Influence of Base Paper Properties on Coating Penetration

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Abstract

The influence of sizing, fiber and pigment type on coating penetration, using commercial paper and two types of handsheets as the base paper which were prepared from thermomechanical pulp (TMP) and hardwood bleached kraft pulp(KP) sized internally with alkyl ketene dimmer (AKD), was studied in terms of characteristics of coating holdout. Laboratory rod draw down coater was used for surface sizing and coating application. Characterization of coating penetration was done by measuring the roughness of the backside of coating layer. The backside of the coating was exposed by dissolving the fibers in a solution of cupriethylenedimine (CED). Data show that internal sizing of base paper is effective and surface sizing is more effective to prevent coating penetration. Comparing between the two types of base papers, backside roughness of coating layer of TMP sheet is much larger and sizing is more effective to reduce coating penetration than those of KP sheet. With regard to pigment type, clay is more effective than calcium carbonate for better coating holdout.

Introduction

The interaction between water and base paper in various coating process is important. The water absorption behavior may determine the initial coating

consolidation and the penetration of coating into paper. However, quantitative studies on this topics especially, the influence of sizing and fiber type on coating penetration have not been reported in literature.

In the paper coating process, a water based pigmented coating is applied to the base paper to improve the optical and printing properties. The coating slurry can be absorbed as a continuum into the bulk of base sheet during coating. Therefore, the water uptake behavior of fibers, especially those at the surface of base sheet subjected to coating, is important for coating holdout and other coating properties.

The term holdout is often used to indicate the resistance of base paper to coating penetration. Coating penetration is the difference between the application solids and the immobilization solids, since this difference determines the amount of water that must be removed before all motion stops. Lack of coating holdout is primarily caused by excessive and/or rapid penetration of the conditions and properties has increased the demand for improved coating holdout. For improving coating holdout, several studied, for example, addition of water retention agent , modification of coating color , or pigmented precoating have been studied. However, base paper treatments are also an important factor for improving coating holdout.

Experimental

This study has four experimental steps: 1) make handsheets with different degrees of sizing and with different fibers and prepare the commercial base paper controlled the sizing degrees by heat treatment, 2) test of sheet properties, 3) apply surface sizing and coatings and 4) characterization of coating penetration. Unbeaten hardwood bleached kraft pulp(KP) and unbleached thermomechanical pulp(TMP) were used for handsheet making. For internal sizing, known amounts of the alkyl ketene dimer(AKD) emulsion by mass was added to a 0.15% pulp suspension with continuous stirring for sizing. After stirring for 30 sec., the pulp

suspension was made into 70g/m^2 handsheets in accordance with TAPPI Test 205. TMP handsheets were treated by heat in the oven at 100°C to adjust sizing degree. Commercial base paper was also treated by heat at 100°C to increase the sizing degree. In case of surface sizing, hydroxyethylated starch was cooked and this starch as 5% consistency was applied to base papers using laboratory rod draw down coater. The roughness of the sheets was measured using the Stylus Profilometer. Laboratory rod draw down coater was used for coating application. Characterization of coating penetration was done by measuring the roughness of the backside of coating layer. The backside of the coating was exposed by dissolving the fibers in a solution of cupriethylenediamine(CED) according to the method described by Dickson and Lepoutre (1). Before dissolution, a piece of backing tape is placed on the coated side of the sample to provide strength to the separated coating. The sample is soaked in CED and then shaken gently for 30-40 minutes after which the gel-like fibers are removed by washing with water. The separated coating is then ready for measuring the backside roughness after drying.

Results and discussion

Characterization of coating penetration with internal sized sheet

The dissolution method(1) of fibers for the exposure of the backside of coating layer was used to examine the degree of mechanical adhesion between the coating and the paper, originally. But, this new method has been used to measure the backside roughness of the coating layer and characterize coating penetration into base paper by Akinli-Kocak(2) and concluded that fiber swelling by water absorption reduces absorption rate and decreases coating into paper due to closing of sheet surface pores by swelling of the fibers. It can be also seen that the larger the coating penetration, the worse is the backside roughness of coating layer from this literature. It seems to have a good relationship between the coating

penetration and the backside roughness of coating layer. Therefore, this method was used to evaluate influence of sizing and fiber type on coating penetration in this study. The results indicate that sizing of base paper is absolutely necessary to get somewhat the higher smoothness of coating surface and to get the lower coating penetration into paper. It is well known in sized paper that the penetration is considerably reduced because the walls of the pores resist wetting. Clark et al(3) have suggested that the water migrates faster than the binder during capillary migration, but both migrate together during the pressure migration stage. They demonstrated that addition of a reactive size reduced the capillary migration although the pressure migration was almost constant. The results imply that coating penetration of TMP sheet is much larger and the sizing is more effective for preventing coating holdout than those of KP sheet. There are several factors(4) that affect the penetration rate of a liquid into paper, among them, pore radius and contact angle i.e.wetting of the fiber surface are the factors that are close related to base paper properties. Sizing mainly changes the contact angle and also pore size and wetting of the fiber surface are affected by fiber type.

Coating penetration with different pigments, clay and calcium carbonate

The results show coating backside roughness of different pigment coating, i.e. kaolin clay and ground calcium carbonate on both internal and surface sizing.

Particle size and shape distribution are probably the most important factors in controlling many physical properties of pigment of importance to the papermaker, such as coating penetration, rheology, optical properties, and smoothness. The clays, inherently, are extremely fine and the shape is not spheres. Shape is closely related to particle size in that the filler clays usually contain an abundance of stacks and the coating clays a preponderance of thin plates(5). The recent move to neutral and alkaline sizing is eliminating the instability of calcium carbonate in acid systems and is resulting in a rapid growth in the use of calcium carbonate for both filling

and coating. It is felt that particle packing plays a role in contributing to the coating properties but the specific mechanism has not been demonstrated. In discussing the coating properties of clay and calcium carbonate, it is necessary to define the product both in terms of its particle dimensions and chemical components. For better coating holdout, this result imply that it is better to use clay than calcium carbonate as a coating pigment. Further study is needed to find out specific mechanism. All of these experimental results were obtained with a laboratory rod draw down coater, therefore other application methods, such as cylindrical laboratory coater, could give somewhat different results.

Conclusions

In this study, the influence of sizing, fiber and pigment type on the coating penetration were investigated and the following conclusions were obtained.

- Internal sizing is effective, but surface sizing is more effective to prevent coating penetration, therefore, surface sizing is necessary with internal sizing for the better coating holdout.
- Coating penetration of TMP sheet is much larger and the sizing for TMP is more effective to reduce coating penetration than those of KP sheet.
- In case of pigment type, clay is more effective than calcium carbonate to reduce coating penetration.

Literature cited

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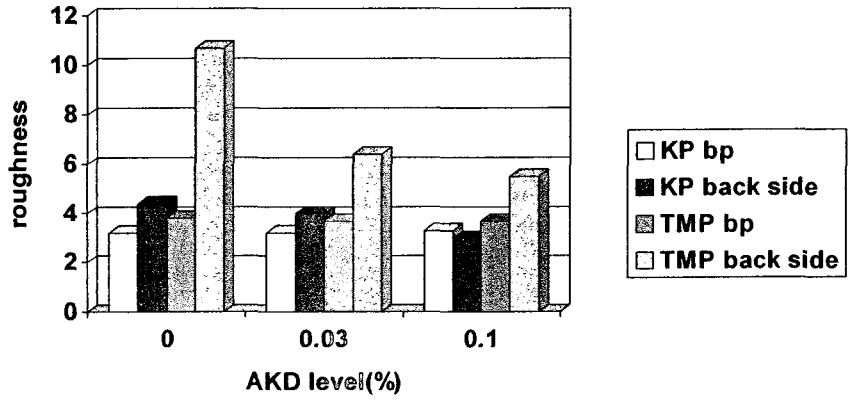

Fig.1 Roughness of coating layer
(bp : top side of KP, TMP hand sheet 70g)

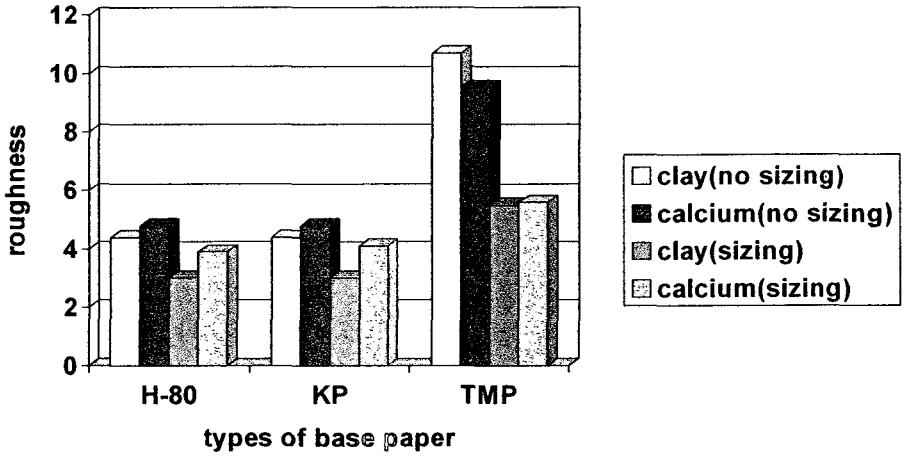

Fig.2 Coating backside roughness of clay and calcium carbonate coating on internal sizing