Case Study: Best Practice of CMM Development and Utilization in China

HUANG Shengchu, Ph.D
Director General
China Coal Strategic Research Center
Email: huangsc@ccsr.cn
www.ccsr.cn
China is the largest coal producer in the world. The coal output was 3.75 billion tons in 2015, decreased by 3.3% in comparison with that in 2014.

Coal consumption totaled at 3.94 billion tons in 2015, decreased by 4.4% in comparison with that in 2014.
CMM drainage increased from 2.2 billion in 2005 to 13.6 billion m$^3$ in 2015.

Volume of CMM utilization are 4.77 billion m$^3$ in 2015, and utilization rate is 35.1%. About 8.8 billion m$^3$ of gas are available for more gas utilization projects.
With a large amount of gassy and outburst-prone coal mines, China is confronted with great challenges in mine safety and improvement of the efficiency of CMM recovery and utilization. Coal mining companies in China have been making great efforts to use innovative technologies in CMM recovery and utilization.

Main difficulties: low permeability, soft coal, small gas flow from a single underground borehole or vertical well, low methane concentration, etc.
2. Case Studies

- **Case Study 1: Pre-drainage of CMM using Multi-literal Horizontal Wells**

  - **Site:** a coal mining panel at Shaqu Coal Mine of Huajin Coking Coal Co., Ltd, Shanxi Province.
    - Length of the panel: 1500m,
    - Width of the panel: 220m
    - Strength of the coal seam to be mine:
      - soft coal, f=0.5
    - Gas content: 11.5m³/t
    - Permeability: 1.78-3.78m²/MPa².d
Difficulties

- Low permeability
- Difficulty to pre-drainage
- Large amount of gas emitted from coal seams to headings
- Tight connection of workings

Safety risks in mining operation
Solution: Pre drainage of CMM using multi-literal horizontal wells

Design of horizontal wells

- The multi-literal horizontal wells reached to all places of the panel
- The horizontal wells were drilled within the coal seam
Drilling wells boreholes

- Drilled 2 main horizontal wells (DS01- well, DS02 – well) with 4 side branches
  - The length of DS01- well: 1027m.
  - The length of DS02 - well: 1056m
  - The length of the 4 side branches of DS02 – well: 272m, 272m, 273m, 797m
- Drilled 2 underground boreholes
  - XC01- borehole (53m long), CX02 – borehole (54m long)
  - Be connected with the directional branches of the horizontal well
Underground borehole joined with surface well
Achievements

- Period of CMM recovery: 672 days,
- Total volume of CMM recovered: 10,130,000 m$^3$
- Averaged CMM flow: 15069 m$^3$ per day
- Methane concentration : > 90%. The CMM was used as fuels for the Power Plant at Shaqu Coal Mine.
Site: No.6 Coal Mine, Hebi Coal Company of Henan Energy and Chemical Industry Group, Henan Province

- High methane content, risk of coal and gas outburst
- Coal seam to be mined: soft coal, $f=1$
- Thickness of the coal seam: 4.72 ~ 13.51m
- Gas emission: 25.07 m$^3$ per tone of coal output
Difficulties

- High gas pressure
- Hugh risk of gas outburst
- Low permeability
- Long extraction period
- Serious accidents of gas outburst

Low tunneling rate 12.26m per month, high methane contents in the air exceeding safety limit.
Drilling boreholes for fracturing
1. Borehole within the coal seam
2. Borehole within the coal seam in the entrance roadway and ventilation roadway
3. Borehole in gas drainage roadway over the coal seam
4. Borehole in gas drainage roadway under the coal seam
Long boreholes in roadways under and above the coal seams for high pressure fracturing

Long borehole in the drainage roadway over the coal seam for high pressure fracturing
- Undertook 6 successful trials of hydraulic fracturing
- Drilled 114 boreholes with 7810 m in total
- Recovered 720,000m³ of CMM
- Length of gas drainage roadway: 400m

<table>
<thead>
<tr>
<th></th>
<th>Permeability t (md)</th>
<th>Gas flow decay coefficient (d⁻¹)</th>
<th>Gas flow from single hole per 100m (m³/d.hm)</th>
<th>Tunneling rate per month (m)</th>
<th>Methane contents exceeding safety limit (%)</th>
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<tbody>
<tr>
<td>Before fracturing</td>
<td>0.03～0.045</td>
<td>0.3871</td>
<td>26.52</td>
<td>12.26</td>
<td>35</td>
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<tr>
<td>After fracturing</td>
<td>5.83</td>
<td>0.044</td>
<td>573.7</td>
<td>40</td>
<td>3.2</td>
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<tr>
<td>Increased by times</td>
<td>129～194</td>
<td>8.80</td>
<td>21.62</td>
<td>3.3</td>
<td>10.9</td>
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</tbody>
</table>
3. Great potential for AMM utilization

- Structure of coal mines in China.

9624 coal mines

- Large Scale Coal Mine: 1196 (12%)
- Medium Size Coal Mine: 1714 (18%)
- Small Coal Mine: 6714 (70%)

Classification of coal mines based on coal production capacity in China 2015
In consideration of the situations that coal supplies are much over demands and gassy coal mines are accident-prone, Chinese Central Government planned to close down about 4000 small coal mines and 300 large coal reserve-exhausted mines with total annual output capacity of 500 million tones of coal in coming 3 to 5 years, for which the Central Government will provide financial support of RMB 60 billion.

There exists a large amount of abandoned mine methane (AMM) in those coal mines to be closed.

Using AMM as fuels for power generation will make great contributions to energy supply and emission reduction.
4. Demonstration of CMM Utilization in different area

- Power generation
- Compressed CMM for vehicles fuel
- Liquefied CBM
- Household use
5. Conclusions

- Many coal mines are confronted with great challenges in mine safety and CMM recovery. Chinese government is encouraging coal mining companies to use best practices in improvement of CMM recovery and utilization with governmental funds and incentive policies.

- These challenges present potential opportunities for cooperation in CMM recovery and utilization between China and other countries. Innovative technologies demonstrated great accomplishments.

- The plans and actions in closing down a large number of gassy and exhausted coal mines offer more opportunities for AMM recovery and utilization. All these efforts will result in reduction of methane emissions from coal mines.
Thank you for your attention

For more information, please contact:
China Coal Strategic Research Center, Beijing
Email: huangsc@ccsr.cn