

The Status and Development of CBM technology of Mining Area

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Review of Chinese CBM Development and Utilization



Geological conditions for Chinese CBM development



Technical approaches for Chinese CBM development



Technical progress of CBM development in coal mining area in China



Global CBM distribution





The global reserve of CBM is 260 trillion m³, 90% is distributed among the 12 main coal-producing countries.





- Russia, Canada, China, US. and Australia CBM reserve all exceeds 10 trillion m³.
- China: the shallow CMB reserve within 2000m is 36.8 trillion m³, the exportable amount is 13.9 trillion m³



CBM distribution in China



History of Chinese CBM development:

✤ Undergrond drainage stage (1950-1979)

In1952, gas drainage station was founded in Chongqing and Fushun Mining Bureau and ect.

- Ground test development and initial stage of gas utilization (1980-2005)
 Technologies were introduced and over 200 wells were dilled, Liulin and
 Jincheng got industrial gas flow, the ascertained CBM reserve is 10.23 billion m³
 ,the drainage of CBM in mines has been upscaled.
- Initial stage of CBM industry development (2005-till now)
 Marked by the entry of Jincheng Coal company, China Petro and Coal seam gas company in China and so on companies. By the end of 2012, CBM wells has
 Cached 12100 national wide, which forms the capacity of 3 billions m^{3.}

Situation of CBM Development and Utilization



❖In 2013:the national CBM extraction quantity is 15.6 billion m³, the used amount is 6.6 billion m³. Among this, the drainaged amount from mines is 12.6 billion m³, the used amount is 4.3 billion m³; the ground CBM production is 3 billion m³, the usage is 2.3 billion m³.

◆12th five-year plan: In 2015, coal-bed methane production will reach 30 billion m³,of which 16 billion m³ developed ground and fully used, 14 billion m³ extracted from mines, utilization rate of more than 60%.

Basic geological features of Chinese Coalfield

- According to the temporal and spatial distribution of coal bearing strata and tectonic characteristics, Coalfield divided into :
- I. Northeast coal-rich region
- **II.** North China coal-rich region
- **III.** South China coal-rich region
- **IV. Northwest coal-rich region**
- V. Dianzang coal-rich region







Basic geological features of Chinese Coalfield

I . Northeast coal-bearing region:

- ✓ Coal-bearing stratum: It is mainly lower cretaceous, the secondary is permocarboniferous and tertiary coal deposit.
- The new generation of Coal-bearing stratum is graben basin in north and east direction, sub-graben, and fault terrace development; the coal stratums in the graben are in north and east direction, asymmetrically. Except Fushun, mainly brown coal.

II. North China coal-bearing region:

- ✓ Coal-bearing stratum: Permo-Carboniferous system and Jurassic system.
- In north china platform, Erdos basin(Such as Dongsheng, Shenmu area) is of a simple structure, the coal stratum is nearly horizontal distributed. In its outer ring area, the coal field has intense deformation.

Basic geological features of Chinese Coalfield

III. South China coal-bearing region:

- ✓ Coal bearing stratum: The Permian and Jurassic.
- ✓ Located in Yangzi platform and South China fold system.

IV. Northwest coal-bearing region:

- ✓ Coal bearing stratum: PermoCarboniferous, cretaceous.
- The large and medium basins have stabilized distribution of coals, but subject to later tectonic movement, the peripheral area of the basin has complex structure, fault terrace development and large tilt angle of coal stratum.

V. Dianzang coal-bearing region:

✓ Coal bearing stratum: tertiary period, carboniferous period.



The small coal basin has very complicated geological structure.

CBM resource is widely spread: Xin, Jin, Shan, Jin, Yu, Wan, Liao, Ji, Hei, Mon, Yun, Gui, Chuan and so on 24 provinces and cities, all the autonomous regions have CBM, among them, CBM reserve of Xinjiang, Shanxi, Shanxi, Innermogolia and Yunnan, Guizhou and Sichuan areas represents 90% of the national total.



- CBM reserve in China is decided by the tectonic plate structure. The Chinese tectonic structure consists of some small platforms, intermediate plates and many minor ones and fold zones, a complex continent. This feature decides that most of our coal-bearing basins have poor stability in terms of tectonic structure, of which is complex and diverse, the geological conditions of coal and the symbiosis CBM are really complex.
 - US. and Canada and other countries have stable platform composition.





Basic geological features of Chinese Coalfield

Common low permeability:

✓ Chinese coal bed has lower permeability, mainly0.1-1mD.The coal beds of less than 0.1mD cover 35%, coal beds with 0.1-1.0mD cover 37%; those that are bigger than 1mD cover 28%.

✓ The permeability of US. black warrior basin is mainly within 1-25mD,that of san juan basin is within 5-15mD,and that of powder river basin is within 35-500mD.



> The Chinese coal bed is mainly of high gas rate, but with low saturation

CBM Distribution in China ✓ Among gas accumulation region with gas rate $\geq 4m^3/t$ in China, the average gas saturation is 20%~91%.The national average is 45%. ✓ Northeast region has the highest $4m^{3}/t$ $8m^3/t$ $12m^{3}/t$ saturation, and northwest has the $16m^{3}/t$ lowest. 450km Nati Gas North South Northeast Northwest onwi China China China China saturation de 14 42 52 53 % 45 30

➤ In China, the low rank CBM reserve covers 36% of all.





3. Technical approaches for Chinese CBM Development





Progress of CBM International Exploration and Development

3. Technical approaches for Chinese CBM Development

- In China, above 70% of coal fields are not applicable for ground development of large scale. Only the Qinshui basin, Erdos basin east side, Weibei Hancheng coal field, and Huanglong coal field are suitable for large scale production of CBM.
- The special geological conditions of CBM China, determined that we must implement CBM ground development and underground drainage development pattern of the combination of the walking, CBM and coal coordinated development of the road



Chinese CBM Distribution and Favorable Areas



3. Technical approaches for Chinese CBM Development



水平井地面开发煤层气示意图



Coordinated development mode of CBM in China

4. Technical progress of CBM development in coal mining area in China

- Science & technology is a key guarantee for goals of CBM development in coal fields
- Since 2008, with the support from "Development of large oil and gas field and CBM", a major national science and technology projects, CBM development in coal mining area in China has achieved a series of breakthroughs.

New understanding of theories

New progress of key technology

New break-though of key equipment

New stage of gathering and transport

New mode for co-development

(1) New understanding of theories

Reveal the relation between CBM development and coal mining in coal field





(1) New understanding of theories

Reveal the relation between CBM development and coal mining in coal field

Positive effect

• CBM drainage provides a safe and highly effective guarantee for coal

• Mining activities form three zones (caving zone, fractured zone, bending zone), which make the surrounding rock, coal seam pressure relief, separates and fracture, permeability increases greatly, can greatly improve the mining area of low permeability coal seam extraction productivity.



Permeability increases 890~2880 times for pressure relief coal bed of X coal filed in Huainan



(1) New understanding of theories

Reveal the relation between CBM development and coal mining in coal field

Negative effect

 The coal mining "three zone" will made fault deformation of casing, reduce the pumping effect, shorten the extraction well Business Hours.





- CBM well pressurized fissure will cause roof failure, adverse mining roof management; may communicate aquifer, produce large amounts of water, become the mine water hazard.
- The casing pipe of CBM well can damage the coal cutter, create sparks and cause safety issues.

Extraction technology of downhole comb drill

✤During bedding drill of loose outburst seam, the hole tends to collapse and embed the drill, which will impact the hole length and drainage effect, in the top and base plate of coal bed constructs the comb drilling holes.

Chuxianzhuang coal field of Huaibei, Zhaozhuang coal field of Jincheng, Zhangji coal field of Huainan and Jiulishan coal field of Jiaozuo have seen successful application. In Jiulishan mine, there are 3 comb holes of top plate of far coal bed(Total length of 2538m), used for CBM drainage in the mining zone, the total gas drained is 1.09 million m³



- Underground horizontal directional composite drilling technology
- Shanxi Dafousi Mining Company has completed the 1212m deep hole drilling, creating the highest record of domestic underground directional drilling
- Branches of single holes reaches 24,the deepest branch hole is 915m;horizontal deviation is less than 5‰ of hole depth, the vertical deviation is less than 1‰ of the hole depth.





"U"well drilling technology

Shanxi Jincheng Panzhuang ground **CBM"U"type butted well:** the drilling depth is1304.33m, the main well hole is 1027.37m, since the 394M into the coal seam, at 727.01m it is butted with the vertical well, the coal bed drilling rate reaches 100%. This well started to drain and produce gas at the end of Feb.,2011 the daily production of single well has reached 21000m3, It keeps that record for more than half year.



Jin Coal Panzhuang SH-U2 U shape horizontal butted drilling site



3D of Jinchengsihe Coal SH-U2 well drilling

Vertical well fracturing and undergrond horizontal hole combined technology

In the well of Sipan area of Jinchengsihe Coal, they use oriented long hole drilling, which passes the vertical YH075 fracture zone, before using oriented holing, the average daily production is 3800m³/d, and after it has reached 5500m³/d







YH-075 well and drilling **26** position under well

- Extraction technology of CBM in coal mining area
- In Sihe Coal, Chengzhuang Coal and Yuecheng Coal, the technology has been tested successfully, the extraction concentration has reached
 50~90%; the extraction rate has reached
 13500m³/d, generally it is m³/d above.
 - Initially formed in the ground hole position selection, type of structure optimization design, the key technique of coal mine ground well risk failure position safety protection, ground pumping control in one of the mining area coal seam gas extraction

technology system.





(3) New break-through of key equipment

Mine kilometer directional drainage drilling technology and equipment

- Invent system of cabled, high strength, large drilling rod and drill-based measuring system.
- ZDY600LD crawler drilling machine drills 1212m in
 Binchang Dafoushi company of Shan Coal and set a national record. It has been used in 10 mining fields.







(3) New break-through of key equipment

- Break-though of remote controlled extraction and drilling technology and equipment
- undergrond drilling of ground remote control has seen break-through, it achieves auto control drilling status, auto handling drill rod, drilling of 15 holes of remote ground control(121.5m for the deepest), it reduces the exposure of personnel for CBM development, and gives a new direction for semi-auto operation.







(3) New break-through of key equipment

- Small-caliber wireless drill accompanied measuring system for underground mining
- This system can generate very stable measuring signal when the slurry pump discharge is greater than96L/min (1.6L/S), it can satisfy the trac k measuring requirement under small discharge and pore diameter.





Wireless drill accompanied measuring system

Ventilation oxidation pilot test technology

Capacity 1000Nm³/h, oxidation rate>96%,the minimal self-heating balance concentration is 0.23%



Ventilation test device with gas



Test device for ventilation and oxidation furnace



Gas safe burning technology

Complete 1000m³/h metal fiber type gas burning system sample machine





1000m³/h burning furnace for pilot test



清水溪试验现场瓦斯焚烧安全监控系统



Auto-ignition and safety monitoring system



Metal fibre and fireretardant gas burner



Gas water separation device Dehydrate and dust-removal

- Deoxidizing and PSA concentration for low concentration CBM
- One-time absorption deoxidizing rate is above90%, the oxygen concentration can fall to 1% from12-14%, energy consumption is lowered by over 20%, one time enrichment can increase by 30% more.
- Construct CBM deoxidizing concentration for18 million Nm3/a CNG Program of Yang Coal Corporation.







100Nm³/h Deoxidizing Unit

PSA Concentration Test Unit

Oxygen-bearing liquidizing purifying device for pilot test

- Build a PPMR pilot test device for oxygen-bearing coal bed with raw material gas handling capacity of 4800Nm³/d, raw methane concentration is 26.98~
 32.05%,after it is liquidized, the purification Can be 99.10% above, the methane recovery rate can reach 98.75%.
 - Feitian Coal's 300,000m³/d liquidizing program is started.



Oxygen-bearing liquidizing purifying device for pilot test



(5) Coordinated development for a new mode

Mode	Typical tech. system	Applicable conditions	Time efficiency
The mode of grond and undergrond combined extraction with single coal seam	Grond and undergrond combined extraction of coal and CBM in a coordinated way of Jinchen 3 areas combined	Single coal bed, simple structure, gentle terrain, hard coal quality, high gas rate, bigger permeability	 1.Pre-extraction of ground well is 5~10 years ahead 2.Under-well pre-extraction is 3~5 years ahead 3.Extract during mining
The mode of grond and undergrond combined extraction with coal seam group	Pressure relief of two Huai protection seam, strengthen coordinated development of coal and CBM	Coal bed groups, gentle terrain, soft and low permeability coal bed, tectonic coal development	 Pre-extraction of mining protection seam is 3~5 years ahead Well top and bottom combined, one well for 3 applications No protection seam strengthened extraction
The mode of undergrond extraction with coal seam group	3-ahead Anti- reflection extraction of coal and CBM in a coordinated development of Songzao 3 areas	Complex geological conditions, wavy and complex terrain, soft and low permeability coal bed	 "3 ahead": 1.Prepare extraction roadway ahead 2.Extractio system runs ahead 3.Extraction of protection seam ahead 35

(5)Coordinated development for a new mode

Results of pilot areas:

- In 2012, there are 3 key pilot test mining areas: Jincheng—2.378 billion m³ (use 1.467 billion m³) ,Two Huai--0.71 billion m³ (use 0.19 billion m³) ,Songzao –0.252 billionm³ (use 0.193 billion m³)
- The extraction rate is 3.34 billon m³, covers 24% of national total, an increase of 226% compared with before implementation of the key pilot program in 2007, the used total is 1.85 billion m³, covering 32% of the national total, an increase of 336% compared with 2007

Pilot mining area		Extrac tion	Used amoun t	Usage	Coal output ⁄10kt	Millio n ton Death rate
Jinc hen	2007	5. 40	2. 50	46. 29%	3221	0. 062
	2012	23. 78	14. 67	61. 69%	5600	0. 053
	2013	25. 16	15. 11	60. 05%		
Two Huai	2007	2. 90	0. 59	20. 34%	5695	0. 40
	2012	7. 10	1. 90	26. 76%	11000	0. 07
	2013	7. 30	2. 40	32. 88%		
Song zao	2007	1.96	1. 15	58.67%	489	1. 432
	2012	2. 52	1. 93	76.83%	571	0. 175
	2013	2. 70	1. 99	70. 37%		
Pilo t area tota l	2007	10. 26	4. 24	41. 32%	9405	0. 34
	2012	33. 40	18. 5	55. 39%	15571	0. 077
	2013	35. 16	19. 50	55. 46%		
Nati onal tota I	2007	47	14	29. 78%	252300	1. 485
	2012	141	58	41. 13%	370000	0. 374

Summary

New technical direction for CBM development and applications:

- Geological conditions vary a lot among various coal fields, coal should be developed in a special way that coordinates the CBM development technology and equipment.
- CBM in coal field is still under-used, technologies and equipment of CBM comprehensive use, flexible and small, should be developed.
- Main efforts should be given to study CBM reservoir-forming rules, high permeability and CBM rich area distribution rules, and favorable area prediction, to study CBM accumulation and reservoir-forming rules of coal measure strata of different coal ranks and depth.



Summary

- The development and utilization of coal mine methane has the advantages of safety, resources, environmental protection, economical benefit, has broad prospects. But the characteristics of our country's existing coal seam gas resources with the complexity and particularity, coal-bed methane development and low saturation, low permeability, low reservoir pressure, high degree of metamorphism "three low and one high" conditions is the world difficult problem.
- CBM development in China must follow the road of coal and CBM coordinated development. From the practical point of view, according to the characteristics of geological structure and coal reservoir respective suit one's measures to local conditions, choose the appropriate mode of technology and development to maximize the extraction quantity and rate, and to assure coal and CBM are both safely and effectively developed.





Thank you !

