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Effect of oil based CMYK process inks on tearing characteristics of paper

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Abstract: Every day we use many different kinds of printed materials exposed to tearing stresses. Interactions between paper and printing inks affect the inter-fiber bonds, accordingly the tearing properties of paper. This study was carried out to determine the effect of tearing resistance properties of papers printed with solid tone oil based sheed-fed offset inks, using Cyan, Magenta, Yellow, Black process series. The static tearing resistance of paper was determined by universal tensile testing device and tearing strength patterns was examined. Decrease of tear resistance and relatively close tear index ratios (cross direction / machine direction) was observed for printed papers. Printing application of solid tone oil based inks increases the force required for initiation of tearing of papers.

Keywords: Tearing resistance, tearing with tensile tester, oil based ink, CMYK

Yağ bazlı CMYK proses mürekkeplerinin kağıdın yırtılma özellikleri üzerindeki etkisi

Özet: Günlük yaşamda yırtılma direncine maruz kalan birçok baskılı malzemeyi kullanmaktayız. Kâğıt ve baskı mürekkebi arasındaki etkileşimler lifler arası bağları ve dolayısıyla kâğıdın yırtılma direncini etkiler. Bu çalışmada Cyan, Magenta, Sarı ve Siyah renk yağ bazlı ofset proses mürekkepleri kullanılarak yapılan zemin ton baskılarının kağıdın yırtılma direncine etkileri belirlenmeye çalışıldı. Kâğıdın statik yırtılma direnci, evrensel çekme testi cihazı kullanılarak belirlenmiştir ve yırtılma direnci modelleri incelenmiştir. Basılı kâğıtlarda yırtılma direncinin azalması ve nispeten yakın yırtılma endeksi oranları (çapraz yön/makine yönü) gözlemlenmiştir. Yağ bazlı mürekkeplerle zemin tonlu baskı uygulaması, kâğıtların yırtılmaya başlaması için gerekli olan gücü arttırmıştır.

Anahtar kelimeler: Yırtılma direnci, çekme testi cihazı ile yırtılma, yağ bazlı mürekkep, CMYK

1. INTRODUCTION

Every day we use many different kinds of paper that are exposed to specific physical stresses. Examples for stresses that some of paper kinds are exposed to: sack paper - bursting strength, bag paper - tensile strength and printed materials - tearing stresses. Therefore, the tearing resistance of printing paper becomes one of its important mechanical properties. Physicochemical interactions between paper and printing ink involve a great number of surface phenomena (Fardim, 2002), which influence the inter-fiber bonds, and accordingly the tearing properties of paper. During printing, the carrier medium tends to get inside the paper through capillaries and voids between fibers-fillers and also into the lumens of cellulosic fibers (Aydemir et al., 2010). The main components of a typical ink are a carrier (binder) and pigments. The carrier is the most dominant component of an ink for the absorbency-based drying process (Aydemir, 2010). It means that the inks' liquid components are absorbed in papers fibers with slow velocity. Working of a fiber network, the same as a sponge, is a very important topic (Thomson, 1999).

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The tear tests of paper are performed in two different manners: in-plane and out-of-plane. The prevalent tearing stresses in printing materials cause an out-of-plane tearing of paper and the Elmendorf tearing device is the common device used for tearing tests. However, the new generation tensile testing devices are also able to measure the energy absorption during destroying the test specimen with tensile forces, accordingly static tearing resistance of paper (tearing with a constant rate of elongation) can be determined by tensile testing devices (Yamauchi and Tanaka, 2002). The results obtained from two devices correlate well despite slightly lower results obtained by a tensile testing device (Atik and Engin, 2010) (Atik and Engin, 2010).

The aim of this study was to determine the effect of oil-based printing ink on out-of-plane tearing resistance of paper. In order to determine the maximum effect of ink, Cyan, Magenta, Yellow and Black (CMYK) process colors solid tone was applied to two sides of paper.

2. MATERIALS AND METHODS

The paper used in this research was an uncoated offset paper with a grammage of 90 g/m², which is common used grade. Oil-based printing ink was used in the operation. Printing applications at solid tones were conducted on two sides of papers with offset inks by Michael Huber Resista Cyan, Magenta, Yellow, Black series (DIN ISO 2846-1). Heidelberg Speedmaster that is controlled by a computer, printing device was operated at 7000 sheet/h speed according to ISO 12647-2: 2004 standard in a controlled atmosphere where samples were also kept for at least 24 hours at standard test conditions (STC) (23 °C ±1°C temperature and %50 ±3% relative humidity) before the printing.

The static tearing tests were performed with the Zwick/Roell universal testing device, having 100 N load cell at STC. The tensile tearing condition was 600 mm/min constant speed of elongation. The samples with 100 mm by 62 mm dimensions were prepared for testing, and slit to have two equal lengths of 44 mm to be torn (Figure / Şekil 1) (Atik and Engin, 2010). According to Lyne the number of the samples torn together does not affect the tearing index of paper, therefore a single sheet was used for testing at the tensile testing device. Results are the average of 30 readings. The dynamic tearing tests were performed with the Elmendorf device according to ISO 1974.

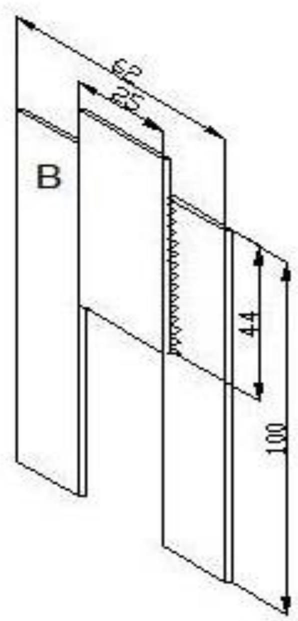

Figure 1. The sample cut scheme for tearing on the tensile testing device
Şekil 1. Çekme test cihazında yırtılma testi için için örnek kesim şeması

3. RESULTS AND DISCUSSION

The basis weight and caliper paper increase after solid tone printing (Table / Tablo 1). The static tear index of unprinted paper is 5.99 mN.m²/g for machine direction (MD) and 6.20 mN.m²/g for cross direction (CD). The dynamic tear index is 6.09 mN.m²/g for MD and 6.49 mN.m²/g for CD. The higher dynamic tear index values are similar to results observed by Atik and Engin (2010) for different paper grades in the previous study.

Table 1. Basic properties of unprinted and printed papers
Tablo 1. Baskısız ve baskılı kâğıtların temel özellikleri

Printing Color	Basis weight (g/m²)	Caliper (µm)
Unprinted	90.49	104
Cyan	93.57	112
Magenta	93.53	107
Yellow	92.29	108
Black	93.67	107

Tearing resistance values allow consistent comparison between unprinted and printed papers. Figure / Şekil 2 shows that the tearing resistance of printed samples decreases in both MD and CD. Another application on a paper surface like foam coating also causes a decrease in tearing resistance of paper (Sievannen, 2010). Meanwhile, the decrease rates in two directions are not equal and CD/MD ratio increases (Figure / Şekil 3). On the contrary, the printing application increases the maximum force to initiate tearing from 5.5% to 9.9% and the work to the maximum force approximately 200% (Figure / Şekil 4-5).

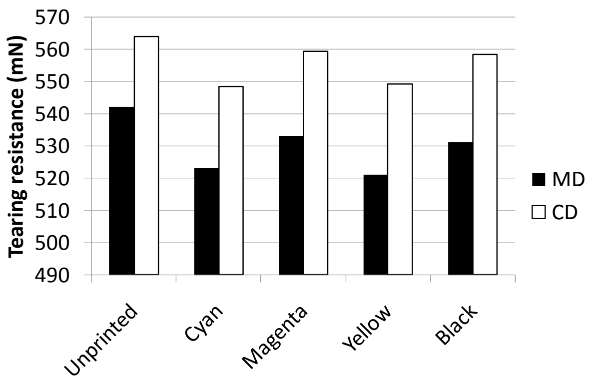

Figure 2. Tearing resistance values of unprinted and printed papers
Şekil 2. Baskısız ve baskılı kâğıtları yırtılma direnç değerleri

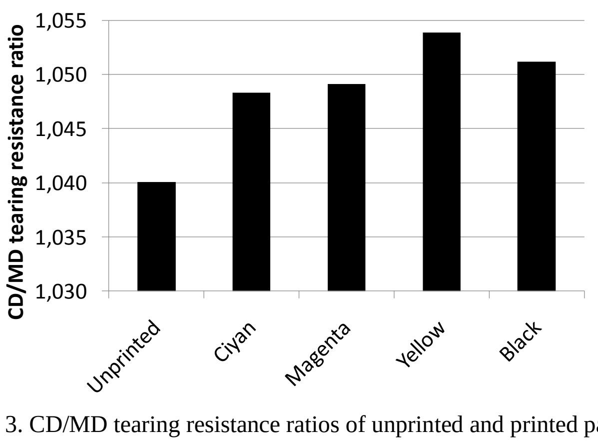

Figure 3. CD/MD tearing resistance ratios of unprinted and printed papers
Şekil 3. Baskısız ve baskılı kâğıtların CD / MD yırtılma direnci oranları

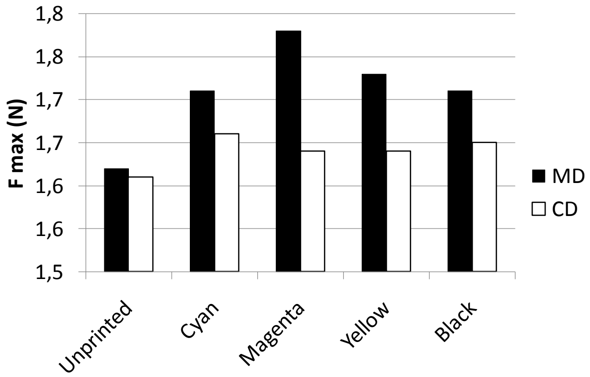

Figure 4. The maximum force to initiate the tearing of unprinted and printed papers
Şekil 4. Baskısız ve baskılı kâğıtlarda yırtılmayı başlatmak için maksimum kuvvet

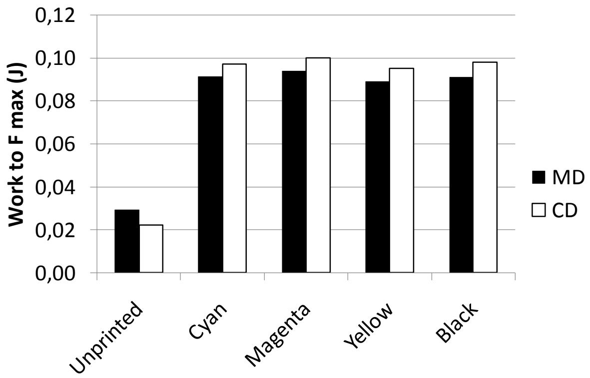

Figure 5. The work to initiate the tearing of unprinted and printed papers
Şekil 5. Baskısız ve baskılı kâğıtlarda yırtılmayı başlatmak için yapılan iş

The tearing curves of all papers had a peak at the beginning (the force to initiate the tearing) sharp drop and nearly leveled or very steady rise through tearing (rest of the straining) and decline steeply at the end (Figure / Şekil 6, 7, 8, 9 and 10). The rise during the progression of the tear can be explained by observed increase of delamination, where the energy consumption increase (Lyne et al., 1972), and pull-out of shortened fiber at the end of straining decrease overall energy consumption.

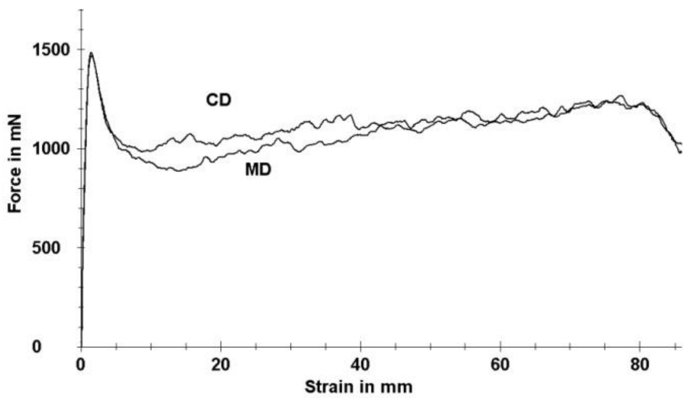

Figure 6. Mean load curve during the tearing of unprinted papers
Şekil 6. Baskısız kâğıtların yırtılması esnasında ortalama yük eğrisi

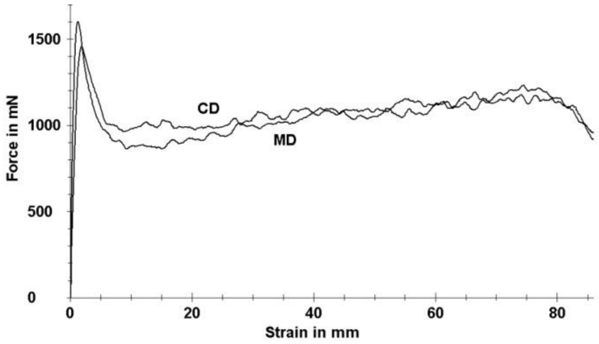

Figure 7. Mean load curve during the tearing of C ink printed papers
Şekil 7. Mavi mürekkep baskılı kâğıtların yırtılması esnasında ortalama yük eğrisi

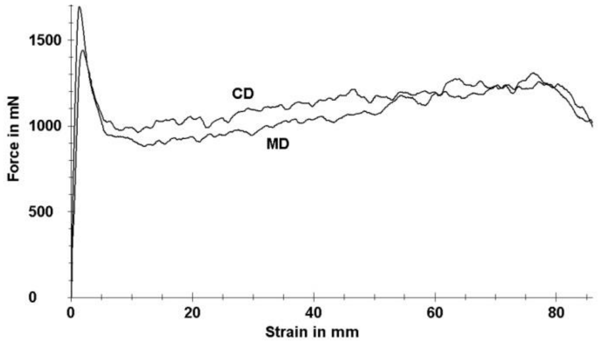

Figure 8. Mean load curve during the tearing of M ink printed papers
Şekil 8. Magenta mürekkep baskılı kâğıtların yırtılması esnasında ortalama yük eğrisi

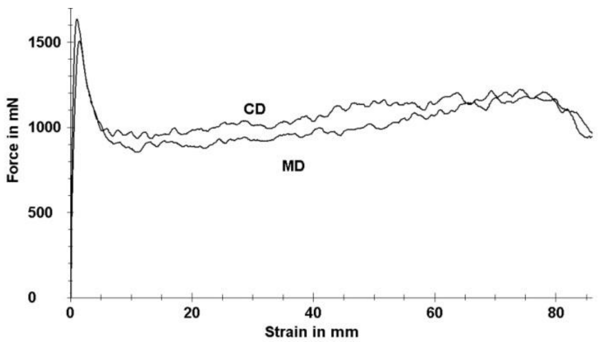

Figure 9. Mean load curve during the tearing of Y ink printed papers
Şekil 9. . Sarı mürekkep baskılı kâğıtların yırtılması esnasında ortalama yük eğrisi

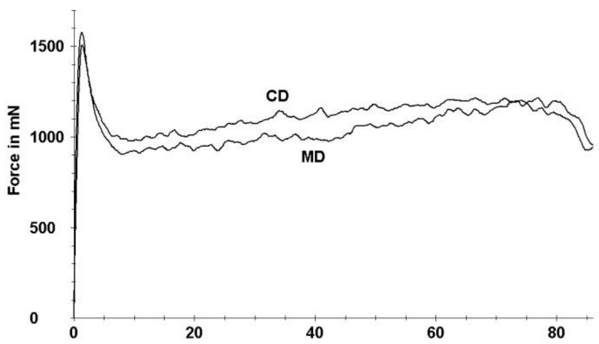

Figure 10. Mean load curve during the tearing of K ink printed papers
Şekil 10. Siyah mürekkep baskılı kâğıtların yırtılması esnasında ortalama yük eğrisi

5. CONCLUSIONS

The solid tone printing decreases the tearing resistance of the paper. On the other hand, the resistance to initiate the tearing of printed papers especially in MD increase. As a result two sides printing on the periphery of printed materials will contribute to the retardation of tearing initiation. Also the solid tone printing on perforation line that is going to be exposed to tearing will facilitate the tearing of paper properly.

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