National Ⅳ Clean Gasoline Production Technology

Science & Technology Management Department

2013

CHINA NATIONAL PETROLEUM CORPORATION

CNPC would like to provide you a comprehensive solution to National IV clean gasoline production!

Contents

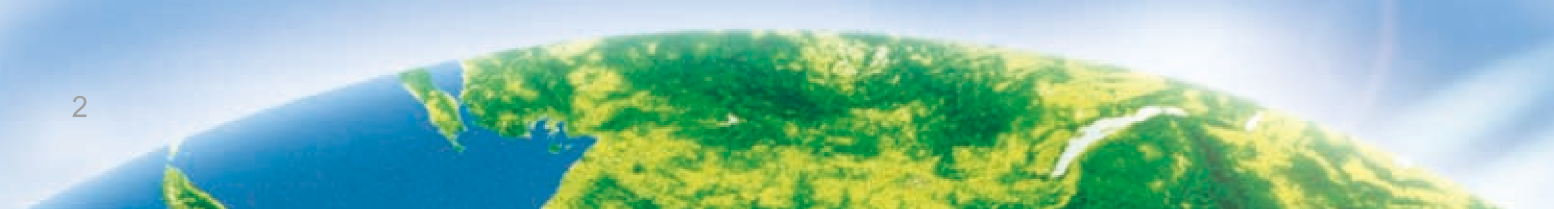
China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorgnized to become an integrated oil company of cross-regions, cross-industries and cross-countries, 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.

National IV Clean Gasoline Production Technology is one of representatives for major innovations of CNPC.

CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT



1 INTRODUCTION

Along with the increasingly strict environmental protection regulations, all the countries around the globe have set higher requirements on the quality of vehicle engine fuel. For example, China has accelerated the pace of gasoline quality upgrading, putting more emphasis on the standards for vehicle gasoline quality of low sulfur, low olefin and high octane number.

China's Standards and Key Indicators for Vehicle Gasoline

Standards	Sulfur, mg/kg	Olefin, v%	Arene, v%	Benzene, v%	Effective Date
National Ⅲ Gasoline (GB17930-2006)	≯ 150	≯ 30	≯ 40	≯ 1.0	2010
National Ⅳ Gasoline (GB17930-2011)	≯ 50	≯ 28	≯ 40	≯ 1.0	2014
Beijing Ⅳ Gasoline (DB11/238-2007)	≯ 50	≯ 25	≯ 60*	≯ 1.0	2008
Beijing Ⅴ Gasoline (DB11/238-2012)	≯ 10	≯ 25	≯ 60*	≯ 1.0	2012

* Olefin+arene (v%)

Since 2000, based on the global development trend of oil refining business and the demand by domestic refineries, CNPC has been hammering at the research and development of clean gasoline production technologies and catalysts, and until now has brought forward multiple series of technologies and catalysts with different models and dimensions.

CNPC has developed the Packaged Technologies for Selective Hydrodesulfurization of Catalytic Gasoline (DSO) and the Packaged Technologies for Hydrodesulfurization and Modification of Catalytic Gasoline (GARDES, M-DSO and DSO-M), through which, the contradiction between the gasoline hydrodesulfurization and the octane number loss has been solved, and the clean gasoline that meets the national IV standard can be directly produced. These two series of technologies were recognized as one of the top ten science and technology progresses of CNPC in 2010, and topped the winner list of CNPC Technology Progress Award respectively in 2011 and 2012. CNPC possesses the High-octane Components Production Technologies with independent intellectual property rights, which mainly include the Etherification Technology of Catalytic Light Gasoline and the C4 Aromatization Technology, covering the synthesis of new catalytic materials, the catalyst preparation, the catalyst products and process technology and other fields. The technologies have filled the technical gap of CNPC, provided powerful technical support for gasoline quality upgrading and delivered significant social and economic benefits.

- National IV clean Gasoline Production Technologies
  - Packaged Techonologies of Selective Hydrodesulfurization of Catalytic Gasoline (DSO)
    - Technology of Catalyst Preparation for Selective Hydrodesulfurization of Catalytic Gasoline
    - Selective Hydrodesulfurization Technology and Catalyst of Catalytic Gasoline
    - Hydrogenation Pretreatment Technology and Catalyst of Catalytic Gasoline
  - Packaged Techonologies of Hydrodesulfurization and Modification of Catalytic Gasoline (M-DSO and DSO-M)
    - Technology of Catalyst Preparation for Hydrogenation and Modification of Catalytic Gasoline
    - Selective Hydrodesulfurization and Modification Technology and Catalyst of Catalytic Gasoline
  - GARDES Technologies
    - Pre-hydrogenation Catalyst and Technology of FCC Full-range Gasoline
    - FCC Full-range Gasoline Separating Technology
    - Selective Hydrodesulfurization Catalyst and Technology of FCC Heavy Distillates
    - Octane Number Resume Catalyst and Technology of FCC Heavy Distillates
    - Graded Optimization Technology of Reaction Process and Catalyst
  - Etherification Technologies of Catalytic Light Gasoline
    - Etherification Technology of Catalytic Light Gasoline
    - Etherification Catalyst of Catalytic Light Gasoline
  - Mixed C4 Olefin Aromatization Technology and Catalyst
    - Mixed C4 Olefin Aromatization Process Technology
    - Mixed C4 Olefin Aromatization Catalyst

2 UNIQUE TECHNOLOGIES

2.1 Packaged Technologies of Selective Hydrodesulfurization of Catalytic Gasoline (DSO)

The selective hydrodesulfurization of catalytic gasoline is a process of clean gasoline production where the catalytic gasoline is treated by reducing sulfur content and controlling olefin saturation. Process flow: the catalytic gasoline undergoes pre-hydrogenation treatment to remove alkadiene and impurities, before being treated by the hydrogenation process of separating fractionation, thereby producing national IV clean gasoline by means of deep desulfurization while controlling olefin saturation.

Selective Hydrodesulfurization Catalyst of Catalytic Gasoline

The process of selective hydrodesulfurization catalyst of treating catalytic gasoline is of flexible flow (either the full-range hydrodesulfurization or the separating fractionation hydrodesulfurization), well-adapted raw material, mild reaction conditions, high desulfurization rate, minor octane number loss and high liquid yield ($\nless$ 99%). The catalyst has a single-pass life of no less than 3 years and a total life of 6 years at least.

GHC-11 Selective Hydrodesulfurization Catalytic

Pre-hydrogenation Catalyst of Catalytic Gasoline

The pre-hydrogenation catalyst is characterized by relatively high hydrogenation activity, selectance and stability with the diolefin saturation rate not less than 50%, the diolefin hydrogenation selectance not less than 95% and without octane number loss for hydrogenation products. The catalyst has a single-pass life of no less than 3 years and a total life of 6 years at least.

GHC-32 Pre-hydrogenation Catalyst

2.2 Packaged Technologies of Hydrodesulfurization and Modification of Catalytic Gasoline (M-DSO and DSO-M)

The Packaged Technologies of Hydrodesulfurization and Modification of Catalytic Gasoline (M-DSO and DSO-M) are key processes for producing clean gasoline, which the olefins are partially transformed into arenes (or isoparaffins) through the aromatization (or isomerization) reaction so as to offset the octane number loss with olefinreducing during hydrodesulfurization while reducing the sulfur content of FCC gasoline. Through developing the selective hydrodesulfurization technology and the hydrogenation and modification technology and carrying out the research on the matching attribute of combination technologies and on the adaptability of raw material, the selective hydrodesulfurization technology and the hydrogenation and modification technology are combined organically, thereby solving the technical problem of great octane number loss brought by high-sulfur catalytic gasoline treatment only by use of the selective hydrodesulfurization technology or by ultra-deep desulfurization for producing ultra-low sulfur clean gasoline, fulfilling the objective of desulfurization, olefin reduction while maintaining the octane number, and providing technical support of upgrading and updating of gasoline for domestic refineries.

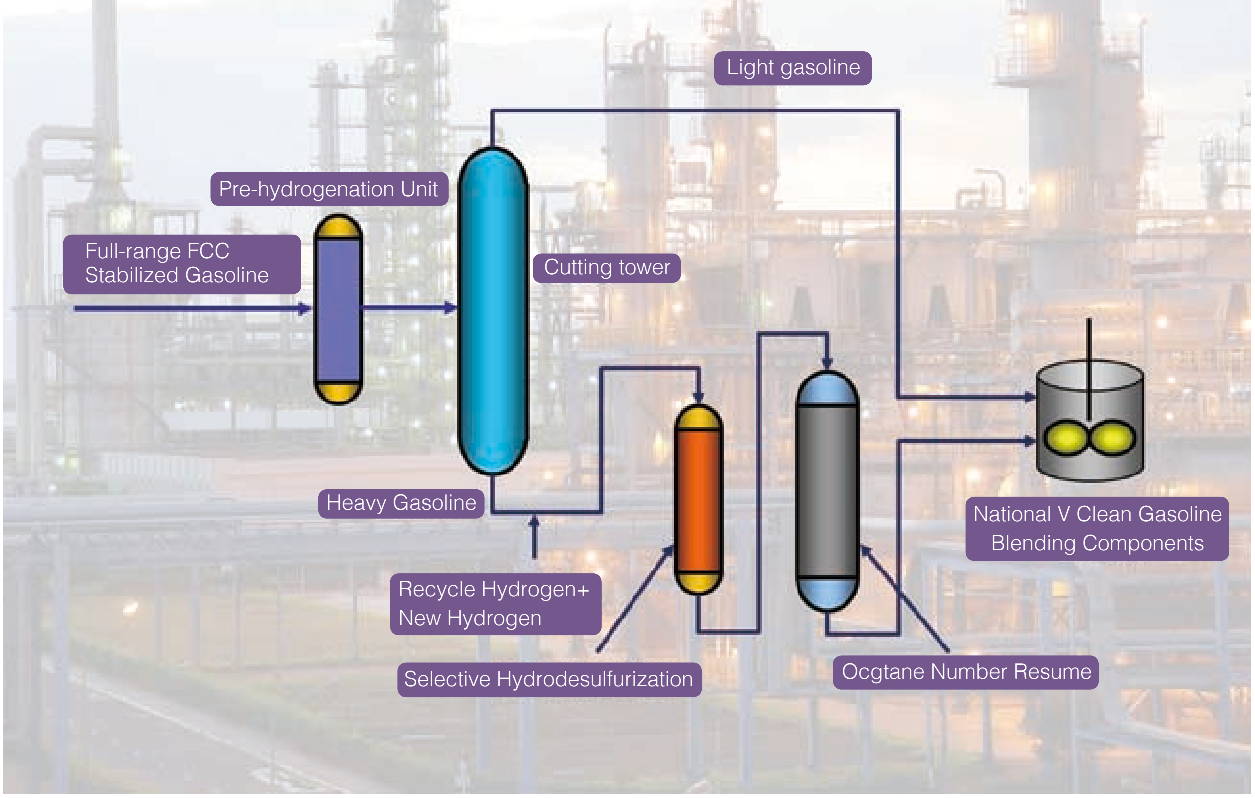
Hydrogenation and Modification Catalyst of Catalytic Gasoline

The hydrogenation and modification catalyst of catalytic gasoline, which takes molecular sieve as the carrier, and base metal as the hydrogenation active component, has multiple functions such as hydro-isomerization, aromatization and desulfurization. The unique Molecular Sieves Synthesis Technology is adopted to prepare ZSM small-particle molecular sieves, which are modified through adjusting their surface acidity by the introduced modifying additives, thus effectively improving the catalyst aromatization (isomerization) performance and solving the problems of the service life, of hydrogenation and modification catalyst.

2.3 GARDES Technologies

Firstly, the full-range catalytic cracking (FCC) gasoline gets through a selective catalyst bed for removing diolefins/mercaptan, allowing mercaptan sulfur and alkadiene to react to generate thioether into heavy fractions; and then the separating of light distillates and heavy distillates cut is carried out. The obtained low-sulfur high-octane number light distillates that are not processed, but the heavy distillates after going through two-stage hydrotreatment, namely, the selective hydrodesulfurization and the octane number resume, are blended to produce clean gasoline that satisfies the national IV standard.

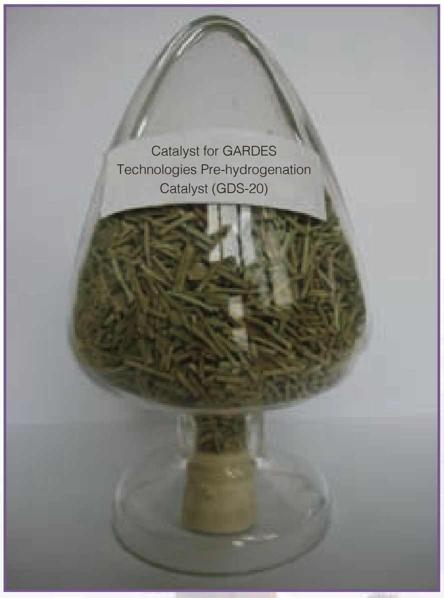
The GARDES Technologies provide the solutions to the problem of relatively high sulfur content in FCC gasoline by selective hydrodesulfurization, at the same time, the problem of excessive octane number loss in gasoline during hydrodesulfurization is solved by adopting the Octane Number Resume Technology.



2.3.1 Pre-hydrogenation Catalyst and Technology of FCC Full-range Gasoline

Under the action of catalyst, the relatively low boiling point of mercaptan sulfur and alkadiene in FCC full-range gasoline react to generate high boiling point of thioether which is transferred into heavy fractions, meanwhile, the remaining alkadiene gets saturated.

In the mild hydrogenating conditions, the alkadiene and mercaptan in FCC full-range gasoline, under the function of catalyst, undergo such reactions as sulfur etherification, selective hydrogenation of alkadiene and olefin isomerization to generate thioether, and consequently the sulfur content in FCC full-range gasoline reaches the national IV gasoline standard.



Technical Features

Both the impurities (e.g. oxy-compounds and organometallic compounds) and the alkadiene in FCC full-range gasoline can be removed and the mercaptan is transformed into thioether, avoiding the coking and inactivation of the catalyst due to polymerization of alkadienes, and safeguarding the long-cycle operation of selective desulfurization catalyst and octane number resume catalyst.

Technical Indexes

The mercaptan sulfur content in FCC full-range gasoline can reach ≤10μg/g through the heavilization transformation of mercaptan in FCC full-range gasoline.

Scope of Application

Applicable to the pre-hydrogenation process for FCC full-range gasoline, which can be used as the first stage process of light gasoline etherification-selective hydrogenation/octane number resume of heavy gasoline.

2.3.2 FCC Full-range Gasoline Separating Technology

Based on the nature of oil products and combining the following process flows, the FCC full-range gasoline is separated into light and heavy distillates at appropriate temperature.

Technical Features

The reasonable proportion of olefin and sulfur in light distillates can be achieved by taking the reins of the separating temperature in a flexible manner based on different natures of FCC full-range gasoline, thereby safeguarding the maximum octane number.

Technical Indexes

The FCC Full-range Gasoline Separating Technology can be used to determine the appropriate separating temperature based on the nature of oil product, so that the modified products can meet relevant requirements.

Scope of Application

Applicable to the separation process of full-range gasoline.

2.3.3 Selective Hydrodesulfurization Catalyst and Technology of FCC Heavy Distillates

Under the action of catalyst, the macromolecule sulfur compounds in the FCC heavy distillates are removed such as thiophene, methyl thiophene, benzo-thiophene and methylbenzothiophene.

At the rim activity site (rim site) of the metal sulfide lamellar crystal, the hydrodesulfurization reaction and the olefin saturation reaction can take place simultaneously, while at the edge active site (edge site), only the hydrodesulfurization reaction can occur. Hence, in order to improve the hydrodesulfurization selectance of catalyst, more edge sites should form in order to improve the hydrodesulfurization activity, at the same time, less rim sites should form as far as possible to inhibit the olefin saturation reaction.

Technical Features

The Selective Hydrodesulfurization Catalyst and Technology of FCC Heavy Distillates demonstrates good desulfurization capability with desulfurization rate up to 87% and olefin saturation rate less than 20%.

Technical Indexes

The Selective Hydrodesulfurization Catalyst and Technology of FCC Heavy Distillates can deliver a desulfurization rate of 87% or above.

Scope of Application

Applicable to the selective hydrodesulfurization process of FCC full-range gasoline or heavy distillates.

2.3.4 Octane Number Resume Catalyst and Technology of FCC Heavy Distillates

The isomerization and aromatization reactions occur under the action of catalyst to generate high-octane components so as to make up for the loss of gasoline octane number. Moreover, this technology also plays a role in removing such micromolecule sulfur compounds as mercaptan and thioether in heavy distillates.

The octane number resume catalyst based on SAPO-11/ZSM-5 not only has smooth pores, but also has suitable contents and strength distribution of Lewis acid and Brönsted acid, showing good concerted catalysis. Therefore, the catalyst allows the isomerization and aromatization reactions to occur, besides, and it can be used to remove micromolecule sulfur compounds and to prevent the hydrogen sulfides and olefins from recombining to generate mercaptan. Accordingly, the treated heavy distillations by octane number recovery catalyst can be directly used for products blending without removal of mercaptan.

Technical Features

With the modified ZSM-5/SAPO-11 molecular sieve, the reaction temperature can be adjusted according to different natures of raw materials so as to control the proportion of isomerization and aromatization reactions. The catalyst features smooth pores, and more suitable contents and strength distribution of Lewis acid and Brönsted acid. It can be used to remove micromolecule sulfur compounds and to prevent the hydrogen sulfides and olefins from recombining to generate mercaptan.

Technical Indexes

The arenes in heavy distillates can be increased by about 3%(V) and the olefins reduced by around 15%(V) , and the desulfurization rate can be as high as 30%.

Scope of Application

Applicable to the hydrogenation and modification process of FCC full-range gasoline or heavy distillates.

2.3.5 Graded Optimization Technology of Reaction Process and Catalyst

The four reaction-separation units, namely, pre-hydrogenation, separation of light and heavy distillates, selective hydrodesulfurization and octane number resume, are reasonably allocated with different catalysts based on the natures of raw materials and requirements of target products, following which, reaction process conditions are adjusted appropriately, in this way, the technology is optimized to produce National IV clean gasoline.

Technical Features

The Graded Optimization Technology of Reaction Process and Catalyst, which features the optimized allocation of reaction process and catalyst, is applicable to the solution of full-range hydrogenation, and the solution of light gasoline etherification, selective hydrodesulfurization of heavy gasoline-octane resume as well as the solution of the prospective solution of light gasoline isomerization, selective hydrodesulfurization of heavy gasoline -octane resume, so it can be widely used in raw material and products solutions.

Technical Indexes

- Process conditions of pre-hydrogenation reactor: reaction temperature140 ~ 160℃, reaction pressure 2.3 ~ 2.6 MPa, WHSV 2.5 ~ 3.5 h^{-1}, hydrogen/oil ratio 5 ~ 8.
- Process conditions of selective hydrodesulfurization reactor: reaction temperature 200 ~ 300℃, reaction pressure 1.5 ~ 2.0 MPa, WHSV 2.0 ~ 3.0 h^{-1}, hydrogen/oil ratio 250 ~ 350.
- Process conditions of octane number resume reactor: reaction temperature 300 ~ 400℃, reaction pressure 1.5 ~ 2.0 MPa, WHSV: 1.5 ~ 3.5 h^{-1}, hydrogen/oil ratio: 250 ~ 350.

Scope of Application

Applicable to producing the National IV clean gasoline.

2.4 Etherification Technology of Light Catalytic Gasoline

The FCC full-range gasoline is divided into two components, namely, light gasoline, heavy gasoline. Firstly the alkadienes and some non-tertiary carbonic olefins that are transformed into tertiary carbonic olefins through isomerism reaction are removed from the light gasoline by mean of selective hydrogenation. Then the tertiary carbonic olefins in the hydrogenated light gasoline and methanol, are transformed into ethers compounds via two-stage etherification reaction under the action of etherification catalyst. Finally, the etherified light gasoline and heavy gasoline are blended to produce the modified gasoline.

Technical Features

- The light catalytic gasoline with the boiling point below 70℃ is used as the raw material to develop the Etherification Technology of "Two Reactors-One Tower" for Catalytic Light Gasoline (LNE), which is of mild process conditions and easy to implement in industry.
- The nickel-based LNEH-1 catalyst in selective hydrogenation of alkadiene developed by CNPC is adopted, which allows the alkadiene in light gasoline to reduce below 100μg/g, and the mono-olefin saturation to stand below 3%. The catalyst has advantages of low operating temperature, high LHSV and high selectance.
- This technology allows the conversion rate of C6 tertiary carbon olefins to reach above 60%, 10% ~ 25% higher compared with the catalytic distillation process.
- The methanol of about 2.5% ~ 4.0% can be converted into high-value gasoline, meanwhile, the gasoline vapor pressure can be reduced by 25% ~ 29%.

Technical Indexes

- After the selective hydrogenation of light gasoline, the alkadiene content is reduced below 100μg/g, and the mono-olefin saturation stands below 3%.
- C_5 tertiary carbon olefins has a conversion rate up to 88% ~ 90%, while for C6 tertiary carbon olefins, this figure is above 60%.
- Once the etherified light gasoline and the unprocessed heavy gasoline are blended, the olefin content drops about 10%, the octane number grows by 1.0 ~ 1.2 unit and gasoline yield rises 2.5% ~ 4.0%.

Scope of Application

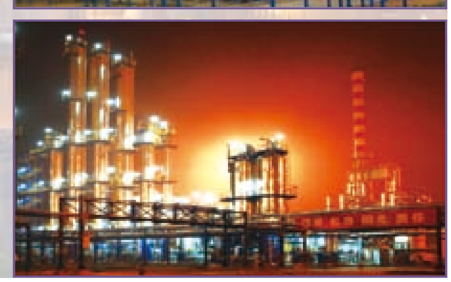
- Applicable to any FCC gasoline.

2.5 Mixed C4 Olefin Aromatization Technology and Catalyst

The reaction process of stationary bed is adopted with mixed C4 olefin as raw material. Under the action of SHY-DL-1 catalyst, C4 undergoes olefin aromatization and alkylation reactions to produce the mixed aromatics components of low olefin, low sulfur content and high octane number, which can be used as both chemical raw materials and gasoline blending components. The cogenerated propane and butane can be used as high quality raw materials for ethylene production by cracking.

Technical Features

- The anti-carbon and anti-inactivation SHY-DL-1 catalyst is prepared by making use of the nanometer molecular sieve that has properties of short pore path, many pores and strong capacity of carbon dissolving, thus solving the technical problems of short one-way operation cycle, fast inactivation and frequent regeneration of catalyst during C4 olefin aromatization.
- The hydrogenating reaction conditions suitable for the reaction process of stationary bed are introduced to further hold up the carbon deposition rate of aromatization reaction, which significantly lengthens the one-way operation cycle of catalyst. In this way, the investment on device and operational cost is lowered, and it is easy to realize the industrialized application.
- The aromatization and alkylation reactions of mixed C4 olefin under the hydrogenating conditions feature low reaction temperature and little output of dry gas and coke. The aromatization process of C4 olefin under the hydrogenating conditions can enhance the conversion rate of butene in C4 raw material to the most extent while reducing the olefin content in the generated gasoline, and improve the distribution of aromatization products, and lengthen the operation cycle of catalyst.



Technical Indexes

- The butene has a conversion rate of higher than 98%, and the average yield of dry gas and coke is less than 2%.
- The olefin content in LPG products is below 1%.
- The yield of mixed aromatics components stands at around 80% (relative to the butene content in mixed C4), its arene content ranges 40% ~ 50% and RON value is up to 95~101.
- SHY-DL-1 catalyst has a single-pass life of more than 2 months and its total life exceeds 2 years.

Scope of Application

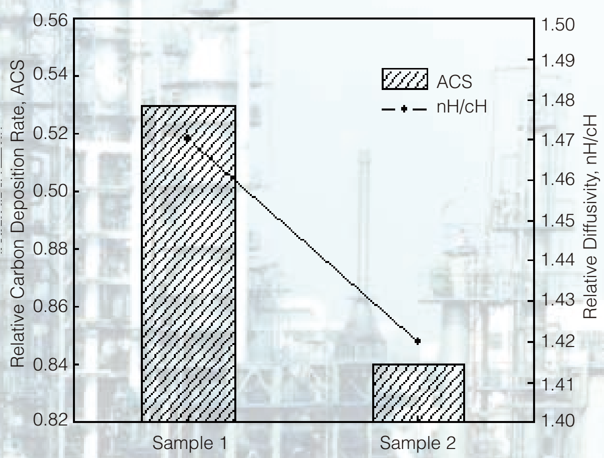
- Applicable to mixed C4 with olefin content above 40%.

Mixed C4 Olefin Aromatization Catalyst

The mixed C4 Olefin Aromatization Catalyst SHY-DL-1, processed by the parent material of ZSM-5 zeolite molecular sieve with particle size smaller than 100nm, presents prominent anti-carbon and anti-inactivation in the aromatization reaction of mixed C4 olefin at low temperature. Under the hydrogenating conditions, the catalyst has a one-way stable operation cycle of more than 2 months, and life expectancy of more than 2 years. The mixed C4 can be one-time made into mixed aromatics components of ultra-low sulfur and high octane number and high grade materials for ethylene production by cracking, with the loss rate (generation of dry gas and coke) less than 2%.

Scope of Application

The well-adapted raw materials mixed C4 olefins from such units as FCC, DCC, steam cracking and MTO, with large market capacity, can be subject to large-scale deep processing. The mixed arenes, as the main products, can be used as chemical materials, and also can be used to make up for the octane number in gasoline. The cogenerated propane and butane can be transformed into ethylene and propylene by steam cracking. This technology is particularly suitable for the refining-chemical integration enterprises to comprehensively utilize C4 by-products.



3 TYPICAL CASES

The DSO Technology was applied in the hydrogenation unit for 320,000t/y gasoline at Yumen General Refinery Plant in July, 2008. Since the launching of the DSO Technology, it has been able to produce the National IV clean gasoline with sulfur content of not more than 50mg/kg by virtue of the raw material catalytic gasoline with mild reaction conditions, minor loss of octane number and high yield, compared with high sulfur content, high olefin content, high gum level and short induction period previously.

The DSO-M Technology was successfully applied in the hydrogenation and modification unit for 600,000t/y gasoline at Urumqi Petrochemical Company in July, 2011. It can be used to produce the National IV clean gasoline with sulfur content less than 50mg/kg, olefin content reduced by 10~15 units and RON loss below 0.7 unit.

The GARDES Technology has been applied in the 200,000t/y industrial unit at Dalian Petrochemical Company since it came into operation on January 4, 2010. The unit, which has maintained stable operation for 20 months, including 16 months during which it ran under the condition of 143% of design space velocity, has a actual capacity up to 300,000t/y, and until now, has produced accumulatively 500,000 tons of clean gasoline that satisfies Shanghai IV standard and Guangdong IV standard.

The GARDES Technology was put into use in the 400,000t/y industrial unit at Jinao (Hubei) Science & Technology Chemical Industry Co., Ltd. starting from April 25, 2012. By this technology, the FCC gasoline [sulfur content greater than 1,200mg/kg, olefin content above 35%(V)] mixed with cocker gasoline has been processed, with the desulfurization rate greater than 85%.

The GARDES Technology began to be used in the 300,000t/y industrial unit at Zhejiang Meifu Petrochemical Industry Co., Ltd. on June 10, 2012. It has been used to process the FCC gasoline with sulfur content greater than 900mg/kg, achieving the desulfurization rate above 85%.

4 R&D EQUIPMENT

The National IV Clean Gasoline Production Technologies are jointly developed by CNPC Petrochemical Research Institute, CNPC Fushun Petrochemical Company and China University of Petroleum (Beijing) relying on the national key laboratory of heavy gasoline, the key laboratory of clean fuel, the key laboratory of catalyst and the hydrogenation catalyst and process engineering test base of CNPC. With many years of experience and key construction, CNPC has been armed with complete equipment for catalyst production, advanced catalyst characterization methods and oil analyzer, as well as more than one hundred sets of mini-sized and medium-sized hydrogenation reaction evaluation units, so it can deliver the best technology and services to users.

Analytical and Detecting Instrument in Laboratory

Sulfur Forms Analyzer

Total Sulfur and Total Nitrogen Analyzer

Hydrocarbon Composition Analyzer

Atomic Absorption Instrument

Mercury Porosimeter

Sulfur and Carbon Analyzer

Production Equipment of Catalyst

Laboratory Equipment of Preparing Catalyst Carrier

Production Equipment of Catalyst Carrier

Catalyst Drying Equipment

Catalyst Roasting Equipment

Catting Device of Oil Products

Gasoline Hydrogenation Catalyst Pilot Plant

Auto Multichannel Micro Activity Comprehensive Evaluation Device

Etherification Pilot Plant

5 QUALIFICATIONS & STANDARDS

The gasoline hydrogenation catalyst manufacturing enterprises under CNPC have complete system certification.

DSO, M-DSO and DSO-M Technologies

GARDES Technology

More than 40 patents pertaining to the National IV Clean Gasoline Production Technologies have been applied for and currently 14 patents have been granted.

Patents of DSO, M-DSO and DSO-M Technologies

SN	Patent Number	Status	Status	Type
1	A method for producing gasoline with high octane number	ZL 200710176984.9	Granted	Invention
2	A catalysgt containing L molecular sieve for selective hydrodesulfurization and modification of FCC gasoline	ZL 200910085754.0	Granted	Invention
3	Preparation and application of a catalysgt for selective hydrodesulfurization of gasoline	ZL 201010252648.X	Granted	Invention

Patents of GARDES Technology

SN	Patent Name	Patent Number	Status	Type
1	A preparation method for SAPO-11 molecular sieve	ZL 200910080107.0	Granted	Invention
2	A preparation method for SAPO-11 molecular sieve and SAPO-11 molecular sieve based catalyst	ZL 200910080106.6	Granted	Invention
3	Comprehensive modifyed H2SM-5 zeolite calalyst and its preparation method and usage	ZL 200610083283.6	Granted	Invention
4	Combined alumina based selective hydrodesulfurization catalyst and its preparation method	ZL 200710177578.4	Granted	Invention
5	Selective hydrodesalfurization catalyst containning mesoporous molecular sieve and its preparation method	ZL 200710177579.9	Granted	Invention
6	Hydro-thermal sediment preparation method of supported monometallic hydrogenation catalyst	ZL 20071098995.X	Granted	Invention

Patents of Etherification Technology of Light Catalytic Gasoline

SN	Patent Name	Patent Number	Status	Type
1	A method for preparing catalyst for selective hydrogenation of gasoline diolefin	ZL 200510090475.5	Granted	Invention
2	Catalyst for selective hydrogenation and its preparation method	ZL 200610072630.5	Granted	Invention
3	A etherification process of light gasoline and modification method for FCC gasoline by this process	ZL 200710064669.7	Granted	Invention

Patents of Mixed C4 Olefin Aromatization Technology and Catalyst

SN	Patent Name	Patent Number/ Application Number	Status	Type
1	A catalyst for aromatization of C4 liquefied natural gas and its preparation method	ZL 200410050202.3	Granted	Invention
2	Pressurized gas sampling distributor	ZL 2010201090110	Granted	Utility model

6 EXPERT TEAM

Lin Aiguo Deputy director at academic board of national key laboratory of heavy gasoline. He has long been engaged in the business development plan of oil refining and chemical engineering, the development and industrial application of process technology of inferior heavy gasoline and the R&D as well as industrial application of catalysts for oil refining. He has won more than 10 technical patents of invention and published many papers at home and abroad.

Lan Ling Professor-level senior engineer, senior technical expert of CNPC. She has long been occupied in the research on gasoline and diesel hydrogenation, and once undertook 1 national key research project and 14 projects at provincial level. Moreover, she presided over to develop the Technology of Hydrogenation and Modification of Inferior Diesel (MCI) and the Technology for Selective Hydrodesulfurization of Catalytic Gasoline (DSO) which have been applied in many domestic enterprises. She won 1 second prize of National Technical Invention Award and 4 awards at provincial level. Besides, she published more than 30 papers. She also was granted more than 20 national invention patents.

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Bao Xiaojun Professor and doctoral supervisor at China University of Petroleum (Beijing), and principal scientist of 973 project “basic research on efficient conversion and optimal utilization of heavy gasoline” and “basic research on stage separation and efficient conversion of heavy gasoline”. He is now the editorial board member of Chinese Journal of Chemical Engineering, Journal of China University of Petroleum, and Journal of Fuel Chemistry and other magazines. He also assumes the post of director at China Society of Particuology and is a member of catalysis discipline committee of China Chemical Society. He mainly takes on the research on the catalytic reaction engineering and new catalysts and catalytic materials. Over 110 papers and 5 works published. Moreover, he has been given more than 20 national invention patents.

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Li Jichun Professor-level senior engineer and senior technical expert enjoying the special government allowance of State Council. He has devoted himself to the research on chemical engineering and technology. He has published 66 papers and 2 works in domestic and foreign publications of chemical industry. He obtained 16 invention patents and 16 Technical Process Awards at provincial level.

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Cui Deqiang Senior engineer. He acts as the principal in the development of catalysts for hydrogenation and modification of FCC gasoline. He mainly goes in for the research, amplification study and industrial production work on catalysts and carriers for oil refining and petrochemical engineering. He once presided over many projects with regard to the R&D and industrial amplification of catalysts, achieving the industrial production and promotion of catalysts and carriers of 9 brands, among which, 1 brand won the third prize of National Technical Invention Award. He published over 10 papers and was granted 6 national invention patents.

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Zhang Xuejun Senior engineer and senior technical expert. He has for a long time been engaged in the research on the technology of gasoline hydrogenation. He has applied for over 20 invention patents. He won 1 first prize of Technology Progress Award at provincial level, 1 first prize and 4 second prizes of Technology Progress Award of bureau level.

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Huo Dongliang Senior engineer. He serves as the principal in the development of catalysts for hydrogenation and modification of FCC gasoline. He is mainly engaged in the development of new process of HZSM-5 molecular sieve/mordenite, the industrial application test of the technology of hydrogenation and modification of FCC gasoline, the field test of catalysts for hydrogenation and modification of 200,000 t/y new FCC gasoline, the industrial test of the technology of hydrogenation and modification of FCC gasoline, the research on catalyst and process for hydrogenation and modification of FCC gasoline. He has applied for 5 national patents and published more than 10 papers.

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Fan Yu Researcher and doctoral supervisor at China University of Petroleum (Beijing). He has presided over 2 projects of National Natural Science Foundation of China, 1 subproject of 973 project “basic research on efficient conversion and optimal utilization of heavy gasoline” and many projects at provincial level. He is mainly occupied in the research on the basic theory and application of clean oil products. He has published more than 40 papers in domestic and foreign journals and has applied for 24 national invention patents.

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