Research Article
Araştırma Makalesi
DOI: 10.24011/barofd.295319

Bartın Orman Fakultesi Dergisi,
19(1): 117-122,
1 Haziran/June, 2017

Journal of Bartin Faculty of Forestry
p-ISSN :1302-0943
e-ISSN :1308-5875

The Effect of Hand sheet Grammage on Strength Properties of Test Liner Papers

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Abstract

In this study, test liner papers in seven different grammage (85 g/m^2, 90 g/m^2, 95 g/m^2, 100 g/m^2, 105 g/m^2, 110 g/m^2, and 115 g/m^2) were made from recycled fibers , and effects of grammage on strength properties of handsheets were investigated. The stretch and TEA values of handsheets were increased with increasing grammage. The tensile and tear indices of handsheets were changed irregularly with increasing grammage. On the other hand, burst index of handsheets was not affected with grammage increases. A negative correlation was also observed between the air permeability and grammage of handsheets.

Keywords: Recycled fiber, Test liner, Grammage, Strength properties.

Test Liner Kâğıtlarının Sağlamlık Özellikleri Üzerine Kâğıdın Gramajının Etkisi

Öz

Bu çalışmada, 7 farklı gramajda (85 g/m^2, 90 g/m^2, 95 g/m^2, 100 g/m^2, 105 g/m^2, 110 g/m^2, ve 115 g/m^2) atık kağıt liflerinden test liner kağıtları üretilerek kağıdın sağlamlık özellikleri üzerine gramajın etkileri incelenmiştir. Kağıtların uzama ve TEA değerlerinin gramaj artışları ile arttığı tespit edilmiştir. Kopma ve yırtılma indisi değerlerinin gramaj artışı ile düzensiz bir değişim gösterdiği belirlenmiştir. Diğer taraftan, patlama indisi değerlerinin gramaj değişiminden etkilenmediği tespit edilmiştir. Ayrıca, kâğıtların hava geçirgenliği ile gramajları arasında negatif bir ilişki gözlemlenmiştir.

Anahtar Kelimeler: Geri dönüşüm kâğıtları, Test liner, Gramaj, Sağlamlık özellikleri.

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Geliş (Received) : 28.02.2017
Kabul (Accepted) : 23.03.2017
Basım (Published) : 01.06.2017

1. Introduction

Grammage or basis weight, the weight per unit area of paper expressed as g/m^2, is the most fundamental property of paper and paperboard. Paper is sold by weight but the buyer is interested in the area of paper per given weight. The paper manufacturer always aims to achieve all desired paper properties with the minimum possible grammage because of raw material costs and environmental reasons. (Mansfield et al. 2004; Sood et al. 2005; Adamapoulos et al. 2014). However, this tends to deteriorate most paper properties such as strength, stiffness and opacity in ratio to the reduction of grammage or even faster (Seth et al. 1989, Skowronski, 1991, Mohlin, 1992, Retulainen, 1996).

In dry and additive-free paper, strength properties that depends on fiber-fiber bonding are approximately proportional to the grammage of the paper (Rienzo and Espy, 1996). In other words, grammage of paper has an significant effect on all paper properties (Seth et al. 1989). Adamapoulos et al. (2014) evaluated effect of grammage on the mechanical properties of grade paper most commonly used by packaging companies throughout Europe. Gülsoy et al. (2016) investigated effect of grammage on unbeaten and beaten kraft pulps of maritime pine and European aspen. They reported that the effect of grammage on strength properties of unbeaten pulps of both species was more prominent than those of beaten pulps. On the other hand, effect of handsheet grammage reduction on tensile strength of pulp investigated by Nazhad et al. (2000). I'Anson and Sampson (2007) noted that handsheet grammage had a significant effect on tensile index of kraft pulp of pine and birch. Also, the relationship between handsheet grammage and paper properties have been evaluated by several authors (Brandon, 1966; Seth et al. 1989; Skowronski, 1991; Mohlin, 1992; Nordstrom and Norman, 1995; Retulainen and Nieminen, 1996; Nordstrom, 2003; I'Anson et al. 2008).

The aim of the present work was to evaluate effects of grammage on properties of test liner handsheets by producing 85 g/m^2, 90 g/m^2, 95 g/m^2, 100 g/m^2, 105 g/m^2, 110 g/m^2, and 115 g/m^2 test liner handsheets.

2. Material and Method

Recycled pulp sample used in this study was obtained from OYKA pulp mill. The kappa number, viscosity, and freeness level of pulp were 31.2, 580 cm^3/g, and 21 ºSR, respectively. The average fiber length, fiber width, lumen width, and wall thickness of pulp sample were measured as 1.66 mm, 28 µm, 10.75 µm, 8.63 µm, respectively. The pulp sample was screened to remove contaminants with a 0.15-mm slotted plate (TAPPI T 275).

15 handsheets in the each grammage (85, 90, 95, 100, 105, 110, and 115 g/m^2) were manufactured from the screened pulp using a Rapid-Kothen Sheet Former (ISO 5269-2). Handsheets conditioned in accordance with TAPPI T 402 before testing. The tensile index, TEA (Tensile Energy Absorption), and stretch (ISO 1924-3), burst index (TAPPI T 403), tear index (TAPPI T 414), and air permeability (ISO 5636-3) of handsheets were measured according to relevant standard methods.

The data of handsheet properties for each handsheet grammage were subjected to analysis of variance (ANOVAs) and Duncan test at a 0.05 probability level. In all the figures, the same lower case letter denotes that the difference in the average values of properties among the compared groups was statistically insignificant (p>0.05).

3. Results and Discussion

Figure 1 shows the effect of grammage on tensile index of test liner paper. Tensile index of paper was irregularly changed with increasing grammage (p<0.05). This finding can be attributed to non-removable various contaminants in the recycled pulp. The grammage increasing from 85 g/m^2 to 115 g/m^2 in test liner paper led to decreasing in the tensile index of 6.56%. The highest and lowest tensile index were found as 28.82 N.m/g and 26.06 N.m/g in the 90 g/m^2 and 115 g/m^2 papers, respectively. The linear correlation between tensile index and grammage have been reported by several authors (Burgess, 1970; Seth et al. 1989; Mohlin, 1992; Nazhad, 2000; Winters et al. 2002; I'Anson and Sampson, 2007; I'Anson et al. 2007; I'Anson et al. 2008; Adamopoulos et al. 2014; Gülsoy et al. 2016).

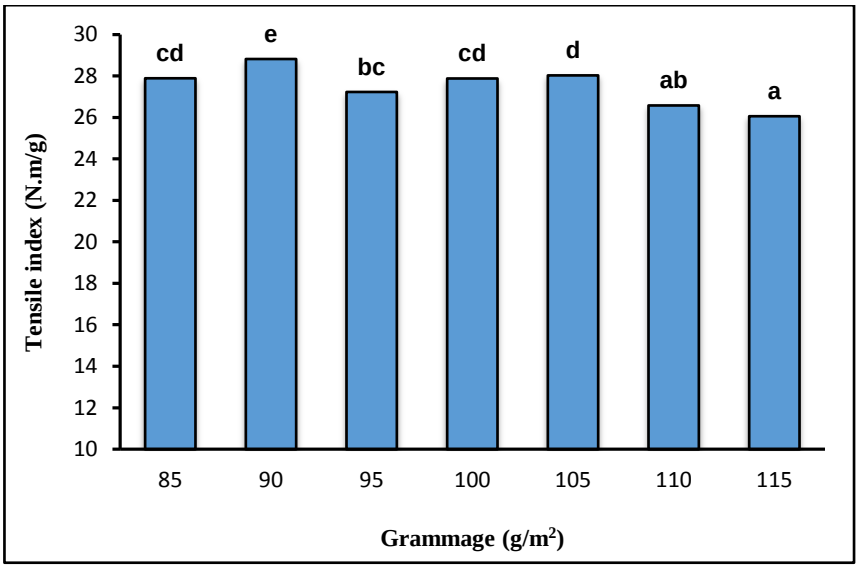

Figure 1. The effect of grammage on tensile index of test liner paper.

Figure 2 shows the relationship between stretch and grammage of test liner paper. As can be seen Figure 2, stretch of paper were irregularly changed with increasing grammage (p<0.05). The grammage increasing from 85 g/m^2 to 115 g/m^2 in test liner paper led to 2.77% stretch loss. The highest and lowest stretch values were found as 1.20% and 1.05% in the 100 g/m^2 and 115 g/m^2 papers, respectively.

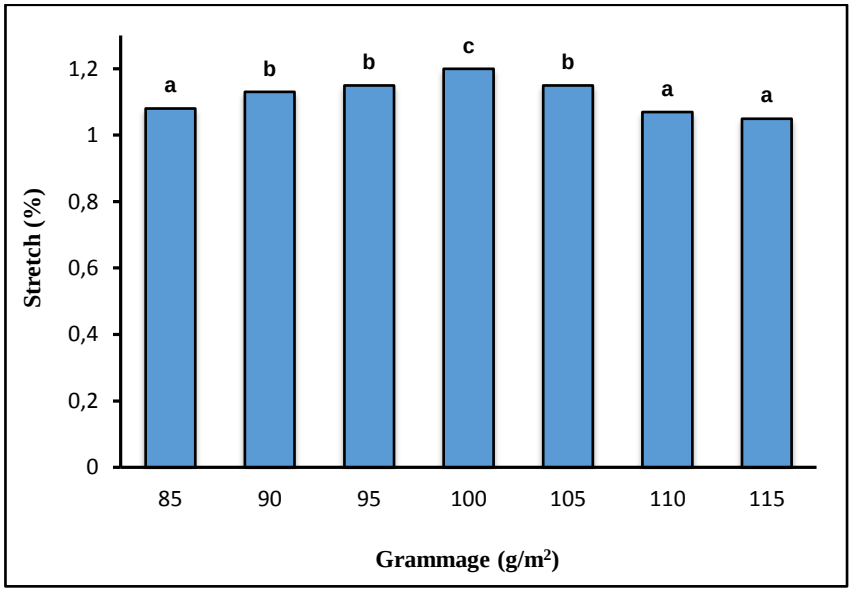

Figure 2. The effect of grammage on stretch of test liner paper.

TEA of test liner paper was irregularly increased with increasing grammage (p<0.05, Figure 3). This result can be ascribed to increasing fiber contact area and increasing fiber number in paper structure by way of increasing grammage. The grammage increasing from 85 g/m^2 to 115 g/m^2 in test liner paper resulted increasing in the TEA of 24.84%. The highest and lowest TEA values were determined in 105 g/m^2 and 85 g/m^2 with 23.69 J/m^2 and 17,27 J/m^2, respectively. Seth et al. (1989) and Gülsoy et al. (2016) noted that there was a linear correlation between TEA and handsheet grammage.

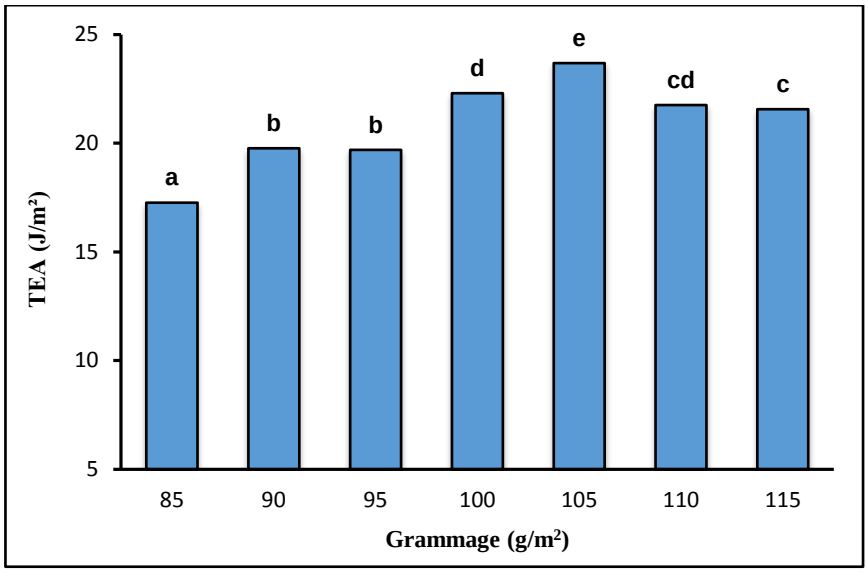

Figure 3. The effect of grammage on TEA of test liner paper.

The relationship between tear index and grammage of test liner paper is illustrated in Figure 4. Tear index of paper was irregularly changed with increasing grammage (p<0.05). The highest and lowest tear index were determined in 105 g/m^2 and 115 g/m^2 with 5.33 mN.m^2/g and 4.60 mN.m^2/g. The grammage increasing from 85 g/m^2 to 115 g/m^2 in test liner paper led to 8.18% tear index gain. On the other hand, Gülsoy et al. (2016) noted that tear index of kraft paper of maritime pine and European aspen increased with increasing handsheet grammage.

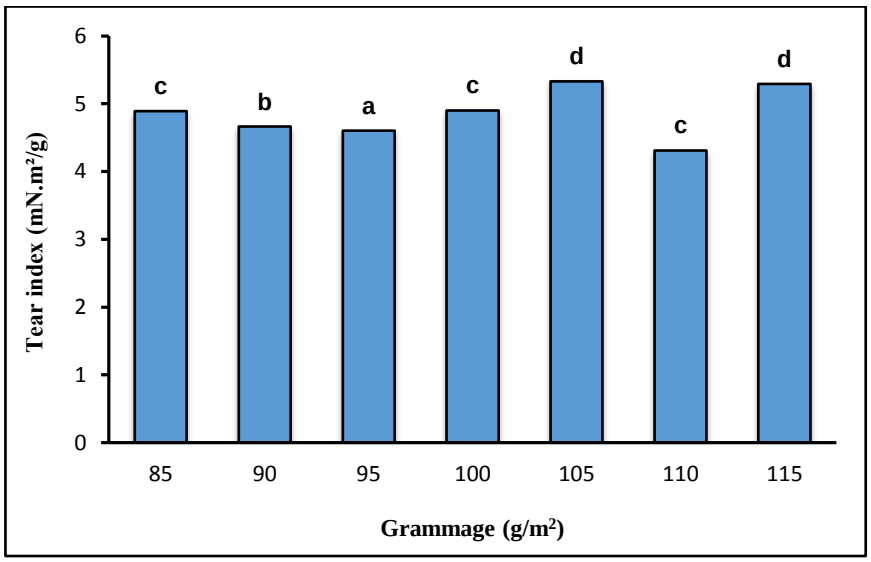

Figure 4. The effect of grammage on tear index of test liner paper.

The effect of grammage on burst index of test liner paper is seen in Figure 5. Burst index of test liner paper was statistically insignificantly changed with increasing grammage except of 105 g/m^2 paper (p>0.05). There was not statistically significant difference between burst index of 85 g/m^2 and 115 g/m^2 test liner paper. On the contrary, the positive correlation between burst index and grammage was reported by Adamopoulos et al. (2014) and Gülsoy et al. (2016).

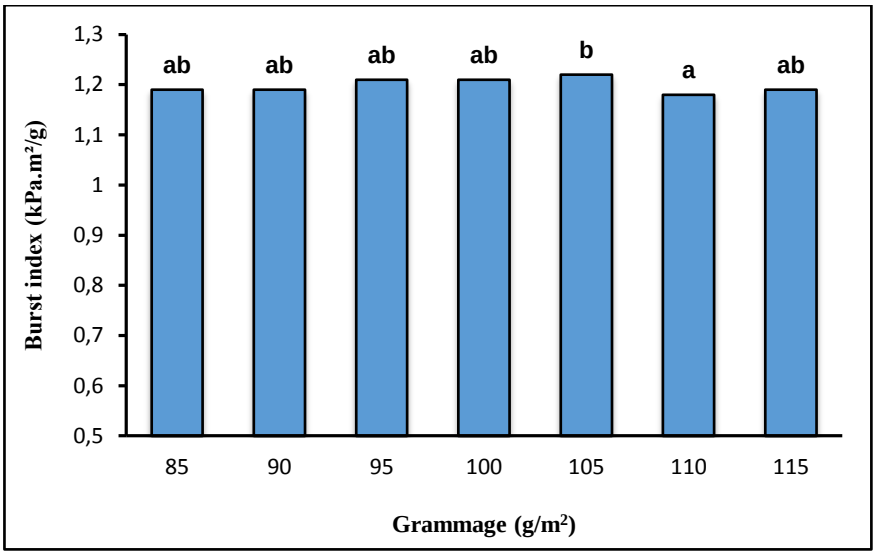

Figure 5. The effect of grammage on burst index of test liner paper.

Figure 6 shows the effect of grammage on air permeability of test liner paper. As can be seen Figure 6, the negative correlation between air permeability and grammage of test liner paper was observed (p<0.05). The grammage increasing from 85 g/m^2 to 115 g/m^2 in test liner paper caused to decreasing in the air permeability of 27.74%. This result can be explained by decreasing intrafiber and interfiber void volume in paper structure with increasing grammage. The highest and lowest air permeability values were found as 3958 ml/min. and 2860 ml/min. in the 85 g/m^2 and 115 g/m^2, respectively.

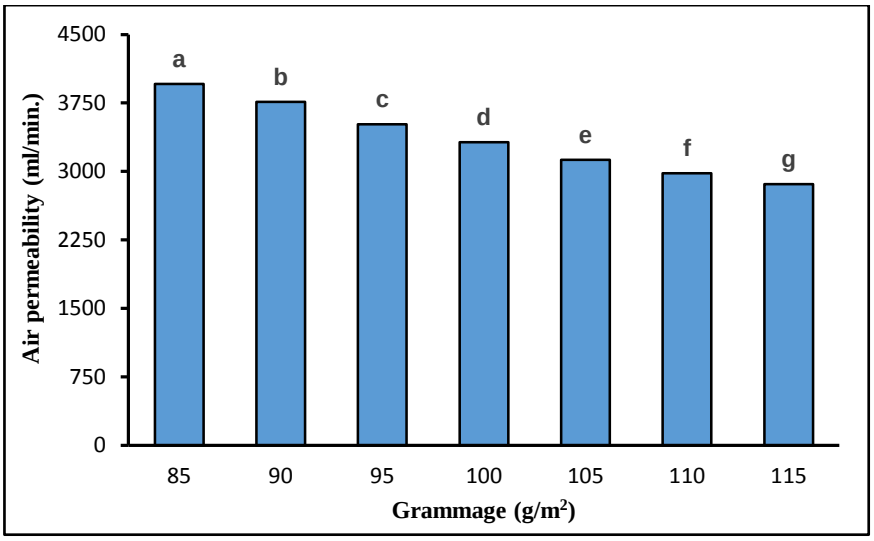

Figure 6. The effect of grammage on air permeability of test liner paper.

4. Conclusions

The results of this study showed that the grammage of test liner paper had an important effect on paper properties. The increasing in the grammage resulted statistically significant changes in tensile index, stretch, TEA, tear index, and air permeability. However, effect of grammage on burst index was statistically insignificant except of 105 g/m2 paper. A negative correlation was also determined between the air permeability and grammage of handsheets. Future researches are required for better understanding of the effect of handsheet grammage on paper properties by using different pulp types (virgin pulp and recycled pulp), different freeness levels (unbeaten pulp and beaten pulp), and different dry strength additives (cationic starch, chitosan).

Acknowledgement

This paper supported by Bartin University Scientific Research Project Commission (Project number: BAP-FEN-CY-014).

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