



Technology

In 2006, CNPC closely associated its technical innovation and R&D with its core business. We focused on tackling critical core technologies and major technical bottlenecks in priority areas such as increasing prospecting efficiency in complicated reservoirs, EOR of mature oilfields, reducing production and operation costs and improving products quality and clean operation, and meanwhile promoted optimal integration of our mature technologies.

In regard to exploration, CNPC has made steady progress in addressing such key technologies as the reservoir formation modes in lithologic strata, foreland basins and carbonate marine-facies, the prediction of reservoirs and the detection of oil and gas, the lithologic recognition of volcanics, and the composite reservoir evaluation. The quality of seismic data from complex mountainous regions is much improved and massive DMBS (Depth-Migration before Stack) is jointly processed. Thanks to the achievements above, significant reserves are discovered with the successful exploration of a number of basins.

As for development and production, focusing on increasing the recovery efficiency and resource utilization, we collected resources of geology, oil reservoir, oil recovery technique and engineering to make joint efforts in solving the problems that most of our major mature oilfields suffer from: high water cut, high percentage of low permeability reserves and increased difficulty of heavy oil development and EOR. We made significant progress in the optimization and adaptation of water-flooding technologies in extremely high water cut reservoirs. Breakthrough was made in the industrial field tests of ASP, steam-flooding, and SAGD. The associated technologies for efficient natural gas development were continuously improved. Horizontal drilling was fully deployed, while drilling speed was significantly increased by using gas drilling technologies. All these enabled the steady production from our eastern major oilfields featuring high water cut and high recovery percent of reserves.

CNPC's R&D of refining and chemicals focused on tackling key technical problems associated with deep processing of heavy oil, sour crude oil processing, low-cost production of alkenes and arenes, and the production of high quality, high value added synthetic resins and rubbers. We have new catalysts that address a series of catalytic cracking challenges like the high percentage of heavy components in raw materials, the high yield of coke, and the low recovery of light oil.

CNPC has developed EILog-06 matching well-logging equipment

and CGDS-I near-bit geosteering drilling system with its independently owned intellectual property right. At a reduced cost of exploration and development, these major technologies and devices has become increasingly prominent in mature oilfields because they can release the intercalated, thin, hard-to-recover, heterogeneous reservoirs or the reservoirs characterized by low pressure, low permeability, and low yield. GEO-EAST2.0 was put into developing while the widely deployed GEO-EAST1.0 fulfilled the processing and interpretation tasks in 42 projects. The High-Resolution Smart MFL Detector for pipelines with a diameter of 1016mm had been put into industrial application.

In 2006, Chinese Academy of Sciences (CAS) became CNPC's long-term partner in fields of developing new exploration theories and methods, EOR technologies, refining and chemical catalysts, new polymers, natural gas conversion, new energy, and Hi-Tech R&D and application. A kicked-off undertaking in their partnership is "Scientific Research Well No.1 in Songliao Basin", one of the projects featured in China's National Basic Research Program. It aims at researching major geological events in the global surface system during the Cretaceous period and to study the Earth's greenhouse climate change, and will provide important data for predicting global climate change in the future so as to help to unveil the geological structure of Cretaceous system and to gain a new understanding on oil and gas resources in the Songliao Basin.

During the past year, CNPC integrated and optimized its scientific research resources. An example of this was the establishment of CNPC Drilling Research Institute and Petrochemical Research Institute, which will help to improve our independent innovation and R&D strength in drilling technologies, reinforce our core competitive edge over competitors in engineering service, enhance the key role in refining and chemical operations with increased competitiveness, profitability and anti-risk ability.

In 2006, CNPC acquired 700 patents out of its 1,221 applications, including 396 applications for invention patents. Awards were given to some of these patents, including China Patent Golden Medal 2006 to "A composite multi-metal-oxide catalyst and its production method", and China Excellent Patent Prize 2006 to "A testing method for dynamic inspection of the advancing direction of injected water in water-injection wells" and two others.

In 2006, CNPC received seven second-class National Science and Technology Advancement Prizes for: "Petroleum geology, exploration technologies and significant oil and gas discoveries for



foreland basins in central and western China", "Research and application of gas drilling technology", "Research and application of effective development technologies for 5Mt/a crude oil production in Daqing peripheral oilfields", "Research and application of chemical flooding for EOR", "Research, development and application of industrial production technology for salt-resistant polyacrylamide with high molecular weight", "Development and application of auxiliary reactors for olefine-reduction upgrading of FCC naphtha" and "Leakage detection and positioning technology for crude oil pipelines". CNPC has won 34 national awards ever since 2002, including three first-class and twenty-nine second-class National Science and Technology Advancement Prizes, and two second-class National Technical Invention Prizes.

Exploration for Carbonate Reservoirs

CNPC has had an ever deeper insight into the growth and distribution modes of good reservoirs in carbonate weathering crusts and reef-bank facies belts, enabling us to rapidly extend the range and scale of exploration and giving a rise to discovering many favorable blocks such as Lungu, Tazhong, Jingbian, Luoheizhai, and Longgang regions. Our understandings on the valid carbonate source rocks and their gas formation provided a theoretical basis for extending the exploration in marine-facies carbonate rocks. Among other things, the research and application of oil-cracking mode of natural gas generation and the theory of "successive generation of natural gas" improves the exploration prospect in the distribution zones of highly-matured carbonate source rocks. All these create a series of technologies to predict carbonate reservoirs and their oil and gas potential, and the matching exploration technologies as well.

In Sichuan Basin, the research and application of the seismic prediction technologies for carbonate reservoirs gave an effective guide to the exploration in Feixianguan formation. As a technical enabler, it helped us prove the nearly 100 billion cubic meters of natural gas reserves in Tieshanpo, Dukouhe, and Qilibei carbonate reservoirs.

Steam Assisted Gravity Drainage

CNPC conducted steam assisted gravity drainage (SAGD) pilot tests in 8 groups of wells to develop ultra heavy oil from the 1,500m-plus deep reservoirs in Liaohe Oilfield. Among of these wells, 4 horizontal wells had the individual production equivalent to 22 vertical wells, with the recovery factor expected up by 30%.

As a technology of our independently owned intellectual property right, SAGD integrates ten technological components like numerical simulation, well drilling and completion, heat exchange of output fluid and dynamic control and monitoring of reservoirs. It has become the major technology for post-steam-stimulation recovery of ultra heavy oil. Based on current screening standard, heavy oil in place in Liaohe Oilfield adaptable to SAGD will exceed 100 million metric tons, and the recovery efficiency may be enhanced by 30% by applying SAGD, representing additional 30 million metric tons of recoverable reserves.

Horizontal Drilling

2006 saw CNPC's massive application of horizontal drilling. This realized a higher productivity from less wells, at reduced cost, land occupation, and risk of environmental pollution. During this year, we completed 522 horizontal wells, which created 2 million metric tons of new productivity, equivalent to over 1,500 new vertical wells. These wells were drilled at a penetration rate of 7.03m/h on average, 6.8% higher than last year, and drilling time and construction cycle decrease by 18.4% and 23.4% respectively. Among of these 522 horizontal wells, 481 were put into production, with an average individual production of 22.5 metric tons per day, as much as 3 to 5 times that of the adjacent vertical wells.

CNPC's horizontal drilling integrates our advanced technologies like reservoir engineering and optimization design, well track control, drilling fluid and oil layer protection, and production engineering. The technology has broken a number of CNPC's records of horizontal wells, including the longest drilling footage in the oil reservoir segment, the highest individual production, the thinnest drilled reservoir, and the largest horizontal displacement.

- Well Xingping-1 of Changqing Oilfield: It is China's first 7-lateral horizontal well with 1,203m-long main horizontal interval, among its horizontal intervals totaling to 3,503m. In reservoirs, it recorded footage of 2,834m and encountering rate of 87.7%.
- Well Nanpu 1-H1 of Jidong Oilfield: This horizontal well recorded the highest individual production, 511 metric tons per day.
- Well HW9817 of Xinjiang Oilfield: With the vertical depth of 135.6m, this well recorded a ratio of horizontal displacement to vertical depth of 2.22.
- Well Nan 219-H320 of Daqing Oilfield: This well has an oil layer as thin as of 0.5m and the encountering rate of 63.36%.



- Well Zhanghai 502FH of Dagang Oilfield: Horizontal displacement 4,128.56m.

Gas Drilling

Gas drilling is still one under-balanced drilling method while it has a good head for eliminating the lost circulation in long bores, as well as the bit sticking due to pressure difference in low-pressure, disintegration and water-sensitive strata, and accelerating bit speed in tight formations, thus greatly enhancing the overall drilling efficiency.

In 2006, CNPC drilled a 6,530m deep well in Sichuan Province. Numbered Longgang 1, this well was drilled at an average rate of 6.4m/h. Up to 3,304m or 50.6% of the total footage was gas drilled, at an average rate of 19.5m/h, more than 16 times the rate of conventional mud drilling. A DTH test also produced satisfactory result. More than 50% of the gas-drilled section was DTH blasted, at an average rate of 26.59m/h, about 50% higher than that of conventional gas drilling. In the 311.2mm borehole, a single DTH hammer created 1,712m of footage.

China Geosteering Drilling System-1

China Geosteering Drilling System-1 (CGDS-I) is a powerful near-bit geosteering system featuring CWD (Control While Drilling) recognition of oil and gas reservoirs. It integrates drilling, logging, and reservoir engineering to ensure the best positioning of bores across reservoirs by near-bit geological and engineering measurement as well as CWD. While the well track is adjusted and controlled with reference to the CWD-monitored strata characteristic information, the bit is steered toward the "oil smell". In industrial tests in Jidong and Liaohe Oilfields, this system was proven to have the best near-bit geological and engineering measurement and sensor-bit clearance, embodying CNPC's core competitiveness to manufacture high-end technological equipment.

High-Resolution Smart MFL Detector for Pipeline

A high-resolution smart MFL (magnetic flux leakage) detector for pipeline with a diameter of 1,016mm was developed in 2006. This detector uses MFL principles for the online detection of loss of metal caused by corrosion, mechanical damage, and material defect in pipelines. It also characterizes pipelines on their flanges, T-joints, and wall thickness variation. The position of the defect can be precisely

indicated with an accuracy of up to 90%. In an industrial application on a 48km-long segment along the Second Shaan-Jing Gas Pipeline, the MFL detector located the pipeline defect with a precision of $\pm 1\%$ to the nearest reference point axially, and $\pm 5^\circ$ radially, and detected a minimum defect depth of 5%. The detector has excellent mechanical pass-through performance. It could safely run across 904mm narrowed or partially transformed pipes. With a digital electromechanical control system and an expert system for data analysis, its safe and secure dynamic performance helps obtain high-quality detection data. The detector also carries an inertial-navigation mapping unit to accurately capture the pipeline route and displacement data.

New LIP Catalysts

Catalysts LIP-100 and LIP-200 were developed to improve propylene productivity of catalyst cracking unit and to maximize the propylene production in China. LIP-100 was a MIP (Maximum Isoparafin Production) catalyst while LIP-200 was for maximized propylene production and increased octane value. Both catalysts met the MIP technical characteristics and satisfied the special MIP requirements for catalysts.

LIP-100 can efficiently transform heavy oil, as shown in an industrial application at Jinxi Petrochemical. With the catalyst inventory of up to 85%, 440 tons of LIP-100 were used and the recovery of liquid hydrocarbon, gasoline, total liquid, and propylene increased by 1.0%, 0.7%, 0.9%, and 1.28% respectively, while the yields of dry gas, coke, and slurry oil decreased by 0.3%, 0.2%, and 0.5%. Industrial tests indicate that LIP-100 is a stable and abrasion-proof catalyst that helps crack heavy oil molecules efficiently and recover target products more. With more heavy oil transformed, the propylene recovery is increased while the coke yield is decreased. LIP-200 has been also put into industrial application. With the catalyst inventory of more than 50%, this catalyst is performing well.



Slurry Bed Hydrocracking of Heavy Oil

Passing the Phase-1 process test, heavy oil slurry bed hydrocracking (SBH) underwent the Phase-2 industrial test. In this test, the anti-coking performance and heavy-oil transformability of industrial reactors were observed at medium severity. The test indicated that the processed atmospheric residue of Karamay oil could reach a light oil recovery of 60% without coking in the reactor – a breakthrough in coking in reactors under high transformation rate. All through the industrial test, all the major systems of the test unit ran smoothly and delivered high transformation but low coking, just as expected. In addition, the complete set of calibration data was obtained. With the success of the test, the technology was ready for industrial application.

SBH for inferior heavy oil is an independently developed refining technology of our own intellectual property right. This technology has the potential for widespread application, since it offers a new approach to processing and exploiting the almost 100 million metric tons of inferior heavy oil in China. The entire technique has been patented as an invention one in China and the US.



World's Largest Reed Marsh

Liaohe Oilfield has made great efforts in protecting the ecologic environment of the wetland, making it the world's largest reed marsh. (See Page 13)



China Green Carbon Fund

To promote tree planting and afforestation, carbon sequestration and exhaust minimization, and to help improve ecological environment and relieve global climate change. (See Page 15)



Green Corridor in Desert

The ecologic shelter-forest for Tarim Desert Highway furnishes a green corridor across the famous Taklimakan Desert. (See Page 14)

Water Cellar

Water cellar is a special rain water-cumulating facility in west China. A 36-cubic-meter water cellar can provide enough drinking water for a family of five for one year. A donation totaling RMB 10.3 million from CNPC's staff can help construct more than 10,000 water cellars for over 10,000 families. (See Page 14)

