Pentane	0.0011	0
n-Hexane	0.0003	0
n-Heptane	0.0005	0
n-Octane	0.0001	0
n-Nonane	0.0001	0
n-Decane	0.0003	0
H2O	0.0156	0
H2S	0.0003	0.0042
N2	0.0025	0.0058
O2	0.0014	0
CO2	0.0599	0.01

Table 1: Stream Flow Compositions.

Other Input Design Parameters

The Table 2 shows other design parameters for simulation development in Aspen Hysys.

Parameters	Values
Length of the flow-line	1000 m
Elevation change of the flow-line	+ 5 m
Insulation material	Urethane Foam
Ambient temperature of the flow-line	10 degree Celsius
Pipe schedule	40
Pipe nominal size	50 mm
Type of flow-line	Buried in soil
Buried depth	1200 mm
Well 1: Stream Flow Parameters	Mass flow rate (5000kg/h), Pressure (2000kPa), Temperature (50 degree centigrade)
Well 2: Stream Flow Parameters	Mass flow rate (4167 kg/h), Pressure (2000kPa), Temperature (50 degree centigrade)

Table 2: Other Input Design Parameters.

Study Methodology

Aspen-HYSYS software is process simulation software and available at the Petroleum and Natural Gas Institute, Faculty of Earth Science and Engineering, University of Miskolc. This software package is the used around the world to design plants and to rate their performance. HYSYS was used to conduct the development and simulation of the stream compositions and stream flows from the two production wells and the 1 km production flow-line. Table 2 shows other design parameters from the two wells. A case study was set-up to investigate the correlation between the thermal insulation thickness of the Urethane Foam and the output temperature from the 1 km long flow-line. It is required that the output temperature must not drop below 20 degree Celsius.

Results

The Figure 1 below shows the process simulation of the two production wells and Table 3 shows the 96 studied cases between the thermal insulation thickness of the Urethane Foam and the output temperature that were investigated. Figure 2 shows the graphical plot of the 96 studied case results between the thermal insulation thickness of the Urethane Foam and the output temperature.

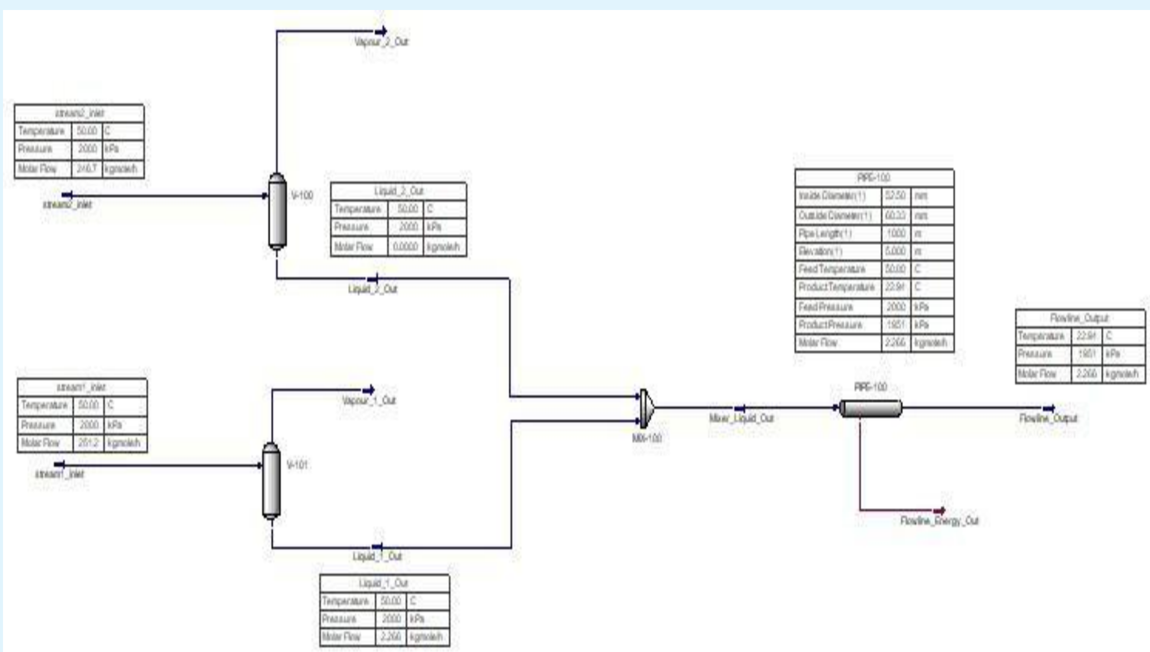

Figure 1: Process Simulation.

State	PIPE-100 - Insulation Thickness m	Flowline Output - Temperature C
Case 1	0.025	11.027846
Case 2	0.03	11.594391
Case 3	0.035	12.196932
Case 4	0.04	12.80614
Case 5	0.045	13.404548
Case 6	0.05	13.983906
Case 7	0.055	14.53881
Case 8	0.06	15.067254
Case 9	0.065	15.568872
Case 10	0.07	16.043944
Case 11	0.075	16.493936
Case 12	0.08	16.920193
Case 13	0.085	17.324165
Case 14	0.09	17.707318
Case 15	0.095	18.071077
Case 16	0.1	18.416798
Case 17	0.105	18.74575
Case 18	0.11	19.059116
Case 19	0.115	19.357989
Case 20	0.12	19.643374
Case 21	0.125	19.916197
Case 22	0.13	20.177307
Case 23	0.135	20.427482
Case 24	0.14	20.667436
Case 25	0.145	20.897825
Case 26	0.15	21.11925
Case 27	0.155	21.332265
Case 28	0.16	21.53738
Case 29	0.165	21.735063
Case 30	0.17	21.925747
Case 31	0.175	22.109832
Case 32	0.18	22.287686
Case 33	0.185	22.459652
Case 34	0.19	22.626047
Case 35	0.195	22.787164
Case 36	0.2	22.943278
Case 37	0.205	23.094643
Case 38	0.21	23.241495
Case 39	0.215	23.38335
Case 40	0.22	23.521847
Case 41	0.225	23.656451
Case 42	0.23	23.787343
Case 43	0.235	23.914692
Case 44	0.24	24.038657
Case 45	0.245	24.159387
Case 46	0.25	24.277023
Case 47	0.255	24.391696
Case 48	0.26	24.503532

Case 49	0.265	24.612646
Case 50	0.27	24.71915
Case 51	0.275	24.823147
Case 52	0.28	24.924737
Case 53	0.285	25.024013
Case 54	0.29	25.121062
Case 55	0.295	25.215969
Case 56	0.3	25.308813
Case 57	0.305	25.399669
Case 58	0.31	25.488609
Case 59	0.315	25.575701
Case 60	0.32	25.661009
Case 61	0.325	25.744595
Case 62	0.33	25.826518
Case 63	0.335	25.906833
Case 64	0.34	25.985594
Case 65	0.345	26.062851
Case 66	0.35	26.138654
Case 67	0.355	26.213047
Case 68	0.36	26.286076
Case 69	0.365	26.357783
Case 70	0.37	26.428209
Case 71	0.375	26.497392
Case 72	0.38	26.565369
Case 73	0.385	26.632176
Case 74	0.39	26.697848
Case 75	0.395	26.762417
Case 76	0.4	26.825914
Case 77	0.405	26.88837
Case 78	0.41	26.949813
Case 79	0.415	27.010273
Case 80	0.42	27.069775
Case 81	0.425	27.128345
Case 82	0.43	27.186008
Case 83	0.435	27.24279
Case 84	0.44	27.298711
Case 85	0.445	27.353795
Case 86	0.45	27.408062
Case 87	0.455	27.461533
Case 88	0.46	27.514229
Case 89	0.465	27.566167
Case 90	0.47	27.617367
Case 91	0.475	27.667848
Case 92	0.48	27.717626
Case 93	0.485	27.766717
Case 94	0.49	27.815139
Case 95	0.495	27.862907
Case 96	0.5	27.910036

Table 3: Cases Set-up to Investigate the Correlation between the Insulation Thickness and Output Temperature.

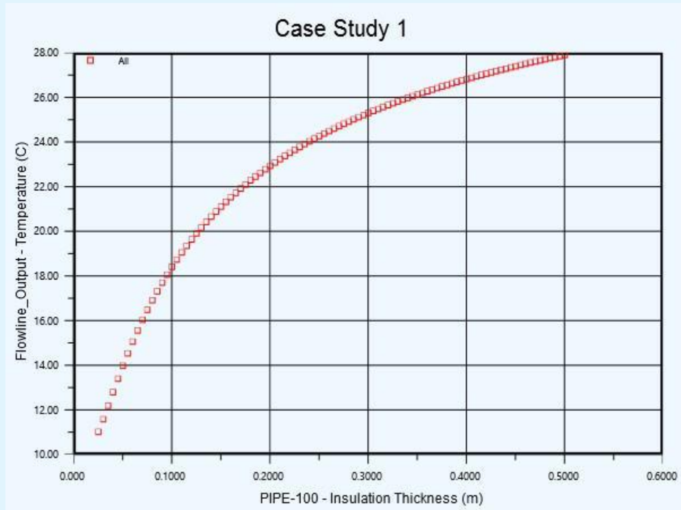

Figure 2: Graphical Plot of the Investigated Cases between the Flow-line Output Temperature and the Thermal Insulation Thickness.

From the Table 3 and Figure 2, a minimum of 150 mm Urethane Foam thermal insulation thickness is required to ensure that the discharge temperature at the discharge end of the flow-line does not fall below 20 degree Celsius.

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