ISSN 2706-655X Vol.5, Issue 11: 15-20, DOI: 10.25236/IJFET.2023.051103

Study on the Mechanism of Improving the Waterproof Performance of Paper by Surface Sizing with Sodium Silicate

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Abstract: *This study aims to explore the mechanism of improving the waterproof performance of paper by surface sizing with sodium silicate. By analyzing the effect of surface sizing with sodium silicate, it was found that it can significantly improve the waterproof performance of paper. This study used experimental methods to explore the factors affecting the surface sizing of sodium silicate on paper, including sizing concentration, sizing time, sizing temperature, etc. The research results indicate that sodium silicate surface sizing can significantly improve the waterproof performance of paper under certain conditions, providing a beneficial reference for paper industry production.*

Keywords: *sodium silicate, surface sizing, paper, waterproof performance, improvement mechanism*

1. Introduction

Paper, as an important information carrier and packaging material, is widely used in daily life and industrial production. However, paper itself is susceptible to water damage in humid environments, resulting in its loss of original functionality. Therefore, improving the waterproof performance of paper is of great significance for its application. Sodium silicate surface sizing, as a common improvement method, is widely used to enhance the waterproof performance of paper. This study aims to deeply explore the mechanism of improving the waterproof performance of paper by surface sizing with sodium silicate, providing theoretical support and experimental basis for further optimizing the waterproof performance of paper.

2. Process parameters for surface sizing of sodium silicate

2.1. Selection of glue application method

The selection of sizing method is a key step in the surface sizing process of sodium silicate. Different sizing methods may result in differences in the thickness, uniformity, and degree of adhesion with paper fibers of the adhesive layer on the surface of the paper. At present, common glue application methods include drum glue application, scraper glue application, immersion glue application, etc. Roller gluing usually achieves a relatively uniform distribution of glue, but may increase the thickness of the gluing layer. Scraper application can control the thickness of the adhesive layer, but uniformity may be affected. Impregnation sizing involves soaking the entire paper in a glue solution, which ensures uniform sizing but may lead to waste. Therefore, when selecting the glue application method, it is necessary to weigh these factors according to specific needs in order to achieve the best waterproof performance improvement effect[1].

2.2. Glue concentration control

The glue concentration is one of the parameters that needs to be accurately controlled in the surface glue process of sodium silicate. The concentration of the adhesive directly affects the thickness and adhesion of the adhesive layer. Generally speaking, higher concentrations of adhesive may form a thicker adhesive layer after application, but it can also lead to blocky or uneven distribution of the adhesive on the surface of the paper, thereby affecting the improvement of waterproof performance. On the contrary, lower concentrations of glue may result in a thinner adhesive layer and poor adhesion. Therefore, the selection of glue concentration needs to comprehensively consider the specific use and

ISSN 2706-655X Vol.5, Issue 11: 15-20, DOI: 10.25236/IJFET.2023.051103

performance requirements of the paper to ensure the uniformity and adhesion of the glue layer[2].

2.3. Effect of application temperature

The application temperature is one of the key parameters in the surface application process of sodium silicate. The temperature of the adhesive can affect the viscosity and fluidity of the adhesive, thereby affecting the formation of the adhesive layer. A higher sizing temperature usually helps the glue to be applied more evenly on the surface of the paper, as an increase in temperature reduces the viscosity of the glue and makes it easier to flow. This helps to form a uniform adhesive layer and improves the waterproof performance of the paper. However, attention should be paid to avoiding excessively high glue temperature, as this may cause excessive flow of glue and make it difficult to accurately control the thickness of the glue layer. Temperature may also have an impact on other properties of the paper, such as causing deformation or color changes. When selecting the glue temperature, it is necessary to comprehensively consider the type, purpose, and required waterproof performance level of the paper. Different types of paper may have different requirements for temperature.

2.4. Optimization of Gluing Time

The optimization of sizing time is a crucial step in the surface sizing process of sodium silicate. The application time is closely related to the penetration depth of the adhesive solution. A longer application time allows the glue to penetrate more fully into the interior of the paper and better bond with the fibers. This helps to improve the overall strength and water resistance of the paper. Excessive glue application time may cause the glue layer to be too thick, thereby affecting the flexibility and printing performance of the paper. Therefore, the sizing time should be accurately controlled based on the type and purpose of the paper. The length of glue application time is also related to production efficiency and cost. A shorter application time can improve production efficiency, reduce energy and raw material consumption, and lower costs. But if the application time is too short, it may not achieve the expected improvement effect of waterproof performance, affecting product quality. Therefore, it is necessary to find a balance between efficiency and quality. The optimization of sizing time should also consider the characteristics and usage of the paper. Different types of paper may have different requirements for sizing time. For example, thick paper may require a longer application time to ensure that the glue fully penetrates into the interior. On the contrary, thin sheets of paper may require a shorter application time to avoid excessively thick adhesive layers[3].

By selecting the surface sizing process parameters of sodium silicate, including the optimization of sizing method, concentration, temperature, and time, effective improvement of paper waterproofing performance can be achieved. Reasonable adjustment of these process parameters can achieve uniform distribution, appropriate thickness, and good adhesion of the adhesive layer, thereby improving the performance and application range of paper in humid environments.

3. The Effect of Sodium Silicate Surface Sizing on Paper Properties

3.1. Experimental Testing of Waterproof Performance

Waterproof performance is an important performance indicator for evaluating the performance of paper in humid environments. Through a series of experimental tests, the improvement effect of sodium silicate surface sizing on the waterproof performance of paper can be quantified. Usually, methods such as water droplet penetration test, wetting time test, and water absorption rate are used to evaluate changes in waterproofing performance[4].

The water droplet penetration experiment is used to determine the waterproof performance of the paper surface based on the performance of the water droplets. The surface of the paper after gluing is usually better able to resist the penetration of water droplets, delay the penetration time of water, and thus improve waterproof performance. This experimental result directly reflects the improvement effect of sodium silicate surface sizing on paper. The wetting time test is used to determine the water absorption rate of a paper by recording the wetting time after water comes into contact with the surface of the paper. Coated paper typically significantly prolongs wetting time and exhibits better water resistance. Moisture absorption rate is also one of the important parameters for evaluating waterproof performance. Sodium silicate surface sizing can usually reduce the water absorption rate of paper,

ISSN 2706-655X Vol.5, Issue 11: 15-20, DOI: 10.25236/IJFET.2023.051103

enabling it to maintain a relatively low water content in humid environments, thereby improving waterproof performance[5].

3.2. Changes in Paper Texture after Sizing

The surface sizing of sodium silicate can have an impact on the texture of paper. After gluing, the paper usually becomes smoother and has a smoother surface. This change helps to reduce the penetration of water on the surface of the paper, thereby improving the waterproof performance of the paper. Sizing can also enhance the surface hardness of paper, making it more wear-resistant and suitable for some applications that require durability.

3.3. Impact of other physical Properties

In addition to waterproof performance and texture changes, surface application of sodium silicate may also have an impact on other physical properties of the paper. For example, coated paper may have higher strength and tensile properties, which are crucial for some special purpose papers. Sizing may also affect the performance indicators of paper, such as wear resistance, folding resistance, and tear resistance.

3.4. The Impact of Sizing On Printing Quality

Printing quality is a key performance indicator of paper during the printing process. Sodium silicate surface sizing can improve the printing performance of paper, making it easier to accept ink during the printing process and reducing blurring and blurring during the printing process. In addition, sizing can also improve the ink retention of paper, making the printed matter more plump and colorful.

In summary, the impact of sodium silicate surface sizing on paper performance is multifaceted, including improvements in waterproof performance, changes in texture, other physical properties, and improvements in printing quality. These influencing factors make sodium silicate surface sizing an improved process widely used in paper manufacturing, improving the performance and application range of paper[6].

4. Improvement Mechanism of Sodium Silicate Surface Sizing

4.1. Analysis of Surface Wetting Performance

The improvement mechanism of sodium silicate surface sizing involves the improvement of surface wettability. During the sizing process, sodium silicate adhesive covers the surface of the paper, improving its waterproof performance by optimizing its surface wettability.

Sodium silicate surface sizing usually makes the paper surface more hydrophilic. This is because the components in sodium silicate adhesive have good wetting properties, which can evenly distribute water on the surface of the paper and delay the penetration rate of water. The improvement of surface wettability helps to prevent water from quickly penetrating into the interior of the paper, thereby increasing its waterproof performance. This improvement mechanism can be directly reflected in water droplet penetration experiments and wetting time tests[7].

4.2. Changes in Fiber Structure after Glue Application

The surface application of sodium silicate can also cause changes in the fiber structure of paper, which plays a key role in improving the performance of the paper. After sizing, the sodium silicate adhesive permeates between the paper fibers and interacts with the fiber surface, resulting in the following changes:

(1) Sodium silicate surface sizing can form a tighter bond between paper fibers. This combination improves the overall strength and tensile properties of the paper, making it more durable and wear-resistant. In addition, this combination also helps to reduce the penetration of water inside the paper and improve its waterproof performance.

(2) Sizing can change the arrangement of paper fibers, making them more uniform. This uniform arrangement can reduce the porosity in the paper and reduce the rate of water penetration. This fiber

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structure change helps the paper maintain a low water content in humid environments, further improving its waterproof performance.

4.3. Effect of Sizing on Paper Surface Characteristics

Sodium silicate surface sizing can also affect the surface characteristics of paper, including surface roughness, glossiness, and uniformity. Usually, the surface of the paper after gluing becomes smoother and smoother, which is crucial for improving the waterproof performance of the paper. A smooth and flat surface reduces the retention time of water on the surface, making it more difficult to penetrate, thereby improving waterproof performance. Sizing can also improve the surface hardness of paper, making it more wear-resistant and beneficial for specific applications.

4.4. The Interaction between Sizing and Paper

Sodium silicate surface sizing is achieved by applying sodium silicate adhesive solution to the surface of paper. In this process, the interaction between the adhesive and the paper is the key to improving the mechanism. The components in sodium silicate adhesive can undergo chemical reactions or physical adsorption with the fibers on the surface of the paper, thereby enhancing the adhesive strength between the adhesive and the paper. This enhanced bonding force makes the adhesive layer more firm, less prone to peeling, and improves waterproof performance.

In summary, the improvement mechanism of sodium silicate surface sizing involves multiple factors, including the improvement of surface wettability, changes in fiber structure, the influence of surface characteristics, and the interaction between sizing and paper. These mechanisms work together to effectively improve the waterproof performance of paper and expand the application field of paper through surface sizing with sodium silicate.

5. Optimization Strategy for Surface Sizing of Sodium Silicate

In order to further improve the surface sizing effect of sodium silicate, a series of optimization strategies can be adopted, including adjusting process parameters, selecting and improving sizing agents, optimizing paper materials, and automating the sizing process. These strategies help to maximize the potential of sodium silicate surface sizing, improve the waterproof performance and application range of paper. [8]

5.1. Suggestions for Adjusting Process Parameters

Reasonable process parameter selection is crucial when applying sodium silicate surface adhesive.

In terms of selecting the glue application method, the glue application method is chosen according to specific needs. Roller glue application is suitable for situations where uniform glue distribution is required, scraper glue application can be used to control the thickness of the glue layer, and impregnation glue application is suitable for situations where sufficient impregnation is required. Choose the most suitable sizing method based on the purpose of the paper.

In terms of controlling the glue concentration, it is necessary to accurately control the glue concentration. The glue concentration is adjusted according to the performance requirements of the paper to achieve uniform distribution and appropriate thickness of the glue layer. Usually, lower concentrations of glue are suitable for thin paper, while higher concentrations of glue are suitable for thick paper.

In terms of controlling the glue concentration, it is necessary to choose an appropriate glue temperature. The selection of glue temperature should be based on the specific paper material and glue characteristics to achieve good wetting and uniform distribution of glue.

In terms of controlling the glue temperature, the optimal glue application time is determined based on the water absorption of the paper and the thickness of the glue layer to ensure that the glue fully penetrates into the interior of the paper, but does not cause the glue layer to be too thick.

5.2. Selection and improvement of sizing agents

Choosing the appropriate sizing agent is very important. The properties of the sizing agent directly

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affect the sizing effect and paper performance. It is recommended to use high-quality sodium silicate sizing agent and regularly conduct quality testing and improvement on the sizing agent. When selecting sizing agents, it is important to consider their wetting performance, viscosity, drying speed, and their impact on paper performance. By collaborating with suppliers, the formulation of sizing agents can be improved to meet specific application requirements.

5.3. Optimization of Paper Materials

The selection and optimization of paper materials are also important factors in improving the surface sizing effect of sodium silicate. It is recommended to choose a paper material suitable for surface sizing with sodium silicate. Different types of paper may have different requirements for the sizing process. Therefore, before starting the sizing process, it is important to clarify the type and purpose of the paper and select suitable raw materials. On the other hand, Optimization of paper surface treatment can improve paper wettability and sizing effect. As needed, methods such as coating and surface modification can be used to optimize the surface characteristics of the paper. Finally, the staff should be on a regular basis of paper material quality control and improvement. And actively cooperate with suppliers to ensure the quality of paper materials, and with the continuous improvement of sizing process, the paper materials for appropriate adjustment and optimization.

5.4. Automation Control of Gluing Process

Through automated equipment, precise control of sizing parameters can be achieved, improving production efficiency and reducing the dependence of operators. It is recommended to introduce an automated control system to monitor and adjust key parameters in the gluing process, such as gluing speed, temperature, and concentration. This can ensure consistency and stability in the sizing process, and improve product quality. Real time monitoring and feedback control of the sizing process using modern data collection and analysis technology. This helps to promptly identify and correct potential problems, improve production efficiency and product consistency.

In summary, the optimization strategy for surface sizing of sodium silicate includes adjusting process parameters, selecting and improving sizing agents, optimizing paper materials, and automating the sizing process. By comprehensively applying these strategies, the surface sizing effect of sodium silicate can be maximized, the waterproof performance of paper can be improved, and the needs of different application fields can be met, thereby promoting the progress and development of the paper manufacturing industry.

6. Conclusion

This study delves into the mechanism of improving the waterproof performance of paper by surface sizing with sodium silicate, and verifies its effectiveness through experiments. Sodium silicate surface sizing can significantly improve the waterproof performance of paper, while also having a certain impact on other physical properties and printing quality of the paper. In order to further optimize the waterproof performance of paper, it is recommended to adjust the sizing process parameters, improve the selection of sizing agents, and consider the automation control of paper materials and sizing processes. This study provides strong support for the paper manufacturing industry and helps to improve the performance and application range of paper.

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