Kafkas Üniversitesi
Artvin Orman Fakültesi Dergisi
(2004) : 1-2 (24-30)

THE PERFORMANCE OF ANIONIC POLYACRYLAMIDE AS A RETENTION AID IN NEWSPRINT PRODUCTION

Sedat ONDARAL
KTU Faculty of Forestry, 61080 Trabzon-TURKEY
e-mail:ondaral@ktu.edu.tr

Geliş Tarihi: 08.03.2004

Abstract: In this study, the performance of anionic polyacrilamide (APAM) being an effective flocculant in fines retention and its effects on drainage time of pulp suspension and papers properties were investigated. It was determined that the first pass fines retentions of furnishes which contained both stone groundwood and kraft pulps progressively increased with increase of APAM dosage. On the other hand, with 1% APAM addition, drainage time for unfilled and filled pulp suspensions which consisted of 80% stone groundwood pulp and 20% bleached kraft pulp increased 164% and 184% more than those of furnishes without APAM addition, respectively. Furthermore, it was determined that the breaking length, the burst index and the paper brightness increased with increasing APAM dosage. Consequently, it was concluded from this study that the drainage time and paper properties must be taken into consideration besides from benefits of fines retention when the APAM is used as a single retention aid.
Key Words: Retention, Anionic Polyacrylamide, Pulp, Flocculation, Drainage Time.

TUTUNDURUCU MADDE OLARAK ANYONİK POLİAKRİLAMİDİN GAZETE KAĞIDI ÜRETİMİNDEKİ PERFORMANSI

Özet: Bu çalışmada etkili bir kümeleyici olan anyonik poliakrilamidin (APAM) kırıntı materyalin tutunmasındaki performansı ile bu maddenin hamur süspansiyonunun drenaj süresine ve bazı kağıt özellikleri üzerine olan etkisi incelenmiştir. APAM dozundaki artış ile hem taş mekanik hamur hem de kraft hamuru içeren tüm süspansiyonlarda ilk geçiş kırıntı tutunumunun arttığı tespit edilmiştir. Diğer taraftan, %1 APAM ilavesi ile %80 taş mekanik hamur ve %20 ağartılmış kraft hamurundan oluşan dolgu maddesi içeren ve içermeyen süspansiyonlarda drenaj sürelerinin APAM ilave edilmemiş süspansiyonlara göre sırası ile %164 ve %184 uzadığı gözlenmiştir. Ayrıca, hamur süspansiyonlarına APAM ilave edilmesi kağıdın kopma uzunluğunu, patlama indisini ve parlaklık değerini düşürmüştür. Bu çalışmadan, APAM' in tek başına tutundurucu olarak kullanıldığında kırıntı tutunum konusunda sağladığı fayda yanında, drenaj süresi ve kağıt özelliklerinin de dikkate alınması gerektiği saptanmıştır.
Anahtar Sözcükler: Tutunum, Anyonik Poliakrilamid, Kağıt Hamuru, Kümelenme, Drenaj Süresi.

1. INTRODUCTION

Paper is a complex composite made of a combination of biological, synthetic, and inorganic materials. The components include wood pulps or other fibers and fines (as well as other components of wood), inorganic and organic fillers, natural and synthetic polymers (for sizing, retention and strength) and other additives to meet specific product and process requirements. Retention of the individual components in appropriate amounts is critical to the properties and quality of the paper sheet as well as minimizing pollution and cost (1). It depends on concentration of pulp suspensions (furnishes), dosage and properties of retention aids, drainage time, freeness of pulp, pH, conductivity, the concentration of dissolved and colloidal substances, zeta potential etc (2, 3, 4).

In the papermaking system, while long fibers can be retained easily on the wire, the retention of fines fraction having smaller dimension can be achieved by addition of chemical retention aids (5, 6). These chemicals are referred as coagulants and flocculants. Highly charged low molecular weight polymers are usually referred to as coagulants, while lower charged high molecular weight polymers are usually referred to as flocculants. Being cationic, coagulants (alum, polyDADMACs, polyethylenimine etc) lower the negative surface charge of colloidal particles, fibers, and fines by adsorbing on their surfaces. These particles form small aggregates that have poor stability when subject to shear but reform upon cessation of the shear forces. Flocculants (such as polyacrylamides and polyethylene oxide), on the other hand, often little effect on the surface charge of colloidal particles and tend to form larger flocs having low stability to shear via a bridging mechanism. Their action on a paper machine is more rapid and visible (7, 8, 9). These polymers increase significantly retention levels of fines fraction but they can deteriorate paper formation because of their forming larger flocs (10). It affects physical and optical properties of paper (11).

In this study, we aimed to determine the fines retention levels and drainage time of different furnishes provided by APAM addition were determined. Additionally, the effects of APAM addition on physical and optical properties of papers were also investigated.

2. MATERIAL and METHOD

2.1. Material

Pulp suspensions used for the experiments were prepared by mixing the unbleached stone groundwood pulp (SGW) and the softwood bleached kraft pulp (KP) at different ratios. These pulps were taken from Seka-AKSU Paper Mill. Pulp suspensions consist of 100% SGW, 80% SGW + 20% KP and 100% KP. The bleached softwood kraft pulp was beaten according to TAPPI 200 om 89. The freeness degrees of SGW and KP, according to TAPPI 227 om 92, were determined as 58 ^{o}SR and 25 ^{o}SR, respectively. Anionic polyacrylamide with low charge density and high molecular weight (NALCO D-4771) was used as a retention aid. APAM dossages were selected as 0, 0.2, 0.4, 0.6, 0.8 and 1 % (oven dry fiber weight). The solution of APAM was prepared by dissolving 1 g of it in 1000 ml water. In addition; kaolin and rosin were added in furnishes as a filler and an internal sizing agent, respectively. Alum was also added into pulp suspensions to adsorb rosin onto fibers and fines.

2.2. Method

2.2.1. Determination of First Pass Retention of Fines

In this study, while filler was not added into furnish in the first part of study, it was added in the second part. The performance of APAM as a retention aid was determined via first pass fines retention of furnishes (FPR) according to TAPPI 261 cm-90. For determination of the first pass retention level of fines, after 500 ml pulp suspension (concentration of 5%) was added into Dynamic Drainage Jar (DDJ), APAM was added to furnish and the stirrer speed was adjusted to 1250 rpm. After 15 seconds, drainage was started. When fhe filler was used in the second part of study, firstly filler was added. After 15 seconds mixing, APAM was added and furnish was mixed again for 15 seconds. Then drainage was commenced. At end of the drainage, the filtrate was collected. The first pass fines retention of sample was determined according to Equation 1:

$$FPR = [1-[W\times(V/U)]/T] \times 100 \qquad (1)$$

Where T is the total fines amount in sample (g), W is the weight of fines in filtrate (g), V is the volume of original sample (assumed numerically equal to the weight of original sample in g) and U is the weight of filtrate.

2.2.2. Determination of Paper Properties and Drainage Time

Furnish consisting of 80% SGW + 20 %KP was selected to determine the effect of retention aid on the properties paper because it was used generally for newsprint manufacture. These properties of paper were breaking length (TAPPI T 404 om-92), burst index (TAPPI T 403 om-91) and brightness (TAPPI 452 om-91). In addition, the effects of APAM addition on the drainage time of furnish were determined according to TAPPI 221 om-88 during papermaking.

3. RESULTS AND DISCUSSION

3.1. The Effects of APAM Addition on the Fines and Total Solids Retention

In the Figure 1 and Figure 2, the first pass retention of fines as a function of polymer dosage is plotted for filled and unfilled furnishes, respectively. As can be seen in these figures, APAM exhibited an increasingly improving performance with increasing its dosage in all furnishes. The first pass fines retention of both unfilled and filled furnishes (80% SGW + 20% MP) were 97% at the 1% APAM dosage where as they were 49% and 39% in the absence of APAM, respectively. Collision rate between APAM and other particles increases with increasing APAM dosage. Therefore, FPR improves (6, 12).

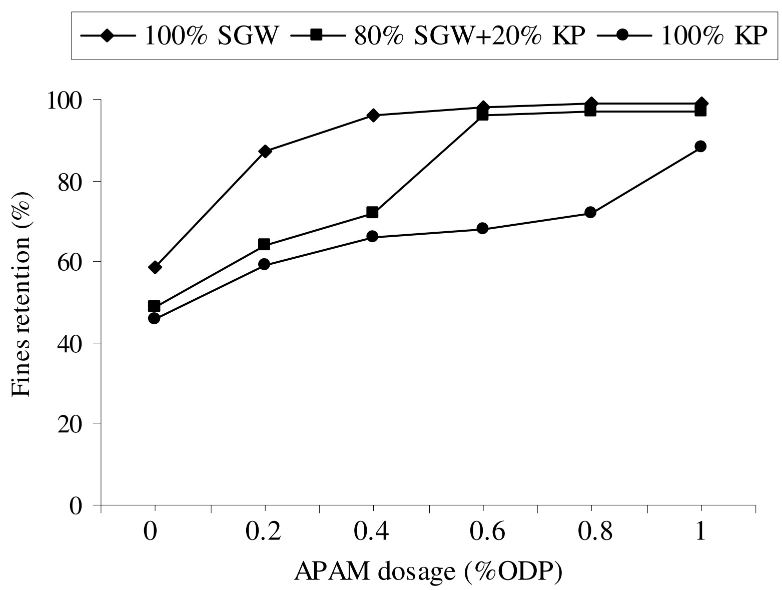

Figure 1. The first pass retention of different furnishes without filler (ODP-oven dried pulp)

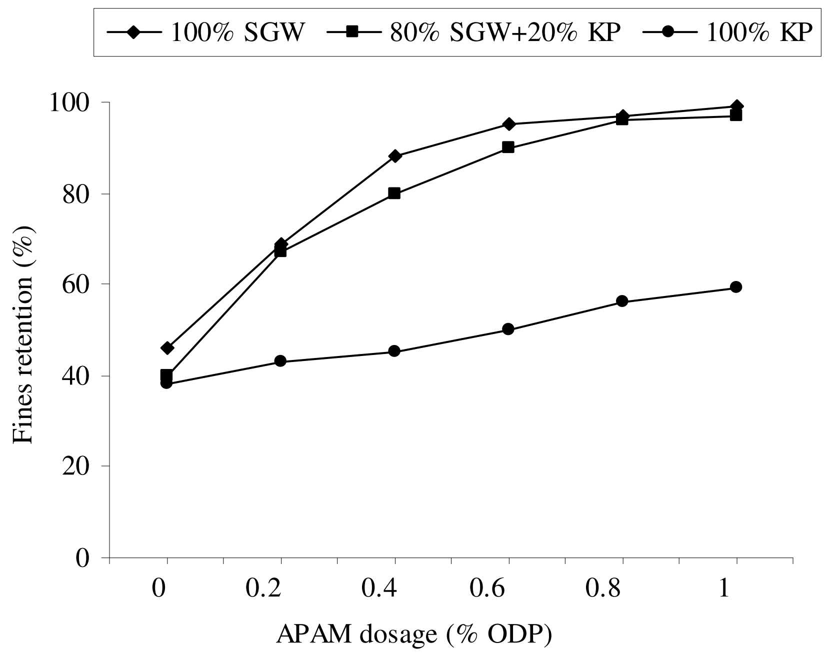

Figure 2. The first pass retention of different furnishes without filler

In addition; the first pass fines retention of furnishes containing mechanical pulp (SGW) was higher than those of mechanical pulp free furnish because mechanical pulp has more lignin and hemicellulose than chemical pulp. These components were rich in functional groups forming cationic sites on where APAM can link in acidic media. The amount of these cationic sites increases with increasing in mechanical pulp content in furnishes. Alum added as a fixing agent forms also cationic sites onto fibers and fines. Consequently, more fines bond each other and longer fiber due to presence of mechanical pulp and it causes to increase in FPR (10). However, the other reasons for the lower FRP of chemical pulp are lower fibrillation and specific surface area of pulp fiber due to its lower freeness degree. Therefore, primer layer of kraft pulp fiber less removes and the seconder layer that has binding ability do not emerged completely (13).

3.2. The Effects of APAM Addition on the Drainage Time of Furnish

The drainage time was determined by measuring the time required to formation of one standard sheet weighing 60 g m^{-2} (moisture-free) at 20 ^{o}C. As presented in Figure 3, the increase of APAM dosage increased the drainage time of furnish. It was observed that increasing of APAM dosage from 0% to 1% increased the drainage time from 13.2 s to 34 s for furnish with filler and from 14.9 s to 42.3 s for furnish without filler. The increase of APAM dosage increased the number of fiber-fiber flocs as well as fiber-fines flocs. Water had a tendency to drain through the thin spots between the bigger fiber-fiber flocs and to be retained inside the flocs. For this reason, the drainage times necessary for forming paper web increased (2, 3).

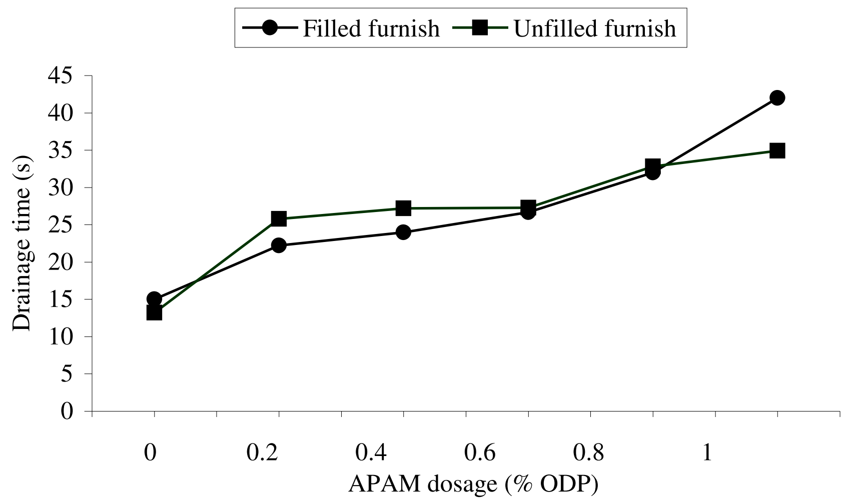

Figure 3. The drainage time of furnish consisting of 80% SGW+20% KP at different APAM dosages

3.3. The Effects of APAM Addition on the Breaking Length and the Burst Index of Paper

The results shown in Table 1 indicated that the breaking length and burst index of both filled paper and unfilled paper, consisting of 80% SGW + 20% KP, decreased with increasing APAM dosage. The breaking lengths of unfilled and filled papers provided by 1% APAM addition were about 28% and 26% less than those made without APAM addition, respectively. Similarly, the addition of 1% APAM decreased the burst index 38% and 43% for unfilled and filled papers, respectively.

Table 1. The effects of APAM addition on the breaking length and the burst index of paper produced from 80% SGW +20% KP

APAM (%)	Breaking Length* (km)		Breaking Length** (km)		Burst Index* ($kPam^2 g^{-1}$)		Burst Index** ($kPam^2 g^{-1}$)	
	Values	SD***	Values	SD***	Values	SD***	Values	SD***
0	2.38	1.41	2.08	1.35	0.76	0.73	0.67	0.67
0.2	2.10	1.35	1.86	1.32	0.63	0.67	0.54	0.64
0.4	1.97	1.35	1.59	1.25	0.56	0.64	0.45	0.62
0.6	1.84	1.29	1.58	1.25	0.55	0.63	0.44	0.60
0.8	1.72	1.28	1.57	1.24	0.49	0.60	0.43	0.57
1	1.72	1.26	1.54	1.23	0.47	0.60	0.38	0.55

*: Unfilled paper, **: Filled paper with kaolin

***: Standard deviation (95% confidence interval for mean)

The main reason of this is deteriorated paper formation that is caused by the bigger and harder flocs formed by APAM. These flocs led to formation of thin zones or points in the papers. During determining these paper properties, breaking and burst occurs in thin sites of paper. This negative effect increases by increasing the defects in paper formation. Additionally, the increase of fines in paper via APAM addition decreases the average fiber length of paper. It also decreases the breaking length and the burst index of paper. It is stated that there is a correlation between the breaking length and the average fiber length and that that the fiber length has an important role in the breaking length of paper. However, it is also stated that the fiber bonding affects the strength properties of paper positively and that fibrous fines have larger surface area and more bonding potential (11). Consequently, the negative effect of formation defect and the decrease in average fiber length on these properties of paper were more dominant although it was expected to form more bonds by increasing fines retention.

3.4. The Effects of APAM Addition on the Brightness of Paper

As can be seen in the Figure 4, the little decrease in brightness value of paper was determined with increasing APAM dosage. This decrease of unfilled and filled paper via addition of 0.2% APAM was found to be 3.8% and 3%, respectively. At the other APAM dosages more than 0.2%, the brightness of paper did not change significantly.

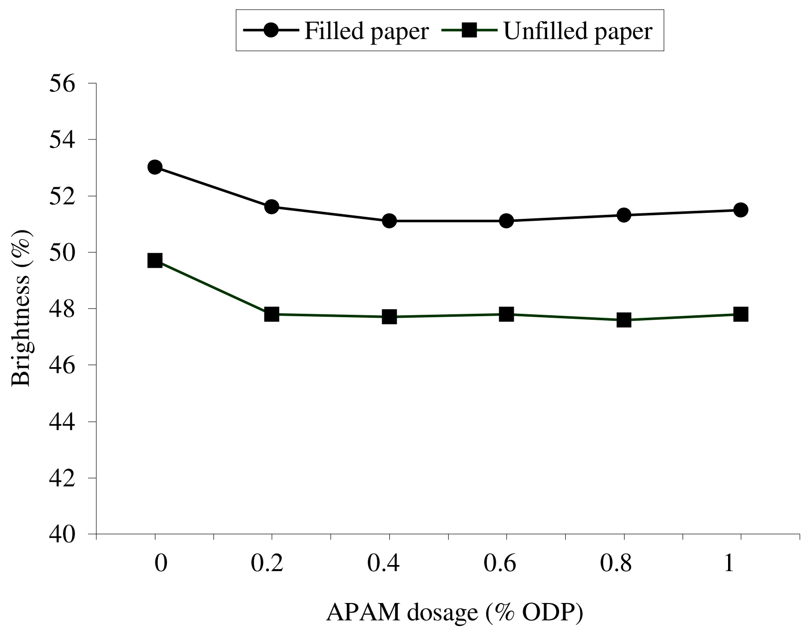

Figure 4. The effect of APAM dosage on the brightness of paper produced from 80% SGW +20% KP

For lignin content in fines has high light absorbing ability, the increase of fines retention causes to decrease papers brightness. In addition to this, paper becomes denser due to increasing fines retention (14). In addition; since filler increased the paper brightness, the papers with filler were brighter than the unfilled papers at the same APAM dosage.

4.CONCLUSION

It was concluded from this study that the increase of APAM dosage increased the first pass retention of all furnish at the constant mixing speed. It was also found that the performance of APAM increased with presence mechanical pulp. On the other hand, the breaking length, the burst index and the brightness of paper and the drainage time of furnish were deteriorated by increasing APAM dosage. These negative effects limit the usage of paper and runability of paper machine. Thus, when all of them mentioned above are taken into consideration, one should note whether or not drainage time and paper properties are sufficient for practical applications besides from the retention benefits provided by APAM addition.

REFERENCES

1. Lancaster, G., Retention: Definitions, Methods, and Calculations In: Retention of Fines and Fillers During Papermaking, 1st ed. (Ed. J.M. Gess), TAPPI Press, Atlanta, pp.3-10, 1998.
2. Miyanishi, T., Shigeru, M., Optimizing Flocculating and Drainage for Microparticle Systems by Controling Zeta Potential, Tappi J., 80 (1997) 262-270.
3. Scott, W.E., Papermaking Chemistry. In: Papermaking Operation, 3rd ed. (Ed. B.A. Thorp), TAPPI and CPPA Press, Canada, pp. 140-191, 1991.
4. Rahman, L., Tay, C.H., Mechanism of Fines Retention By Polyethylene oxide in Newsprint-Effect of Stock Variation, Tappi J. 69 (1986) 100-105.
5. Hulko, V.M., Deng, Y., Effects of Water-Soluble Inorganic Salts and Organic Materials on the Performance of Different Polymer Retention Aids, Journal of Pulp and Paper Science, 25 (1999) 378-383.
6. Eklund, D., Lindström, T., Retention and Dewatering. In: Paper Chemistry, Dt Paper Science Publications, Grankula, Finland, pp.145-179, 1991.
7. Norell, M., Johansson, K., Persson, M., Retention and Drainage, In: Paper Chemistry (Eds. J. Gullichsen, H. Paulapuro and L. Neimo) TAPPI Press, and Fapet Oy, Helsinki, Finland, pp. 43-81, 1999.
8. Asselman, T., Garnier, G., Adsorption of Model Wood Polymers and Colloids on Bentonits, Colloids and Surfaces J., 168 (2000) 175-182.
9. Polverari, M., Allen, L., Sithole, B.,. Effect of System Closure on Retention and Drainage Aid Performance in TMP Newsprint Manufacture - Part2, Tappi J., 84-3 (2001) 1-24.
10. Unbehend, J.E., Wet-End Chemistry of Retention, Drainage and Formation Aids.In: Stock Preparation, 3rd ed. (Eds. R. W. Hagemeyer, D. W. Manson and M. J. Kocurek), TAPPI and CPPA Press, Monteral, Canada, pp. 112-157, 1992.
11. Casey, P.J. Pulp and Paper Chemistry and Technology, Volume 3, 3rd Edition, Willey-Interscience Publication, Toronto, Canada, pp.1789-1795, 1981.
12. Horn, D., Linhard, F., Retention Aids. In: Paper Chemistry, 3rd ed. (Ed. J. C. Roberts), Blackie Academic and Professional, Glaskow, Scotland, pp.64-82, 1996.
13. Eroğlu, H., Kağıt ve Karton Üretim Teknolojisi, Karadeniz Teknik Üniversitesi, Orman Fakültesi, Genel Yayın No: 90, Fakülte Yayın No: 6, Trabzon, pp: 132-138, 1990.
14. Paavilainen, L., Importance of Particle Size, Fiber Length and Fines for Characterization of Soft Wood Kraft Pulp, Paper and Timber J., 72 (1990) 23-33.
15. Tappi Test Methots, 2002. Standart Methots for Pulp and Paper, Technical Association of Pulp and Paper Ind., TAPPI Press, Atlanta.