Effect of CaCO₃ Addition on Base-sheet of Paper-making Process Reconstituted Tobacco

Jiajun Wang, Jun Wen, Jian Zeng*

Technology Center, China Tobacco Guangdong Industrial Co., Ltd., Guangzhou, 510385, China

*Corresponding author e-mail: zengjianzb@126.com

Abstract. CaCO₃ and wood pulp were added in base-sheet. And the effects on the permeability, physical properties, smoke index and microstructures were researched. The results indicated that: 1) With the increase of CaCO₃ adding rate, wood pulp addition rate was 6%, the bulk thickness and air permeability of base-sheet increased slightly, while the tensile index and tear index of base-sheet decreased gradually. 2) Base-sheet permeability analysed showed that CaCO₃ on the surface of base-sheet was conducive to the formation of more pores, the liquid infiltration from the surface of the base-sheet to the interior, the permeability and liquid absorption properties of the base-sheet were improved. 3) Add 50% calcium carbonate, the CO, TPM and deliveries of tar in mainstream smoke of base-sheet decreased by 17.25%, 19.51% and 18.75%, respectively.

1. Introduction
Tobacco stems and dust account for one third of the raw tobacco in the tobacco leaves process of re-drying and cigarette production [1, 2]. Paper-making reconstituted tobacco is tobacco leaf remanufactured by certain processing technology, which uses tobacco dust, tobacco stem and other tobacco waste produced in tobacco processing [3]. Base-sheet has advantages, such as good mechanical properties, low deliveries of tar, low density of tobacco and high filling power [4-6].

In recent years, guar gum additives have been widely used in the cigarette paper industry [7-11]. It provides excellent performance such as good retention, filtration and enhancement effects for cigarette paper, and no odor when burning, can meet the needs of cigarette paper. At present, in all the major cigarette paper factories in China, Guar gum has basically replaced starch as reinforcing, retaining, filtering and paper surface performance improver. CaCO₃ has been widely used in cigarette paper [12-15], and there are few reports on the application of CaCO₃ in base-sheet [16-18]. A certain amount of CaCO₃ is usually added to base-sheet. It can improve the permeability and physical properties of the base-sheet, reduce the production cost, as well as improving the smoking quality of reconstituted tobacco.

2. Experimental
2.1. Materials
China Tobacco Guangdong Industrial Co., Ltd.. provide tobacco dust and tobacco stem.
2.2. Hot water extraction
The extracted parameters were as follows:
- Extraction temperature: 80 ℃
- Liquid-solid ratio: 6:1
- Extraction duration: 50 min

2.3. Fiber refining
Tobacco stem refining consistency was 20%, it was defibrillated by refiner.

2.4. CaCO₃ size test
CaCO₃ size was tested by laser particle size analyzer (Malvern, mastersize2000, British).

2.5. Base-sheet manual preparation and test
Prepared base-sheets of 60 g/m², and the wood pulp addition rate was 6%. All base-sheet physical properties were tested according to standards.

2.6. SEM observation of base-sheet
Base-sheet process reconstituted tobacco were scanned by Hitachi S-3700N.

2.7. Retention performance evaluation of CaCO₃
The base-sheet was dried under 105 ℃ to determine the absolute dry quality. Then the dried base-sheet was calcinated in an oven under 575 ℃ for 6h to determine the quality of burning ash (mmash). Therefore, the content of ash content (A) of base-sheet can be calculated: A = mmash / m × 100%.

2.8. Smoke index test
Base-sheet process reconstituted tobacco was processed into cigarettes manually after shredding. And the main stream smoke was tested. (Cerulean SM450, British).

3. Results and discussion
3.1. Study on size distribution of CaCO₃
CaCO₃ size was tested by laser particle size analyzer. Surface area, span, and maximum size of CaCO₃ was 2.26m²/g, 1.037, and 8.71μm, respectively. Volume average diameter D(4,3) and surface area average diameter D(3,2) of CaCO₃ were 3.509μm and 2.653μm. d(0.1), d(0.5) and d(0.9) of CaCO₃ were 1.743μm, 2.836μm and 4.683μm, respectively.

CaCO₃ size distribution diagram was demonstrated in figure 1. It can be seen from figure 1 and the measured experimental data, the overall distribution diagram was narrow, the span was short, the peak was high, and the specific surface area was large. This indicates that the particle size distribution was uniform.

3.2. Effect of CaCO₃ adding rate on physical properties of base-sheet
After added 6% wood pulp, the effects of CaCO₃ adding rate on the physical properties of base-sheet were shown in table 1. The content of long fiber of the base-sheet with tobacco dust and stem pulp was reduced, and the tear index and tensile index was decreased gradually, when the CaCO₃ was increased. It was clearly indicated that tensile index decreased gradually from about 17.76 N·m/g to 11.66 N·m/g, and tear index decreased gradually from about 2.05 mN·m²/g to 1.68 mN·m²/g with CaCO₃ dosage increased from 10% to 70%.
Table 1 Effect of CaCO₃ dosage on physical properties of base-sheet

| CaCO₃ dosage/% | 0    | 10   | 20   | 30   | 40   | 50   | 60   | 70   |
|---------------|------|------|------|------|------|------|------|------|
| Tensile index /N·m·g⁻¹ | 18.29 | 17.76 | 15.55 | 13.15 | 12.76 | 13.27 | 11.66 | 11.66 |
| Tensile strength /kN·m⁻¹ | 1.59  | 1.27  | 1.10  | 1.00  | 0.96  | 0.95  | 0.87  | 0.86  |
| Tear index /mN·m²·g⁻¹ | 2.19  | 2.05  | 1.94  | 1.91  | 1.88  | 1.87  | 1.83  | 1.68  |
| Bulk /cm⁴·g⁻¹ | 2.33  | 2.34  | 2.43  | 2.40  | 2.46  | 2.43  | 2.41  | 2.45  |
| Air permeability /μm·Pa⁻¹·s⁻¹ | 2.06  | 2.06  | 3.46  | 5.08  | 5.33  | 5.45  | 5.57  | 6.94  |
| Ash/% | 6.14  | 7.51  | 8.90  | 10.11 | 11.72 | 12.42 | 14.01 | 14.42 |

*Wood pulp dosage was 6%, guar gum dosage was 0.25%.

With the increased of CaCO₃ dosage percentage in base-sheet, the bulk of base-sheet showed uptrend along (Table 1). The interspaces of tobacco stem fiber was filled by CaCO₃, it contributed to bulk of base-sheet, which was the main cause of the increasing bulk of base-sheet when the CaCO₃ adding rate was increased in paper-making process reconstituted tobacco. The effected of CaCO₃ dosage to air permeability of base-sheet were showed Table 1. It increased with the increased CaCO₃ dosage percentage of base-sheet.

3.3. Effect of CaCO₃ on the permeability of base-sheet

The effect of different dosage of CaCO₃ on the permeability of the base-sheet was shown in table 2, when the wood pulp adding rate was 6%. Characteristic value t95 represents the porosity of base-sheet surface. It can be seen from table 2, the t95 value without CaCO₃ supplementation was 0.602 s. The t95 value decreased gradually from 0.417 s to 0.281 s, with the increased of CaCO₃ dosage from 30% to 70%. It indicated CaCO₃ was beneficial to produce more pore structure surface of base-sheet, favorable to infiltrate from surface to internal, which is the reason for the improvement of improve liquid permeability and solution adsorption performance of base-sheet.

Table 2 Effect of CaCO₃ dosage on liquid permeability of reconstituted tobacco paper-base

| CaCO₃ dosage/% | 0    | 30   | 50   | 70   |
|---------------|------|------|------|------|
| Max/s | 0.169 | 0.149 | 0.133 | 0.113 |
| Cobb30/g·m⁻² | 26.7 | 26.8 | 27.3 | 27.5 |
| Cobb60/g·m⁻² | 28.5 | 28.7 | 29.0 | 29.5 |
| t95/s | 0.602 | 0.417 | 0.335 | 0.281 |

*Wood pulp dosage was 6%.

Wettability Max refers to the time during the base-sheet is fully wetted and the signal strength reaches the maximum, it increases with the increased time that liquid stays on the surface of paper. It can be seen from table 2, Max value and t95 value both showed similar decreasing trend with the increase of CaCO₃ dosage. The Max value without CaCO₃ was 0.169 s, when the CaCO₃ dosage increased from 30% to 70%, the Max value decreased from 0.149 s to 0.113 s. With the increasing of CaCO₃ dosage, more CaCO₃ remains in the base-sheet. It was beneficial to form more loose pore structure between fiber and fiber, and to improve permeability and solution adsorption performance of base-sheet.

The effects of CaCO₃ dosage on Cobb30 value and Cobb60 value of base-sheet were shown in table 2, when the proportion of wood pulp was 6%. It can be seen from table 2, the effects of CaCO₃ dosage have little impact on Cobb30 value and Cobb60 value of base-sheet.

3.4. SEM analysis of base-sheet

SEM photograph of different CaCO₃ dosage made base-sheet with the 6% proportion of wood pulp were demonstrated in figure 2 and figure 3. It was clearly indicated form fig.2 that when the CaCO₃ dosage increased, the base-sheet surface become smoother and smother. It can be seen from the Fig.3, the texture of base-sheet became loose, when the CaCO₃ dosage increased, so that the permeability and absorption property of base-sheet improved obviously.
3.5. Effect of CaCO$_3$ on the base-sheet smoke index

The effects of CaCO$_3$ dosage on smoke of base-sheet were shown in table 3, with the 6% proportion of wood pulp. With the increased of CaCO$_3$ dosage, the permeability and flammability of the base-sheet was improved. Moreover, the increased of CaCO$_3$ reduced the proportion of tobacco
dust and tobacco stem in cigarette, the deliveries of tar was also reduced. It can be seen from table 3, the CO, deliveries of tar and TMP was 19.7 mg, 8.0 mg and 10.25 mg, respectively, without CaCO₃ supplementation. When CaCO₃ dosage was 50%, in mainstream smoke, the CO, deliveries of tar and TMP was 16.3 mg, 6.5 mg and 8.25 mg, respectively. Add 50% calcium carbonate, the CO, TPM and deliveries of tar in mainstream smoke of base-sheet decreased by 17.25%, 19.51% and 18.75%, respectively.

| CaCO₃ dosage /%  | 0    | 30   | 50   | 70   |
|----------------|------|------|------|------|
| Tar /mg        | 8.0  | 6.9  | 6.5  | 6.3  |
| TPM /mg        | 10.25| 8.86 | 8.25 | 8.25 |
| Nicotine /mg   | 0.02 | 0.02 | 0.02 | 0.02 |
| CO /mg         | 19.7 | 18.6 | 16.3 | 16.1 |

*Wood pulp dosage was 6%.

4. Conclusion

With the increase of CaCO₃ adding rate, wood pulp addition rate was 6%, the bulk thickness and air permeability of base-sheet increased slightly, while the tensile index and tear index of base-sheet decreased gradually.

Base-sheet permeability analysed showed that CaCO₃ on the surface of base-sheet was conducive to the formation of more pores, the liquid infiltration from the surface of the base-sheet to the interior, the permeability and liquid absorption properties of the base-sheet were improved.

Add 50% calcium carbonate, the CO, TPM and deliveries of tar in mainstream smoke of base-sheet decreased by 17.25%, 19.51% and 18.75%, respectively.

References

[1] Qing Han, Meiyun Zhang, Yangyu Wu and Fuwang He, Manufacture techniques of papermaking tobacco leaf, Journal of northwest university of light industry. 1(2002)19-22.
[2] Xingping Tang, Xuerong Chen, Dasong Dai, Rongtang Hu and Kexiang Bao, Preparation of tobacco slice from tobacco leaf offal by papermaking, Journal of Fujian Agriculture and Forestry University (Natural Science Edition). 2(2007) 205-207.
[3] Yong Joo Sung and Yung Bum Seo, Thermogravimetric study on stem biomass of Nicotiana tabacum, Thermochimica Acta. 486(2009)-1-4.
[4] Yingju Miao, Weijuan Liu, Gang Liu, Jing Che and Yaming Wang, Present status of preparation technology of reconstituted tobacco, China Pulp & Paper. 7(2009) 55-60.
[5] Weisheng Wang, Ye Wang, Liangju Yang, Baizhan Liu and Minbo Lan, Studies on thermal behavior of reconstituted tobacco sheet, Thermalchimica Acta. 437(2005)7-11.
[6] Zugang Chen, Bing Cai, Jianxin Wang, Mingqiao Ye and Xiong Bin, Comparison between domestic and foreign paper-process tobacco sheets, Tobacco Science & Technology. 2(2002) 4-10.
[7] Jiheng Chang, Congyang Niu, Caiyun Zhang and Linag Xu, Preliminary experiments on extraction technology in paper-process reconstituted tobacco production, Tobacco Science & Technology. 1(2002) 14-17.
[8] Xinsheng LI, Xinlong YAN, Guangqing ZHANG, Shumei WANG, Application of cationic guar gum in producing reconstituted tobacco by papermaking technique paper chemicals. 6(2008) 41-42,46.
[9] Xiang Xu, Qingbin Han, Jinsong Li, et.al, Characteristics of guar gum and its application in cigarette paper making, China Pulp & Paper. 2(2003)34-37.
[10] Huiren Hu, Yangbing Wen, Shulan Shi, et.al, Comparison of application of chitosan and guar gum in tobacco sheet manufacture by papermaking process, China Pulp & Paper. 7(2010) 32-36.
[11] Jinshi Fan, XinYang Hu, Fushan Chen, Preparation of amphoteric guar gum and its strengthening effects on cigarette paper, Paper and Paper-making. 5(2011) 36-39.
[12] Yin Wang, Application of CaCO3 in cigarette paper-making, Paper Chemicals. 3(2007) 40-45.
[13] Qiliang Wang, Fengchi Shen, Hougong Li, Application trial of precipitated CaCO3 for high-quality cigarette paper, China Pulp & Paper. 8(2003)28-29.

[14] Dequan Liang, Effect of home-made and imported CaCO3 on cigarette paper quality, Paper Chemicals. 4(2009)34-35, 45.

[15] Hongyan Li, Application of CaCO3 in cigarette paper manufacture, Paper Chemicals. 4(2008)42-44.

[16] Deping Sun, Liang Wang, Fenglan Wang, et al., Application of GCC in the production of base sheet of reconstituted tobacco, China Pulp & Paper Industry. 24(2010)54-58.

[17] Jian Zeng, Kefu Chen, Jianping Xie, et al., Effects of CaCO3 addition on base-sheet process reconstituted tobacco, Tobacco Science & Technology. 10(2013)5-7, 16.

[18] Weiying Wu, jinSong Li, Selection of CaCO3 for cigarette paper production, China Pulp & Paper. 2(2005)26-29.