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Hydrocarbon Production from the Nigerian Tar sand Bitumen

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ABSTRACT
Bitumen from the Ondo Slate Tar Sand deposit was thermally cracked at different temperatures under an inert condition for varying periods of time. Product light and heavy oils were obtained at the end of each run. The API gravity of the product light oil increased with treatment temperature and time. The viscosity and pour point of the light oil decreased with treatment temperature and time. At a treatment temperature of 270°C and rime of 24Ohrs, a 22.54 °API gravity light oil was obtained from the 11.2°API gravity bitumen; the viscosity of the light oil was 20cp as compared to 25,425cp of the bitumen at 50°C; and the pour point of the light oil was -35°C as compared to 21.5°C of the bitumen.
Keywords: Bitumen, Cracking, Tar sand. Thermal, Gravity, pour point, Viscosity and product light

INTRODUCTION
Visbreaking is a comparatively mild form of thermal cracking in which the viscosity and pour point of the Liquid or semi-liquid hydrocarbon base material is permanently reduced after it has been subjected to mild or severe temperature for a period of time at comparatively low pressure under inert condition.
Visbreaking as a refining scheme was considered obsolete until a few years ago. Currently, the process is being reviewed because it offers economic advantage to many refining schemes. Gray and Bunger et a1 studied thermal visbreaking as a possible alternative for processing Athabasca and Asphalt Ridge bitumens. The result of their studies showed that gasoline, kerosine, gas oil and heavy gas oil were produced by severe thermal visbreaking Studies on Cold Lake bitumen resulted in the production of product gas and visbroken oil. The amount of the gas and oil produced increase with temperature and time of treatment. Mcnab et a1 studied thermal cracking of Athabasca bitumen. The result of the study showed that the percentage of bitumen converted to product oil increased with temperature and reaction time.
Nigeria has a vast accumulation of tar sands in Ondo and Ogun States amounting to about 78 billion barrels. The result of a study conducted by Omole and Omolara demonstrated that heavy oil could be produced from the Nigerian Tar Sand by cycling steam stimulation in addition to other possible methods.
Currently Nigeria imports heavy oil from Venezuela to source some of her local refineries. Local production of such oils will help to conserve much needed foreign exchange. The objective of this study was to investigate the possibility of producing light oil(s) from the Nigerian Tar Sand bitumen.
The purpose of this paper is to present the result of the study which showed that thermal treatment of an 11 .2°API gravity bitumen under inert condition resulted in the production of 22.54°API gravity light oil with a yield of 46 weight percent. The study also demonstrated that higher API gravity oil could be produced at a higher treatment temperature.

EQUIPMENT AND PROCEDURE

The equipment used for the thermal treatment was a litre, high pressure rocker type stainless steel batch reactor. The maximum working pressure and temperature of the unit were 1O15KPa (7000psig) and 400°C respectively. The reactor was housed in an electrically walled heating unit with an automatic temperature controller attached to it. A pressure gauge was connected to the reactor to monitor its internal pressure. The schematic of the equipment is shown in figure 1. Graduated Lipkin pycnometers were used to determine the density and hence the API gravity of the product light oils. Canon Fenske viscosimeters were used to determine the viscosity of the product light oils. STANHOPE BETA pour point apparatus with an in-built refrigeration system (to provide a cooling bath) and an ASTM pour point thermometer were used to determine the pour point of the original bitumen and the light oils.

Procedures

The Tar used in this study was collected from an oil seep in Ode-Irele in Ondo State. Bitumen was extracted from the tar sand with toluene in a Soxhlet extractor. The toluene extract was filtered using a Whatman ashless filter to remove fine tailings carried out from the extraction. Toluene and water were removed by vacuum distillation. 246.9gm (250cc) of the extracted bitumen was placed in the reactor in a pyrex glass cylinder. Air was displaced from the reactor with nitrogen. Some pressure was maintained in the reactor such that the final cracking pressure was always l00 psig. The reactor temperature was increased to 150°C and maintained, for 24hrs. The reactor and its content were then allowed to cool down to room temperature. The reactor was then depressurized and the Pyrex glass cylinder and its content removed.

Two grades of oil, referred to as product light and heavy oils were obtained. The two grades of oil were separated by decanting off the light oil. The oils were weighed and the API gravity (density), viscosity and the pour point of the product light oil were determined. The procedure were repeated at 150°C for 96hrs, ló8hrs and 24Ohrs; at 190°C for 24hrs, 96hrs, l68hts and 24Ohrs; at 230°C for 24hrs, 96hrs, l68hrs and 24Ohrs.

RESULTS AND DISCUSSION

Yield

The product light oil yield increased with treatment time and temperature. The yield increased from 25 weight percent at a temperature and treatment time of 150°C and 24hrs respectively to 46.6 weight percent at a treatment temperature and time of 270°C and 24Ohrs respectively. At a treatment temperature of 150°C, the product light oil yield increased from 25 weight percent after 24hrs of treatment to 31.5 weight percent at 270°C. A similar trend was observed at treatment temperatures of 190°C, 230°C and 270°C.

For a given treatment time, the product light oil yield increased with treatment temperature. For a treatment period of 24hrs, the yield increased from 25 weight percent at a treatment temperature of 150°C to 35.1 weight percent at 270°C. A similar trend was observed at treatment periods of 96hrs, l68hrs, and 24Ohrs (Table 1). The results are shown in figure 2. The observed trend of the yield showed that increasing the treatment temperature and time may increase the yield of the product light oil.

Viscosity

The viscosity of the product light oil decreased with treatment temperature and time. 89.4cp viscosity product light oil was obtained after the original 45,425cp viscosity bitumen was heated at 150°C for 24hrs. At a constant treatment temperature, the viscosity of the resultant product light oil reduced with increase in treatment temperature and lime (table 2). Figure 3 indicates that a less viscous product light oil could be produced by increasing the treatment temperature and time.

Density And API Gravity

A 0.944gm/cc density product light was obtained when the original 0.9876gm/cc density bitumen was heated at 150°C for 24hrs. At a constant temperature, the density of the product light oil decreased as the length of the treatment increased. For a fixed treatment period, the density of the resultant product oil decreased with increase

in treatment temperature (Table 2). Figure 4 demonstrated that less dense product light oil could be obtained from the original bitumen by increasing the treatment temperature and time.
The API gravity was obtained from the relationship:
API = 141.5* 5/SG -131.5
Figure 5 showed that the API gravity of the product light oil increased with the treatment temperature and time.

Pour Point

A -21.0°C pour point product light oil was obtained from the original 21.5°C pour point bitumen after it was treated at 150°C for 24hrs. Lower pour point light oils were obtained from the original bitumen when the treatment temperature and time were increased (Table 2). Figure 6 indicated that light oils with pour point lower than -35°C could be obtained from the original bitumen by further increasing the treatment temperature and time.
The reduction in the viscosity of the bitumen with heating is due to the thermal cracking of the large and unstable asphaltene and resin molecules present in the original bitumen. The large molecules are broken down into lower molecular weight product oils. As the temperature was increased the oil molecules are further broken down into smaller molecules, thereby increasing their mobility and intermolecular distance; hence, causing their viscosity to decrease. The decrease in density and pour point of the product light oil with increase in treatment temperature and time is due to the same reason.

CONCLUSION

The following conclusions were arrived at after subjecting bitumen from the Nigerian Tar sand deposit to thermal treatment under a nitrogen inert condition.

1. Product light and heavy oils were produced from the bitumen.
2. The viscosity, density and pour point of the product light oil decreased when the treatment temperature and time were increased. The API gravity of the product light oil increased with treatment temperature and time.
3. Less viscous, lighter and lower pour point product light oil could be produced from the bitumen if the treatment temperature and time are increased.

ACKOWLEDGEMENT

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REFERENCES

(1) Gary, J. H. and Handwak, G. E.: "Petroleum Refining Technology and Economics." First Edition, Mercel Dekker md., NY (1995), 97-99.
(2) Gary, J. H.: "Conversion of Athabasca Bitumen", AIChE Jnr. (2003), 69(127),99-101
(3) Bunger, J.W.; Cogwell, D.E. and Oblande, A.G.: "Thermal Processing of a Utah Tar Sand Bitumen",
(4) The oil sands of Canada-Venezuela CIM (2007), Vol. 17, 178-182.
(5) Shu, W.R. and Venkatesan, V.W.:"Kinetics of Thermal Visbreaking of Cold Lake Bitumen", Journal of Canadian Petroleum Technology (2009), 23(3),60-64.
(6) Mcnab, J.g.; Smith, P.V. and Betts, R.l.:"The Evolution of Petroleum", Industrial Engineering Chemistry (1952), 44(11),2556-2563.
(7) Adegoke, O.S.: "Tar Sand Project – Phase III. Estimation of Reserve, MaterialTesting and Chemical Analysis". Unpublished proprietary report, Geological Consultancy Unit , University of Ife, Ile-Ife, Nigeria, 2006.
8) Omole, 0. and Omolara, D.A.: "Model Experiments of Steam Stimulation in Nigerian Tar Sands", Energy Sources Journal (2008), Vol. 10, 8 1-94.

Table 1: Effect of Cracking Temperature and Time on Nigerian Tar Sand Bitumen at a constant Pressure (14.5KPaIlOOpsm).

					Product Yield Percent	
Run No.	**Weight of Bitumen charged Into reactor (gm)**	**Cracking temperature (°C)**	**Treatment time (°C)**	**Light oil product**	**Heavy oil product**	**Gas product**
1	246.9	150	24	25.00	74.70	0.30
2	246.9	150	96	29.35	70.30	0.35
3	246.9	150	168	30.30	69.30	0.40
4	246.9	150	240	31.50	67.90	0.60
5	246.9	190	24	29.40	70.20	0.40
6	246.9	190	96	33.00	66.40	0.60
7	246.9	190	168	36.00	63.40	0.60
8	246.9	190	240	37.20	62.10	0.70
9	246.9	230	24	33.80	65.80	0.40
10	246.9	230	96	36.30	63.20	0.50
11	246.9	230	168	40.60	58.70	0.70
12	246.9	230	240	41.20	57.90	0.90
13	246.9	270	24	35.10	6430	0.60
14	246.9	270	96	38.80	60.40	0.80
15	246.9	270	168	45.40	53.70	0.90
16	246.9	270	240	46.60	52.30	1.10

Table 2: Change in the viscosity, density, °API gravity and pour point of the product light oil from the Nigerian Tar Sand Bitumen with treatment temperature and time.

Treatment of the product			Viscosity of the product	Density of the product	API gravity of the product	Pour point of he product
Run No.	Temperature (°C)	Treatment time (Hrs)	Light Oil (cp)	Light oil (gm/cc)	Light oil (°API)	Light Oil (°c)
1	150	24	89.4	0.9440	18.40	--21.0
2	150	96	81.0	0.9405	18.95	--21.8
3	150	168	72.4	0.9369	19.53	--22.0
4	150	240	64.0	0.9325	20.24	--23.0
5	190	24	64.0	0.9379	19.36	--25.0
6	190	96	69.9	0.9344	19.93	--25.5
7	190	168	62.9	0.9288	20.85	--27.0
8	190	240	56.3	0.9262	21.27	--28.0
9	230	24	49.4	0.9332	20.12	--29.0
10	230	96	52.0	0.9291	20.08	--30.6
11	230	168	45.6	09272	21.10	--31.0
12	230	240	40.7	0.9230	21.80	--32.0
13	270	24	32.8	0.9274	21.08	--32.0
14	270	96	27.6	0.9237	21.69	--32.7
15	270	168	23.6	0.9212	22.10	--34.0
16	270	240	20.0	0.9186	22.54	--35.0

Viscosity of original bitumen at 50°C = 25425cp
Density of original bitumen at 30°C = 0.9876gm/cc
Gravity of original bitumen at 30°C = I 1.78°API
Pour point of original bitumen at 30°C 21.5°C

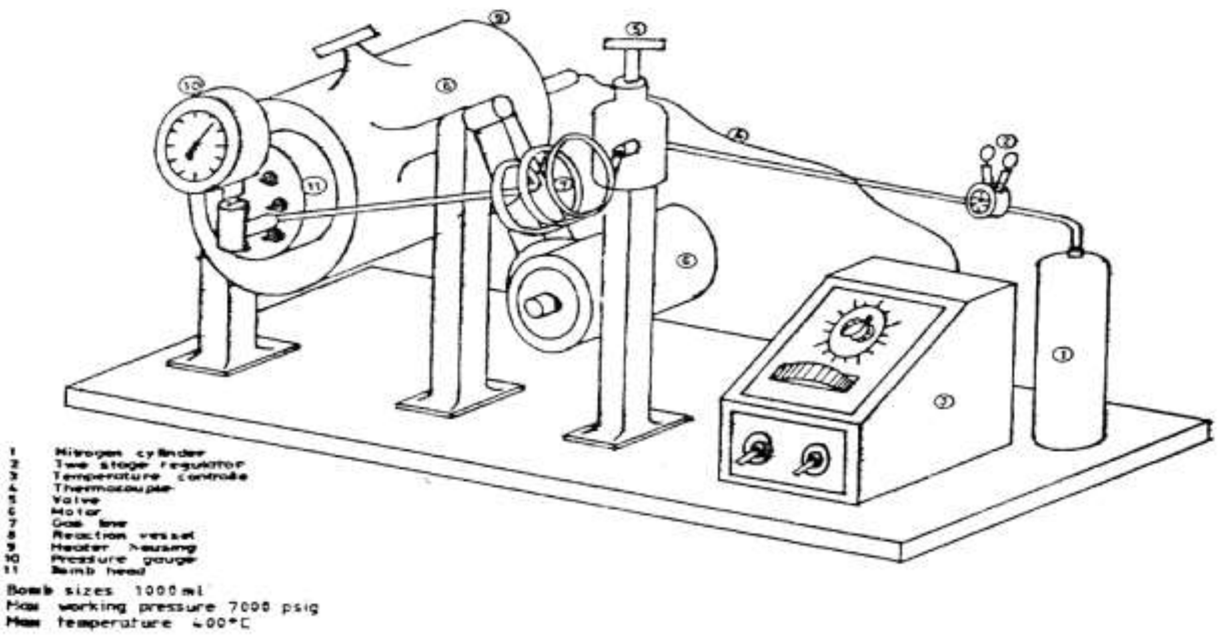
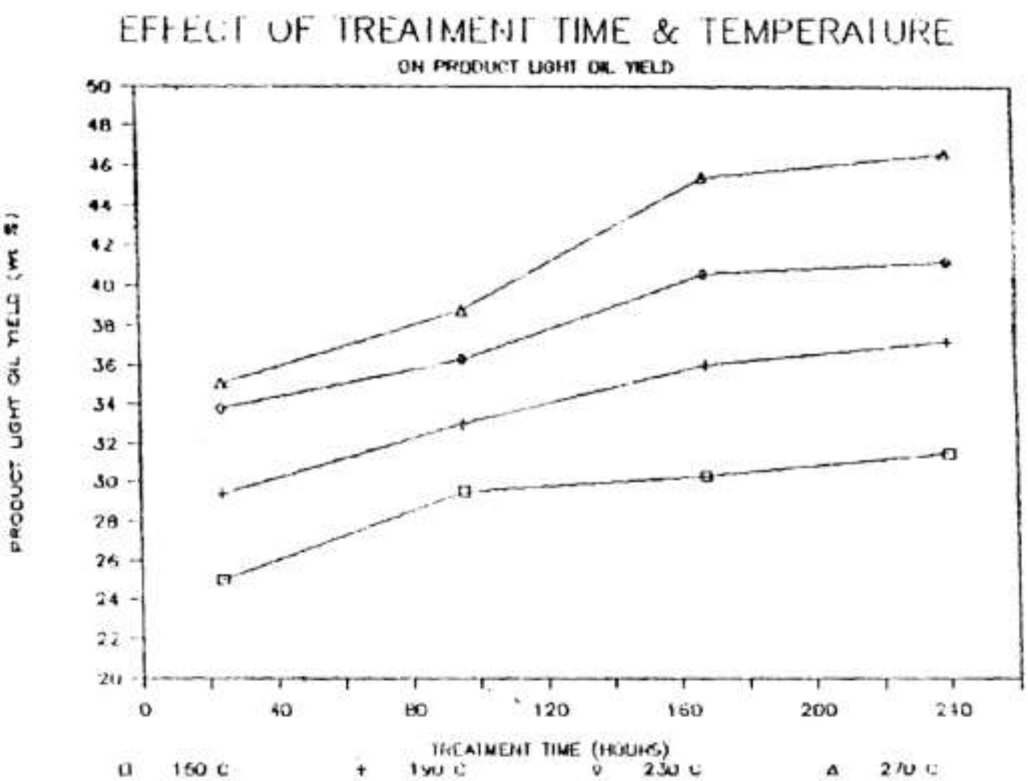
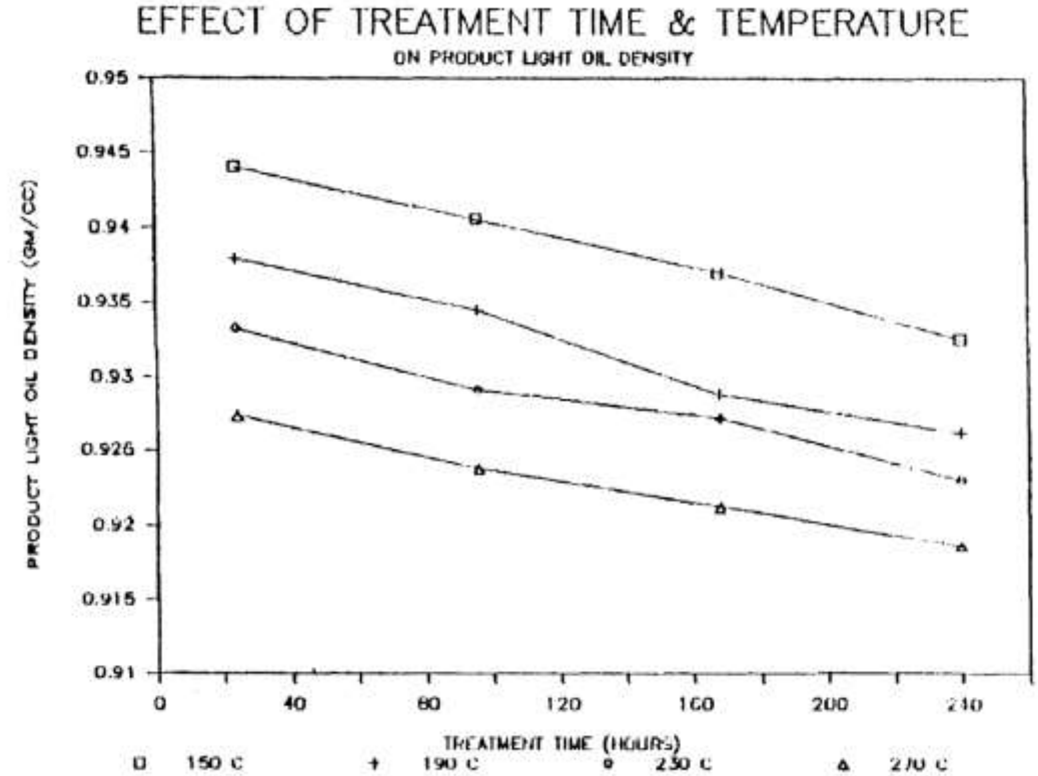
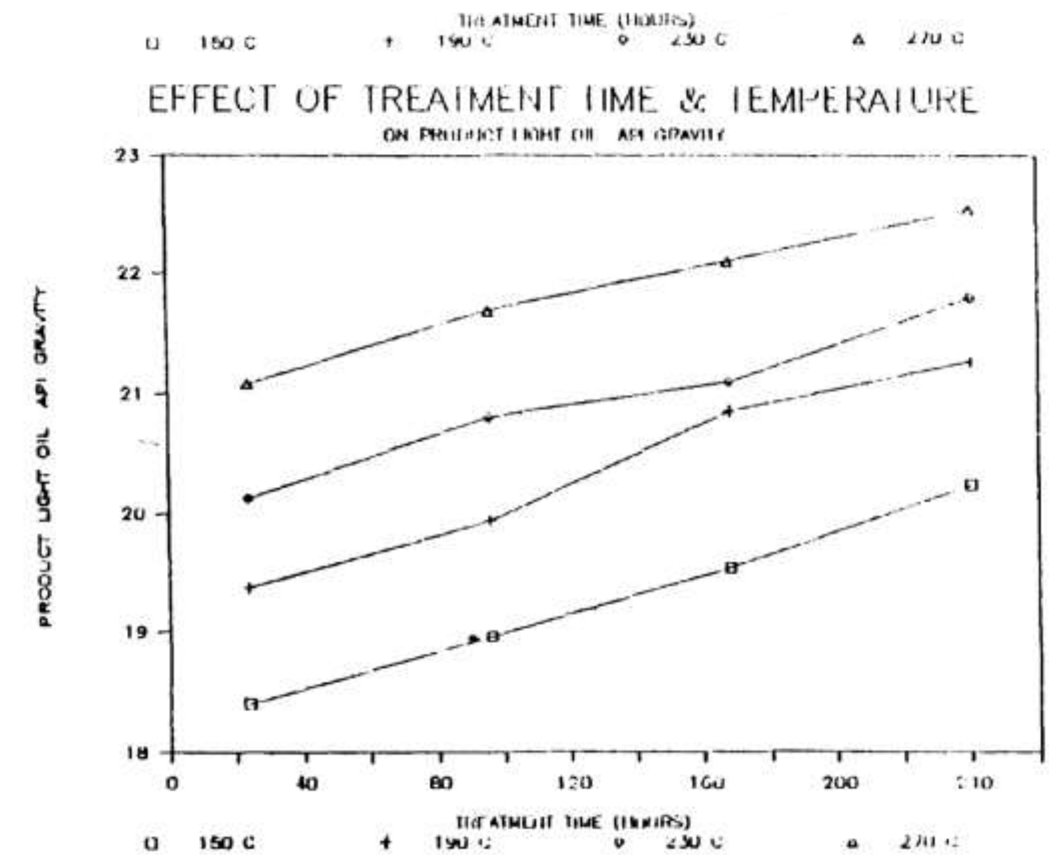
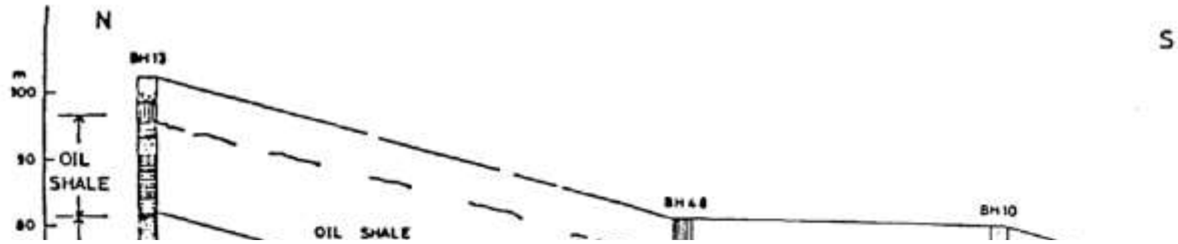


Fig. : Schematic of the High Pressure Reactor (ROCKER TYPE)




EFFECT OF TREATMENT TIME & TEMPERATURE
ON PRODUCT LIGHT OIL DENSITY
PRODUCT LIGHT OIL DENSITY (GM/CC)
0.95
0.945
0.94
0.935
0.93
0.926
0.92
0.915
0.91
0
40
80
120
160
200
240
TREATMENT TIME (HOURS)
150 C
190 C
230 C
270 C


EFFECT OF TREATMENT TIME & TEMPERATURE
PRODUCT LIGHT OIL API GRAVITY
23
22
21
20
19
18
0
40
80
120
200
TREATMENT TIME (HOURS)
150 C



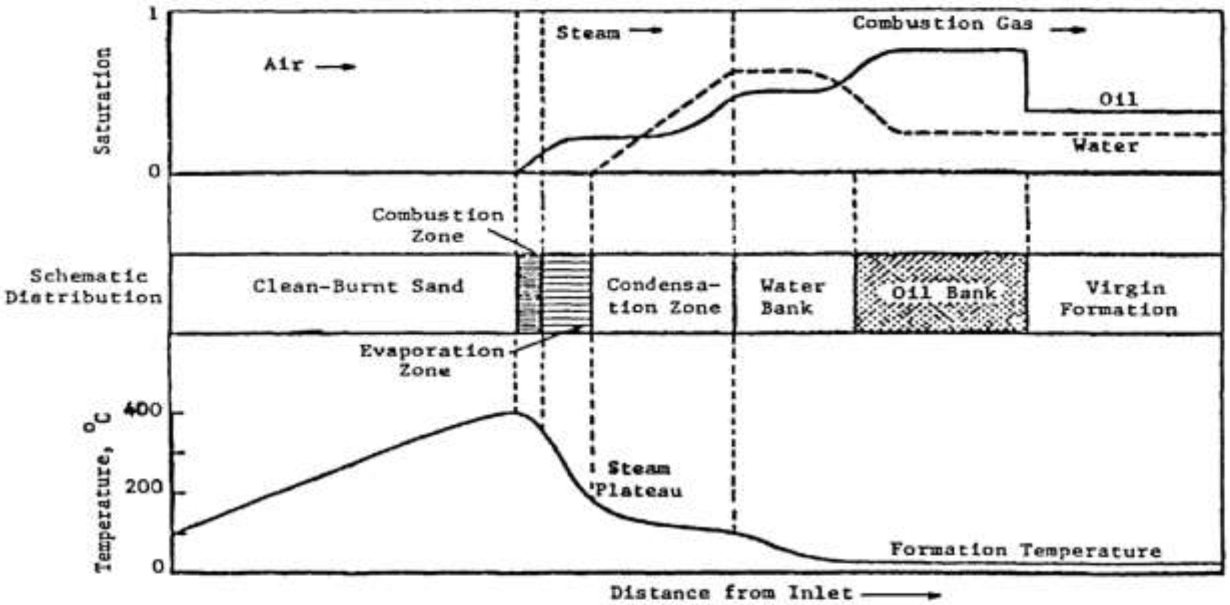


Figure 2: Schematic diagram of the forward combustion process

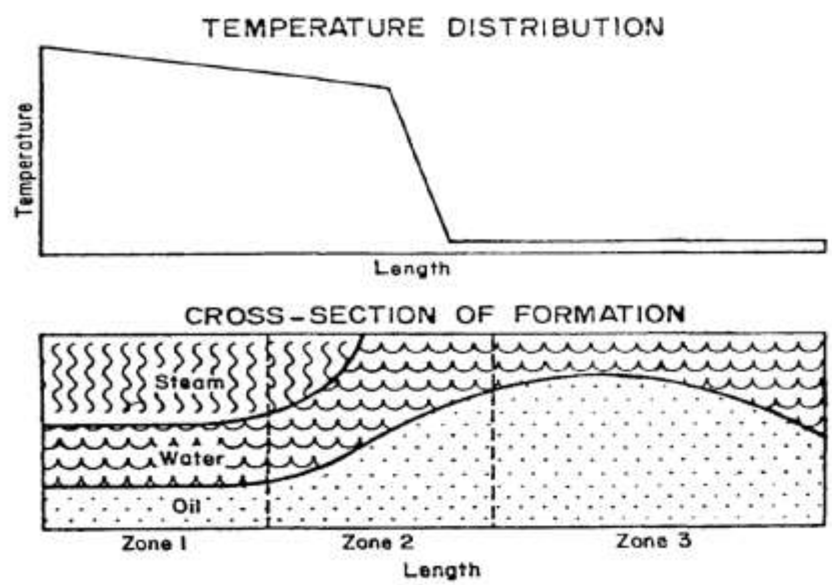


Figure 3: Schematic diagram of the steam injection process

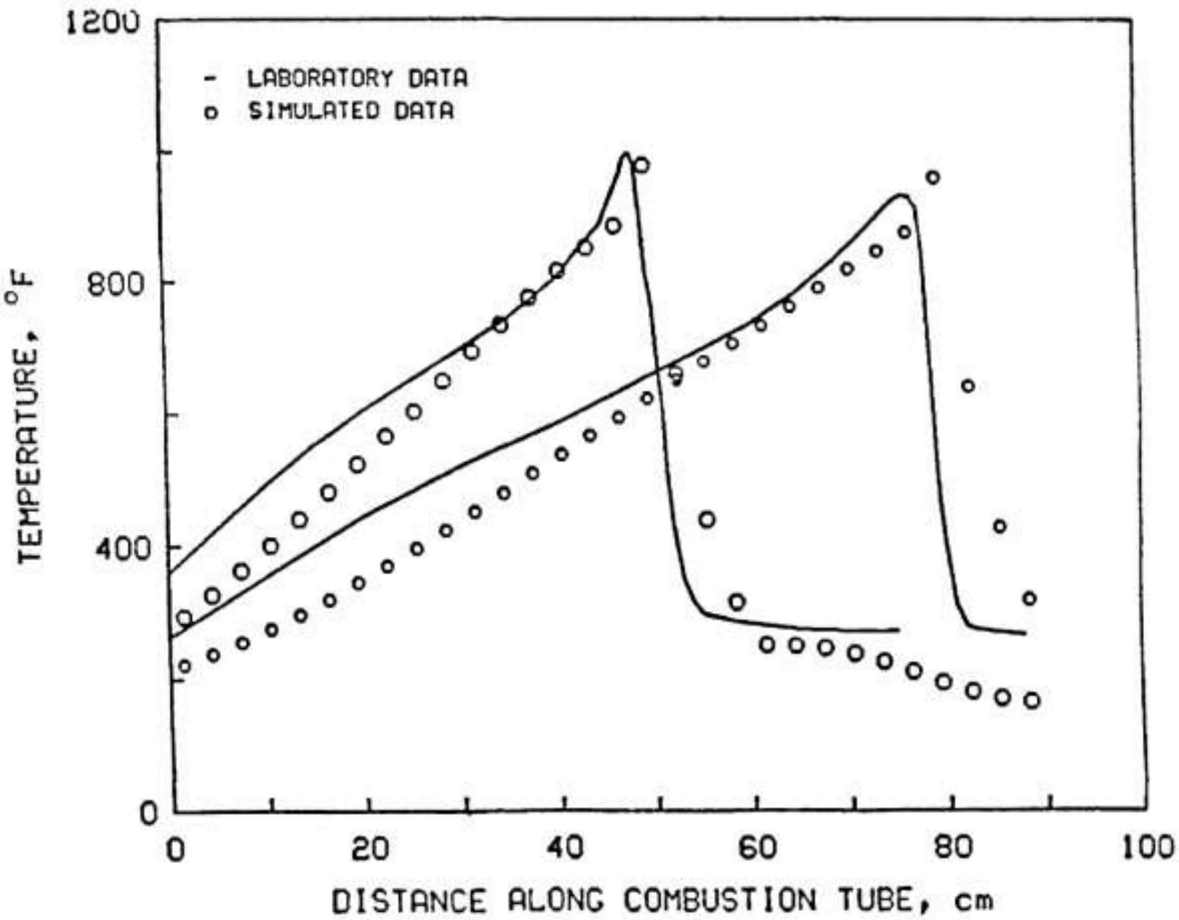


Figure 4: Simulated and laboratory in-situ combustion temperature profiles

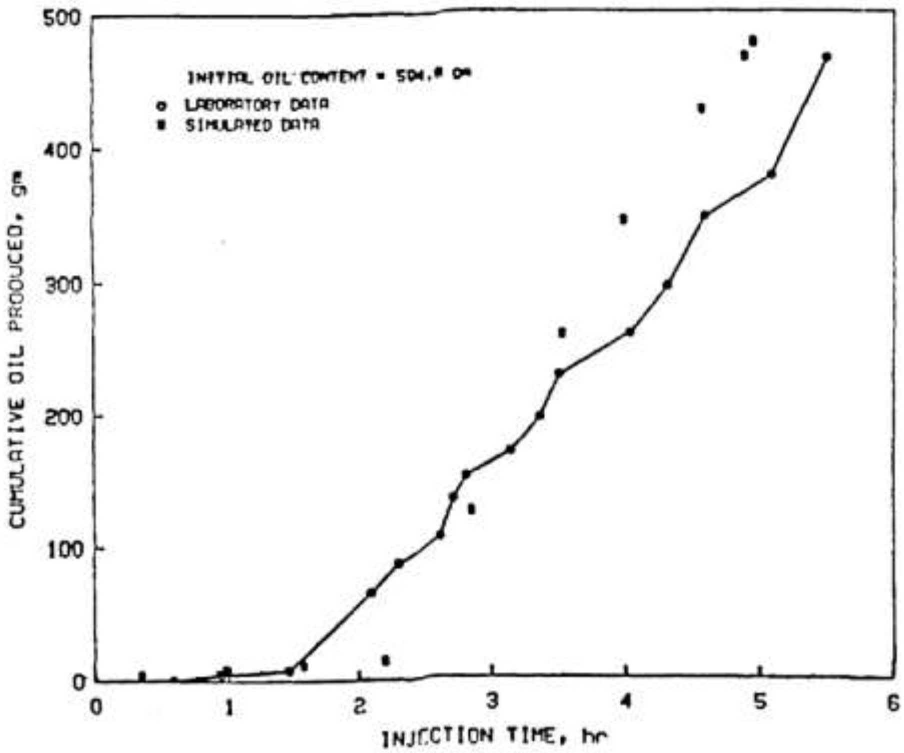


Figure 5: Simulated and laboratory in-situ combustion cumulative oil production

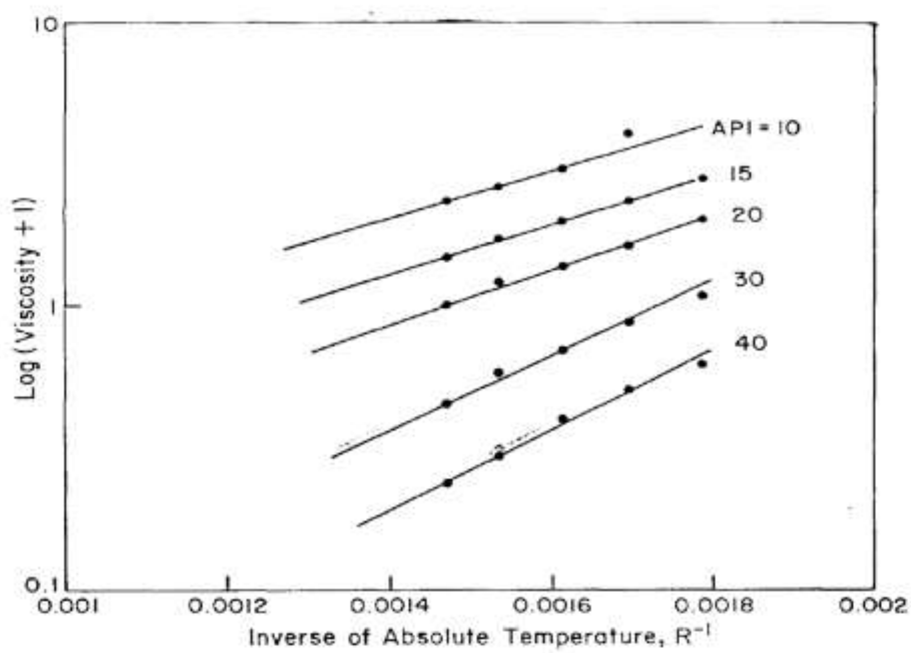


Fig. 6 Semilog graph of log(viscosity + 1) vs. inverse of absolute temperature for different API gravity oil

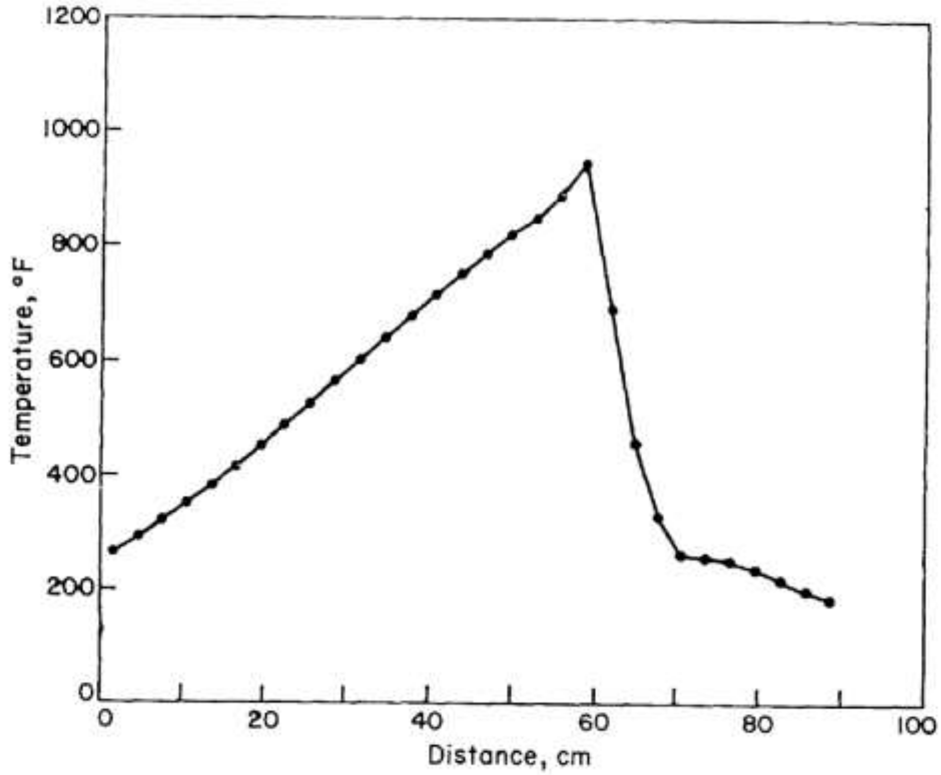


Fig. 8 Simuated combustion temperatures for 10 API gravity oil