METHANOL AS A FUEL IN INDUSTRIAL BOILERS AND COOKSTOVES IN CHINA

Kai Zhao, Expert Presenter and Principal Author of: Methanol New Energy Applications in China: Boilers and Cook Stoves

Tim Chan, Moderator
ABOUT MI
The Methanol Institute (MI) was established in 1989 to lobby the US Congress in support of using methanol and derivatives for high-quality, environmentally-friendly transportation fuels.

29 years later, MI is truly recognized as the global trade association for the methanol industry. We have facilitated methanol's expansion to every corner of the world, from our Singapore headquarters and regional offices in Washington DC, Brussels, and Beijing.
Our Members
Committee Structure

Marine Fuels Committee
- Best Practices & Safety
- R & D

Product Stewardship Committee
- Marketing & Contacts
- Conversion technology
- Environmental
- Economics
- Advocacy

Legislative & Regulatory Affairs Committee
- Strategic Partnerships
- Technical Support
- Safe Handling tools
- Health effects research
- Training

Global Fuel Blending Committee
- Global Reach
- Research
- Commerciality
- Specifications

Technical Support Committee
- Bridging science & regulatory
- Public policy
- Derivative support

Bootleg Alcohol Prevention Sub-Committee
- Awareness
- Education
- Prevention

Market Development Committee
- Technical assistance
- Market research
- Development

Engagement
METHANOL GROWTH IN APPLICATIONS OF INDUSTRIAL BOILERS AND COOK STOVES IN CHINA
Contents

- Methanol Fuel Application Update
- Methanol as a Boiler Fuel
- Methanol as a Cook Stove Fuel
- Safety Precautions and Recommendations in Practice
- Contacts
01 Methanol Fuel Applications
Methanol’s Evolving Global Demand

Methanol Downstream in China 2016 vs 2017

Source: CNFIA Statistics
Methanol consumption increased to 69.5 MMTs in 2017, 13% incremental to 2016

Total Fuel Application (Direct Fuel, DME, MTBE) accounting for 25% of the total consumption in 2017

Formaldehyde share dropped, MTBE share will be affected potential in 2020 when E10 promoted nationally.

Methanol Direct Fuel in Industrial Boilers and Cookstoves increasingly contributed in the directive fuel blending

Cooking application suspected to contribute in “Others” in the official statistics

Source: CNFIA Statistics
METHANOL AS A BOILER FUEL
Methanol Boiler Basics - Structure

Diagram showing the structure of a methanol boiler, including the methanol storage tank, high methanol tank/pump, methanol burner, and the boiler itself. The diagram highlights key components such as the drum and combustion chamber.
• Widely used for heating and industrial stream, new built and replacing coal

• Capacity ranged from 1 to 20 t/h

• Fuel: 100% methanol to methanol blends with methanol content over 60% in vol.

• One steam ton capacity consuming 110 kg of methanol, industrial use can be long hours

• Estimated more than 1000 units, consuming over 2 MMTs methanol in 2017

Source: Methanol New Energy Applications in China: Boilers and Cook Stoves
Methanol Opex comparable to NG depending on regions, helped to fill the clean fuel gap in last winter when NG was short of supply
- Methanol as liquid fuel has superior Capex benefit to NG
- Diesel being eliminated due to its emissions despite its price dropping quickly
- Coal is 100% off the market in most cities of China

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Methanol (Low Price)</th>
<th>Methanol (High Price)</th>
<th>NG (Low Price)</th>
<th>NG (High Price)</th>
<th>Diesel</th>
<th>Coal</th>
<th>Commerical and Industrial Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Price (RMB)</td>
<td>1.8/kg</td>
<td>4/kg</td>
<td>2.2/m3</td>
<td>10/m3</td>
<td>5.5/kg</td>
<td>0.4/kg</td>
<td>0.9/kwh</td>
</tr>
<tr>
<td>Unit Price/0.1cal (RMB)</td>
<td>3.8</td>
<td>8.4</td>
<td>2.6</td>
<td>11.8</td>
<td>5.5</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>Thermal Efficiency</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>55%</td>
<td>96%</td>
</tr>
<tr>
<td>Actual Economics (RMB/0.1 cal)</td>
<td>4.2</td>
<td>9.3</td>
<td>2.9</td>
<td>13.1</td>
<td>6.1</td>
<td>1.45</td>
<td>11</td>
</tr>
</tbody>
</table>
Emission Tests in China

- Methanol Fuel Blends: Jin Jing Da
- Neat Methanol: Lin Jing

- Methanol showing superior emission benefits to other hard fuels and diesel
- Methanol has no Sulphur and NOx emission is superior than NG boiler
- Methanol boiler easily fulfilling the latest Chinese emission standard even in Key Regions like Beijing, Shanghai etc.

The Boiler Burner Authority on New Classification to include Methanol as Burner Fuel

- Burner Test Lab of China Special Equipment Inspection and Research Center
- Alcohol based fuel in liquid fuel category for boiler burners
- Standard will be in effective since 2018
- Original emission concentrations, designing specifications, etc.
Methanol Based Fuel Group Standards Under CPCIF

- CAAEFA leading a research group on two Group Standards under CPCIF
- More than 12 cooperative companies from China including boiler manufacturers, fuel suppliers, storage/tanker producers
- MI and MI member Methanex also contributed
- Anticipated to be effective in NOV of 2018

### 1. Methanol Based Fuel for Boilers

- Burner and fuel composition tests conducted by National Lab of Coal Clean Utilization in Shan Dong University
- Methanol Boiler Fuel is classified into MF50, MF75 and MF100

**Important Note:** The table referred here is the draft by 5th of June, 2018. Detailed specification numbers may be changed.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>MF50</th>
<th>MF75</th>
<th>MF100</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Methanol content (volume fraction)/%</td>
<td>48-52</td>
<td>73-77</td>
<td>≥98</td>
<td>Appendix A</td>
</tr>
<tr>
<td>2</td>
<td>Density * (20°C)/(g/cm³) no more than</td>
<td>0.86</td>
<td>0.84</td>
<td>0.81</td>
<td>GB/T 1884, GB/T 611</td>
</tr>
<tr>
<td>3</td>
<td>Lower calorific value/(KJ/Kg) no less than</td>
<td>27170</td>
<td>22990</td>
<td>19228</td>
<td>GB/T 384</td>
</tr>
<tr>
<td>4</td>
<td>Ash content (mass fraction)/% no more than</td>
<td>0.01</td>
<td></td>
<td></td>
<td>GB 508</td>
</tr>
<tr>
<td>5</td>
<td>Condensation point/°C not higher than</td>
<td>-30</td>
<td></td>
<td></td>
<td>GB 510</td>
</tr>
<tr>
<td>6</td>
<td>pH</td>
<td>6~8</td>
<td></td>
<td></td>
<td>See 4.3.1</td>
</tr>
<tr>
<td>7</td>
<td>Sulfur content b (mass fraction)/% no more than</td>
<td>0.02 (general area)</td>
<td></td>
<td></td>
<td>GB/T 11140, SH/T 0253, SH/T 0689</td>
</tr>
<tr>
<td>8</td>
<td>Nitrogen content c (mass fraction)/% no more than</td>
<td>0.015 (general area)</td>
<td></td>
<td></td>
<td>SH/T 0162, SH/T 0657, SH/T 0704</td>
</tr>
<tr>
<td>9</td>
<td>Chlorine content/(mg/kg) no more than</td>
<td>2</td>
<td></td>
<td></td>
<td>GB/T 18612</td>
</tr>
<tr>
<td>10</td>
<td>Low-temperature anti-phase separation (-20°C, 4h)</td>
<td>Clear and transparent, without phase separation</td>
<td></td>
<td></td>
<td>See 4.3.2</td>
</tr>
<tr>
<td>11</td>
<td>Copper sheet corrosion (50°C, 3h) class no more than</td>
<td>1</td>
<td></td>
<td></td>
<td>GB/T 5096</td>
</tr>
</tbody>
</table>

Notes:

a) In case of any discrepancy, the determination result as per the method in GB/T 1884 shall prevail;
b) In case of any discrepancy, the determination result as per the method in SH/T 0689 shall prevail;
c) In case of any discrepancy, the determination result as per the method in SH/T 0704 shall prevail;
d) The classification of the general area and key area according to the limitation of the sulfur and nitrogen content shall be subject to the regulations in GB 13271-2014.
2. Technical requirements for storage and supply facilities of methanol based fuel for boilers

- Specifications in safe use and storage of fuel, on volume, safety distance, precautions, etc.
- Max. Storage capacity less than 150m³, less than 20m³ in the urban built-up area
- Skid Mounted storage allowed, which will facilitate promotion
- Safe distance based on above-ground/under-ground storage tank and different nature of buildings

Table 4.3 The fire protection spacing for the storage tank, unloading (fuel supply) pump, the vent pipe opening and other buildings (structures) (m):

<table>
<thead>
<tr>
<th>Building (structure)</th>
<th>Underground storage tank</th>
<th>Aboveground storage tank</th>
<th>Skid mounted storage tank</th>
<th>Unloading (fuel supply) pump, and the vent pipe opening of storage tank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V ≤ 150 m³</td>
<td>V ≤ 90 m³</td>
<td>V &gt; 20 m³</td>
<td>V ≤ 20 m³</td>
</tr>
<tr>
<td>Important public building</td>
<td>35 m³</td>
<td>35 m³</td>
<td>30 m³</td>
<td>30 m³</td>
</tr>
<tr>
<td>A place near open flame or spark</td>
<td>17.5 m³</td>
<td>12.5 m³</td>
<td>25 m³</td>
<td>25 m³</td>
</tr>
<tr>
<td>Protection category of building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Category I protection</td>
<td>14 m³</td>
<td>11 m³</td>
<td>20 m³</td>
<td>16 m³</td>
</tr>
<tr>
<td>Under Category II protection</td>
<td>11 m³</td>
<td>8.5 m³</td>
<td>16 m³</td>
<td>12 m³</td>
</tr>
<tr>
<td>Under Category III protection</td>
<td>8.5 m³</td>
<td>7 m³</td>
<td>12 m³</td>
<td>10 m³</td>
</tr>
</tbody>
</table>

Important Note: The table referred here is the draft by 5th of June, 2018. Detailed specification numbers may be changed.
Using methanol burner for ceramic sintering, metal alloying, tobacco drying, etc.

Better ceramic surface finish: less flaws, brighter color due to the clean exhaust gas from methanol

Better energy efficiency reported: less air intake comparing to NG

Source: Da Wei Energy
METHANOL AS A COOK STOVE FUEL
• A methanol cook stove composed of a methanol fuel storage tank, supply pump, tank, and the stove itself.

• Different forms methanol Cook Stoves: Single stove, dual stoves for stir frying, steaming

• Fuel: 100% methanol to methanol blends (emulsified with water), stored in day tank/cylinder for small amount in the kitchen, and large amount stored outside the kitchen

• Widely used in restaurants, central kitchens: mainly cost driven, to replace LPG and NG
Basic Conditions of Methanol Cook Stoves

- Usually called “Alcohol Based Fuel”, complying with two Standards: Alcohol Based Liquid Fuel and Stove for Alcohol based domestic fuel NY312-1997

- Market for Cooking Application estimated over 5 MMTs in China by 2017.
Economics and Status

- The prices used are the consumer received prices in the field investigation.
- Methanol Opex is among pipeline NG (with subsidy) and LPG.
- Chinese kitchens (large capacity for hundreds people) and restaurants have very limited connection the NG with high infrastructure cost.
- Methanol as liquid fuel has superior Capex benefit to NG.
- Diesel and coal are banned to be used in China.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Methanol</th>
<th>Natural Gas</th>
<th>Liquefied Petroleum Gas</th>
<th>Diesel</th>
<th>Coal</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per unit mass</td>
<td>¥3.4/kg</td>
<td>¥1.85/m³</td>
<td>¥9.2/kg</td>
<td>¥8.7/kg</td>
<td>¥0.4/kg</td>
<td>¥0.78/kWh</td>
</tr>
<tr>
<td>Price per kcal (¥0.0001/kcal)</td>
<td>6.4</td>
<td>2.2</td>
<td>8.1</td>
<td>8.6</td>
<td>0.8</td>
<td>9.1</td>
</tr>
<tr>
<td>Thermal Efficiency</td>
<td>56%</td>
<td>75%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>80%</td>
</tr>
<tr>
<td>Actual Economics (¥0.0001/kcal)</td>
<td>11.4</td>
<td>2.9</td>
<td>16.2</td>
<td>21.5</td>
<td>2.7</td>
<td>11.4</td>
</tr>
</tbody>
</table>
• Regions like Tianjin, Gansu, Shanxi, Shaanxi, Guilin and Gansu supportive

• Regions like Xiamen, not allowing

• The differences dependent on how safely methanol fuel distributed, local cooking fuel supply conditions, company-government engagement, etc.
04 SAFETY PRECAUTIONS AND RECOMMENDATIONS IN PRACTICE
Potential Risks of Methanol in Fuel Applications

• **Inhalation & Ingestion (Toxicity):** no color, rare cases of mis-drinking reported[^1]

• **Fire:** unsafe installation of methanol storage, one exploration on roof top of School Kitchen[^2]

• **Emission** (*cook stoves*): lack of indoor air tests on un-burnt methanol and emissions should be paid attention, especially formaldehyde

• Personnel lack of knowledge, especially for the Cook Stoves

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Best Practice of Methanol Cook Stoves

• Cookstove with electronic control
• Indoor fuel storage in cylinder
• Flame sensors and alarm
• IoT remote monitoring

Source: Shengbao Energy
MI officially released an industry insight report on methanol as industrial boilers and cook stoves in 2018: [http://www.methanol.org/energy/boiler-cookstoves/](http://www.methanol.org/energy/boiler-cookstoves/)

- **MI Safety Manual and Technical Bulletins**