بسم الله الرحمن الرحيم

Sudan university of science and technology

College of petroleum & mining engineering

Department of petroleum engineering

Investigation of wax precipitation in RAWAT new pipeline

التحقيق في ترسيب الشمع في خط أنابيب الراوات الجديد

A Research Submitted to College petroleum & Mining Engineering in partial fulfillment of Requirements for the Degree of B. SC in petroleum Engineering

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بسم الله الرحمن الرحيم

قال تعالى:

(۞ لَّيْسَ الْبِرَّ أَن تُوَلُّوا وُجُوهَكُمْ قِبَلَ الْمَشْرِقِ وَالْمَغْرِبِ وَلَٰكِنَّ الْبِرَّ مَنْ آمَنَ بِاللَّهِ وَالْيَوْمِ الْآخِرِ وَالْمَلَائِكَةِ وَالْكِتَابِ وَالنَّبِيِّينَ وَآتَى الْمَالَ عَلَىٰ حُبِّهِ ذَوِي الْقُرْبَىٰ وَالْيَتَامَىٰ وَالْمَسَاكِينَ وَابْنَ السَّبِيلِ وَالسَّائِلِينَ وَفِي الرِّقَابِ وَأَقَامَ الصَّلَاةَ وَآتَى الزَّكَاةَ وَالْمُوفُونَ بِعَهْدِهِمْ إِذَا عَاهَدُوا ۖ وَالصَّابِرِينَ فِي الْبَأْسَاءِ وَالضَّرَّاءِ وَحِينَ الْبَأْسِ ۗ أُولَٰئِكَ الَّذِينَ صَدَقُوا ۖ وَأُولَٰئِكَ هُمُ الْمُتَّقُونَ)

سورة البقرة –الأية (177)

Dedication

إلي من أبصرت بها طريق حياتي واستمديت منها قوتي واعتزازي بزاتي الي الكفاح الذي لايتوقف الي الشامخه التي علمتني معني الاصرار وان لاشئ مستحيل مع قوة الارادة و الإيمان, الي ينبوع العطاء المتفاني مدى عمري إلي والدتي الغاليه امد الله في عمرها وجزاها الله عني خير الجزاء.

الي من علمني ان الدنيا كفاح وسلاحها العلم والمعرفه الي الذي لم يبخل علي بأي شئ الي من سعي لأجل راحتي و نجاحي

أبي الحبيب

انت الجواب حين أسأل ما التفاؤل..

الأهل والأصدقاء

الكتابه لاتكفي لأصف كيف أحبكم والعمر قصير لكي أكتب حبكم

أراكم بسمتي ....وارى جمال الايام انتم .

إلي كل من علمني حرف

بفضل الله ثم بدعمكم وصلت الي ما أنا عليه الأن .

Acknowledgment

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ABSTRACT

Pipelines are considered one of the best ways to transport oil and petroleum products, but they face some difficulties and problems during operation.

One of the problems facing oil transportation through pipelines is the deposition of wax inside the pipeline, which leads to the difficulty of transportation.

This study focused on building a model for wax deposition in the RAWAT-ALJABLINE pipeline by using the (Olga) and (PIPESIM) program, where a region where the wax deposits as a result of low temperature was assumed.

Keyword:

- Pipeline
- Olga software
- PIPESIM software
- Wax deposition model

التجريد

تعتبر خطوط الانابيب من افضل الطرق لنقل النفط والمنتجات البترولية الا انها تواجه بعض الصعوبات والمشاكل خلال التشغيل ،اجريت الدراسة علي مشاكل التشغيل في خط انابيب الراوات الجبلين.

من المشاكل التي تواجه عمليات نقل النفط عن طريق خطوط الانابيب هي ترسب الشمع داخل الانبوب مما يؤدي الي صعوبة النقل.

هذه الدراسة ركزت علي بناء نموزج لترسب الشمع في خط انابيب الراوات -الجبلين عن طريق استخدام برنامج (اولغا) و (بايبسيم) حيث تم افتراض منطقة يترسب فيها الشمع نتيجة لانخفاض درجة الحرارة

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Chapter 1

Introduction

1.1. Pipeline:

The pipeline is defined as a line of connected pipes with pumps and control devices for carrying liquids or gases over a long distance, Pipelines play a vital role in the transmission of oil and gas from the source to the destination for further refining, processing and storage, and are the energy lifelines of the country as they transport the products through long distances and harsh terrains economically and efficiently.

Pipelines have been the preferred mode of transportation for liquid and gas over competing modes such as truck and rail for several reasons: they are less damaging to the environment, less susceptible to theft, and more economical, safe, convenient, and reliable than other modes. This method maintains security and accelerates the transport of oil because the route does not contain barriers or barriers due to easy access to crude oil and refineries or ports, as well as with regard to oil products transported using oil pipelines, which are called the material being transported, and it is an exaggeration to say that the renaissance of our time and the continuous development around the world is caused by the presence of pipelines about thousands of kilometers long.

A pipeline consists of underground and underwater pipes fittings, head and booster pumping stations, petroleum tanks, and line auxiliary structures.

Fig (1.1) pipeline

1.1.1 Problem faced pipeline operation:

The world demand for energy has led oil companies to expand their operations in cold environments such as the offshore deep water and onshore for more reservoirs. During hydrocarbon transportation in the cold environment, these oil companies are challenged by wax deposition problem building up on the pipeline. Crude oil is a complex mixture and contain a main component of saturates (paraffins/waxes), aromatics, asphaltenes, naphthenes and resins. The high molecular weight paraffin (wax) is naturally responsible for the problems during production and transportation in the hydrocarbon pipeline systems. **(Muhammad Ali Theyab* and Sarah Yousif Yahya)**

The transportation of highly waxy crude oil in a cold environment is challenging especially when the ambient, temperature is below the pour point temperature, However, during the transportation in a pipeline, the temperature of oil decreases below the wax appearance temperature due to the heat loss to the surroundings causing wax deposition. If the transportation in a pipeline is stopped due to a planned maintenance or an emergency situation such as severe weather conditions (Venkatesan et al., 2002).

Fig (1.2) wax precipitation in pipeline

Applying appropriate and effective treatments depends on a thorough understanding of the physics of the wax deposition process.

1.2 Problem statement:

Wax deposition in ALRAWAT-ALJABLINE pipeline which is consequences in difficult transport operations and required higher cost of repair and maintenance.

1.3Project objectives:

1\ Design new pipeline from ALRAWAT to ALJABLINE

2\ Predicting of wax deposition in the Rawat pipeline.

3\ To establish a model for Wax deposition using Olga software.

4\Analysis of applied model in this study.

5\ To study and implement heating scenario.

Chapter 2

Literature Review

2.1 Theoretical Background:

2.1.1 Wax:

Defined as a complex solid or semi-solid petroleum substance at ambient temperature, consisting of a series of hydrocarbon it is highly viscous, wax is a component of crude oil that remains in solution until operating condition are favorable to its precipitation.

2.1.1.1 Temperature:

Temperature seems to be the predominant and most critical factor in wax precipitation and deposition due to its direct relationship with the solubility of paraffin. paraffin solubility increases with increasing temperature and decreasing temperature.

2.1.1.2 WAX Appearance Temperature:

The wax appearance temperature is the temperature at which wax crystals begin to precipitate out of hydrocarbon fluids usually observed under prescribed microscopic experiments. The wax appearance temperature is an important parameter used in describing and measuring wax deposition behavior in oil and gas production. Wax precipitation temperature, wax appearance point, and wax formation temperature are familiar terms with same meaning used in many articles. It is often denoted by the acronym ‘WAT’. The ‘WAT’ acronym will in this text be used when the wax appearance temperature or the wax precipitation temperature is implied (Oluwatosin Emmanuel, 2013).

2.1.2 Problem Associated of wax deposition:

Generally, wax formation and deposition lead to the following:

- Placing additional strain on pumps, consuming more energy, and required additional investment for replacing pumps.
- High pressure is required to transport the crude.
- Difficulty of restarting the pipeline after shutdown especially if the pipeline temperature is reduced to lower than pour point temperature.
- Wax deposition on the internal wall of the pipe reduces the pipeline internal diameter and hence increases pressure losses
- wax deposits can lead to increased pipeline roughness problem

2.1.3 Ways of wax treatment:

If wax deposition cannot be prevented, then it is imperative to regularly remove accumulated wax from the inside of pipeline walls in order to prevent the total blockage of the line. Several methods have thus been developed for the removal of wax deposits, including complete blockages of pipelines. Traditional methods of wax removal in the petroleum industry have always had problems and limitations, and they include mechanical removal, the use of bottom hole heaters, the use of exothermic reactions such as that between magnesium bars and hydrochloric acid, and the use of paraffin solvents (Dhurjati & Anglus,2011).

2.1.3.1 Heating Treatment:

To maintain the oil temperature always above the pour point along the pipeline. This can be applied by installing one or more heating stations.

is the use of inductive heating of a plugged section of pipe, They proposed this as an alternative to the use of chemicals that react exothermically at the wax blockage to melt it, for cases when the pipeline is completely blocked in a horizontal section so that it is impossible to flow chemicals to the blockage. They tested this method using the experimental setup shown in Fig (2.1) They found that the steel layers which compose commercial flexible

lines can be heated by induction and the heat transferred to a solid wax plug in the interior of the line. They also found that their mathematical model, which agreed well with available experimental results, suggested that the power levels required for large-scale inductive heating might be feasible for removing wax blockage in field applications with undersea pipelines (Dhurjati & Anglus,2011).

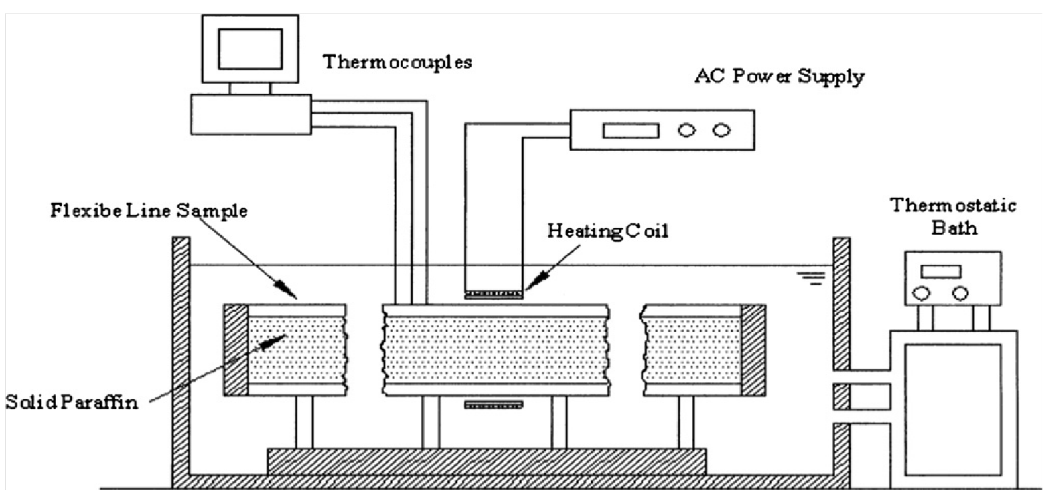


Fig (2.1) Schematic view of experimental test section for wax removal by inductive heating

2.1.3.2 Chemical Treatment:

By adding chemical flow improver to the transported oil. The chemical improvers enhance the transportation process of the crude by decreasing the pour point temperature and viscosity.

2.1.3.3 Mechanical Treatment:

2.1.3.3.1 Pigging:

The practice of pigging is a way in which wax removal is commonly accomplished in the field. With this method, deposited wax is mechanically removed by launching a pipeline pig along the line to scrape wax from the walls as it is forced along by the oil pressure(Dhurjati & Anglus,2011).

The efficiency of this method depends on wax deposition prediction, therefor it is characterized by a high efficiency when there is a proper wax deposition prediction technology (Lee, 2008)

Fig (2.2) Cleaning pigs

2.2 Literature Review

The relevant and important studies related to this thesis were studied and written to get a better understanding of the concepts of the thesis

In 2011 DHURJATI and ANGELUS discuss the timely removal of deposited wax is required to address the reduction in flow rate that it causes as well as avoid the eventual loss of pipeline in the event that it becomes completely clogged, furthermore mechanisms governing wax deposition in pipeline and methods of inhibiting the formation of wax on pipeline.

In 2016 Muhammed and Pedro Diaz describes the underlining wax models implemented in OLGA, depending on the experimental data of this study. OLGA software was used to simulate the wax deposition process to predict the behavior of the wax deposition. A comparison between the experimental wax thickness and the predicted wax thickness was presented.

Since simulations based on the default wax parameters did not achieve a complete match with experiments, it was important to find out to what extent tuning of wax parameters was necessary.

In2020 Obaseki, M., Paul, E Figure(2.3) shows that wax started deposited at the point where oil temperature goes below wax appearance temperature (WAT) and this happened at about 4.3km from the pipe inlet which corresponds to about 7 hours of flow from the inlet. The field data and the simulation data at length 4.5km along the pipe were compared. The correlation between the data shows that the R2 value is 0.997 as shown in Figure 2, indicating perfect correlation. The plot in figure 3 shows that the simulated result is perfectly close the field data obtained at 4.6km length from the pipe inlet. Thus, the error plot in Figure 5 shows an average percentage error of 3%. Thus, field data in a real sense means the data collected outside laboratory findings setting. The field data was obtained through the company reviewing documents and records

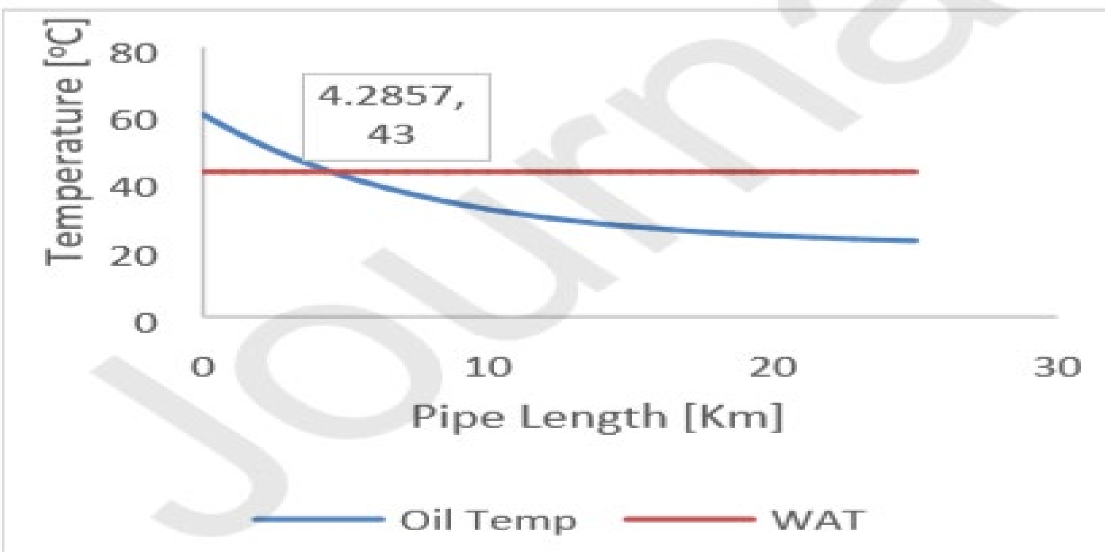


Fig (2.3) Plot of Temperature Profile and WAT

In 2016 S.Li,Q.Huang,K.Fan Experiment results manifest that beneficiated oil acquires obvious modification effect and the reheating temperature of intermediate heat stations should be above 55°C to avoid effect deterioration.

In2016 MYSARA MOHYALDINN discussed the effect of flow improver (pour point depressant) on the operation of HEGLIG-Port SUDAN pipeline has been studied. two types of PPD25J1 and PPD25J2 have been used with difference doses and different operation scenario where presumed .For every scenario, The pressure required are to transport the flowing fluid through the pipeline has been calculated and pressure transfers between pump stations has been established. The optimum scenario has been selected based on critical analysis of the operation cost at different operation scenario and PPD concentration. It has been found that the optimum operation scenario is obtained by adding the PPD type 25J1 to the flowing fluid at 500 ppm.

In 20 February 2011 Ararimeh Aiyejina [a], Dhurjati Prasad Chakrabarti This paper seeks to review the current state of research into these areas, highlighting what is so far understood about the mechanisms guiding this wax deposition, and how this knowledge can be applied to modelling and providing solutions to this problem

Chapter3

METHODOLOGY

3.1 Introduction:

Considerable effort has been carried out over the last decade to provide process solution for reservoir fluids with high wax content. A great deal of this effort has been directed to developing models in process simulators that predicts wax deposition in the pipelines.

This chapter also describes the underlining wax models implemented in OLGA, the case inputs into OLGA simulation obtained from PVT sim – a tab generating PVT package

3.2 PIPESIM:

Schlumberger's PIPESIM is a base system analysis software for well modeling, nodal analysis, artificial lift design, pipeline simulation, and process facilities simulation.

3.2.1 GIS:

This tutorial covers the GIS capability that was introduced in PIPESIM that allows the user to build a pipeline network model overlain on a GIS map. This feature allows you to build a model more closely representing real world conditions, because the exact pipeline terrain profiles, following the real route on the earth can be automatically collected by PIPESIM.

3.3 OLGA:

OLGA software is a dynamic multiphase simulator widely used in the Oil and Gas industry for transient simulation. Coined as a short form for "Oil and Gas simulator, the modeling tool makes it possible to simulate fluid flow, ensuring improved efficiency and optimization of offshore oil and gas production. OLGA is used for modeling and simulation of networks of wells, pipelines, risers and process equipment, covering the production system from bottom hole to the processing facilities

During operation phase, several events where OLGA simulation is extensively used to define wax deposition.

3.3.1 wax deposition model:

In order to form an OLGA model, it was necessary to gather data (PVT file and wax file), to build the model and define the simulation case, and to run simulations and view results in the form of graphs. Wax deposition simulations performed in this work are done. OLGA receives the crude oil propriety input values (for example, the weight percentage of carbon numbers, density, compressibility, viscosities, surface tension, enthalpies, heat capacities and thermal conductivity) in pressure and temperature values. These properties enter the OLGA simulator as a tab file.

3.3.2 Wax file:

The wax deposition module in OLGA further requires details about the wax component, structure, porosity, etc., converted to a wax file. The wax file provides information about the wax fraction as a function of the wax forming components, temperature and pressure, and wax mixture. Results and prediction of the OLGA.

3.3.3 PVT file:

A hypothetical fluid from a typical production oil field with subsea production flow line for subsea transport of oil is created for wax simulation. The oil is imputed into PVT sim for characterization (A PVT Laboratory analysis of the fluid will be used to create a compositional fluid model for used in MULTIFLASH calculations) where molar concentration of characterized fluid is obtained.

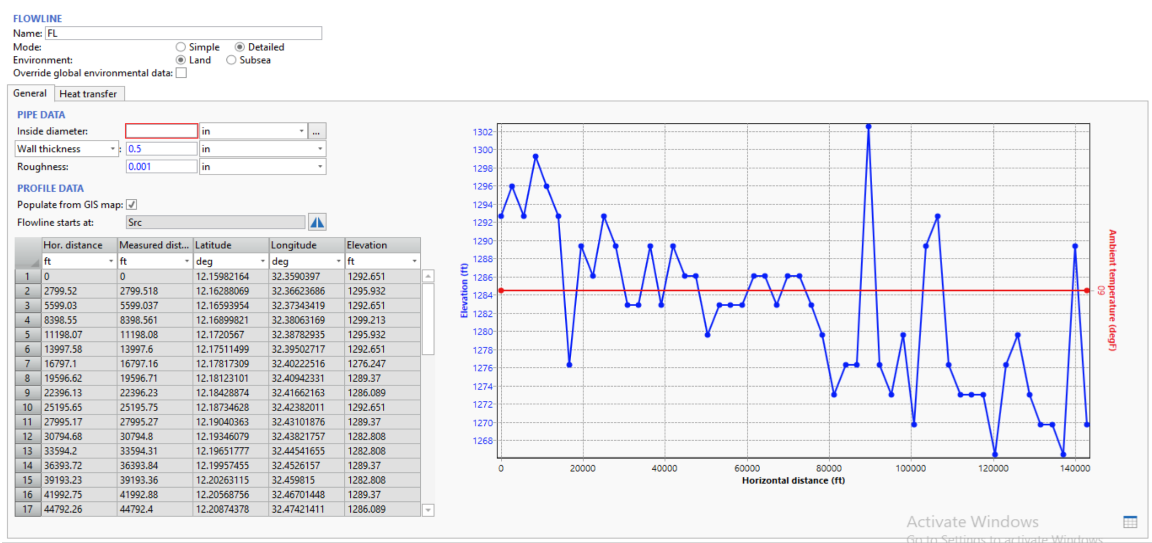
3.4 To form WAX deposition module, follow the steps below(input):

3.4.1 Steps 1:

This scenario represented the ideal situation for a pipeline route which would be a straight line pipeline that connects the field and the CPF. This straight route pipeline did not avoid or deviate from any obstacles and did not consider any of the factors that affected the pipeline. The distance between FPF and CPF is 72.166 km.

Fig (3.1) Distance between FPF & CPF

The elevation its determine from Pipesim using GIS by capture elevation



	Hor. distance	Measured dist...	Latitude	Longitude	Elevation
	ft	ft	deg	deg	ft
1	0	0	12.15982164	32.3590397	1292.651
2	2799.52	2799.518	12.16288069	32.36623686	1295.932
3	5599.03	5599.037	12.16593954	32.37343419	1292.651
4	8398.55	8398.561	12.16899821	32.38063169	1299.213
5	11198.07	11198.08	12.1720567	32.38782935	1295.932
6	13997.58	13997.6	12.17511499	32.39502717	1292.651
7	16797.1	16797.16	12.17817309	32.40222516	1276.247
8	19596.62	19596.71	12.18123101	32.40942331	1289.37
9	22396.13	22396.23	12.18428874	32.41662163	1286.089
10	25195.65	25195.75	12.18734628	32.42382011	1292.651
11	27995.17	27995.27	12.19040363	32.43101876	1289.37
12	30794.68	30794.8	12.19346079	32.43821757	1282.808
13	33594.2	33594.31	12.19651777	32.44541655	1282.808
14	36393.72	36393.84	12.19957455	32.4526157	1289.37
15	39193.23	39193.36	12.20263115	32.459815	1282.808
16	41992.75	41992.88	12.20568756	32.46701448	1289.37
17	44792.26	44792.4	12.20874378	32.47421411	1286.089

Fig (3.2) elevation of pipeline

3.4.2. Step 2:

The diameter is assumed to be 12.09 in this thesis, carbon steel was selected as pipeline material

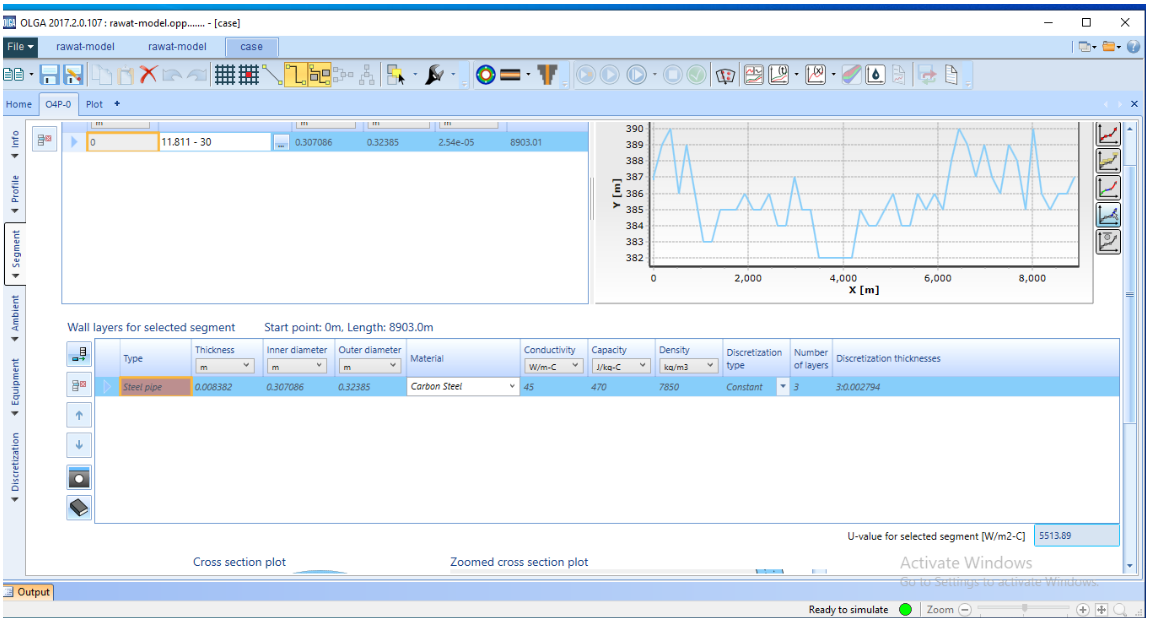


Fig (3.3) Diameter and material selected

3.4.3. Step 3:

Specify the ambient temperature (temperature of the environment surrounding the pipeline)

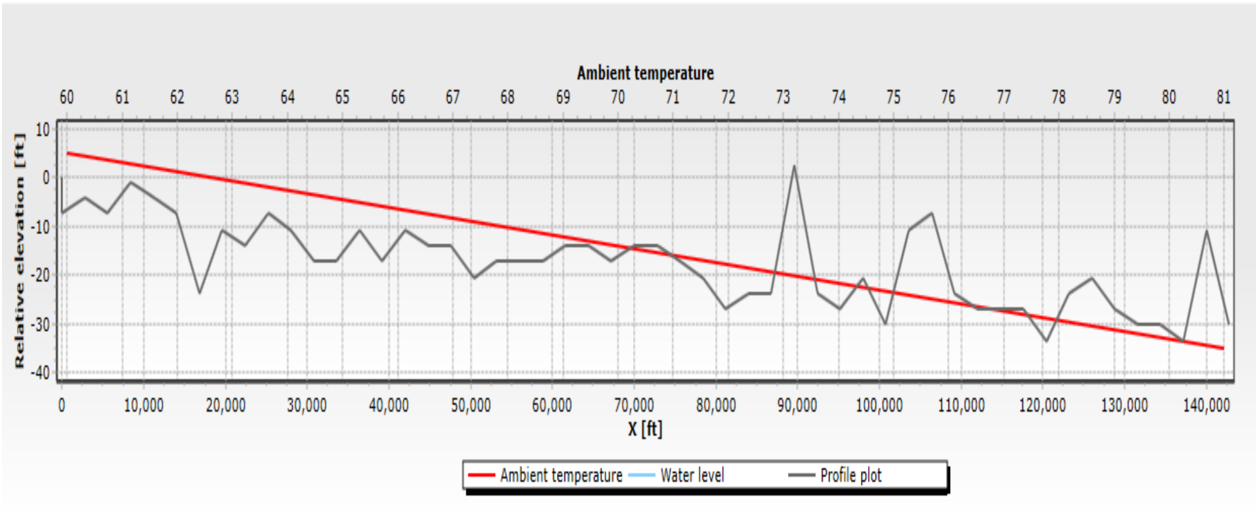


Fig (3.4) Ambient temperature

3.4.4. Step 4:

The mass source label (is the fluid coming from the reservoir or wellhead) and at what rate the source type (of course a mass source) and the temperature of the fluid, how is the rate changing with time (zero mean constant with time).

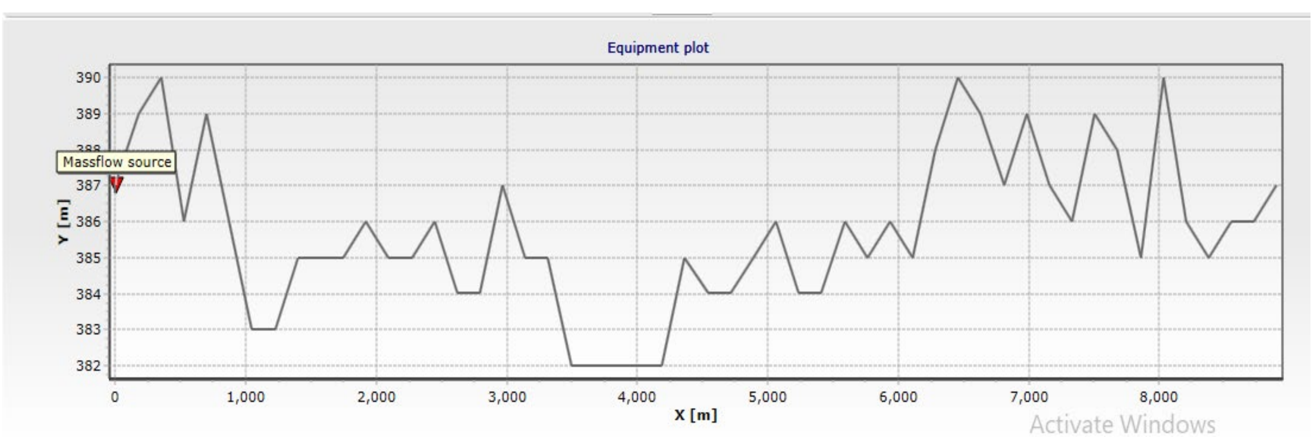


Fig (3.5) Equipment plot

3.4.5 Step5:

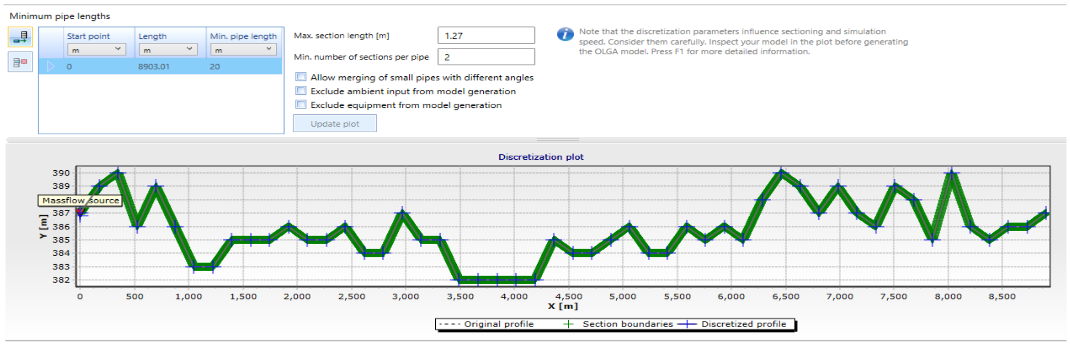


Fig (3.6) Discretization plot

3.4.6 Step 6:

Prepare the OLGA input using the following keywords:

OPTIONS to set WAXDEPOSITION = ON

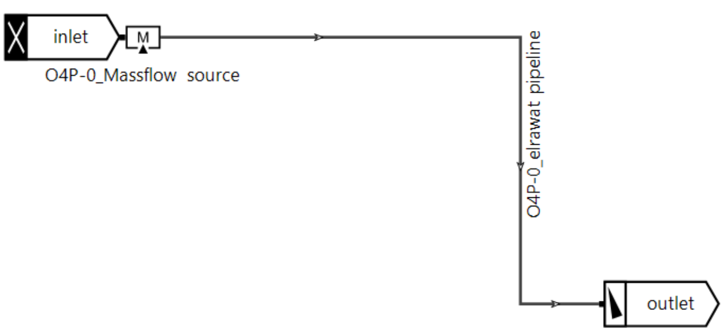


Fig (3.7) Pipeline inlet and outlet

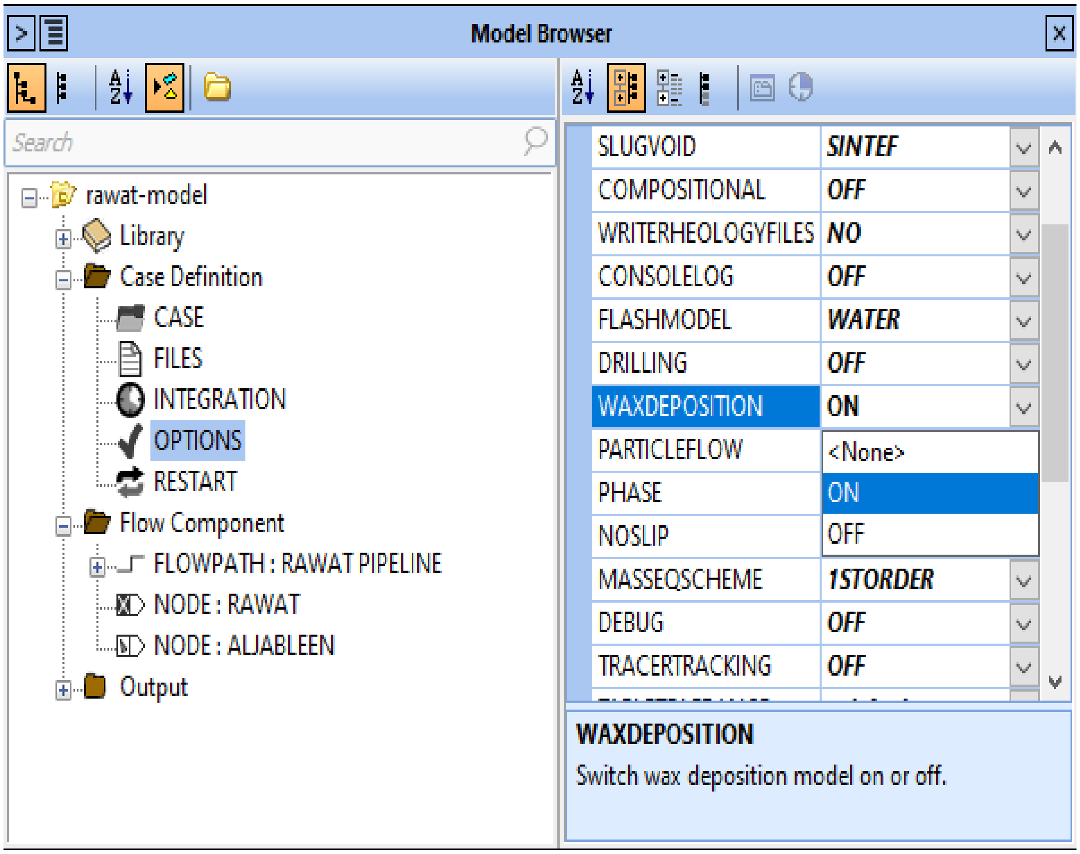


Fig (3.8) options

3.4.7. Step 7:

Generate a WAX file and an OLGA fluid table

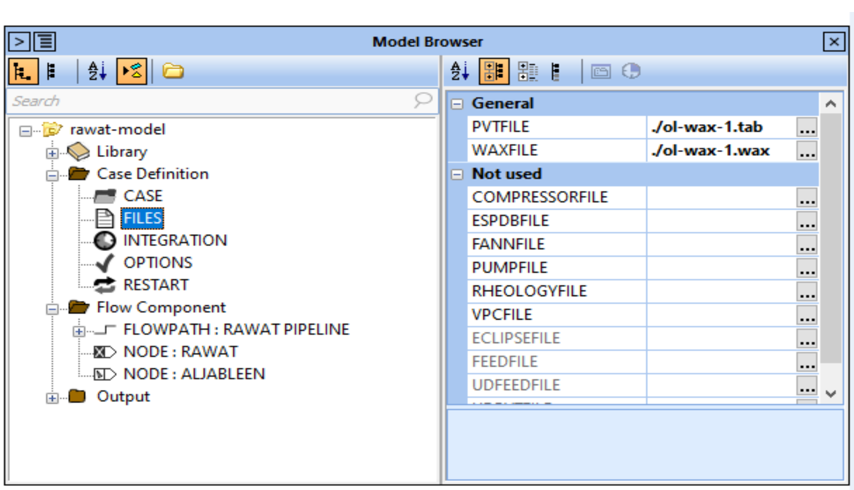


Fig (3.9) specified files

3.4.8. Step 8:

Simulation run time or Integration time (the duration required to run the simulation) should be specify. For wax modelling, it is advisable to give enormous time for deposition to occur because it is a slow process

3.4.9. Step 9:

RUN batch the model

Chapter 4

Results and Discussion

In this chapter the output from Olga simulator show an interpretation of phenomena of wax deposition and a scenario assumed was implemented to predict the wax deposition and solve it.

4.1 Output:

The keyword Profile Data in the input file specified the output from the simulation.

4.1.1 Profile file:

The profile file is used for plotting several variables related to wax deposition.

4.1.2 Output variables:

Fluid temperature and wax appearance temperature is selected to describe the wax deposition and plot them with pipeline length in the X-axise , the fluid temperature and wax appearance temperature in Y-axise.

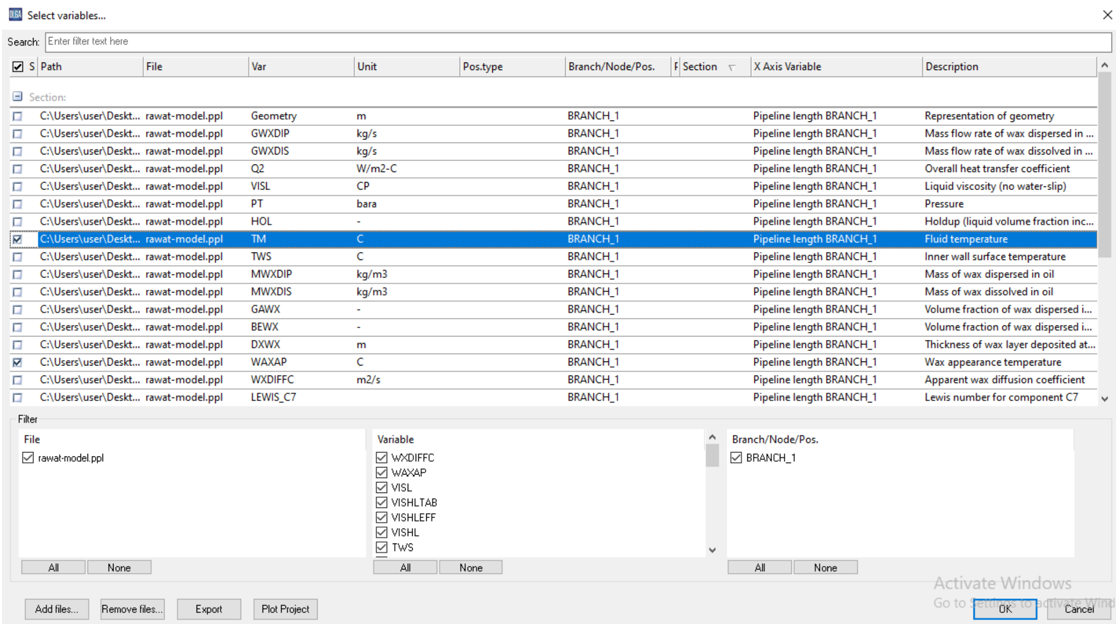


Fig (4.1) variable selected

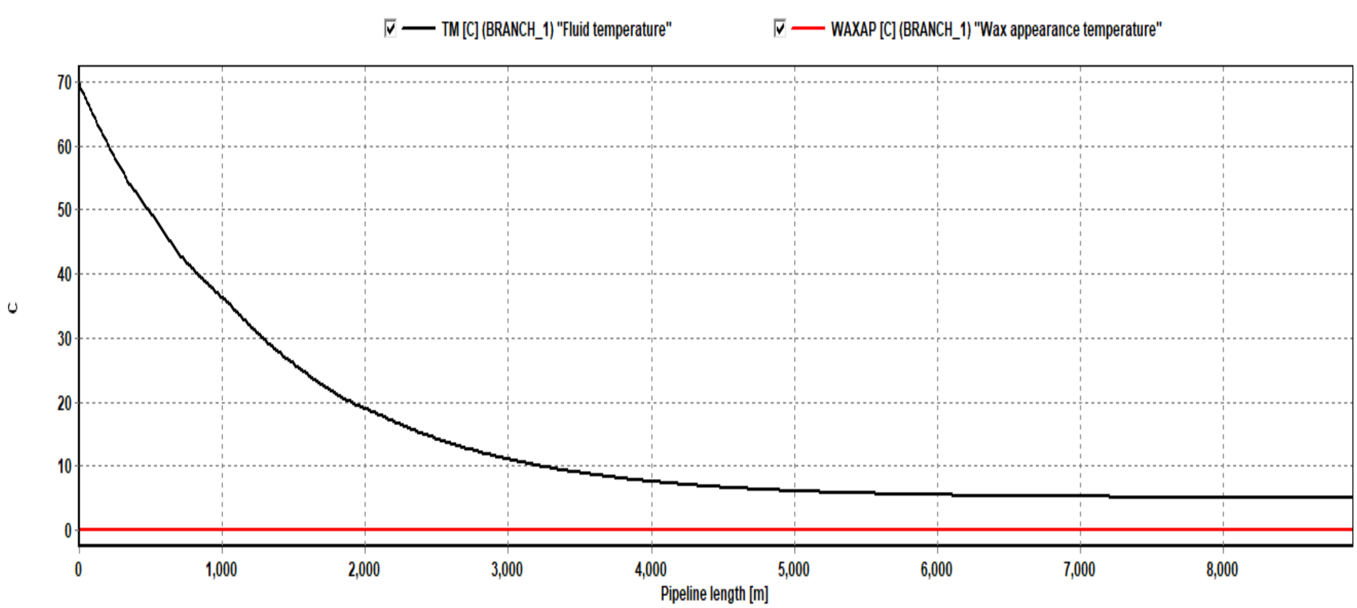


Fig (4.2) profile plot

Fig (4.2) The temperature of the oil remained greater than the temperature of wax deposition along the pipeline, and this explains the lack of wax formation

4.2 Temperature Decline Scenario:

If we assume that the temperature of the oil will drop below the temperature at which the wax is deposited as a result of the decrease in the ambient temperature and this decrease leads to the deposition of wax inside the pipeline in this region.

The following figure shows that the region between 1000-2000, the oil temperature began to gradually decrease to less than the degree of wax deposition.

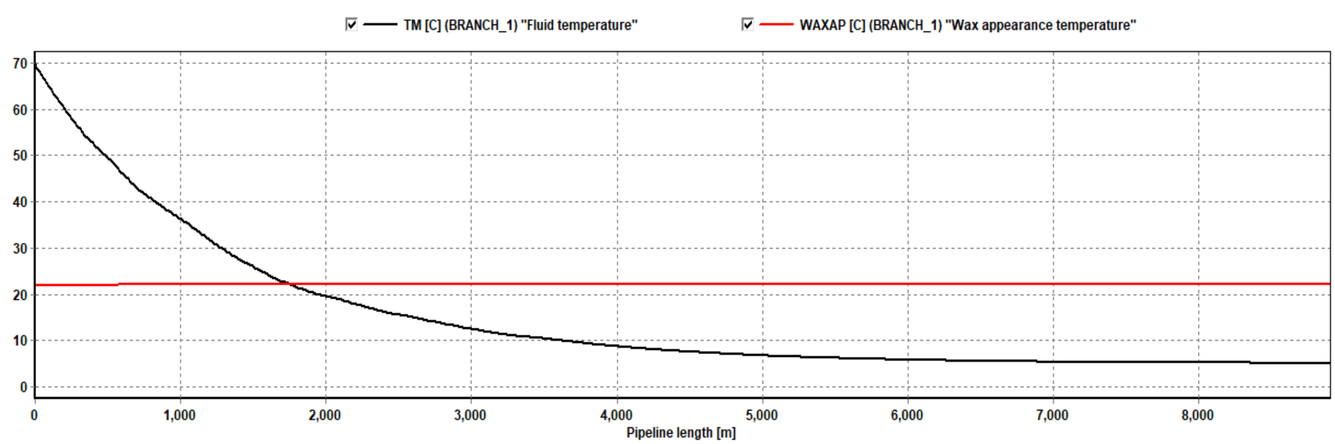


Fig (4.3) profile plot after decline of oil Temperature

3D showing wax deposition along one flow path (the length of the pipeline) in a 3D view.

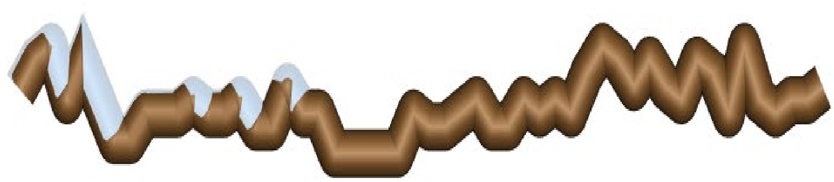


Fig (4.4) 3D plot

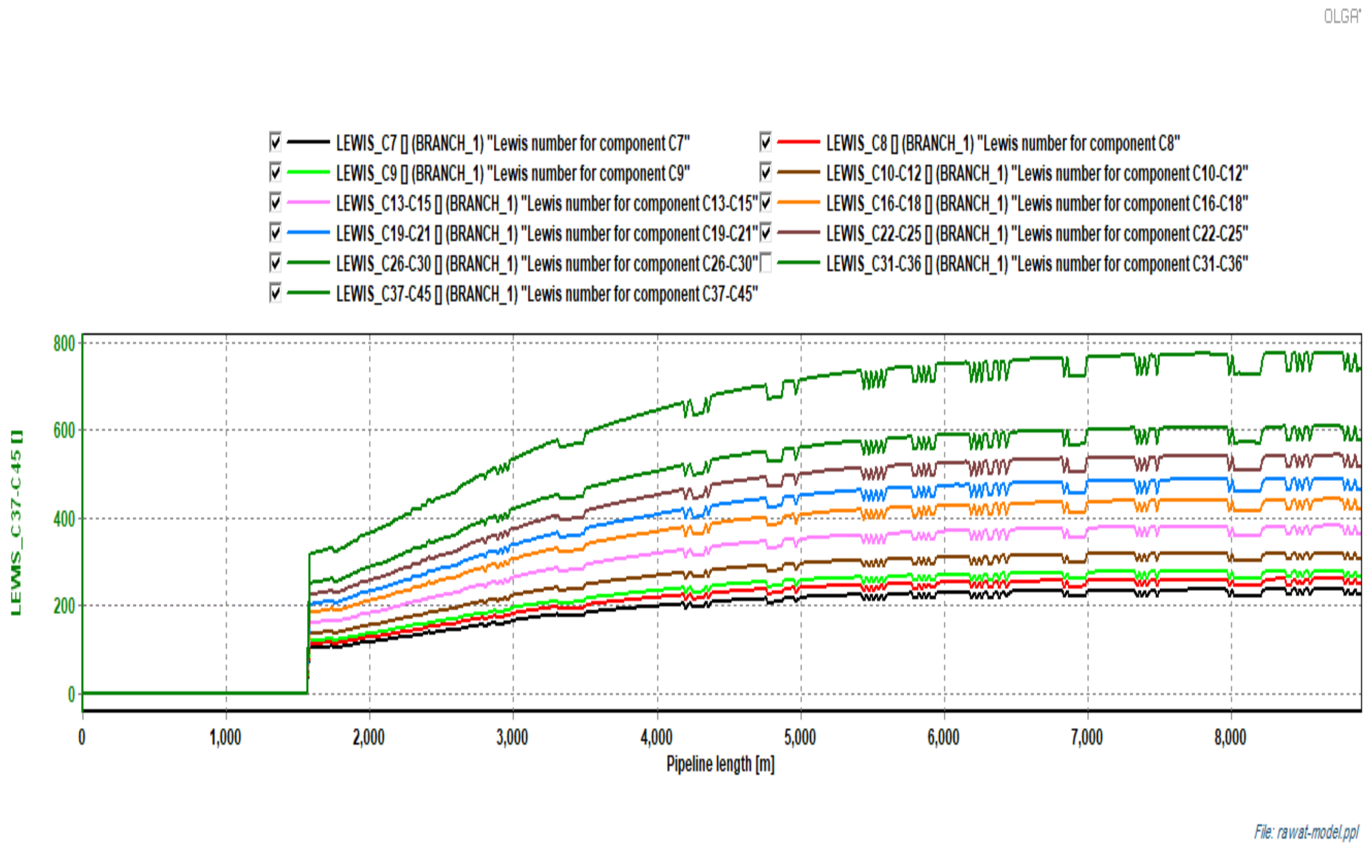


Fig (4.5) Lewis number plot

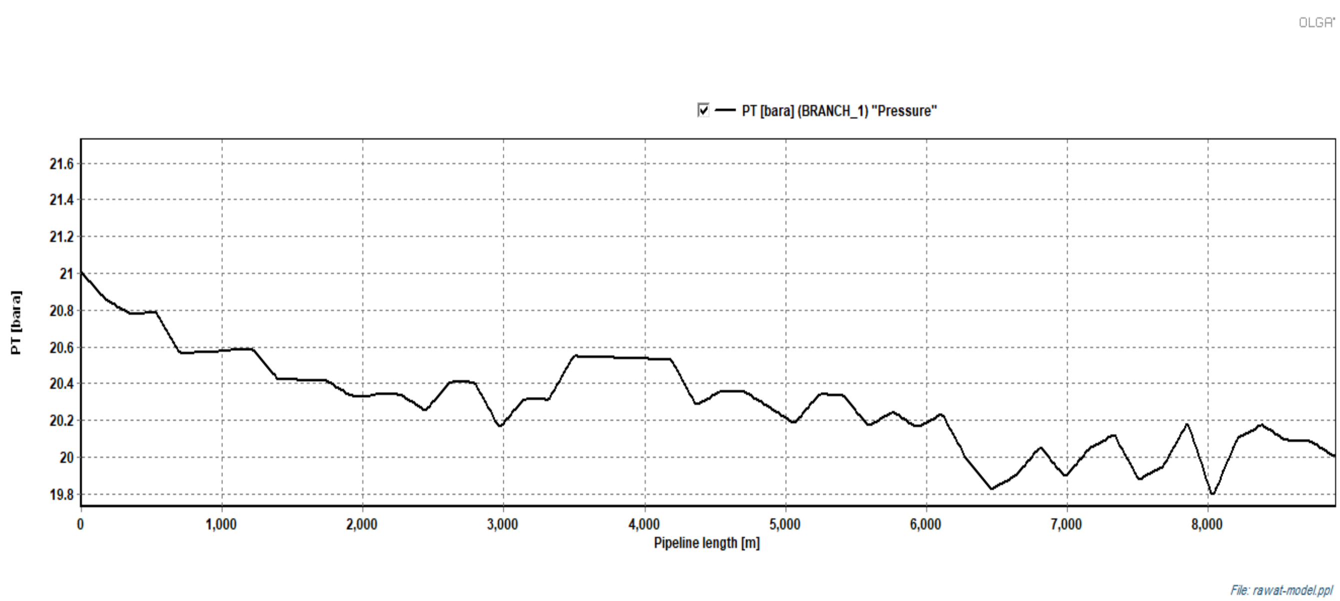


Fig (4.6) pressure profile before temperature decline

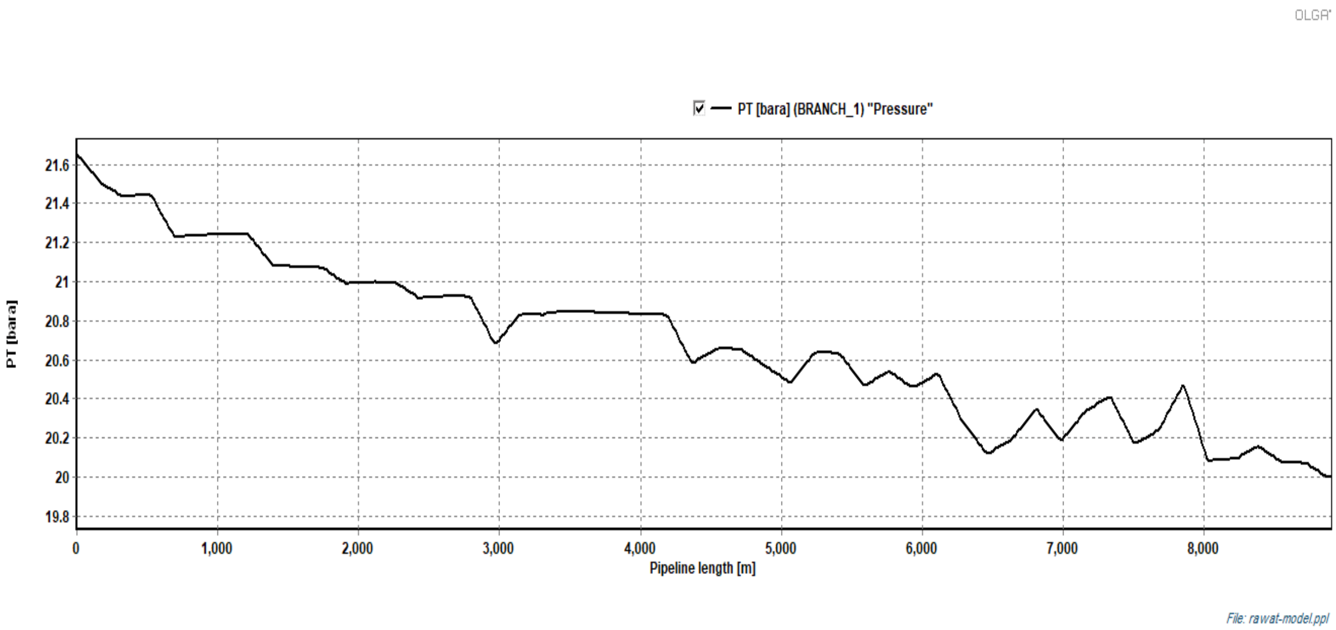


Fig (4.7) Pressure profile after temperature decline

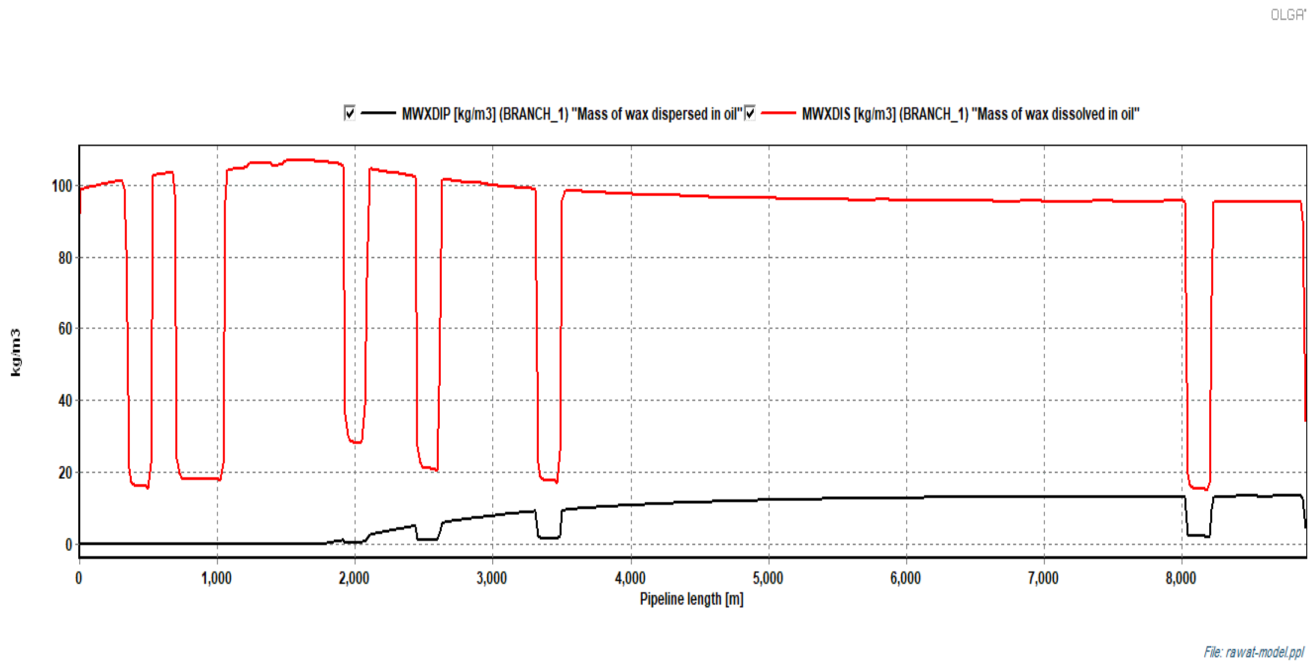


Fig (4.8) mass of wax dispersed and dissolved in oil

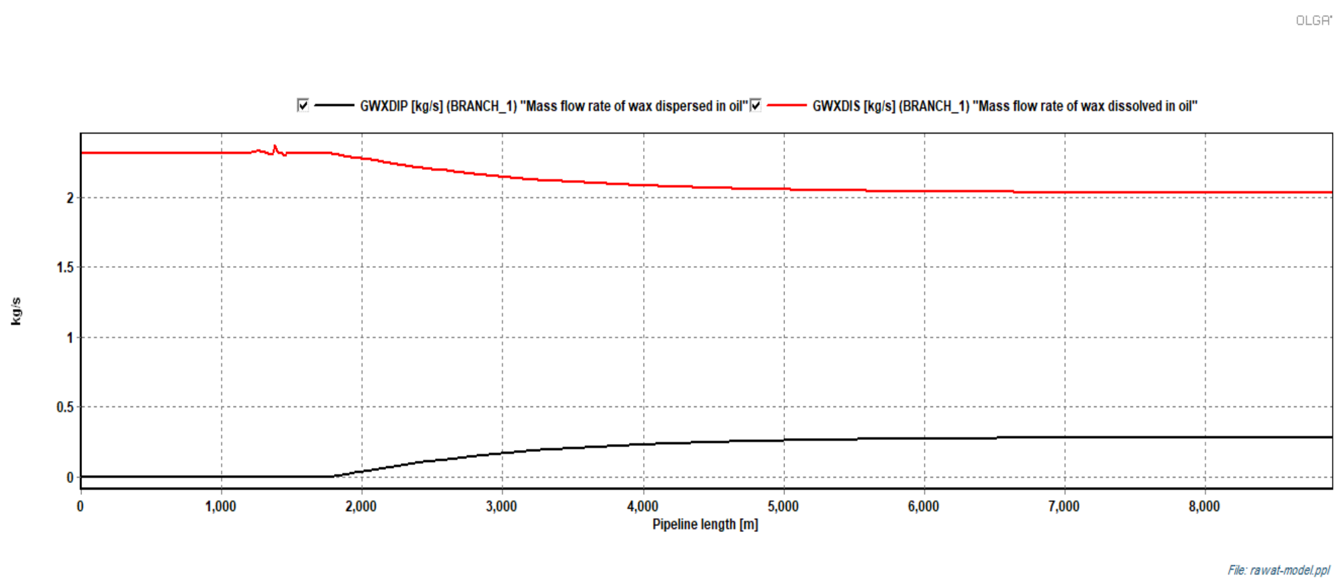


Fig (4.9) mass flow rate of wax dispersed and dissolved in oil

Chapter 5

Conclusions &Recommendations

5.1 Conclusions:

The aim of this research presented in were to establish a fundamental understanding of wax deposition in ALRAWAT –ALJABLINE pipeline

The area of Al-Rawat and Al-JABLINE was determined by GIS in the Pipsim software, and the distance between them was found to be 72.166 km, and the elevation of the pipeline was determined.

A simulation model was built and profile plot show that no wax precipitation a long pipeline.

In the hypothesized scenario, due to a decrease in temperature in the region between 1000-2000 ft , the results of the model showed the formation of wax in this region.

5.2 Recommendations:

1\ By applying the OLGA software, we could anticipate wax deposition location in the pipeline

2\ The pipeline route in this study does not represent the actual rout of ALRAWAT- ALJABLINE Pipeline.

3\ To make more detailed of pipeline design requirement.

4\ Wax removal by installing a heat exchanger in the area where the temperature is expected to drop.

References:

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3\ Diaz, P. and M. Theyab (2017). "An experimental and simulation study of wax deposition in hydrocarbon pipeline." Global Journal of Engineering and Science and Researches **4**(7): 85-98.

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2\ Ajayi, O. E. (2013). Modelling of controlled wax deposition and loosening in oil and gas production systems, Institutt for energi-og prosessteknikk ortation technology with pour point depressant and wax deposition in a crude oil pipeline." Petroleum Science and Technology **34**(14): 1240-1247.

5\ Obaseki, M. and P. T. Elijah (2021). "Dynamic modeling and prediction of wax deposition thickness in crude oil pipelines." Journal of King Saud University-Engineering Sciences **33**(6): 437-445.

6\ OLGA Guideline

7\ PIPESIM Guideline

Appendixes

1. Introduction

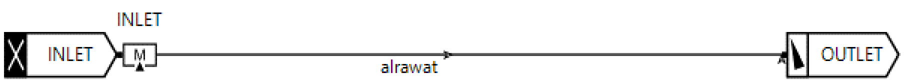
Project	OLGA Sample cases
Case description	Verification of wax module
Date	June 11, 2005
Author	Schlumberger
PVT File	./ol-wax-1.tab
Wax File	./ol-wax-1.wax

2. Simulation Options

Overall setting	Flow model	OLGAHD
	Mass eq scheme	1STORDER
	Compositional model	OFF
	Debug	OFF
	Drilling	OFF

	Phase	THREE
	Elastic walls	OFF
	Void in slug	SINTEF
	Steady state	ON
	User defined plug-in	OFF
	Temp. calc.	WALL
	Wax deposition	ON
	Restart	OFF
Integration	Simulation starttime	0 s
	Simulation stoptime	10 d
	Minimum time step	0.1 s
	Maximum time step	1 d

3. System Layout – Graphics



Layout filter On

4. System Layout – Table

4.1 Summary

4.1.1 Overall

No. of Branches	No. of Pipes	No. of Sections
1	52	512

4.1.2 Flows

Branches	No. of Pipes	No. of Sections
alrawat	52	512

4.2 Layout

1 - 1	alrawat	PIPE_1	12.09 in	2.54E-05 m	0 m	387 m	PIPELINE
1 - 2	alrawat	PIPE_2	12.09 in	2.54E-05 m	174.553 m	389 m	PIPELINE
1 - 3	alrawat	PIPE_3	12.09 in	2.54E-05 m	349.109 m	390 m	PIPELINE
1 - 4	alrawat	PIPE-4	12.09 in	2.54E-05 m	523.662 m	386 m	PIPELINE
1 - 5	alrawat	PIPE-5	12.09 in	2.54E-05 m	698.215 m	389 m	PIPELINE
1 - 6	alrawat	PIPE-6	12.09 in	2.54E-05 m	872.767 m	386 m	PIPELINE

1 - 7	alrawat	PIPE-7	12.09 in	2.54E-05 m	1047.323 m	383 m	PIPELINE
1 - 8	alrawat	PIPE-8	12.09 in	2.54E-05 m	1221.876 m	383 m	PIPELINE
1 - 9	alrawat	PIPE-9	12.09 in	2.54E-05 m	1396.429 m	385 m	PIPELINE
1 - 10	alrawat	PIPE-10	12.09 in	2.54E-05 m	1570.985 m	385 m	PIPELINE
1 - 11	alrawat	PIPE-11	12.09 in	2.54E-05 m	1745.538 m	385 m	PIPELINE
1 - 12	alrawat	PIPE-12	12.09 in	2.54E-05 m	1920.091 m	386 m	PIPELINE
1 - 13	alrawat	PIPE-13	12.09 in	2.54E-05 m	2094.644 m	385 m	PIPELINE
1 - 14	alrawat	PIPE-14	12.09 in	2.54E-05 m	2269.199 m	385 m	PIPELINE
1 - 15	alrawat	PIPE-15	12.09 in	2.54E-05 m	2443.752 m	386 m	PIPELINE
1 - 16	alrawat	PIPE-16	12.09 in	2.54E-05 m	2618.305 m	384 m	PIPELINE
1 - 17	alrawat	PIPE-17	12.09 in	2.54E-05 m	2792.861 m	384 m	PIPELINE
1 - 18	alrawat	PIPE-18	12.09 in	2.54E-05 m	2967.414 m	387 m	PIPELINE
1 - 19	alrawat	PIPE-19	12.09 in	2.54E-05 m	3141.967 m	385 m	PIPELINE
1 - 20	alrawat	PIPE-20	12.09 in	2.54E-05 m	3316.523 m	385 m	PIPELINE
1 - 21	alrawat	PIPE-21	12.09 in	2.54E-05 m	3491.076 m	382 m	PIPELINE
1 - 22	alrawat	PIPE-22	12.09 in	2.54E-05 m	3665.628 m	382 m	PIPELINE
1 - 23	alrawat	PIPE-23	12.09 in	2.54E-05 m	3840.181 m	382 m	PIPELINE
1 - 24	alrawat	PIPE-24	12.09 in	2.54E-05 m	4014.737 m	382 m	PIPELINE
1 - 25	alrawat	PIPE-25	12.09 in	2.54E-05 m	4189.29 m	382 m	PIPELINE
1 - 26	alrawat	PIPE-26	12.09 in	2.54E-05 m	4363.843 m	385 m	PIPELINE
1 - 27	alrawat	PIPE-27	12.09 in	2.54E-05 m	4538.399 m	384 m	PIPELINE
1 - 28	alrawat	PIPE-28	12.09 in	2.54E-05 m	4712.952 m	384 m	PIPELINE
1 - 29	alrawat	PIPE-29	12.09 in	2.54E-05 m	4887.505 m	385 m	PIPELINE
1 - 30	alrawat	PIPE-30	12.09 in	2.54E-05 m	5062.057 m	386 m	PIPELINE
1 - 31	alrawat	PIPE-31	12.09 in	2.54E-05 m	5236.613 m	384 m	PIPELINE
1 - 32	alrawat	PIPE-32	12.09 in	2.54E-05 m	5411.166 m	384 m	PIPELINE
1 - 33	alrawat	PIPE-33	12.09 in	2.54E-05 m	5585.719 m	386 m	PIPELINE
1 - 34	alrawat	PIPE-34	12.09 in	2.54E-05 m	5760.275 m	385 m	PIPELINE
1 - 35	alrawat	PIPE-35	12.09 in	2.54E-05 m	5934.828 m	386 m	PIPELINE
1 - 36	alrawat	PIPE-36	12.09 in	2.54E-05 m	6109.381 m	385 m	PIPELINE
1 - 37	alrawat	PIPE-37	12.09 in	2.54E-05 m	6283.934 m	388 m	PIPELINE
1 - 38	alrawat	PIPE-38	12.09 in	2.54E-05 m	6458.489 m	390 m	PIPELINE
1 - 39	alrawat	PIPE-39	12.09 in	2.54E-05 m	6633.042 m	389 m	PIPELINE
1 - 40	alrawat	PIPE-40	12.09 in	2.54E-05 m	6807.595 m	387 m	PIPELINE
1 - 41	alrawat	PIPE-41	12.09 in	2.54E-05 m	6982.151 m	389 m	PIPELINE
1 - 42	alrawat	PIPE-42	12.09 in	2.54E-05 m	7156.704 m	387 m	PIPELINE
1 - 43	alrawat	PIPE-43	12.09 in	2.54E-05 m	7331.257 m	386 m	PIPELINE
1 - 44	alrawat	PIPE-44	12.09 in	2.54E-05 m	7505.81 m	389 m	PIPELINE
1 - 45	alrawat	PIPE-45	12.09 in	2.54E-05 m	7680.366 m	388 m	PIPELINE

1 - 46	alrawat	PIPE-46	12.09 in	2.54E-05 m	7854.919 m	385 m	PIPELINE
1 - 47	alrawat	PIPE-47	12.09 in	2.54E-05 m	8029.471 m	390 m	PIPELINE
1 - 48	alrawat	PIPE-48	12.09 in	2.54E-05 m	8204.027 m	386 m	PIPELINE
1 - 49	alrawat	PIPE-49	12.09 in	2.54E-05 m	8378.58 m	385 m	PIPELINE
1 - 50	alrawat	PIPE-50	12.09 in	2.54E-05 m	8553.133 m	386 m	PIPELINE
1 - 51	alrawat	PIPE-51	12.09 in	2.54E-05 m	8727.686 m	386 m	PIPELINE
1 - 52	alrawat	PIPE-52	12.09 in	2.54E-05 m	8902.242 m	387 m	PIPELINE

5. Insulation and Walls

5. 1 Material

Label	Density	Conductivity	Heat Capacity
STEEL	7850 kg/m3	50 W/m-K	485 J/kg-C
CONCRETE	2250 kg/m3	1.7 W/m-K	880 J/kg-C
POLYPROP	960 kg/m3	0.12 W/m-K	1675 J/kg-C

5. 2 Walls

Label	Material	Wall thickness	Elastic
PIPELINE	STEEL	0.4 cm	OFF
	STEEL	0.4 cm	
	STEEL	0.2 cm	
	CONCRETE	0.2 cm	
	CONCRETE	0.4 cm	
	POLYPROP	0.3 cm	

6. Boundary Conditions

6. 1 Nodes

Label	Type	Pressure	Temperature	GMF	WMF
INLET	CLOSED			-1	
OUTLET	PRESSURE	20 bara	25 C	1 -	0 -

6. 2 Heattransfer

Branch	Pipe	Interpolation	Houteroption.	Hambient	Tambient
alrawat	(PIPE_1, PIPE_2, PIPE_3, PIPE-4, PIPE-5, PIPE-6, PIPE-9, PIPE-10, PIPE-11, PIPE-12, PIPE-13, PIPE-14, PIPE-15, PIPE-18, PIPE-19, PIPE-20, PIPE-26, PIPE-29, PIPE-30, PIPE-33, PIPE-34, PIPE-35, PIPE-36, PIPE-37, PIPE-38, PIPE-39, PIPE-40, PIPE-41, PIPE-42, PIPE-43, PIPE-44, PIPE-45, PIPE-46, PIPE-47, PIPE-48, PIPE-49, PIPE-50, PIPE-51, PIPE-52)	SECTIONWISE	HGIVEN	500 W/m2-C	5 C
alrawat	(PIPE-7, PIPE-8, PIPE-16, PIPE-17, PIPE-21, PIPE-22, PIPE-23, PIPE-24, PIPE-25, PIPE-27, PIPE-28, PIPE-31, PIPE-32)	SECTIONWISE	HGIVEN	500 W/m2-C	5 C
alrawat	(PIPE-7, PIPE-8, PIPE-9, PIPE-10, PIPE-11, PIPE-12, PIPE-13)	SECTIONWISE	AIR		
alrawat	(PIPE-7, PIPE-8, PIPE-9, PIPE-10, PIPE-11, PIPE-12, PIPE-13)	SECTIONWISE	AIR		

6. 3 Sources

Label	Abs. Pos.	Branch	Pipe	Section	Massflow	Type	Time	Temperature	GMF	WMF	Gas fraction eq	Oil fraction eq	water fraction eq
INLET		**alrawat**	**PIPE_1**	**1**	**17.51 kg/s**	**MASS**	**0 s**	**70 C**	**-1**	**0 -**	**1**	**1**	**1**