

# Effect of Diatomite on DCS in White Water during the Process of Waste Paper Recycling



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**Abstract:** With the increasing of waste paper recycling degree in papermaking industry, more attention was paid on how to solve resin trouble and stickies trouble effectively in the process of second fiber utilization industry. Diatomite was selected to be used as resin adsorbent in waste paper system. The effect of diatomite on dissolved and colloidal substances (DCS) accumulation in white-water, pulp drainage and paper performance was investigated. The improvement of diatomite on resin trouble was analyzed as well. Results showed that the addition of diatomite as resin adsorbent can relieve DCS accumulation and resin trouble effectively in waste paper recycling process. Under the help of diatomite, the drainage time was reduced about 25.8% and the effect of retention and drainage was improved greatly. As for the paper sheet property, the ash and brightness were increased 9.13% and 5.30% respectively. The break length and sizing degree were reduced 14.43% and 18% respectively, but it can still meet the requirement of customers.

**Key words:** waste paper recycle; diatomite; DCS; stickies

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## 废纸回用过程中硅藻土对白水中 DCS 的影响研究

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**摘要:** 利用硅藻土作树脂吸附剂加填到废纸回用体系中, 探讨了硅藻土的加入对白水中胶体和溶解物质 (DCS) 累积、浆料滤水以及成纸性能的影响, 分析硅藻土对树脂障碍的缓解改善情况。研究表明废纸回用体系中硅藻土的加入可以缓解白水中 DCS 的积累和胶黏物问题, 有利于白水循环程度的提高。研究表明浆料滤水时间减少 25.8%, 助留助滤效果明显。成纸灰分和白度分别提高 9.13% 和 5.30%, 裂断长和施胶度分别降低 14.43% 和 18%, 物理强度和施胶度均可满足用户要求。

**关键词:** 废纸回用; 硅藻土; DCS; 胶黏物

How to reduce the amount of water and the pollution load has become a serious problem in paper-making industry currently. With the increase of waste paper recycling degree in papermaking industry, more and more impurities<sup>[1-2]</sup> were accumulated in white-water system. Much more negative impacts were caused by the accumulation of these substances<sup>[3-4]</sup>. Recently resin adsorbent, which generally included two categories, macromolecular organic resin or biological enzymes<sup>[5-6]</sup> and inorganic mineral powder materials, were used to solve resin trouble and stickies trouble at home and abroad. However the minerals powder as control agent has more advantages than that of organic resin or biological enzymes<sup>[7-8]</sup>. Therefore the application of white-water closure system has more important realistic significance for modern papermaking system<sup>[9]</sup>. Diatomite has many

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special advantages such as unique micro-pore structure, high porosity and large pore volume<sup>[10]</sup>. All these made the diatomite having a high value to be used as polymer materials, filler, strengthen agent of coating materials, filter aid and adsorption<sup>[11-12]</sup>. Less dosage and high efficiency can be achieved as well. The effects of diatomite as resin adsorbent on dissolved and colloidal substances (DCS) accumulation, pulp drainage and paper performance were investigated in this paper. The improvement of diatomite on resin trouble and the effect of retention and drainage were analyzed as well. Moreover the feasibility of white-water closure in production water system with waste paper as raw materials was analyzed. All these works will improve the recycling degree of waste paper and the continuable development of papermaking industry.

## 1 Experiment

### 1.1 Material

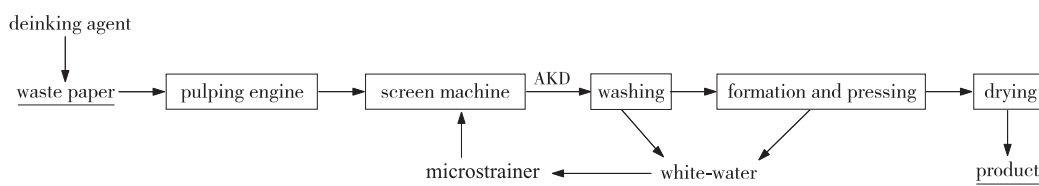
White water was taken from a paper mill in Liaoning Province with waste paper as the main raw materials. Diatomite was taken from a mill in Jilin Province and the dosage was 3% (for oven-dry pulp).

### 1.2 Chemicals

Alykl ketene dimmer (AKD) was used as sizing agent and the dosage was 2.5% (for oven-dry pulp).

### 1.3 Experiment condition

The exprimnet process was as followed.



### 1.4 Experiment method

The total solid content was measured with drying method. White water was filtered by qualitative filter paper. The content of DCS was obtained through the determination of filtrate after drying in 105 °C. And the content of suspended substance (SS) was obtained though the determination of filter cake after drying in 105 °C.

Chemical oxygen demand (COD) was determined according to GB/T 15456 – 1995.

Turbidity was determined according to GB 13200 – 1991.

Paper strength was determined by TH-1 tensile strength instrument and the paper burst was determined by DC-NPY1200 burst instrument<sup>[13-14]</sup>.

Brightness was determined according to GB/T 7974 – 2002.

## 2 Results and Discussion

### 2.1 Influence of diatomite on white-water

In order to discuss the effect of diatomite, the experiment was carried on production line in paper mill directly. Sample 01 was the control sample from waste paper without sizing agent and diatomite. In sample 02, diatomite was added but without sizing agent. In sample 03, both diatomite and sizing agent were added. White-water of different samples were collected respectively. Total solid content, the content of DCS and SS were determined according to the method mentioned in papermaking industry material handbook. Then the filter cake was burned in  $(575 \pm 25)^\circ\text{C}$ , the ash was the content of inorganic and the difference between SS and ash was the content of organic. The filter liquor was burned in  $(575 \pm 25)^\circ\text{C}$ , the ash was the content of inorganic and the difference between DCS and ash was the content of organic. Results are showed in Table 1.

Table 1 revealed that with the addition of diatomite the density of white water changed little. The total solid content in white-water decreased after adding diatomite while the content of paper ash increased a little. It indicated that diatomite improved retention effect. Diatomite retained not only itself but also some fine component which reduced fiber loss effectively.

**Table 1 Influence of diatomite on white-water**

| index  |           | 01#   | 02#   | 03#    |
|--|-----------|-------|-------|--------|
| density/( $\text{g} \cdot \text{L}^{-1}$ )             |           | 999.9 | 999.8 | 1000.3 |
| total solid content/( $\text{g} \cdot \text{L}^{-1}$ ) |           | 5.16  | 4.86  | 4.71   |
| filter cake/( $\text{g} \cdot \text{g}^{-1}$ )         | SS        | 0.57  | 1.29  | 1.56   |
|  | inorganic | 0.13  | 0.61  | 0.78   |
|  | organic   | 0.44  | 0.68  | 0.78   |
| filter liquor/( $\text{g} \cdot \text{L}^{-1}$ )       | DCS       | 4.59  | 3.57  | 3.15   |
|  | inorganic | 2.75  | 2.33  | 2.15   |
|  | organic   | 1.84  | 1.24  | 1.00   |
| paper sheet ash/%                                      |           | 6.09  | 7.55  | 7.78   |

After adding diatomite, the content of SS in white-water increased while the content of DCS decreased. The proportion of inorganic substance in SS was large. That is because the small part of diatomite was retained in paper sheet, most of diatomite existed in the way of SS for its small particle size. Although the proportion of organic substance in SS was decreased, compared with the system without adding diatomite, the absolute content of organic substance was still increased. All these indicated that much more organic substance can be absorbed by diatomite for its porous property.

The decrease of DCS in filter liquor and the organic substance content suggested that the pore of diatomite has great effect on dissolved organic substance. Dissolved organic substance can be absorbed by the diatomite in its pore as well and retained in paper sheet or SS. The function mentioned above was strengthened by the AKD process after using diatomite. Moreover the adsorption of diatomite was improved greatly.

## 2.2 Influence of diatomite on stock drainage

The drainage property was measured with Schopper-Riegler beating degree tester. 2 g Oven-dried pulp was diluted to 0.5% concentration with 400 mL recycled pure white-water. Then the solution was poured to filter bucket and kept for 5 seconds. Start the hand wheel, pick up the tapered cover and start timing at the same time. While lateral tube stopped, watering timing was stopped as well. Collect white-water, turbidity and COD were measured. Then the white-water was filtered by qualitative filter paper, turbidity and COD were measured again. Moreover the ashes of pulp which were retained on the wire and filter cake on the filter paper were measured respectively.

AKD was added in both samples 04 and 05. But diatomite was only added in sample 05 and the dosage was 3.5% (for oven-dry pulp). Results are showed in Table 2.

**Table 2 Influence of diatomite on stock drainage**

| items                  |   | 04#   | 05#   |
|------------------------|---|-------|-------|
| water filtering time/s |   | 93    | 69    |
| before filtering       | COD/( $\text{mg} \cdot \text{L}^{-1}$ ) | 1176  | 1280  |
|                        | turbidity/NTU                           | 165.4 | 196.0 |
| after filtering        | COD/( $\text{mg} \cdot \text{L}^{-1}$ ) | 256   | 80    |
|                        | turbidity/NTU                           | 69.6  | 29.7  |
| stock ash/%            |   | 7.12  | 7.77  |
| filter cake ash/%      |   | 40.55 | 41.12 |

Results showed that the drainage time was shortened from 93 s to 69 s and it reduced 25.8%. All these revealed that diatomite improved the effect of drainage greatly.

Before filtered with filter paper, the turbidity and COD were changed slightly. That is because the diatomite was not separated from the papermaking system. Although some organic substance was adsorbed by the diatomite, the turbidity and COD were increased slightly. Turbidity and COD of white-water were decreased after filtered with qualitative filter paper obviously. COD was decreased from 265 mg/L to 80 mg/L and the turbidity was reduced from 69.6NTU to 29.7NTU. All these showed that diatomite can adsorb most organic substance of white-water.

### 2.3 Influence of diatomite on paper sheet property

The effect of diatomite on physical performance of paper sheet was investigated for the retention of diatomite in paper sheet while it was added to the stock to deal with resin trouble effectively. The basic weight of hand paper sheet was 80 g/m<sup>2</sup>. The dosage of diatomite in sample 06 was increased 3% based on control sample.

Results in Table 3 showed that paper ash increased 9.13% after adding diatomite. This indicated that some of diatomite was retained in the paper sheet. However the brightness and water absorbability of paper sheet were increased 5.3% and 18%, respectively, due to the high brightness and porous structure of diatomite. As for the porous structure, some AKD sizing agents was adsorbed by diatomite which made sizing effect reduced about 18%. The breaking length and tear index of paper were decreased 14.43% and 5.27%, respectively, due to the bad influence of diatomite on hydrogen bond forming. However it can meet the requirement of customers.

Table 3 Influence of diatomite on paper property

| index  | control | 06#    | customer requirement |
|--|---------|--------|----------------------|
| bulk density/(cm <sup>3</sup> ·g <sup>-1</sup> ) | 2.00    | 2.11   | —                    |
| ash/%  | 7.12    | 7.77   | —                    |
| brightness (ISO)/%                               | 45.3    | 47.7   | 45.0                 |
| breaking length/km                               | 2.91    | 2.49   | 2.30                 |
| tear index/(mN·m <sup>2</sup> ·g <sup>-1</sup> ) | 11.01   | 10.43  | —                    |
| sizing degree/(g·m <sup>-2</sup> )               | 270.98  | 319.78 | 330.00               |

### 2.4 Influence of diatomite on production cost

The effect of diatomite on DCS accumulation, stock drainage performance and paper sheet physical performance was satisfied for both paper mill and customer. Moreover the production cost was most important for paper mill, so the cost was considered as well. The cost was obtained based on one ton packing paper. The price of waste paper and diatomite was 2.5 and 1.1 yuan per kilogram respectively. 1.2 ton waste paper was used to yield one ton packing paper. The dryness and pureness of diatomite were 95.29% and 94.80%, respectively. With the recycling of white water, the multiple pass retention of diatomite can reach 39%.

Result revealed that after adding about 3% diatomite (worth 33 yuan), the multiple pass retention can reach 39% (which can save about 38.86 yuan) through white-water closure circulation and 5.86 yuan (38.86 - 33 = 5.86) can be saved per ton packing paper. Furthermore for the adsorption of diatomite on SS and DCS, waste water disposal load, paper machine idleness expense and the consumption of wire and felt will be decreased significantly. All these will reduce the product cost of corporation.

## 3 Conclusion

DCS accumulation and resin trouble in white-water of waste paper system can be relieved effectively by the addition of diatomite.

**3.1** After adding about 3% diatomite, the drainage time was reduced about 25.8% and the effect of retention and drainage was improved greatly as well. The multiple pass retention can reach 39% and 5.86 yuan can

be saved per ton packing paper.

**3.2** As for the paper sheet property, the ash and brightness were increased about 9.13% and 5.30% respectively. On the other hand the breaking length, tearing index and sizing degree were reduced about 14.43%, 5.27% and 18% respectively. However, it still can meet the requirement of customers and the product cost can be reduced.

**3.3** With the help of diatomite, the waste paper recycling degree will be increased greatly and the continuous development of papermaking industry will be realized.

#### Reference:

- [1] BROUILLETTE F, DANEALUT C, DORRIS G M. Effect of initial pH on the release of dissolved, colloidal and suspended solids during repulping of ONP and OMG[J]. *Journal of Pulp and Paper Science*, 2002, 28(2): 146-150.
- [2] BROUILLETTE F, DANEALUT C, DORRIS G M. Effect of initial repulping pH on the deflaking rate of recovered papers[J]. *Pulp and Paper Canada*, 2003, 104(7): 77-81.
- [3] 劳嘉葆. 造纸工业污染控制与环境保护[M]. 北京: 中国轻工业出版社, 2003: 109-112.
- [4] 施英乔, 丁来保, 李萍, 等. 废水污染负荷与造纸原料结构关系的研究[J]. *林产化学与工业*, 2003, 23(2): 25-27.
- [5] CALERO-RUEDA O, GUTIERREZ A, DEL RIO J C, et al. Hydrolysis of sterol esters by an esterase from *Ophiostoma piceae*. Application to pitch control in pulping of *Eucalyptus globulus* wood[J]. *International Journal of Biotechnology*, 2004, 6(4): 367-375.
- [6] JONES D R, FITZHENZY J W. Esterase type enzymes offer recycled mills an alternative approach to stickies control[J]. *Pulp and Paper*, 2003, 104(2): 28-31.
- [7] LI Dong-mei, LI Qian, ZHAO Zhen-dong, et al. Study on preparation of bio-fuel oil from rosin residue in industrial deep processes[J]. *Biomass Chemical Engineering*, 2011, 44(4): 13-16.
- [8] BOURASSA C, DIAMOND M, SAIN M, et al. Mill system closure and trash catching porous fillers in papermaking[J]. *Tappi Journal*, 2003, 86(2): 14-18.
- [9] 景宜, 勇强, 尤纪雪, 等. 低纤维素酶活的木聚糖酶对二次纤维 AKD 施胶效果的影响[J]. *林产化学与工业*, 2002, 22(4): 43-46.
- [10] ZAITAN H, CHAFIK T. FTIR determination of adsorption characteristics for volatile organic compounds removal on diatomite mineral compared to commercial silica[J]. *Comptes Rendus Chimie*, 2005, 8(9/10): 1701-1708.
- [11] KHRAISHEH M A M, AL-DEGS Y S, MCMINN W A M. Remediation of wastewater containing heavy metals using raw and modified diatomite[J]. *Chemical Engineering Journal*, 2004, 99(2): 177-184.
- [12] ZHANG Wen-qi, RAO Pin-hua, ZHANG Hui, et al. The role of diatomite particles in the activated sludge system for treating coal gasification wastewater[J]. *Chinese Journal of Chemical Engineering*, 2009, 17(1): 167-170.
- [13] LIU Bing-yue, HAN Ying. Recycled Fiber and Waste Water Deinking Technic[M]. Beijing: Chemical Industry Press, 2005: 323, 439.
- [14] ZHANG Ying. Papermaking Industry Material Handbook[M]. Beijing: China Standard Press, 1998: 47-48, 57-58.