

New Technologies of Processing Inferior Heavy Oil

Science & Technology Management Department

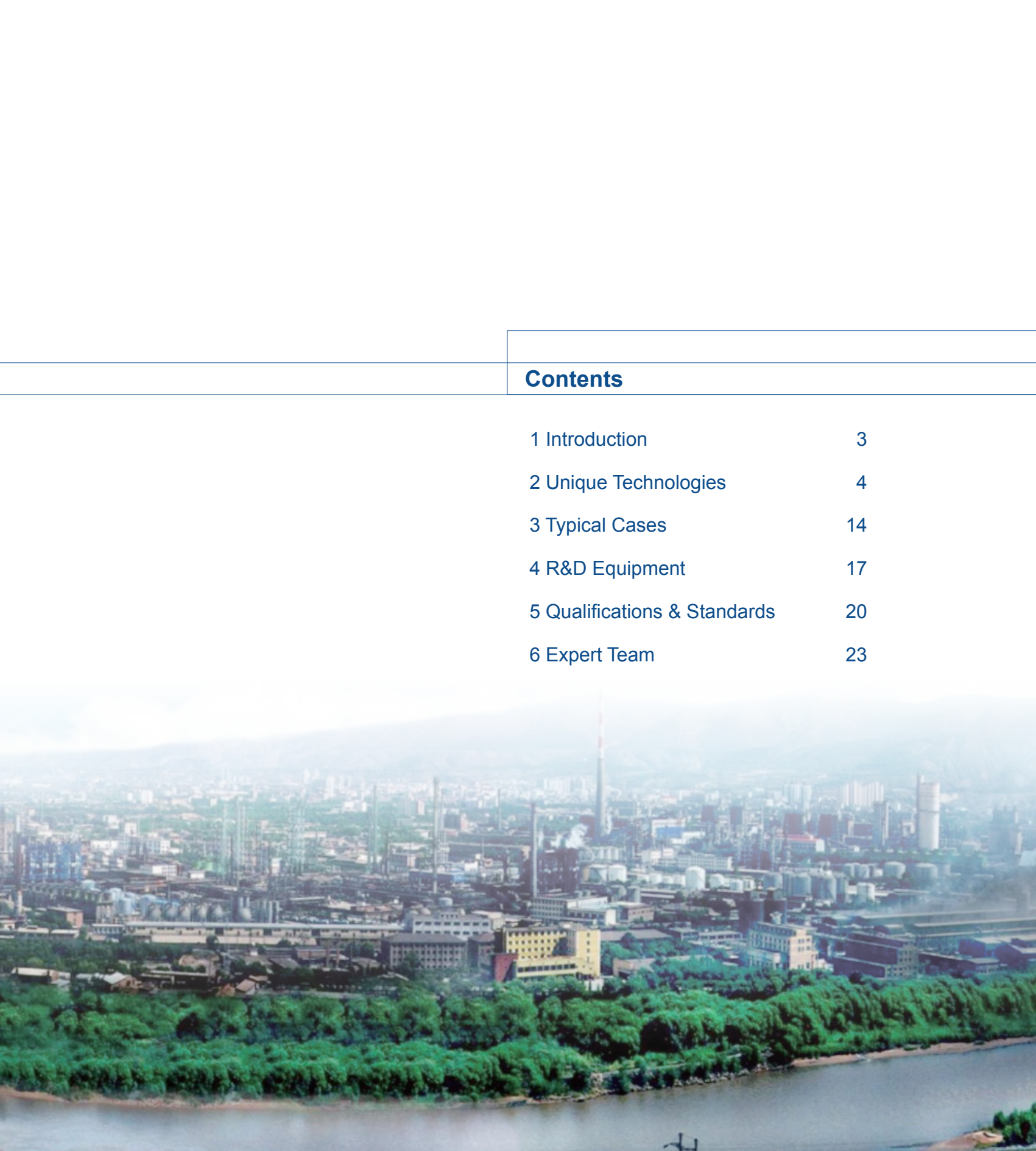
■ 2013



CHINA NATIONAL PETROLEUM CORPORATION

*New technologies of processing inferior heavy
oil in China – to facilitate efficient resource
utilization!*





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China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorganized to become an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integrations of upstream and downstream operations, internal and external trade, production and marketing. CNPC's business covers six main sectors: oil and gas operations, petroleum engineering service, petroleum engineering construction, petroleum equipment manufacturing, financial services and new energy development. In 2012 CNPC produced 110 million tons of crude oil and 79.82 billion cubic meters of natural gas, while crude processing volume reached 191 million tons. The total revenue of RMB 2,690 billion with a profit of RMB139.1 billion had been achieved the same year.

CNPC was ranked 4th among the world's largest 50 oil companies and 6th in Fortune Global 500 in 2012.

CNPC strictly follows by the combined strategies of increasing resource capacity, expanding market shares and consolidating the international role, and persists in regarding technical innovation as a key framework to advance technological progress. To develop its core businesses, focuses will be placed on the solutions of key bottleneck technologies and key proprietary technologies. Thanks to continuously improving of the technical innovation system, optimizing the configuration of technological resources and strengthening the construction of strong talent teams, CNPC's technological creativity has been considerably upgraded. Consequently, a large number of technologies have been developed independently, with its own intellectual property.

[New Technologies of Processing Inferior Heavy Oil](#) is one of representatives for major innovations of CNPC.

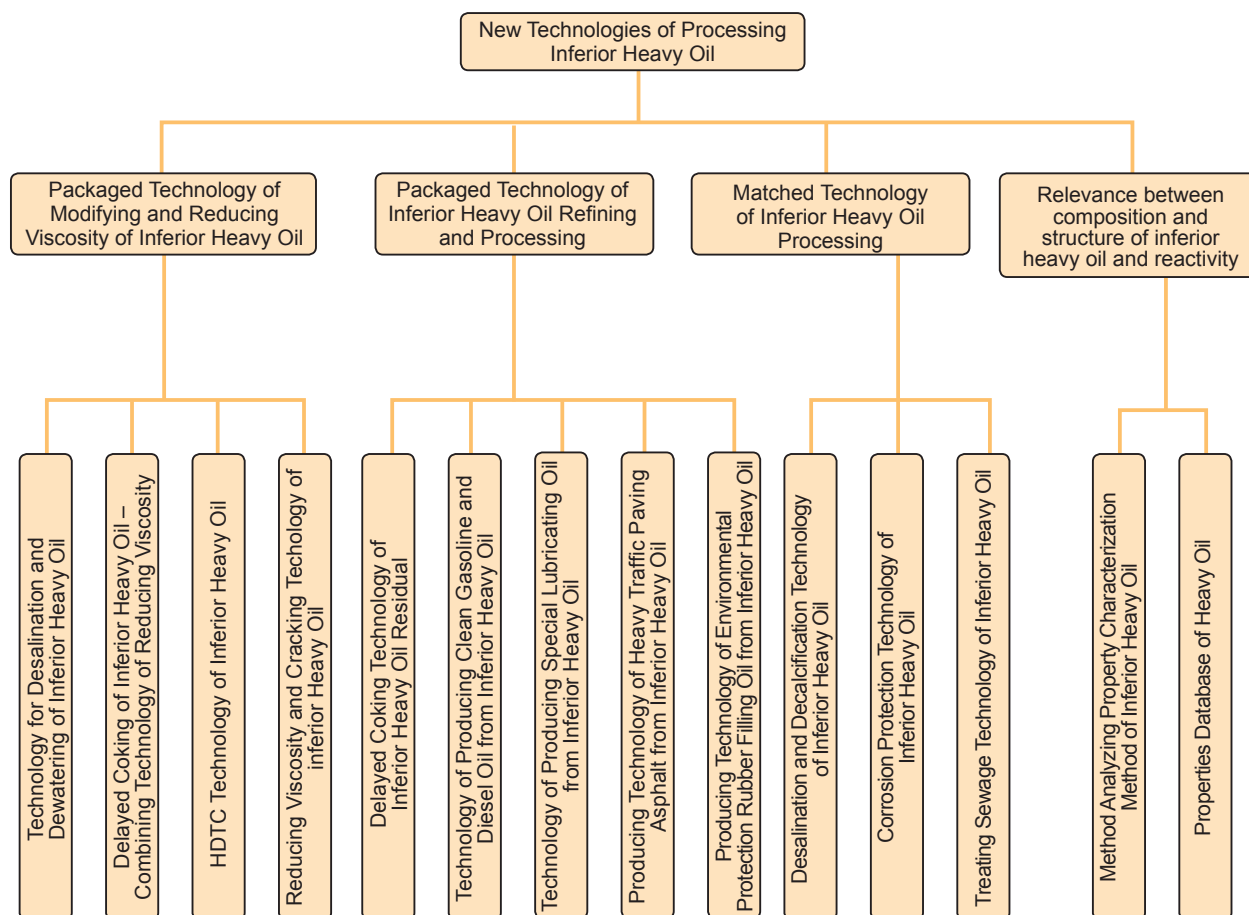
CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT

1

INTRODUCTION

Considering the requirements of development and utilization of inferior heavy oil in China and abroad, CNPC developed new technologies of processing inferior heavy oil such as extremely heavy oil, super heavy oil, and oil sand bitumen, and succeeded in key technologies including hydrogen-

donating thermal cracking, delayed coking, bitumen production, corrosion protection, sewage treatment, established the first database for heavy crude oil in the world. CNPC possesses over 133 domestic and overseas patents of invention, technology secrets, standard and software copyrights.



2 UNIQUE TECHNOLOGIES

2.1 Packaged Technology of Modifying and Reducing Viscosity of Inferior Heavy Oil

Packaged technology of modifying and reducing viscosity of inferior heavy oil includes technologies of desalination, dewatering, combined delayed coking – viscosity reduction of inferior heavy oil, hydrogen-donating thermal cracking, and viscosity breaking.

2.1.1 HDTC Technology of Inferior Heavy Oil

During HDTC, an amount of hydrogen donor is

supplied to residual oil thermal cracking process, which partially terminates macro-molecule free radicals produced in thermal cracking to increase conversion rate and to improve peptization of residual oil, which further raises storage stability of product oil.

Technical Features

- Optimizing the appropriate fraction for hydrogen donor to optimize process parameters.
- For Venezuelan vacuum residual oil $> 420^{\circ}\text{C}$, after HDTC and blending, kinematic viscosity of



Tubular device of long term storage stability of modified oil from inferior heavy oil



HDTC industrial application of inferior heavy oil

modified oil at 50 °C can be controlled at around 200mm²/s with API scale 11~12 and without stratification after stored for 90 days.

Scope of Application

Applicable to modification, viscosity reduction and processing of Venezuelan wellhead oil, which can reduce viscosity of crude oil with long storage ability of modified oil, satisfying requirements for long delivery of Venezuelan super heavy oil.



2.1.2 Reducing Viscosity and Cracking Technology of Inferior Heavy Oil

During viscosity reduction and cracking, through mild thermal cracking, residual oil with high viscosity is mildly cracked to produce fuel oil with low viscosity and low flow point that meets specification requirements.

Technical Features

- Optimize process parameters of viscosity reduction and cracking.
- For Venezuelan residual oil >350°C, after viscosity reduction, cracking and blending, kinematic viscosity of modified oil at 50 °C can be controlled at around 200mm²/s with API scale 11~12 and without stratification after stored for 90 days.



Plants for viscosity reduction and cracking

Scope of Application

For Venezuelan residual oil $>350^{\circ}\text{C}$, and Venezuelan vacuum residual oil $>420^{\circ}\text{C}$, after viscosity reduction and cracking, product is blended with crude oil to reduce viscosity of crude oil. Modified oil can satisfy requirements for long term storage stability and is applicable for long delivery of Venezuelan super heavy oil.



2.2 Packaged Technology of Refining and Processing Inferior Heavy Oil

Packaged technology of refining and processing inferior heavy oil includes technologies of residual oil delayed coking, cascade separation of residual oil, producing clean diesel oil, producing special lubricating oil, producing heavy traffic paving asphalt, and producing environmental protection rubber filling oil. CNPC developed a package of mature technology solutions for most inferior crude oil in the world.





2.2.1 of Delayed Coking Technology of Inferior Heavy Oil Residual

As a method for deep thermal conversion of heavy oil, The delayed coking technology features in high adaptability, high deep conversion, and low in investment. In addition, product coker gasoline can be used for producing ethylene after hydrogenation. The coker diesel oil has high cetane number. The coker gas and rich gas can be used for producing hydrogen. With significant advantages and zero release, coking process has been one of the preferred selection for modification of heavy oil.

Technical Features

- Restraining the production of coke, optimize process parameters during delayed coking, and the developed process package of delayed coking of 4,300,000 t/y heavy oil.
- Improving liquid yield and reducing energy consumption by modifying heating furnace, coking drum, and fractionating system.
- Combination of optimized viscosity reduction coking process improves total liquid yield by 5% and reducing coke produced by 1.5% comparing to process of delayed coking.





Scope of Application

Venezuelan vacuum residual oil of super heavy oil, Venezuelan MEREY 16 vacuum residual oil, vacuum residual oil of Liaohe extremely heavy oil, Karamay Fengcheng vacuum residual oil of extremely heavy oil.



2.2.2 Technology of Producing Heavy Traffic Paving Asphalt from Inferior Heavy Oil

Heavy traffic paving asphalt is mainly used for heavy traffic roads such as express way and airport road which require road asphalt with better load bearing and abrasion resistance. Such asphalt is conventionally produced from less-waxy naphthenic crude. In process of producing heavy traffic paving asphalt from inferior heavy oil, Venezuelan super heavy oil and Liaohe extremely heavy oil are used. Product satisfies quality requirements.

Technical Features

- Three types of process-straight distillation, modification-distillation were successfully developed to produce heavy traffic paving asphalt with Liaohe heavy oil which possesses excellent performance under low temperature. Product satisfies technical requirements.
- Modified asphalt with high performance is produced with industrial bitumen as matrix asphalt.



Scope of Application

Applicable to heavy traffic paving asphalt with high performance is produced with Venezuelan super heavy oil and Liaohe heavy oil.

2.2.3 Technology of Producing Environmental Protection Rubber Filling Oil from Inferior Heavy Oil

Introduction

Raw material of Karamay Fengcheng extremely heave oil is atmospherically and vacuum distilled to produce test oils such as transformer distillate oil, second vacuum distillate, third vacuum distillate, fourth vacuum distillate and residual oil. Rubber filling oils of KN4006, KN4010, and KN4016 that satisfy technical requirements can be produced by three-phase high-pressure hydrogenation.

With Liaohe furfural extract oil as raw material, modified furfural is used as solvent for refining process to improve yield of refined oil. Under appropriate conditions, the CA value can be over 18.0% with all environmental indexes satisfying requirements by EU environmental protection instructions. Yield will be about 40.0%.

Technical Features

- For aromatic oil produced by Liaohe Heavy oil, the conventional solvent refining process is improved and a new technology is innovatively developed.

Scope of Application

With Liaohe Heavy arene-rich furfural extract oil as raw material for first time at home, the environmental protection rubber filling oil with relative high arene content, which that satisfies EU environmental protection regulations is produced.



2.3 Matched technology of inferior heavy oil processing

Matched technology of inferior heavy oil processing includes technologies of desalination and decalcification, corrosion protection, and sewage treatment. In addition to packaged technologies of inferior heavy oil refining and processing, CNPC also developed relevant matched technologies. Metal in inferior heavy oil is difficult to be eliminated due to high content and serious effect on subsequent process. High sulfur and nitrogen contents impose corrosion on equipments. There might be significant amount of metal, hydrocarbon, and sulfocompound in sewage from refineries and may pollute environment without treatment. CNPC provides matched technologies of refining and processing to eliminate the above problems in inferior heavy oil processing.



2.3.1 Desalination and Decalcification Technology of Inferior Heavy Oil

During processing of crude oil, calcium deposit produced by decomposition of organic calcium salt may impose effect and sodium salt may bring corrosion to plants. Under appropriate conditions, desalination is optimized to eliminate salts and calcium in inferior heavy oil.

Technical Features

- Optimize plant structure of crude oil decalcification.
- Establish and configure online analysis to remove delayed analysis on key data during

industrialization process.

- Optimize design parameters of regenerative reactor to allow successive operation instead of intermittent operation, which improves automation and stable operation of plants.
- Propose technologies for electro-desalting super heavy oil blended with olefins, which settle problems caused by effects of high water content in heavy oil on electro-desalting plants and difficulties in dewatering.

Scope of Application

Applicable to desalination and decalcification of inferior heavy oil, especially Karamay Fengcheng extremely heavy oil.



2.3.2 Corrosion Protection Technology of Inferior Heavy Oil

Inherent substances in crude oil, such as inorganic salts of NaCl and CaCl_2 may produce HCl or sulfide such as H_2S , S or mercaptan through hydrolysis, which may impose strong corrosion on equipments. Additives added during recovery or delivery may also impose corrosion on equipments. For long stable plant operation, appropriate corrosion protection measures shall be taken to reduce corrosion.

Technical Features

- Optimize existing corrosion protection technology during crude oil processing with high sulfur and acid contents in China to develop packaged corrosion protection technologies of crude oil processing with high sulfur and acid content.
- Requirements of plant corrosion protection of inferior heavy oil processing can be satisfied by screening appropriate low temperature



corrosion inhibitor and developing technologies of detecting corrosion.

- With Mannich alkali corrosion inhibiting composition as key constituent, three types of corrosion protective neutralizers was developed for processing Karamay low condensation oil, Fengcheng super heavy oil and Venezuela super heavy oil with inhibition efficiency over 90%.
- With decalcification corrosion inhibitor, corrosion inhibition can be up to 98%, which reaches national advanced level.

Scope of Application

Applicable to corrosion protection of equipments of inferior heavy oil processing such as Venezuelan super heavy oil, Liaohe heavy oil, Karamay Fengcheng super heavy oil.



2.3.3 Treating Sewage Technology of Inferior Heavy Oil

As inferior heavy oil is high in acidity, density and viscosity with high colloid, asphaltene and metallic contents which cause high pollutants and complex composition in processing sewage, there are difficulties to satisfy discharge requirements with conventional sewage treatment. Technologies of loop flotation and source control enable treated sewage from refineries to satisfy national discharge standards.

Technical Features

- Process sewage of inferior heavy oil is high in oil content and severe in emulsification. Over 95% of oil in process sewage of inferior heavy oil can be removed by combining CNPC independently developed surfactants and loop flotation separation technology.
- Optimization of combined technologies of loop flotation and biodegradation allow over 80% COD in process sewage of inferior heavy oil to be eliminated.
- Packaged technologies of processing sewage enable processed sewage of inferior heavy oil to meet discharge requirements with 100% overall discharge compliance.



Test facility of loop flotation separation column

Scope of Application

Applicable to treatment of process sewage of inferior heavy oil such as Venezuelan super heavy oil, Liaohe heavy oil, Karamay Fengcheng super heavy oil with sewage discharge indexes satisfying national standards.

1

替代传统的曝气池
substitution of ALR for aeration basin

2

厌氧—好氧耦合处理难降解有机物
Aerobic-anaerobic coupled in ALR

3

现场一体化小型处理设备
Site-integrated airlift bioreactor system

Technology development of sewage treatment by multistage loop column

3 TYPICAL CASES

3.1 HDTC

In 2009, industrial test was successfully completed for plant 400,000 t/y at Guangdong Gaofu. In 2010, industrial application was successful for plant 1,000,000 t/y at Liaohe Petrochemical.

Temperature at reactor inlet(°C)	420	425	420
Main properties of product oil			
Viscosity(50°C)(mm ² /s)	2191	956.9	1296.0
Stability(S value)	2.0	6.4	2.3
Spot test, class	I	I ⁺	I ⁺
Toluene insoluble(m%)	0.01	0.03	0.09
Toluene insoluble(m%)			
Viscosity(50°C)(mm ² /s)	132.5	113.6	114.8
Stability (S value)	0.1	0.1	0.1
Spot test, class	I	I ⁺	I ⁺
Toluene insoluble(m%)	0.007	0.02	0.07

	Item	Flow (ten thousand tons)	Yield (%)
Input, 4.72 million tons	Inferior heavy oil	400	100
	Diluents	72	
Output, 4.72 million tons	Gas	7.56	1.89
	Diluents	72	
	Synthetic oil	392.44	98.11



Plant 400,000 t/y at Guangdong Gaofu



Plant 1,000,000 t/y at Liaohe Petrochemical

3.2 Delayed Coking Technology of Inferior Heavy Oil Residual

In 2011, industrial application for delayed coking of Venezuelan super heavy oil obtained success on 1,000,000 t/y coking delaying plant at Liaohe Petrochemical, which indicates CNPC has become the third organization possessing completely independently developed coking technology for Venezuelan super heavy oil after Foster Wheeler and ConocoPhillips of USA.



Coking delaying plant of 1,000,000 t/y at Liaohe Petrochemical

Items	Circulating ratio 0.3	Circulating ratio 0.1	Circulating ratio 0.6
	Yield(%)	Yield(%)	Yield(%)
Dry gas	9.44	7.95	10.88
Liquefied gas	2.36	2.05	2.56
Gasoline	12.58	11.23	14.81
Diesel oil	37.57	31.31	39.15
Wax oil	8.03	20.15	0.44
Shed oil	2.17	1.83	2.52
Coke	27.71	25.35	29.54
Loss	0.14	0.13	0.1
Yield of light constituent	50.15	42.54	53.96
Liquid yield	58.18	62.69	54.4
Total yield	99.86	99.87	99.9

3.3 Producing Technology of Heavy traffic paving Asphalt from Inferior Heavy Oil

In 2010, industrial application of technology for producing heavy traffic paving asphalt from inferior heavy oil achieved success at plant 1,000,000 t/y at Liaohe Petrochemical.

Considering large molecular weight and high asphaltene content in Venezuelan super heavy oil, technology for mild thermal cracking of blending with Liaohe heavy oil was developed, which has produced over 600,000 tons of asphalt with excellent properties at high and low temperature and increase benefit by 300 million RMB.

In 2011, the 2nd runway at Kunming Airport is completely supplied with such kind of asphalt.



1,000,000 t/y production units at Liaohe Petrochemical



Field application of heavy traffic paving asphalt produced by Venezuelan super heavy oil

Analysis items		AH-90	AH-70	AH-110	Test method
Penetration at 25℃ (1/10mm)		64.6	84.9	105.6	GB/T 4509
Softening point(℃)		48.8	47.5	43.5	GB/T 4507
Penetration ratio(25℃)(%)		56.2	53.5	51.1	GB/T 4509
Ductility, 5cm/min	15℃	16.0	27.0	79	GB/T 4508
	10℃	6.3	8.5	30.0	
Kinetic viscosity at 60℃ (Pa·s)		340	299	340	T0620-2000
Kinetic viscosity at 60℃ (Pa·s)		70~22	70~22	64~22	

4 R&D EQUIPMENT

■ CNPC Petrochemical Research Institute

◇ Over 100 units of heavy oil property and constituent analysis and evaluation equipments/facilities.

◇ Internationally advanced and well equipped pilot test base for various pilot tests.



X-ray diffractometer (left)
X ray fluorescence spectrophotometer (right)



Coupled Full 2D gas
chromatography-time of flight
mass spectrometer



Gas chromatograph

■ CNPC Liaohe Petrochemical Company

◇ Large modern petrochemical company with capacity of 4,500,000 t/y crude oil.

◇ Advanced refining and processing plants which may produce dozens of products in four series-fuel oil, lubricating oil, paving asphalt and polypropylene.

◇ Asphalt production take 1/6 in China with national market share of 1/10, which stays at the No.1 position.

◇ With the resource superiority in specialized low-freezing naphthenic based crude oil, on the basis of lubricating oils such as transformer oil, refrigerator oil, marine diesel engine oil, total loss system oil, industrial gear oil, air compressor oil, rubber filling oil, lithium base grease, the production process are further optimized to produce high quality lubricating oils.



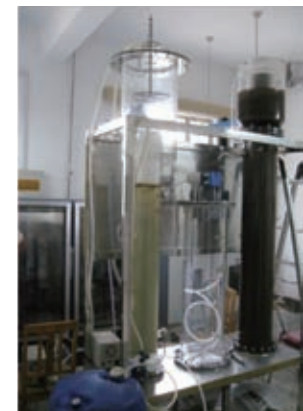
1,000,000 t/y coking
delaying plant



1,000,000 t/y hydrogen-
donating thermal cracking
plant



1,000,000 t/y viscosity
reduction – cracking plant



Loop flotation separation
column for treating sewage



■ CNPC Karamay Petrochemical Company

◇ Large modern petrochemical company with capacity of 5,000,000 t/y crude oil.

◇ 39 units of production facilities with original value of fixed asset of 4.9 billion RMB. On-stream period of plants for viscous oil is up to 3 years with the operation level advanced in petrochemical industry in China.

◇ Flexible process, advanced technologies and various product lines allow the company to stay in frontier market and to develop marketable products. The company is the first one of producing ultra high voltage transformer oil and high grade rubber oil KN series.

◇ Comprehensive scientific research institute integrates crude oil assessment, petroleum product

development, petroleum processing, fine chemical engineering and microbial engineering to research and produce various series of products including transformer oil, asphalt, rubber oil, internal combustion engine oil, gear oil, fine chemical engineering.

Other scientific research equipments at divisions of processing inferior heavy oil



Pilot plant for viscosity reduction-coking



Pilot plant for coking at Jinzhou Petrochemical

5

QUALIFICATIONS & STANDARDS

The Main Patents

- 201010283025.9 A process of hydrocarbon oil demetalization
- 201010283241.3 A method of recycling demetalization agent used in hydrocarbon oil
- 201110277535.X A method of optimizing temperature at outlet of delayed coking heating furnace
- 201110231630.6 A method of assessing stability of heavy residual oil
- 201120503695.7 A desuperheating washing device of preventing coking at lower delayed coking fractionating tower
- 201110380287.1 A method of in-line salt-leaching in fractionating tower of delayed coking plant
- 201120525072.X A timing coke burning system for heating furnace of delayed coking plant
- 201010578968.4 A method of hydrogen-donating thermal cracking
- 201010578975.4 A combined process of inferior heavy oil processing
- 201120143703.1 A plant of delayed viscosity reduction and cracking
- 201110118039.X A plant of delayed viscosity reduction and cracking
- 201110277535.X A method of optimizing temperature at outlet of delayed coking heating furnace
- 201110231630.6 A method of assessing stability of heavy residual oil
- 201120503695.7 A desuperheating washing device of preventing coking at lower delayed coking fractionating tower
- 201110380287.1 A method of in-line salt-leaching in fractionating tower of delayed coking plant
- 201120525072.X A timing coke burning system of heating furnace of delayed coking plant
- 200920107142.2 A plant of deep treating sewage from super viscous oil
- 200910081479.5 A method of deep treating sewage from super viscous oil
- 201120523563.0 A plant of regulating biochemical properties of deep contaminated water from processing of inferior heavy oil
- 201110418658.0 A process of improving process sewage from inferior heavy oil for discharge compliance
- 201120526325.5 A coupled device of purifying and biodegrading sewage from inferior heavy oil
- 201110418825.1 A coupled process of purifying and biodegrading sewage from inferior heavy oil
- 201110238857.3 Multi-branched Mannich base corrosion inhibitor and its preparation
- 201110240108.4 Mannich base decalcification and corrosion inhibitor and its preparation and application
- 201110238858.8 Mannich corrosion inhibitor and its preparation
- 201110240414.8 Metallic corrosion inhibition neutralizer and its preparation
- 201010218651.X A method of treating emulsifier oil in sewage

- 200910236167.7 A method of inferior wax oil hydrogenation
- 201010578980.5 A method of improving activity of hydrogenation catalyst used for treating inferior wax oils
- 201010578970.1 A method of removing nitride in inferior wax oil
- 201110314562.X A method of preparing base oil of refrigerator oil
- 201010578980.5 A method of reducing low-temperature flowability of transformer oil
- 201110056086.6 A method of improving anti-gassing property of transformer oil and an equipment of producing transformer oil
- 201120059860.4 An equipment of producing
- 201120146454.1 An equipment of producing traffic paving asphalt from super heavy oil
- 201110119790.1 An equipment and method of producing road asphalt from super viscous oil
- 200810223448.4 A method of producing environmental protection rubber oil with high aromatic content
- 200820122919.8 An equipment of producing environmental protection rubber oil with high aromatic content
- 201020513895.6 An equipment of producing rubber filling oil
- 201020513899.4 An equipment of producing aromatic rubber filling oil
- 201120059918.5 An equipment of refining solvent of environmental protection rubber filling oil
- 201120059763.5 An equipment of refining solvent of environmental protection rubber filling oil
- 201120059617.2 A method of producing environmental protection rubber filling oil
- 201110054614.4 A method and equipment of refining solvent of environmental protection rubber filling oil
- 201110054612.5 A method of optimizing raw materials to improve aromatic content in environmental rubber filling oil
- 201110055775.5 A method and equipment of refining solvent of environmental protection rubber filling oil
- 201020513893.7 A device of improving penetration index (PI) of asphalt with low sulfur
- 201110315374.9 A method of degreasing sewage from super viscous oil
- 201120240922.1 A flotation equipment of treating sewage containing emulsified oil
- 201110314545.6 A flotation-biochemical method and equipment of treating sewage from super viscous oil
- 201110380234.X A method of treating organic sewage with high calcium content
- 201110380288.6 A process of treating industrial organic sewage containing acetate

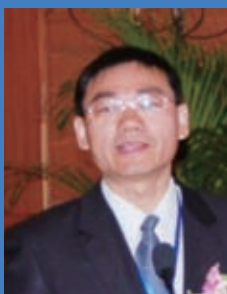


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EXPERT TEAM



Lin Aiguo Senior technical expert, professorial senior engineer. deputy Director of academic board of national key laboratory of heavy oil. He has been dedicated in planning business development in oil refining and chemical engineering, technology development and industrial application of inferior heavy oil, research and development and application of refining catalyst. He has been granted with over 10 patents of invention and has a number of research papers published.
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Fu Xingguo Senior technical expert, professorial senior engineer. He has been dedicated in technological development and industrial application of heavy oil processing, technological development and industrial application of biofuel, research and development of standards for clean fuel. He has been granted with over 10 Provincial and Ministerial awards for science and technology, 30 patents of invention in China and abroad, and has over 50 research papers published.
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Xie Chongliang Senior technical expert. He has been dedicated in plant engineering design and development of relevant technologies in heavy oil cracking including delayed coking, as well as optimization design of large refineries. He ever participated in over 30 projects of refinery engineering design and scientific research, was granted with 1 bronze for national excellent engineer design, 10 first and second prizes for Provincial and Ministerial excellent engineer design and consultation, has over 10 research papers published.
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Zhen Xinping Senior technical expert, professoriate senior engineer. He participated in project of “technical research, development and industrial application of producing high end products from naphthenic crude oil”. In 2011, he was granted with the first prize for National Prize for Progress in Science and Technology. In addition, he was granted with over 12 Provincial and Ministerial awards for science and technology, and has over 10 research papers published.
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Huang He Senior technical expert, professoriate senior engineer. He is dedicated in resource assessment and process research in viscous oil and super viscous oil, responsible for research and development of technology for asphalt, special naphthenic oils. He was granted with 4 patents and has over 20 research papers published.
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Zhang Zhihua Senior technical expert, professorial senior engineer. He has over 60 papers published, granted with 29 patents of invention; 2 patent excellence awards, 2 first and 2 second prizes for technological innovation of the Group, 2 first and 1 second prizes for technological innovation of the Corporation, 2 second prizes for Scientific and Technological Advancement of Heilongjiang Province, and 1 special award of Heilongjiang Province.
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Xiong Liangquan Senior technical expert, professorial senior engineer. He participated in project of “technical research, development and industrial application of producing high end products from naphthenic crude oil”, was granted with first prize for National Prize for Progress in Science and Technology in 2011, over 20 scientific and technical awards, 5 patents, has over 15 papers published.
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Zhao Yusheng Senior technical expert, professorial senior engineer. He participated in a number of major ministerial and provincial projects including “domestication of residual oil hydrogenation catalyst”, “technological transformation of plants for residual oil hydrogenation and industrial application of upstream protective agent”, “research and development of catalyst for residual oil hydrogenation on static bed”. He was granted with 4 Provincial and Ministerial awards for science and technology, 36 patents, has over 20 papers published.

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Wang Zongxian Professor of China University of Petroleum (Huadong), doctoral supervisor. He primarily participates in projects of petroleum chemistry and processing, ever participated in over 30 national, ministerial and provincial scientific research projects. He was granted with 13 Research and Teaching Awards, 15 patents of invention, has over 150 papers published with 70 papers introduced in to SCI, EI and ISTP.

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Zhao Suoqi Professor of China University of Petroleum (Beijing), doctoral supervisor. He is currently deputy director of key laboratory in heavy oil, responsible for international cooperation and exchange. He is also deputy director and secretary of section of supercritical fluid of China Institute of Chemical Engineering, editorial board member of Petro. Sci. & Tech. He was granted with 3 patents, 1 patent each in USA, France, and Canada, 2 software copyrights and has over 140 papers published.

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