Technical Measures to Promote Coal Mine Methane (CMM) Utilization

Shengli Oil Field Shengli Power Machinery Group Co., Ltd
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Current Status of CMM
Recovery and Utilization
Current Status of Methane Recovery and Utilization

- **Coal production phase**
  - Resource exhaustion and abandoned mines
  - Normal mining
  - Pre-draining or only gas production

- **Graph**
  - CBM
  - Available CMM
  - CMM (available and drained methane of low concentration)
  - VAM
  - AMM

- **%CH₄**

- **Legend**
  - CBM
  - Available CMM
  - CMM (available and drained methane of low concentration)
  - VAM
  - AMM
Current Status of Methane Recovery and Utilization

CMM drainage rate of most coal mines is around 30%

The CMM drainage concentration of most coal mines is around 25% *

Note: X-coordinate refers to CMM Drainage Rate(%), Y-coordinate represents the number of mines(number)

Note: X-coordinate is CMM drainage concentration(%), Y-coordinate is the number of coal mines(number)

The actual airflows of the fans in most mines are around 4450m$^3$/min

Concentration of most mines is around 0.2%

Current Status of Methane Drainage and Utilization

1. Concentration < 1%, “VAM”
2. Concentration: 3%-30%, low-concentration draining Methane
3. Concentration: 30%-80%, high-concentration draining methane
4. Concentration > 90%, CBM, currently in trial stage
I. Targets of methane drainage and utilization project

- In the year 2006, the CMM drainage rate of China reached 30%, with the drainage volume of 4 billion m$^3$ and utilization volume of 0.8 billion m$^3$.
- In the year 2010, the drainage rate of China’s coal mines increased to 50%, with the drainage volume amounting to 10 billion m$^3$ and utilization volume of 5 billion m$^3$.

II. Actual data of methane drainage and utilization

<table>
<thead>
<tr>
<th>Project</th>
<th>2000 (Year)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage volume</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(100 million cubic meters)</td>
<td>8.7</td>
<td>23</td>
<td>32.4</td>
<td>44</td>
<td>53</td>
<td>58</td>
<td>65</td>
</tr>
<tr>
<td>Utilization rate</td>
<td>57%</td>
<td>26%</td>
<td>35%</td>
<td>29%</td>
<td>30%</td>
<td>31%</td>
<td>—</td>
</tr>
</tbody>
</table>
The situation of VAM

- VAM emission takes up the majority of total methane emission. In the year 2007, pure methane emission reached some 24.4 billion m³, among which VAM alone is 20 billion m³.

- For a million-ton-yield mine with high methane concentration, its VAM emission can amount to 5000～10000 m³/min which makes the methane emission 25～50 m³/min. It means 10-20 million m³ of methane are emitted to the atmosphere which is equivalent to 0.15-0.3 million tons of carbon dioxide.
Key technologies of CMM utilization
Shengli Power Machinery Group is committing so many years to the research and development of the key technologies and equipments of CMM utilization. Three steps are clarified to implement the overall work plans.

- **First:** Technology research and equipment manufacturing of high-concentration CMM over 30%

- **Secondly:** Technology research and equipment manufacturing of low-concentration CMM below 30%

- **Thirdly:** Oxidation-utilizing technology research and equipment manufacturing of lower-concentration methane and CMM.
2-1. Key technology of CMM power generation

In the year 2000, gas and electronic control mixer was invented and patented. By using the technology, Shengli Power Machinery Group invented the first CMM power generation set in China. The example was a small village-run coal mine in Jincheng, Shanxi where its electricity was first generated by high-concentration CMM of over 30%. Shortly after, the high-concentration CMM market is entering into a stage of stable development.
2 Research background
2-2. Safe conveying system of low-concentration CMM water mist

In the year 2005, “the conveying and power generation technology of low-concentration CMM water mist” was successfully developed. A set of complete CMM power generation technology and a series of supplementary product were developed. Recently among a dozen of provinces, cities and autonomous regions, over 100 low-concentration power stations were put into place, with the total installed capacity of 0.6million kWh.
2 Key technologies
Key technologies
Starting from the year 2006, the methane oxidation technology and device for VAM have been under research. In 2007, an oxidation device of 10,000 m$^3$/h was approved by the panel of Development and Reform Commission in Fuxin, Liaoning Province. In 2010, a 60,000 m$^3$/h oxidation device passed the technical test of the Energy Bureau in Binchang, Shanxi Province.
2 Key technologies
3 Application mode and benefit analysis
Ways of Methane Utilization
Achievements of Shengli Power Machinery Group

1. **CMM power generation:** since 2000, over the years especially after 2006, more than 120 CMM power plants have been built over the country with the sales number of 500kW low concentration generation sets being over 1500, installed capacity 750000 kW, daily generation 10 million kWh, and annual CO₂ emission reduction 15 million tons.
2. VAM oxidation

- Since August 2007, 10000 m³/h VAM oxidation device has been put to trial operation in Fuxin, Liaoning Province.
2. VAM oxidation

- Since March 2010, 60000m$^3$/h VAM oxidation device has been put to trial operation in Bingchang, Shanxi Province.
2. VAM oxidation

- Since April 2010, 60000m³/h VAM oxidation device has been put to trial operation in Pingmei, Henan Province.
Resource: It’s a coal mine in western China where there is a ground-fixed methane draining plant with five sets of drainage system, and the drainage volume is shown in the following table; An air shaft is also built with an VAM concentration of 0.3%-0.4%, and flow rate about 10000m³/min.

Program: To make use and reduce emission of methane according to the principle of methane “zero emission”. Normally, CMM drained by system 3# and 4# is used for 24 internal combustion engines of 500kW-type, while CMM drained by system 1#, 2# and 5# is mixed with VAM to higher the latter’s concentration to 0.38%-0.48%, for the use of 10 oxidation device of 60000m³/h-type so as to replace coal burning boiler to supply heat for production and living in the coal mine.

<table>
<thead>
<tr>
<th>Drainage system no.</th>
<th>Mixed flow rate (m³/min)</th>
<th>Pressure(k Pa)</th>
<th>Methane concentration</th>
<th>pure Methane flow rate (Nm³/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1#</td>
<td>189</td>
<td>-42</td>
<td>0.8%</td>
<td>0.9</td>
</tr>
<tr>
<td>2#</td>
<td>167</td>
<td>-58</td>
<td>2.2%</td>
<td>1.6</td>
</tr>
<tr>
<td>3#</td>
<td>233</td>
<td>-26</td>
<td>13.2%</td>
<td>22.8</td>
</tr>
<tr>
<td>4#</td>
<td>294</td>
<td>-17</td>
<td>13.5%</td>
<td>33.0</td>
</tr>
<tr>
<td>5#</td>
<td>201</td>
<td>-28</td>
<td>4.3%</td>
<td>6.2</td>
</tr>
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</table>
I. Gross investment: **RMB 170.58 million Yuan**

(1) Investment in power generation project: RMB 84.31 million Yuan;

(2) Investment in VAM oxidation project: RMB 86.27 million Yuan.
II. Annual economic benefits: RMB 114.95 million Yuan

(1) Power generating benefits:
20 engines (4 back-ups) × 500kW × 90% × 8760h × 0.535 Yuan/kWh = RMB 42.18 million Yuan

(2) Heat recovery benefits:
(7t + 18t) × 0.133t/t × 612 Yuan/t × 8760h = RMB 17.82 million Yuan

Including:
   a. Steam prepared by flue gas waste heat of generating sets:
      0.35 ton/set × 20 sets = 7 ton
   b. Steam prepared by oxidation device: 1.8ton/set × 10 sets = 18 ton
   c. Coal price: 612 yuan/ton

(3) CERs benefits:
(64.5 + 35) m³/min × 60s × 8760h × 0.71kg/m³ × 18.5 × 0.08 Yuan/kg = 54.95 million
III. Annual operating costs: **RMB21.82 million Yuan**

(1) **Internal combustion engine operating costs:**

\[
0.15 \text{ Yuan/kWh (consolidated operating cost)} \times 78.84 \text{ million kWh} = \text{RMB11.82 million Yuan}
\]

(2) **Oxidation device operating costs:** RMB10 million Yuan

Including:

a. Electricity fee
b. Water fee
c. Labor cost
d. Equipment maintenance cost

IV. **Equipment depreciation & financial costs:** RMB20 million Yuan

V. **Annual earnings:** RMB 73.13 million Yuan
Various ways of methane oxidation utilization

1. To oxidize methane so as to realize emission reduction benefits
Various ways of methane oxidation utilization

2. To oxidize methane so as to realize emission reduction benefits, and prepare saturated vapor for coal mine refrigerating, heating, and ventilating and preheating of mine shaft.
3. To oxidize methane so as to realize emission reduction benefits, and get superheated steam for power generation.
Technical standards and preferential policies
In 2007, organized by NDRC and SAWS, Shengdong Group took up the responsibility to draft 4 national safety standards for safe transmission and power generation of low concentration methane, playing an active role in regulating and promoting the use of low concentration methane in China. These standards were issued by SAWS in December 2009, and came into force on July 1st, 2010.

※ AQ1077 – 2009 Safety Criterion for Power Station with Coal Mine Gas Reciprocating Internal Combustion Engine;
※ AQ1078 – 2009 General Specifications for Transmission System of Low Concentration Coal-mine Gas Blending With Water Mist
※ AQ1074 – 2009 General Technical Specifications of Coal-mine Gas In-line Bellows Flame Arrester
Promote the revision of *Coal Mine Safety Regulation in 2010*

Article 148:

Methane drained with concentration lower than 30% should not be used as gas or combusted directly; for internal combustion engine power generation or other uses, the utilization and transport of methane shall be in accord with relevant regulations, and prepared with safety technical measures.

Previous regulation: The concentration of methane for use should be 30% at least, and the related methane utilization system must be equipped with safety devices to prevent backfire, return-air and explosion.
Notice to Print and Distribute the Opinions of CMM Administration and Exploitation

Extra Urgent NDRC Energy[2005]No.1119
4 Supportive policies

- General office of the State Council: *Opinions on Speeding up CBM(CMM) Drainage and Exploitation* issued by State Council [2006]No.47
- Department of Environmental Protection & AQSIQ: *CBM(CMM) Emission Standards* GB21522-2008
5 Suggestion and conclusions
4 Conclusion

- **CMM power generation**: After years of efforts, CMM power generation has been accepted by the public. Especially for low concentration CMM power generation, over four years of promotion and application, industrial standards has been formed, the revision of relevant articles in Coal Mine Safety Regulations been promoted, and thus complete systems of both technologies and policies of CMM power generation taken shape. However, the enactment and implementation of policies still need to be strengthened.

- **VAM oxidation**: The technology of VAM oxidation is basically mature; however, for the poor economy of ventilation oxidation utilizing and the long application period of CERs income of Clean Development Mechanism, it is suggested that central government make new supportive policies of coal mine ventilation oxidation utilizing, and set up VAM oxidation devices at coal mines with better conditions for demonstration and dissemination.
VAM oxidation technology is currently an important and the only practical way to improve CMM utilization, but still much work need to be done on the aspects of management and concept.

(1) Statistically, average VAM concentration in China now is around 0.2%. Based on the current oxidation technology, to realize VAM oxidation as much as possible, VAM shall be improved to 0.30% or higher (but lower than 0.75%) to make it easy for oxidation through scientific management, proper air distribution and total coal mine ventilation reduction.

(2) If the above measure is not easy to realize, change the underground movable or fixed type of CMM drainage and recovery to ground fixed type, or build a ground fixed drainage and recovery station which is easy to disassembly and move. As coal mining goes on, regular movement will make it convenient to drain and recover CBM, and the recovered methane will be used in ways of civil use, power generation, oxidation, etc.