Technology to Improve Paper Manufacture Using Recycled Fiber
~ Special Focus on Dry Strength Agents ~

Seido Kan
Director, Overseas Business Division
SEIKO PMC CORPORATION
In Japan

Papermaking Challenges

○ Environmental Conservation
  ● Resource saving: Increased recycled fiber use
  ● Cleaning and control of wastewater

○ Quality, Productivity, Cost Reduction
  ● High Quality Paper
  ● Faster Machines

The Japanese unique papermaking situation promoted the innovation of papermaking chemicals.

In China

There are many similarities in papermaking challenges between Japan and China. Japanese technology can make a significant contribution to China's paper industry.

Papermaking practices in Japan have been driven in large part by the increased use of recycled fiber. The unique development of PAM type Dry Strength Agents have allowed the industry to achieve paper quality, machine productivity, and water conservation while using high levels of recycled fiber.
- RCP usage rate in China is higher than Japan.
- RCP collection rate in China is still low.
- China has imported substantial amount of high fiber-quality AOCC.
Historically Driven by US RCP (AOCC):

- **Advantage:** High Fiber Strength,
- **Disadvantage:** High Contaminant Levels (3 to 5%, sometimes as high as 15%)
- **Recent tighter regulations on imports.** (max 0.5% contaminants allowed)
- **China situation is changing.** More domestic collection and lower AOCC imports is likely.

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**Graph:**

- **Y-axis:** Million tonnes
- **X-axis:** Year (2006-2024)
- **Legend:**
  - Blue: Net Imports
  - Red: Domestic Collection

**Label:**

- **China will approach Japan's paper making situation**
Recycled Fiber by origin – Impact on China

Recycled Fiber, Strength Comparison by Source

<table>
<thead>
<tr>
<th>Raw material</th>
<th>AOCC</th>
<th>JOCC</th>
<th>COCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst index</td>
<td>kPa/(g/m²)</td>
<td>2.34</td>
<td>1.71</td>
</tr>
<tr>
<td>RCT index</td>
<td>N·m²/g</td>
<td>186</td>
<td>157</td>
</tr>
<tr>
<td>Folding endurance</td>
<td>Times</td>
<td>83</td>
<td>38</td>
</tr>
</tbody>
</table>

*Hand sheet making results in Seiko PMC Lab*

- Recycled fiber deteriorates, raw material strength decreases
- Problems due to contaminants derived from recycled paper (poor chemical efficiency, deposits in paper, paper machine sheet breaks)
Closing up the water loop

Usage of fresh water in paperboard mills

<table>
<thead>
<tr>
<th>Location</th>
<th>Usage of fresh water (m3/paper ton)</th>
<th>Electric conductivity of process water (mS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>6 ~ 10</td>
<td>100 ~ 300</td>
</tr>
<tr>
<td>China</td>
<td>0 ~ 5</td>
<td>300 ~ 1,500</td>
</tr>
</tbody>
</table>

Seiko PMC Experiences

- Chinese paperboard mills recover more water than Japanese mills due to water scarcity (i.e. Closing a water loop). This results in a much higher conductivity in typical China mills.

- High electric conductivity is an inhibiting factor of chemical performance.
Papermaking Challenges in Japan

Environmental conservation, Improved productivity, Cost reduction

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Problems to be solved</th>
<th>Chemical and Mechanical Solutions</th>
</tr>
</thead>
</table>
| Increased usage and decreasing quality of RCP | • Quality degradation of waste paper strength  
• pH increase (derived from calcium carbonate in recycled paper)  
→ machine dirt, paper deposits | • Upgrade of refining, pulp cleaning  
• Development and improvement of dry strength resins  
• Improvement of wastewater treatment  
• Application of coagulant, retention aids  
• Improvement of paper machine, equipment. |
| Reduced fresh water Consumption             | • Decline in efficiency of chemicals  
• Machine dirt, and paper deposits                                                    |                                                                                                     |
| Upgrade and speed up of the paper machine   | • Maintaining machine speed (good drainage and dewatering )                            |                                                                                                     |

In response to challenges accompanying changes in the papermaking environment in Japan, development of papermaking chemical technology has been made alongside with papermaking technology development. **Dry Strength Resin (DSR)** technology has played a unique role.
The history of paper recycling in Japan

Paper recycling started in Heian-period

Paper came from China

Waste paper recovery was a business in Edo-period

Starch could not meet the strength required

The use of RCP in paperboard became active

New type dry strength resin ‘PAM’ was invented!!

600 800 1000 1600 1800 1900
隋(Sui) 宋(Song) 明(Ming) 清(QING)
Comparison of Starch and PAM

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>PAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper strength enhancement effect</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Wastewater treatment load</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Price</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

- More difficult for starch to deal with strength decreases and reduced productivity from using waste raw materials.
- Starch has higher wastewater treatment load.
- Usage and technology development of PAM have progressed in paperboard production.
Evolution of PAM Dry Strength Resins

Technology transition of PAM

- **1960’s**: Anionic PAM
- **1970’s**: Modified PAM (Hoffman, Mannich)
- **1980’s**: Amphoteric PAM
Amphoteric PAM shows stable and high performance against fluctuations in paper making pH due to increased use of waste paper.

Advantages of Amphoteric PAM

Performance comparison of various PAM types depending on papermaking pH

Seiko PMC Lab Results

Amphoteric PAM shows stable and high performance against fluctuations in paper making pH due to increased use of waste paper.
Advantages and Growth of Amphoteric PAM

Amphoteric PAM not only improves paper strength but also enhances paper machine productivity (lowering costs).

① Improved retention of fines and fillers → Cleaner wet-end, lower machine deposits, fewer sheet defects
② Improved drainage and dewatering → Reduced steam consumption, higher machine speeds
③ Improved fixation of sizing agents → Improved sizing efficiency (costs)

PAM Consumption by type in Japan

Due to superior performance, growth of amphoteric PAM has progressed.
Most Recent Developments

Technology transition of PAM

1960’s Anionic

1970’s Modified PAM Hofmann Mannich

1980’s Amphoteric

Branched, High MW

Improved MW distribution

Ion group localization (poly-ion complex)

Highly controlled structures

Amphoteric PAM continues to be improved and can be optimized for many paper making systems.
Latest Technology Improvements and Benefits (1)

**High branched, High molecular weight**

Many reactive groups with a large binding range

![Diagram](image)

PAM

Pulp fiber

Branched
High molecular weight

High branched
High molecular weight

**Improved Fixation and Enhanced Paper Strength**
Latest Technology Improvements and Benefits (2)

Poly-ion complex formation by ion group localization

Solution of Poly-ion complex PAM

Improved Drainage and Retention Performance
Latest Technology Improvements and Benefits (3)

Highly-controlled molecular weight distribution

Cost-Performance Improved by Reducing Low MW components
Latest Technology Improvements and Benefits (4)

< Mill trial 1 >
Paperboard Grade: Corrugated medium
Objectives: **Reduce PAM dosage and improve retention**
Trial: Amphoteric (single) → Dual Amphoteric

Results: **Total dosage was reduced, 9kg/t → 5kg/t (solids basis)**
First pass retention was improved by 5 points, **58% → 63%**

< Mill trial 2 >
Paperboard Grade: Corrugated medium
Objectives: **Reduce load on WW treatment system; improved strength and speed**
Trial: Starch → Half of the starch replaced by Amphoteric PAM
(Starch : Amphoteric = 50kg/t : 0kg/t → 25kg/t : 5kg/t  solids basis)

Results: **RCT index 170 N•m²/g → 205 N•m²/g,**
**Plybond strength 400mJ → 450mJ**
**Machine speed up from 540m/min to 580m/min.**
**COD of wastewater was reduced by replacing starch with PAM**
Summary

○ Recent Chinese market trend
  • The use of Domestic RCP likely will increase due to restrictions on imports of AOCC.

○ Similarity of Japanese / Chinese papermaking conditions
  • High waste paper utilization rate, low fresh water usage.

○ Japanese paper making technologies
  • Developed under unique paper making conditions.

○ Japanese papermaking chemicals help the Chinese paper manufacturer by achieving –
  • Improved sheet quality and paper machine productivity.
  • Improved cleaning and control of waste water – reduced environmental impact
  • Improved ability to manage future changing and challenging recycled fiber sources.
  • Lower total production costs.
SPMC Corporate Profile

Corporate Vision
Explore the Future through Eco-Friendly Technology

President
Satoshi Takizawa (since March, 2014: Here today)

Consolidated Sales
US$ 230mil @FY2017
Leading company of functional paper chemicals in Japan
(Paper Chemicals US$ 150mil)

Employees
600 (group total), ¼ of the total are in R&D

China Presence
Seiko PMC (Shanghai) Commerce & Trading Corp.
Contact: Jiongnian-Liu (劉 炯年)
Phone 137-6448-6481
E-mail jnliu@seikopmc.co.jp
Seiko PMC (ZHANGJIAGANG) Corp.
(Manufacturing Plant)
SPMC  China Focus

SPMC regards China as the most important market for its paper chemical business.

SPMC provides products to and creates solutions with the Chinese paper manufacturer.

✔ Optimize use of COCC under new recycle fiber environment
   → produce high quality paper
   → improve paper manufacturing efficiency (drainage, dewatering, etc.)

✔ Wastewater treatment in low-alum environment
   → reduce water treatment burden (Microbial Products)

✔ Quality Improvement of Household Paper
   → produce tissue papers with more softness and moisture, etc.
     (Creping Aids, Softeners)
SPMC Product Overview

Paper Making Chemicals

Functional Chemicals

- Dry Strength Agents
- Wet Strength Agents
- Internal Sizing Agents
- Surface Sizing Agents
- Printability Aids
- Anti-Slip Agent
- Paper Thickness Improver
- Water Repellent Agents
- Softeners

- Other functional Chemicals
  (Oil-Resistant Agent, Moisture-Proof Coating Agents etc...)

Process Chemicals

- Coagulants
- Retention Aids
- Creping Aids
- Microbial Products
- Other
  (Filler Treatment Agent)

Eco-Friendly products of SPMC other than paper making chemicals

- Water based Resins for Printing Inks
- Cellulose Nanofiber
Thank You