

Introduction of several Clean Coal Utilization Technologies

Shaanxi Yanchang Petroleum (Group) Co., Ltd

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Part 1: Brief Introduction of YCPC

As a state-owned enterprise in Shaanxi Province, Shaanxi Yanchang Petroleum (Group) Co. Ltd (YCPC) is one of the only four companies in China which have the license to explore and exploit crude oil and nature gas. It is also a large-scale energy & chemical company, which integrates the development, conversion and high-efficiency utilization of multiple energies, including crude oil, natural gas, coal and salt. It's main products include crude oil, gasoline, diesel oil, natural gas, Polyethylene, Polypropylene, methanol, acetic acid, rubber tires, chemical fertilizer, and etc.



**Yanchang Petroleum
Plant, founded in 1905**

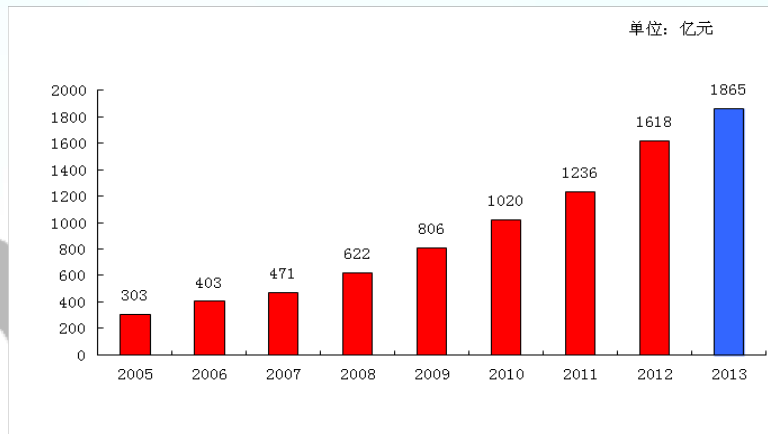


**The first on-land crude oil well
of China**

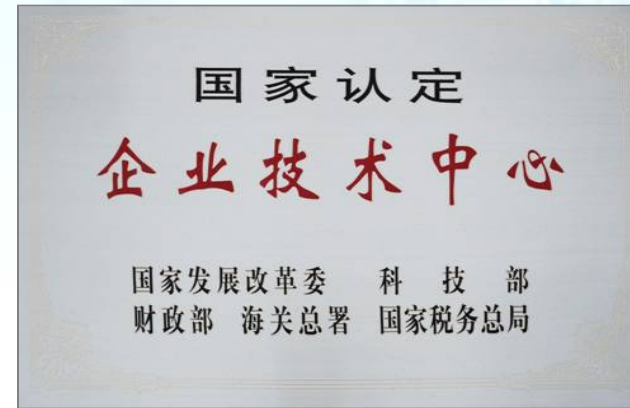
Part 1: Brief Introduction of YCPC

In 2013, YCPC entered the Fortune Global 500 list for the first time, thus making it the first company in the middle and western area of China which achieved that accomplishment. In 2015, YCPC ranked 380 in the list with a revenue of 208 billion RMB.

In recognition of its accomplishments in technology and innovation, YCPC was granted “National Certified Enterprise's Technical Center” by Chinese government .The company has 4 research institutes and 1 engineering corporation, 13 national and provincial engineering technology R&D centers, 3 pilot-scale-test bases, and etc.



Sales per annum (RMB)



National Certified Enterprise's
Technical Center

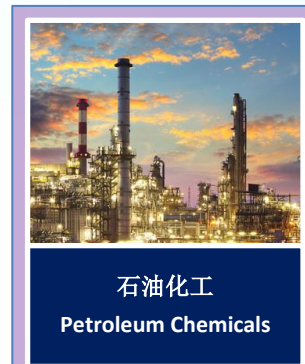
Part 1: Brief Introduction of YCPC

R & D investment:

In recent years, YCPC spends about 4% of its sales on R & D activities. This figure was 7.3 billion RMB in 2013 and 8 billion RMB in 2014.

R & D directions:

The R & D efforts of YCPC mainly focus on 5 directions, which cover the upstream and downstream of its industry with the benefit of synergy.



Part 1: Brief Introduction of YCPC

Global cooperation: YCPC takes full advantage of domestic and foreign resources and makes cooperation with a wide range of famous companies ,universities and research institutes all over the world in the field of technology research and development.

KBR



AIST

Schlumberger



西安交通大学
XIAN JIAOTONG UNIVERSITY



西北大学
NORTHWEST UNIVERSITY

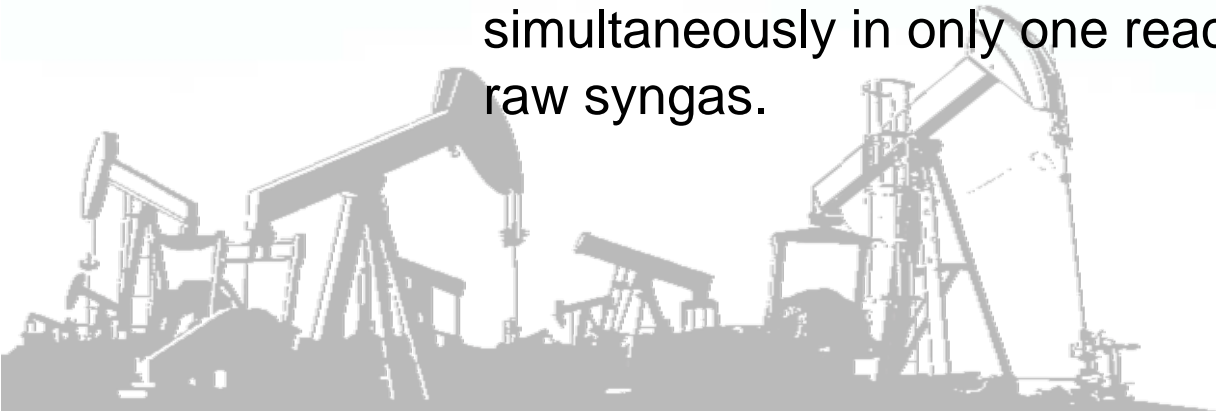


Part 2: CCSI Technology

1. Introduction

◆ 1.1 Principles of CCSI

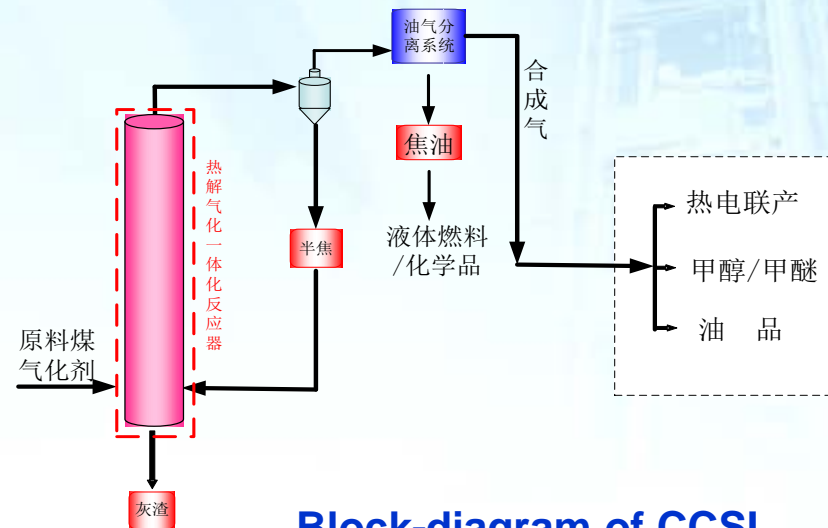
We try to extract the liquid coal tar, which has high added-value, as much as possible by the process of low-temperature pyrolysis combined with gasification, which are designed to maximize the utilization of coal constitutions and chemical structures on the basis of a thorough analysis of the different constitutions, structural characteristics and reactivity of coal. We call the new technology CCSI (Coal to Coal Tar and Syngas Integration), with which we can complete the semi-coke gasification and coal pyrolysis simultaneously in only one reactor with the products of coal tar and raw syngas.



Part 2: CCSI Technology

◆ 1.2 Characteristics

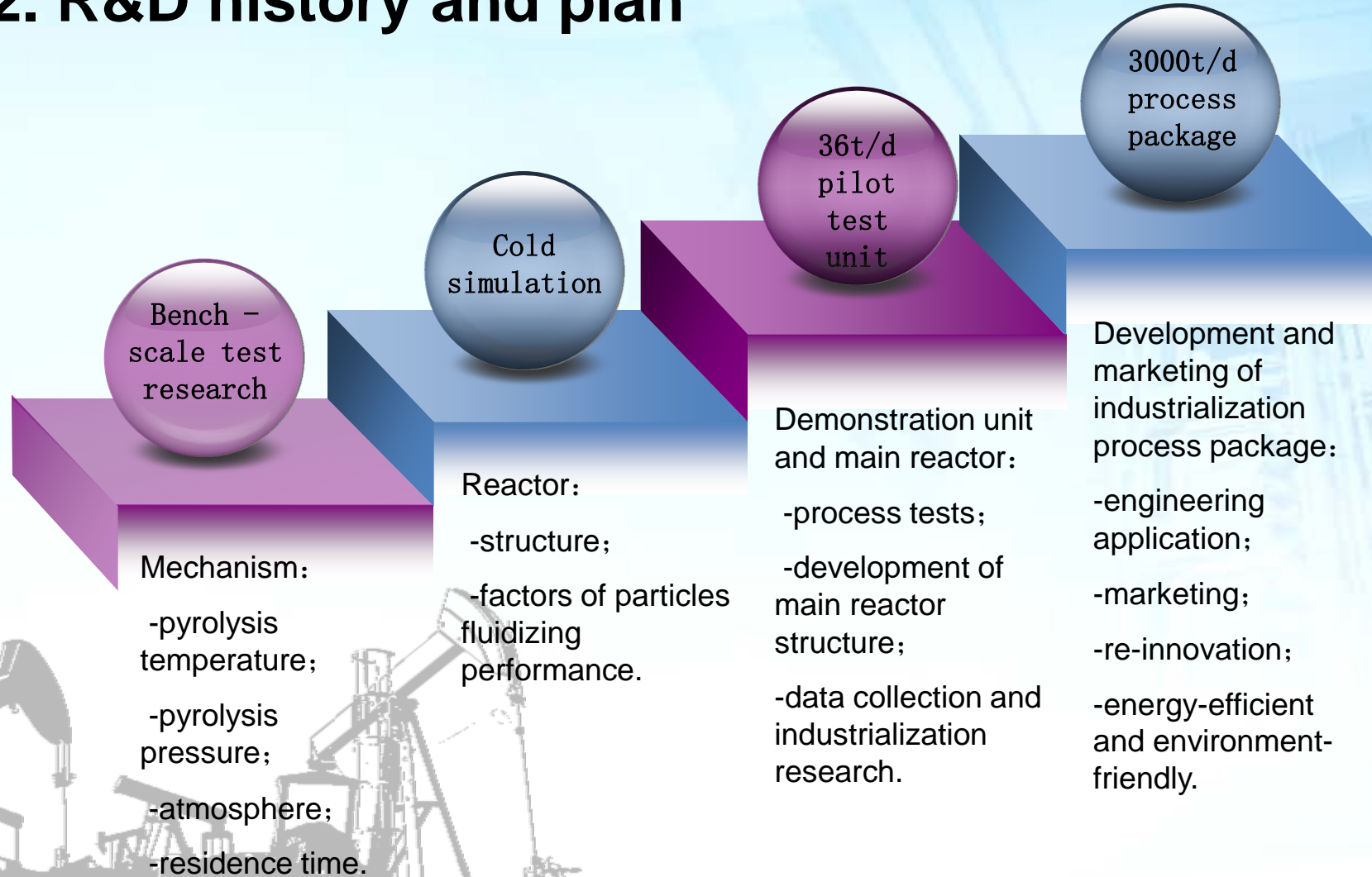
- cascade and clean coal-utilization technology with products of coal tar and raw syngas;
- a technology of circulating fluidized bed in CCSI reactor;
- a kind of pressurized process;
- flash pyrolysis;
- using hot gas and ash as heat carrier to pyrolysis section ;
- pyrolysis reaction in rich hydrogen atmosphere.



Block-diagram of CCSI

Part 2: CCSI Technology

2. R&D history and plan



Part 2: CCSI Technology

◆ 2.1 Bench Scale Tests

After setting up the bench-scale unit (10kg/h, 1.0MPa), we conducted 134 coal feeding tests between 2012 and 2014. The tests are stable and productive with a coal tar yield more than 15(wt%, d), which is higher than that of ordinary coal pyrolysis process.



Bench-scale test unit



Coal tar



Part 2: CCSI Technology

◆ 2.2 Pilot-scale Cold Model Experiment

From January to August in 2014, we built the CCSI cold experiment unit made of plexiglass, with air and sands as feeding at 0.3MPa, to simulate the main process and test the reactor's structure, laying the foundation of pilot and commercial unit design and construction.

Cold
experiment
unit



Part 2: CCSI Technology

◆ 2.3 Pilot test plant under construction

In June of 2014, we started the design and construction of the pilot test unit (36 t/d, 1.0MPa) for CCSI. The investment budget is 134 million RMB and we plan to conduct the commissioning tests in September of 2015.



Pilot-test unit

Part 2: CCSI Technology

● Design Conditions

Coal feeding: 36t/d

Operating pressure: 1.0MPa(G)

Pyrolysis Operating temperature: 600°C

Gasification operating temperature: 1100°C

● Expected Performance

Yield of coal tar: 15 wt% (Dry coal)

Raw syngas: 64401.12 Nm³/d

(CO+H₂) Content: ≥72%

Carbon Conversion ratio: 98%

Part 2: CCSI Technology

◆ 2.4 Commercial plant planning

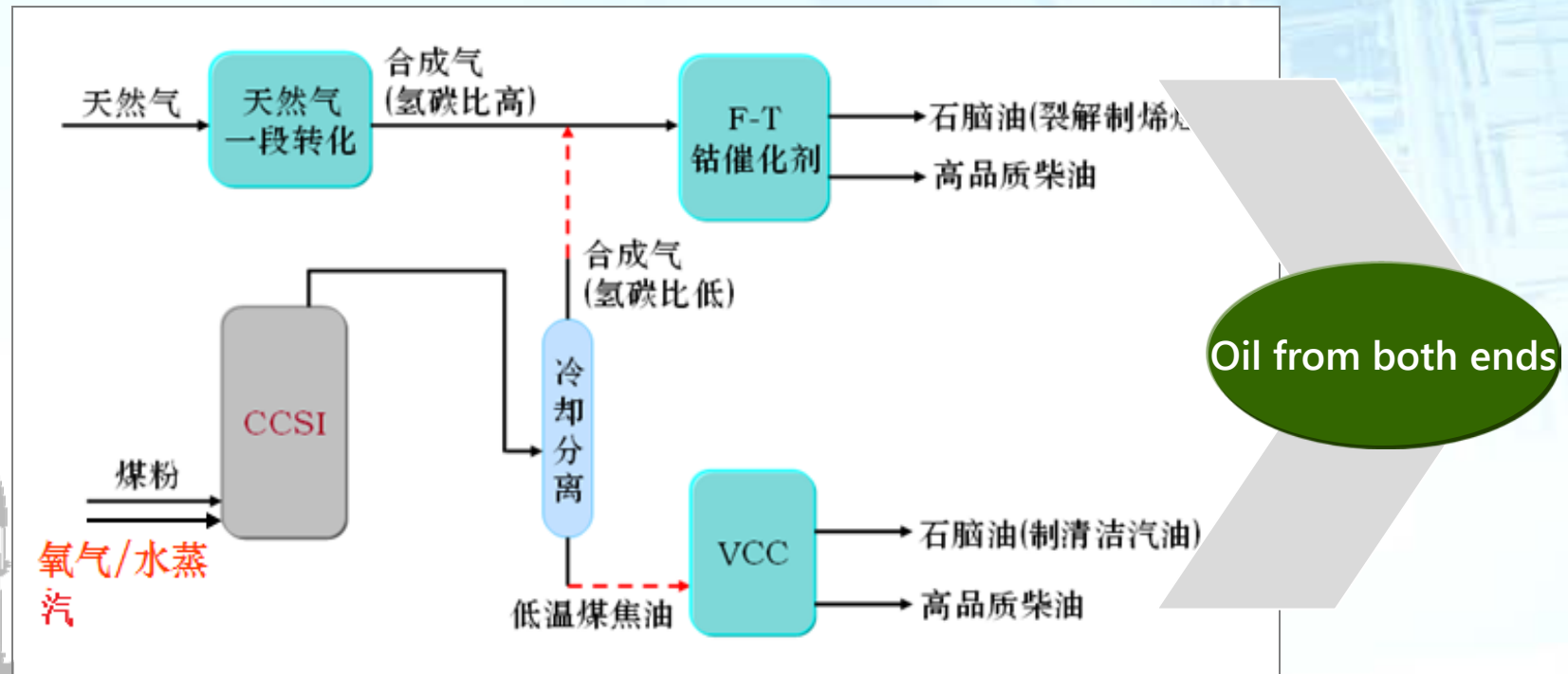
- We started the development of the 3000 tons coal per day CCSI's process design package in June of 2015, and expect to finish it in 2016.
- Design work of the Commercial plant is expected to start in the end of 2016.
- CCSI's two major possible applications are as following:



Part 2: CCSI Technology

- **First possible application: “Oil from both ends”**

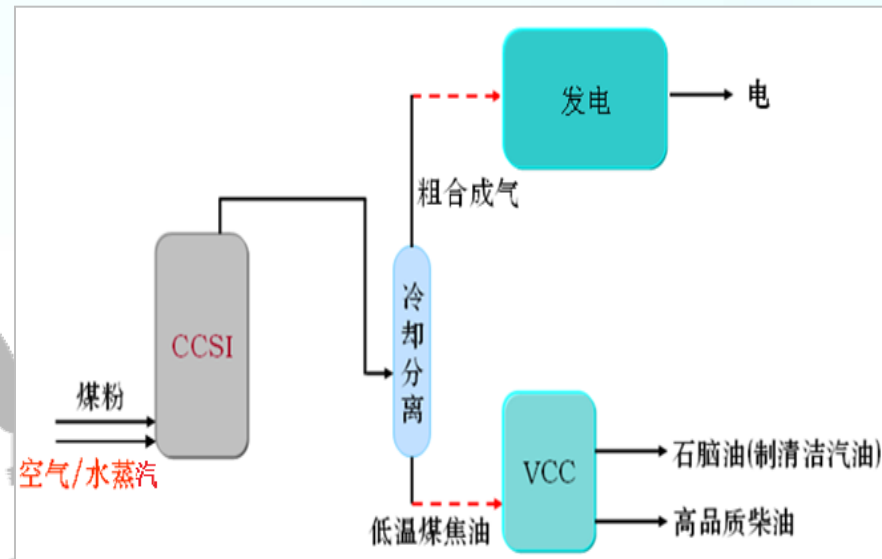
Integrated with Fischer-Tropsch Synthesis process, CCSI will be able to produce coal tar (oil) from the upper end and the light oil from lower F-T end using the raw syngas as feedstock from the upstream.



Part 2: CCSI Technology

- **Second application: “co-generation of oil and power”**

When CCSI is integrated with a power plant, we can get the coal tar while feeding the raw syngas into the boiler as fuel to generate power, or sending the raw syngas into the combustion turbine directly to generate power. For example, a 1 million t/y CCSI plant integrated with a power plant will be able to get 150,000t/y coal tar and, in the meantime, support a 300MW power station.



1 million
t/y CCSI
plant



1025 t/h
boiler



300MW
Power
unit

Process of CCSI co-generation of oil and power

Part 2: CCSI Technology

Advantages of “co-generation of oil and power” using CCSI technology

- No air separation unit (the gasification agent is air).
- Huge reduction in NO_x emission and $\text{PM}_{2.5}/\text{PM}_{10}$ emission.
- Profits from oil equals the profits from power generating.
- More efficient CO_2 capture and less global-warming gas emission.

Substitue syngas for coal in power generation, the true “green power” !



Part 3: KSY Technology

◆1. Introduction

KSY is a technology developed by the combined research efforts of KBR, Southern Company from the U.S.A and YCPC from China. It is mainly composed of the TRIG^R technology from KBR and TCD technology from YCPC. It's a dry pulverized coal circulating fluidized bed gasification technology, with the production of (CO+H₂) as the feedstock for downstream industries.



Part 3: KSY Technology

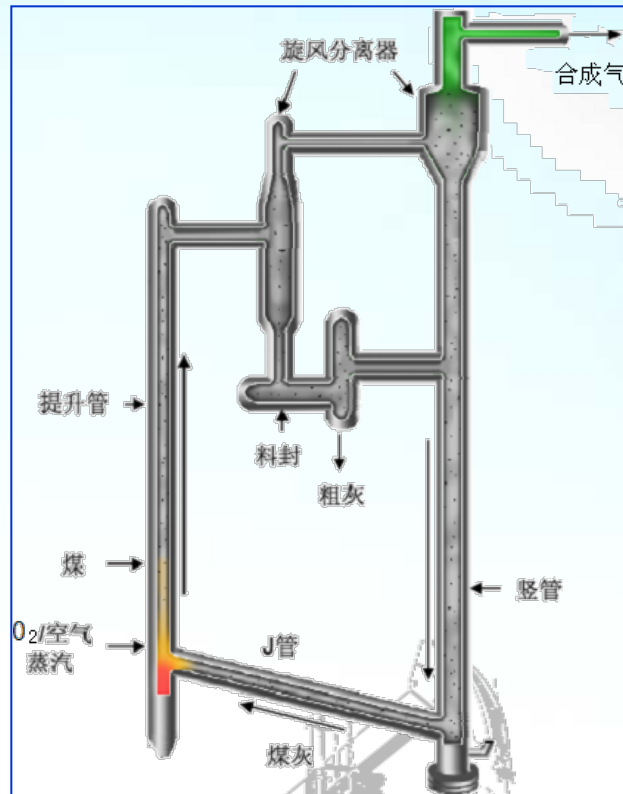


Illustration of TRIGR[®]

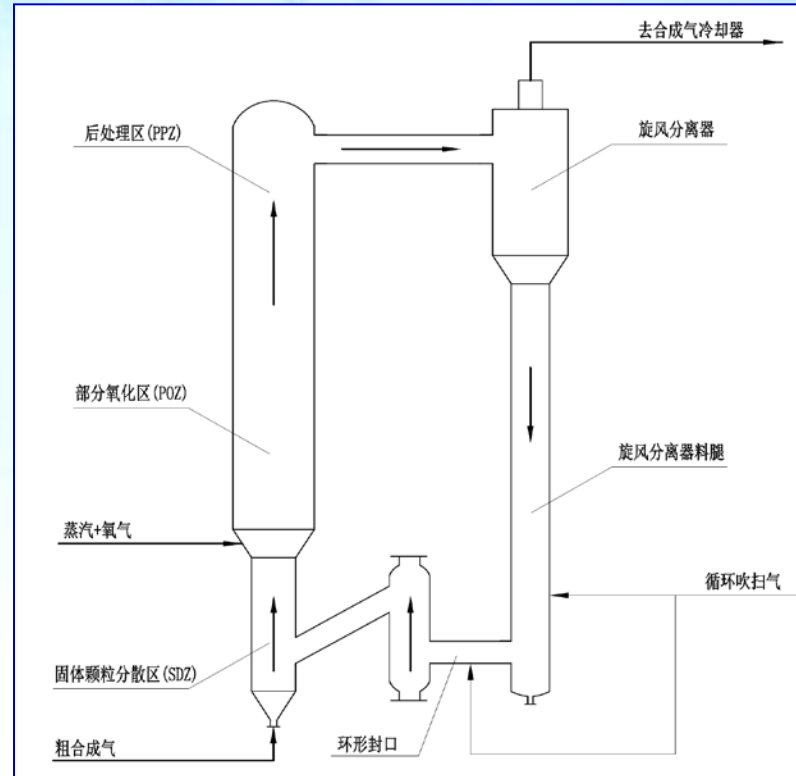
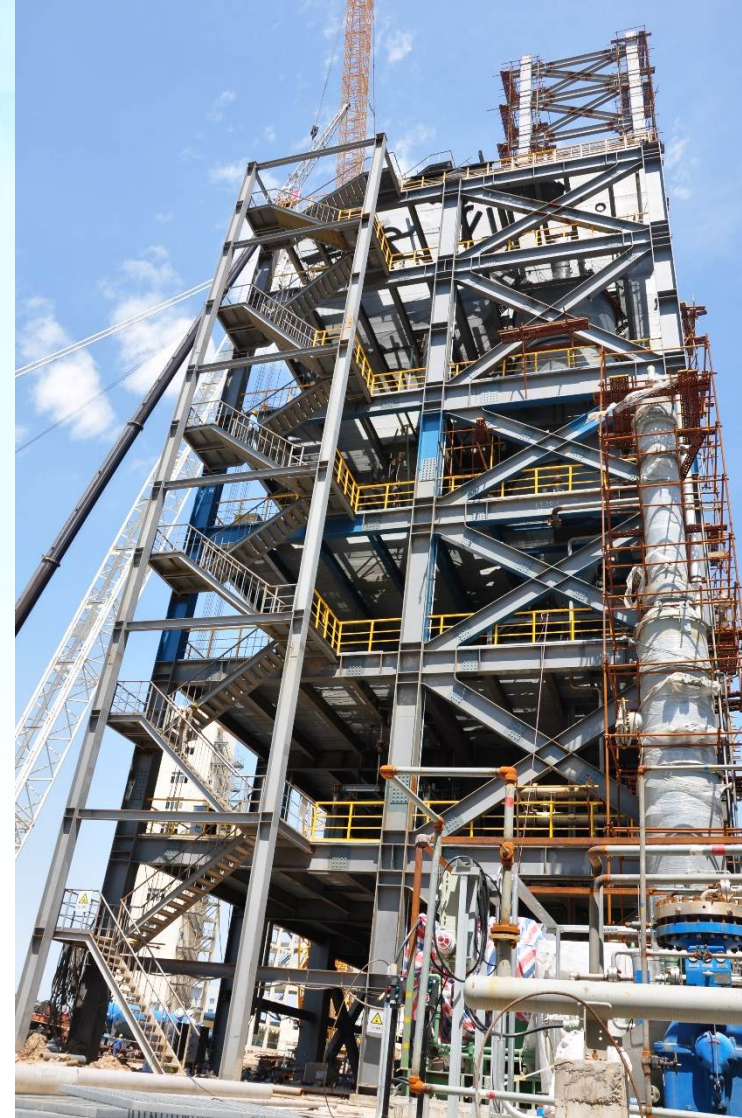


Illustration of TCD

Part 3: KSY Technology



- KSY demonstration test unit (100 t/d coal, under construction)

Part 3: KSY Technology

◆ 2. Demonstration test project under construction

Currently, a 100t/d KSY demonstration test project is under construction in Xingping City of Shaanxi province by YCPC. So far, all devices have been installed and we expect to complete the construction in September of 2015 and start the test run in October.

Coal feeding: 4.5t/h

Design pressure: 2.5 MPa

Operating temperature (gasifier): 1000-1150°C

Operating temperature (TCD): 1200-1250°C

Carbon conversion ratio: around 98%

(CO+H₂) content: ≥ 78%

Part 3: KSY Technology

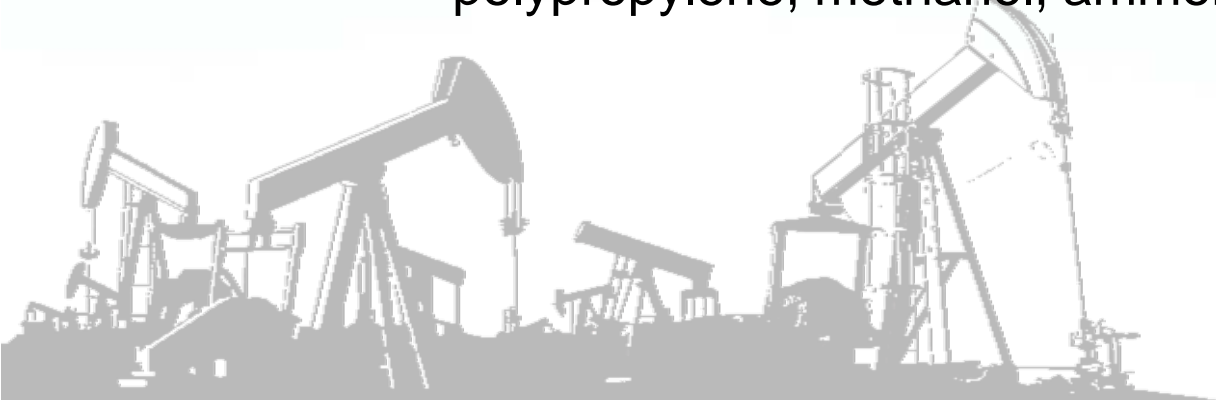
◆ 3. Advantages

- Wider input choice: besides lignite, KSY has more choices of input than TRIG^R, such as low rank coal and semi-coke, providing a brand new high-efficiency utilization technology for such feedstock. Furthermore, ash content in the feedstock of KSY process can be higher than 40%, making a breakthrough for gasifiers, for ash content can never be more than 20% before.
- Advantage of scale: as a circulating fluid-bed technology with pressure of 4.0MPa, KSY technology can be easily developed to a capacity of 5000t/d and hugely reduce the number of gasifiers needed in the large coal-to-liquid or gasification projects.
- Cost advantage: no internal components in the key equipment, easy to maintain and operate, low construction and operation cost.
- Environment-friendly: KSY process with dry ash to offside directly, no black water blow-down. Less water consumption and less waste emission.

Part 3: KSY Technology

◆ 4. Application planning

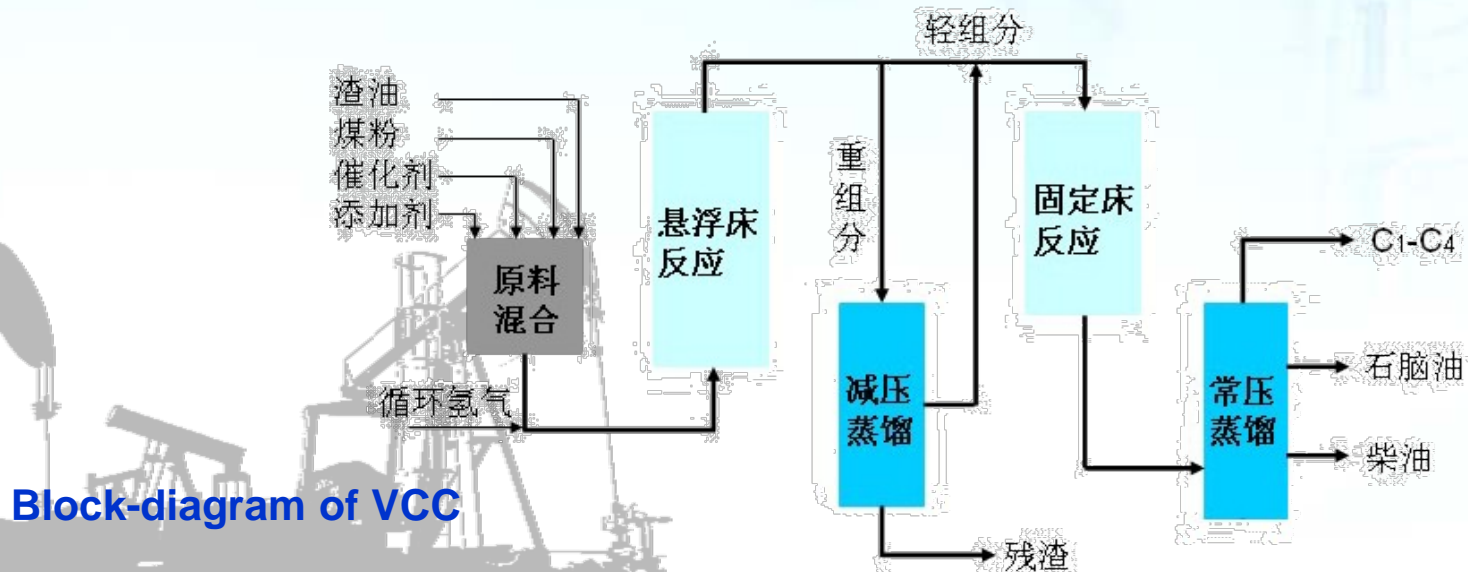
- The development of the 4.0MPa commercial process design package has been started in June 2015 while the 100t/d pilot unit is under construction.
- The syngas produced by the commercial unit in the future can be used as the input of IGCC power station. It can also be used in the production of synthetic oil, nature gas, polyethylene, polypropylene, methanol, ammonia, and etc.



Part 4: Oil-Coal Slurry to Liquid

◆ 1. Introduction

Oil-Coal Slurry to Liquid is light oil production technology developed by KBR, BP and YCPC on the basis of the VCC (Veba-Combi-Cracking) . Through cooperation with KBR and BP, YCPC built a pilot test unit , in the meantime, developed and built a 450 thousands t/y commercial plant with this technology.



Part 4: Oil-Coal Slurry to Liquid

◆ 2. Recent development

Since July of 2014, the 150 kg/d pilot test unit has been running plenty of evaluation tests, including oil-coal slurry to liquid, coal tar hydrogenation, heavy oil hydro-cracking. The satisfying results of these experiments show an average light oil yield of 70% and coal conversion of 90%.



One barrel per day pilot test unit



Analysis and Testing Center

Part 4: Oil-Coal Slurry to Liquid

◆ 3、 Commercial demonstration plant

The 450,000 t/y oil-coal slurry to liquid Jingbian project built by YCPC, which has a investment budget of 1.88 billion RMB, has been completed in January of 2015. High-quality oil has been produced with a coal concentration of 40%, which will go still higher in the future. At the beginning of August 2015, the performance test has been finished, showing that this commercial plant has reached the design condition.



油煤共炼示范项目 Commercial plant

Part 4: Oil-Coal Slurry to Liquid

◆4. Advantages

- Supplement for oil production

In face of the global heavy-oil trend and oil constraints in the future, oil-coal slurry to liquid technology will help to increase the production and supply of oil for China which has an abundance of coal and a scarcity of oil.

- Environment-friendly technology

This technology makes full advantage of heavy oil, residues and low rank coal, which have limited value in use, to produce light oil. It is an environment-friendly technology.

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Thanks !

