Ministry of Science and Education of Republic of Kazakhstan
Institute of Combustion problems
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The development of methods for processing and using of oil sands as the alternative hydrocarbon feedstock

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One of the most important achievements of recent years is the creation the technology for extraction of "heavy" oil from oil sands, that is intensively developing on Canada. The extraction of this deposits of oil sand which are rich of hydrocarbons brought Canada to 2-ond place in the word oil resources terms and has radically changed the geopolitical situation in the oil industry.

Venezuela also has the richest deposits of oil sands (Orinoco belt), as well as Russia and Kazakhstan. The processing of these resources will probably postpone the peak of world oil production to the middle of the current century.

Oil sand is a natural combustible mineral resources whose organic part is a natural bitumen.

Oil sands reserves in western part of Kazakhstan are significant and using them as a valuable material for fast developing area of road construction is an actual problem which solution can greatly reduce the final cost of road construction.

Kazakhstan is the 9th largest country in the world, covering an area of 2,717,300 km^2 and government has agreed the program for the improvement of infrastructure and road construction across the country.

V.S. Arutyunov. Syr'yevaya lovushka ili fundament dlya protsvetaniya // Khimiya i zhizn' – XXI vek, № 7. – Moscow, 2010. – P.15-19.

Actuality of the theme

Nowadays the oil production sector has a leading positions in the structure of national economy of Kazakhstan.

Being as an oil producing country, Kazakhstan also has over 50 huge oil sands (oil-bituminous sands, tar sands, extra heavy oil) deposits, which can ne used as an alternative source of hydrocarbons. The organic part of oil sands ranges from 9 to 95% according to the type of deposit and the depth of oil sands deposit

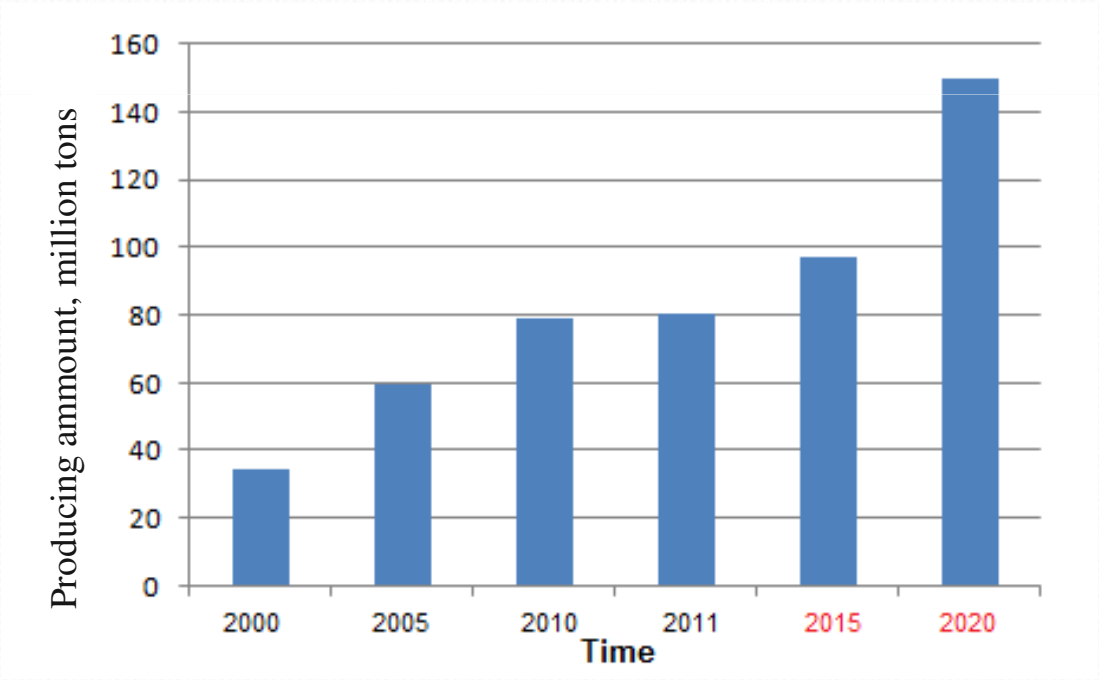


Figure 1. Oil production in Kazakhstan

Oil bitumen are widely used in many industries, therefore their production is a fast growing sector of economy.

Oil bitumen can be used as a main source in road construction, but the main problem in this field is the poor quality of bitumen used in asphalt-concrete pavements. Characteristics of bitumen completely mismatch with the climatic conditions of our country, it doesn't maintain sharp differences of temperatures from -40 up to 40°C .

Our country to satisfy the need of bitumen materials still import it from Russia and Iran

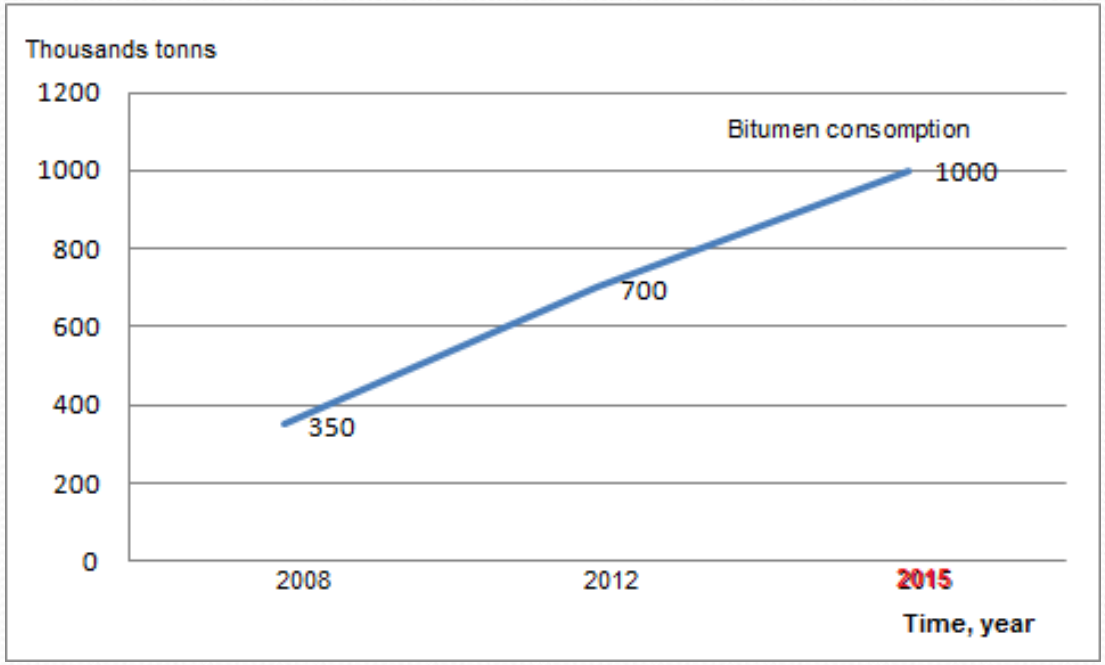


Figure 2. Bitumen consumption in Kazakhstan

The research of the Laboratory of oxidizing processes of hydrocarbon raw material of ICP is based in processing of oil sands of Kazakhstan Republic in 3 ways:

- Extraction of organic part of oil sands of Kazakhstan deposits using different organic solvents with subsequent oxidizing it to bitumen, that is used for road construction
- Thermal processing of oil sands of Kazakhstan deposits with obtaining of synthetic oils
- Ultrasound processing of oil sands using aqueous solutions of alkaline metals as a surfactants.

Figure 3. Pictures of oil sands

Extraction of oil sands

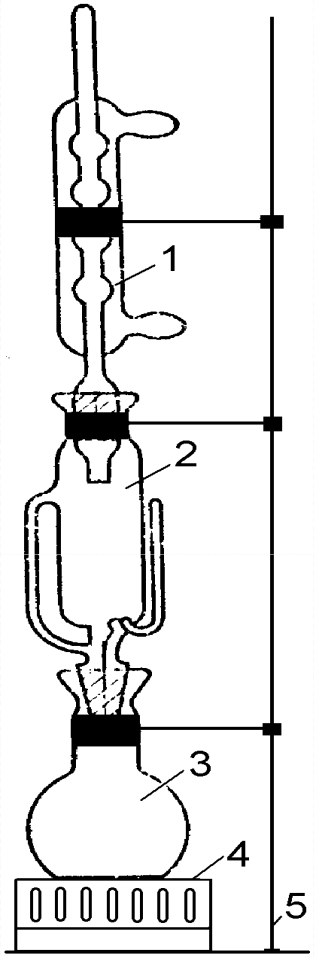


Figure 4. Installation for extraction of organic part
1-reflux condenser, Soxhlet apparatus
3-flask, 4- heating plate, 5-upright

Used Solvents for extraction

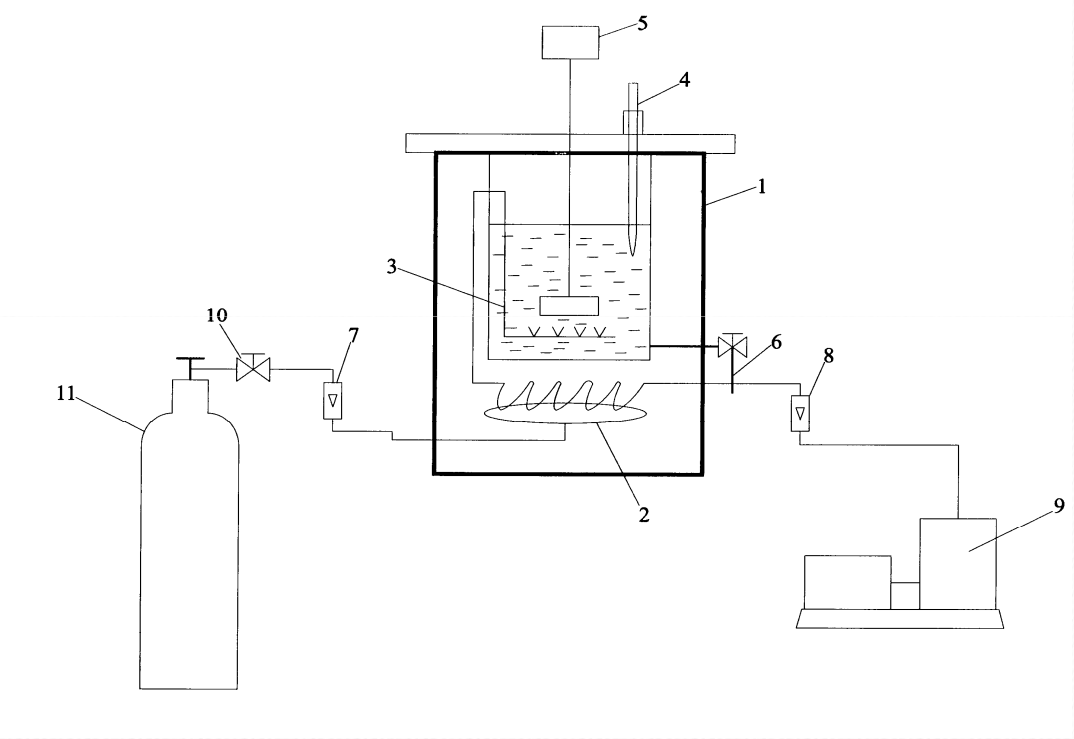
Solvents	Hexane	Toluene	The ethanol and benzene mixture (the ratio of ethanol: benzene was equal to 1: 4)
Boiling point of solvents, °C	69	111	80.1 and 78.37

Figure 5. Picture of sand after extraction:
1- Hexane; 2- Toluene;3- ethanol/benzene

Table 1. Extraction of organic part of oil sands of Munaily Mola deposit using different solvents

Solvents / Characteristics	Hexane	Toluene	Ethanol and benzene mixture
Content of organic part, wt. %	15.5	16.5	15.9
Density, g/cm^3	0.997	0,998	0.987

Figure 6. The scheme of oxidizing of organic part of oil sands with subsequent obtaining of bitumen with special characteristics for road construction



1 – reactor, 2 – burner, 3 - the tube for supplying of air, 4 - thermometer, 5 - a motor for stirring, 6 - the tube for draining of bitumen, 7, 8 – rotameters, 9 – compressor, 10 – valve, 11 - cylinder propane-butane mixture.

Physic-chemical parameters of bitumen obtained by oxidizing of natural bitumen of Beke deposit at T=230°C

Name of parameter	Sample № 1	BND 90/130	Sample № 2	BND 40/60	Sample № 3
Needle penetration depth at 25 °C, 0.1 mm	115	91-130	46	40-60	30
Ring and ball Softening point, °C	44	not less than 43	52	not less than 51	65
Ductility at 25 °C, cm	76	at least 65	45	at least 45	8
Flash point, °C	237	no less than 230	235	Not less than 230	220

Physic-chemical parameters of bitumen obtained by oxidizing of natural bitumen of Beke deposit at T=240°C

Name of parameter	Sample № 1	BND 60/90	Sample № 2	BND 40/60	Sample № 3	BN 70/30
Needle penetration depth at 25 °C, 0.1 mm	62	61-90	43	40-60	29	21-40
Ring and ball Softening point, °C	53	Not less than 47	61	Not less than 51	70	70-80
Ductility at 25 °C, cm	64	At least 55	31	At least 45	12	at least 3.0
Brittleness temperature, °C	-16	not higher than -15	-10	not higher than -12	-	-
Flash point, °C	225	230	232	230	239	Not less than 240

Physic-chemical parameters of bitumen obtained by oxidizing of natural bitumen of Beke deposit at T=270°C

Name of parameter	Sample № 1	BN 70/30	Sample № 2	BN 90/10	Sample № 3
Needle penetration depth at 25 °C, 0.1 mm	32	21-40	12	5-20	7
Ring and ball Softening point, °C	72	70-80	85	90-105	92
Ductility at 25 °C, cm	18	at least 3.0	4,0	at least 1.0	2,1
Flash point, °C	238	not less than 240	235	not less than 240	

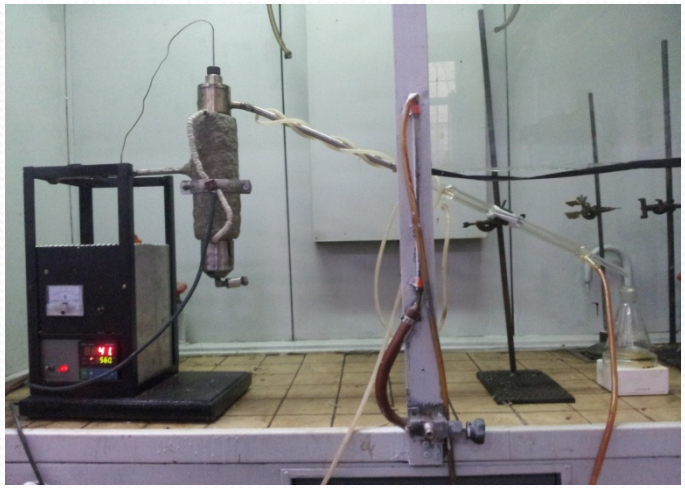


Figure 7. Laboratorial installation for thermal processing of oil sands

Figure 8. Pilot installation for thermal processing of oil sands

Table 5. Characteristics of organic part of oil sand of Beke deposit obtained by extraction

Parameters	Oil sand of Beke deposit
Density, g/cm^3	1,112
Total sulfur content, %	1,5
Elemental composition, % Carbon Hydrogen Oxygen Nitrogen	 84,79 11,68 2,95 0,58
The ash content, %	0,35
Coking,%	30
Ring and ball Softening point, °C	20,0
Temperature of hardening, ° C	18,0
Needle penetration depth at 0 °C, *0,1 mm	17

Table 6. Physic-chemical properties of oil sands products obtained using thermal method

Parameters	Oil sand of Beke deposit
Yield of products , wt. % Gaseous Liquid Solid residue	 5,4 9,6 85,0
Characterization of liquid fraction : Density, g/cm^3 Total sulfur content, wt. %	 0,850 0,77
The ash content, wt. % Coking, wt. %	0,38 15
Flash point, °C Temperature of hardening, ° C	42 -38

Table 7. Detonation characteristics of oil fractions obtained by thermal processing Beke oil sands

Parameters	Obtained synthetic oil	Gasoline fraction 80-180 ^{0}C	Diesel fraction 180-250 ^{0}C	Gasoil Fraction 250-320 ^{0}C
1. Octane number	-	80	not determined	not determined
2. Cetane number	-	-	above 45	not determined
3. Flash, ^{0}C	-	-	35-40	-
4. Density at 20 ^{0}C, kg/m^3	0,870	0,754	0,817	0,864
5. Temperature of hardening, ° C	-40	not determined	-50-55	-45
6. Filterability temperature limit, ^{0}C	Above -35-40	not determined	above -40	above -25
7. Benzene, vol.%	-	1	not determined	not determined

Fractional composition , wt. %:	Natural bitumen of Beke oil sands
I.B.P. – 180 °C	8,9
180-250 °C	13,0
250-350 °C	35,0
350-F.B.P.	34,5

Table 8. Fractional composition of organic part of Beke oil sand extracted with organic solvents

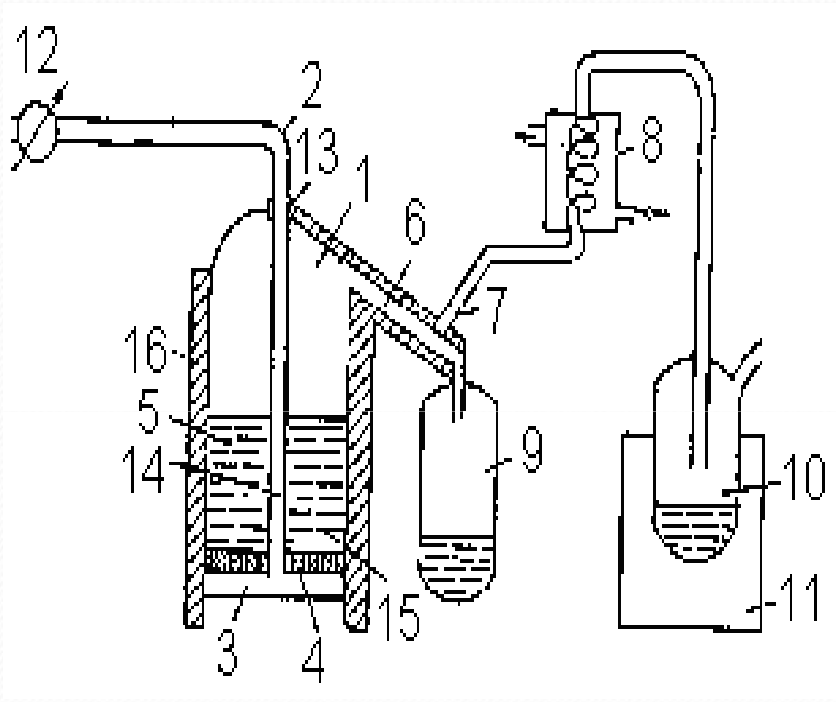
Fractional composition , wt. %:	Organic part of Beke oil sands
I.B.P. – 180 °C	19,6
180-250 °C	24,0
250-350 °C	43,0
350 - F.B.P.	13,4

Table 9. Fractional composition of synthetic oil obtained by thermal processing of Beke oil sands

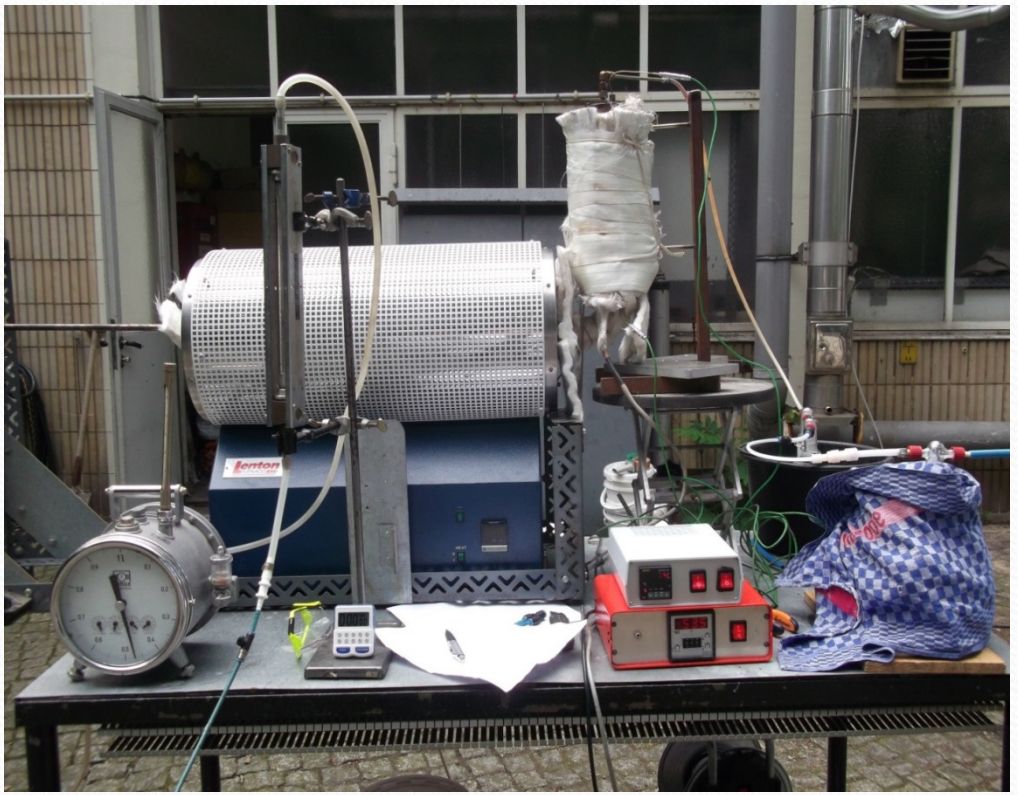
Figure 9. Thermal Processing of Munaily Mola oil sands in the presence of hydrocarbon gas

A – Scheme of installation for Processing of oil sands in the presence of hydrocarbon gas;

B – Picture of installation for Processing of oil sands in the presence of hydrocarbon gas



A



B

1 - cylindrical reactor, 2 – tube for gas, 3 – collector for gas, 4 - perforated diaphragm, 5 - raw material, 6 - tube for gas and products output, 7 – tube, 8 - refrigerator, 9 – product container, 10-Trap for gaseous products, 11 - liquid nitrogen or mixture of dry ice-acetone, 12 – flowmeter, 13, 16 – heating element

Table 10. Fractional composition of organic part of Munaily Mola oil sand obtained by its thermal processing with different flow rate of propane-butane mixture into reaction zone

Gas flow rate, l / h	The yield of liquid fractions, wt. %			Solid residue, wt.%
	I.B.P.– 180°C	180-240°C	240-350°C	
Without gas	6,1	15,1	46	28,8
27	8,1	29,9	33,3	23,9
45	10,3	36,3	27,6	21,3
66	11,3	39,7	24,6	18,8
84	10,7	36,4	26,8	21,1
108	10,5	35,8	27,2	19,6

Hydrogenation of natural bitumen of Munaily Mola oil sand obtained by extraction with organic solvents in Soxhlet apparatus.

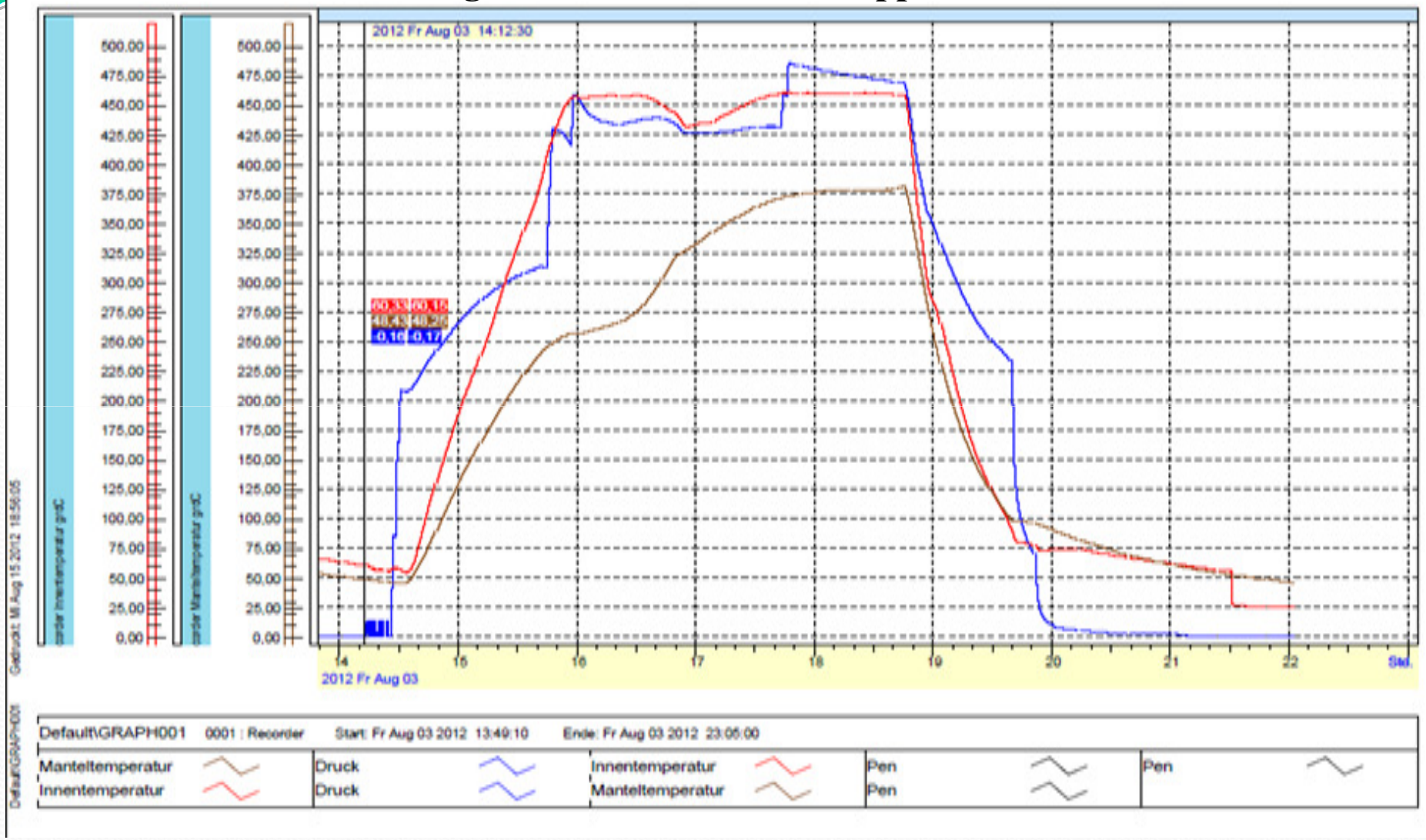


Figure 10. The temperature and pressure profiles over time for process of Hydrogenation of natural bitumen of Munaily Mola oil sand

Table 11. Fractional composition of hydrogenated natural bitumen Munaily Mola

Parameters	Fractions of hydrogenated natural bitumen		
	I.B.P. – 215 °C	216 – 316 °C	**316 °C – F.B.P.**
Pressure, mbar	808	805 – 60	**60 -**
Weight of fraction, gr	80,39	72,72	**43,88**
Yield of fraction, %	**40,81**	**36,91**	**22,27**

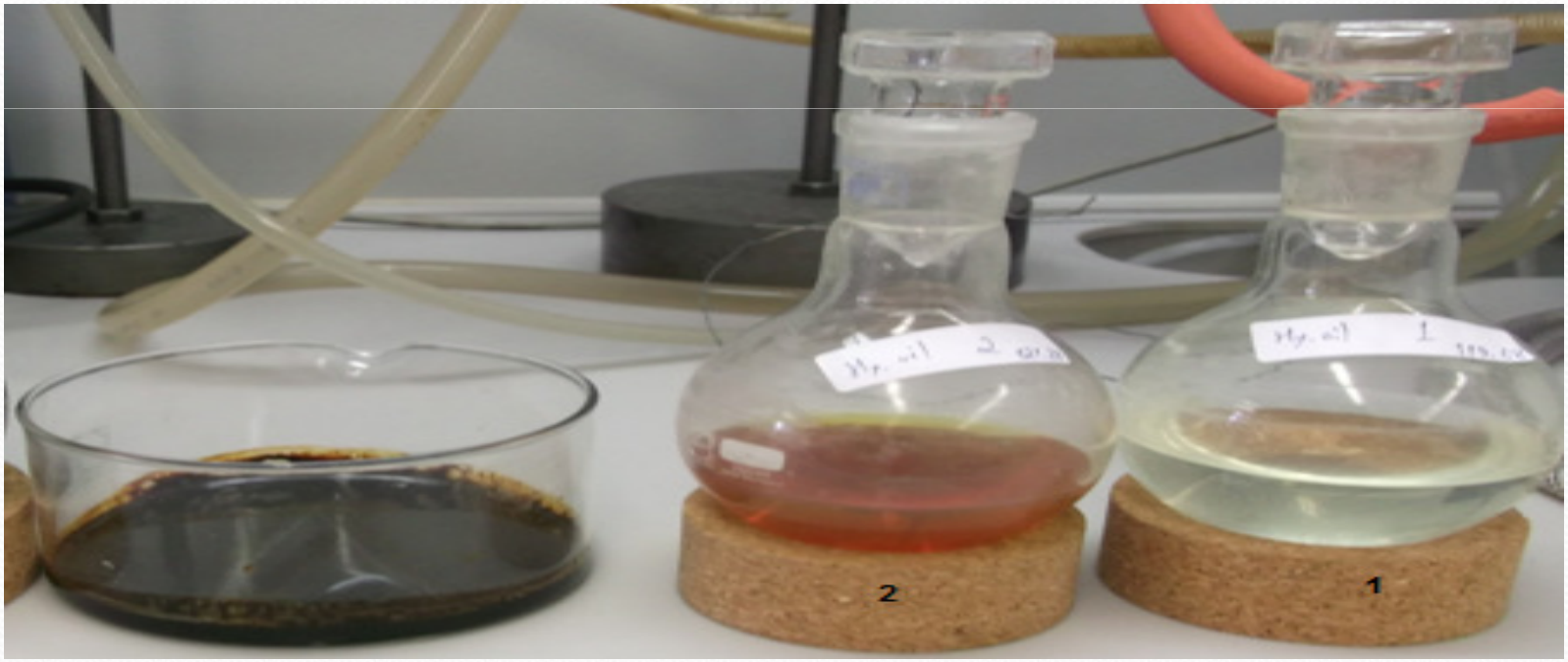


Figure 11. Picture of obtained fractions of hydrogenated natural bitumen of Munaily Mola oil sand

Conclusions

- ✓ It is was shown that extracting of organic part of oil sands using Soxhlet Apparatus with its subsequent oxidizing leads to formation of bitumen of different types that can be used in road construction
- ✓ It was shown that thermal processing of oil sand leads to obtaining of organic part with density close to heavy oils. The comparison of physic-chemical properties and fractional compositions of extracted natural bitumen in Soxhlet Apparatus and organic part of oil sands that was obtained by thermal method allow us to call the product of thermal processing of oil sand as a synthetic oil
- ✓ It was shown that addition of hydrocarbon gas inside the reaction zone makes the possibility of increasing of yield light fractions of organic part that was obtained by thermal method
- ✓ As a alternative way of increasing of light fractions of natural bitumen obtained by extraction in Soxhlet Apparatus using hydrogenation was shown. It was found that after the hydrogenation process the light fraction I.B.P. – 215°C increased to 41%. Unfortunately hydrogen that used in hydrogenation of natural bitumen is still to expensive to scale-up this process.