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Investigation of the effects of silicone oil coating and hot air drying on the optical and physical properties of heat-set web offset printing papers

ABSTRACT

Heat-set web offset printing is a printing system that ink dries quickly with hot air. It is one of the preferred printing techniques with high speed printing process and print quality. Web offset printing machines produce approximately 60,000-70,000 iph (impressions per hour). Because of this speed, printing paper should be very durable during the printing process. In this study, three different (70 g/m^2 high-grade, 70 g/m^2 glossy coated and 90 g/m^2 matte coated) roll papers were used. All these papers were printed with Goss M600 web offset printing machine. Three kinds of samples (non-oven - non-silicone, ovened – non-silicone and ovened - siliconed) were taken from every paper type and optical and physical tests were applied to these samples. It was determined that heat-set web offset printing papers showed different responses to temperature and silicone oil coating in the direction of the obtained results. All printed papers were compared only to their own kind, not the other type of papers.

Dogan Tutak
Cem Aydemir
Ahmet Akgul

Marmara University,
School of Applied Science,
Department of Printing Technologies, Istanbul, Turkey

Corresponding author:
Dogan Tutak
e-mail: dtutak@marmara.edu.tr

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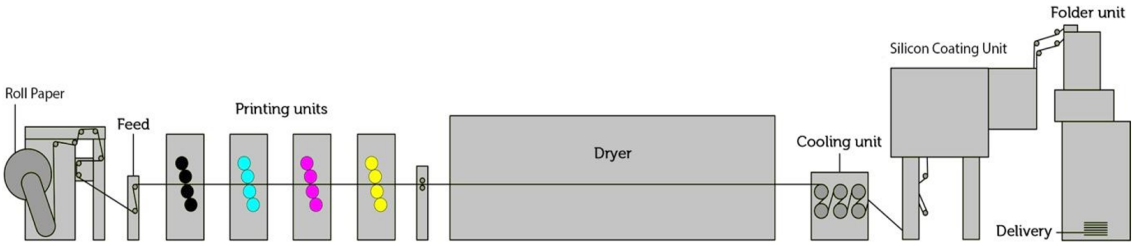
KEY WORDS
Heat-set web offset, silicone oil film, CIE L*a*b*, paper gloss, paper strength

Introduction

Web offset printing machines use an irrevocable printing method with high production speed (Kulachenko, Gradin, & Westerlind, 2005) and offset printing quality, especially for companies which have a high production capacity. Heat-set web offset printing is a versatile printing technique in terms of paper and production. The products produced with heat-set printing are usually high circulation products such as magazines, catalogs, mails, newspapers, flyers, animation books and user guides. Generally, paper types from 35 g/m^2 to 150 g/m^2 WFC (Wood free Coated), MWC (Medium weight Coated), LWC (Lightweight Coated), MFC (Machine finished Coated), SC (Super calendared), UWF (Wood free uncoated)) and newsprint papers are preferred for heat-set printing. Heat-set printing has a market worth of 80 billion Euros worldwide. In particular, when coated papers are used in high quality jobs such as magazines and catalogs, ink cannot be absorbed by the paper therefore a heat-set process should be applied to dry it quickly (Weboffsetprint, 2018). In heat-set printing, the ink is applied to the paper surface by the printing units, and then the printed paper is passed through an oven to provide the drying of the ink by means of hot air. During this passing, the drying takes place by evaporation of the binding agents (mineral oils) in the ink. However, surface characterization of the paper is of utmost importance during the settlement and absorption of the fluid ink on the paper surface (Akgul, Aydemir & Tutak 2017). However, despite all this process even after the printed papers have been out of the oven, it is still not possible to achieve 100% drying, thus protecting the ink by silicone coating on it (Kozak, 2018).

In heat-set web offset printing, the printing units aligns as horizontal. Printing units are followed by dryer and chill rolls, which work together to ensure that the ink on the printed sheet is dry and set to prevent ink set-off (Kulachenko, 2006). As the paper passes through the oven, the oil-based solvents in the ink reach a “flashpoint” or evaporation point. What is left-over are waxes, resins, and pigment (Sapru, 2016).



» **Figure 1:** *Heat-set web offset printing machine (Saxoprint 2013)*

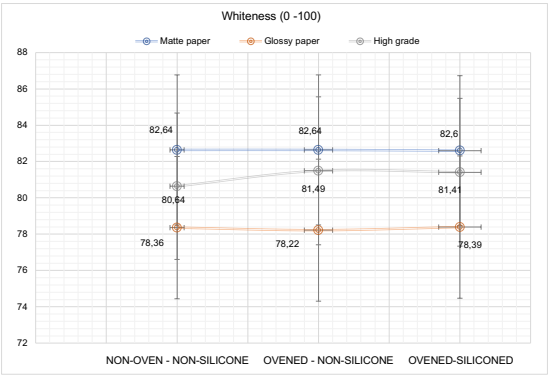
The oven temperatures around 250°C can heat the printed paper up to 120°C. After the oven, there is the cooling roller unit. In this unit, paper is suddenly cooled down to around 20-30°C which results in a hardening of the ink. Thus, bringing the typical heat-set printing shine of the printing ink (Carrasco, Stoenand & Gregersen, 2004). Finally, the paper is provided with additional protection in the form of a water silicone mixture. This provides the paper with moisture following drying and, at the same time, increases the scratch resistance of the surface (Saxoprint, 2013). If the moisture distribution in the paper is not evenly distributed within the structure, it can cause unwanted defects on the printed layer and dimensional changes of paper. At the end of it, the print quality is low (Tåg et al. 2013). It also affects the paper and fiber structure. In Heat-set printing, papers must rely on the effects of hot air drying, web tension, high speed, and ink / fountain solution balance (KCL, 2018). The more important print quality is, the more important the behavior of the paper in the printing process (Ural, Ozomay & Ozdemir, 2018).

Experimental Part

In this study, three different (70 g/m^2 high-grade, 70 g/m^2 glossy coated and 90 g/m^2 matte coated) roll papers were used as press substrate. All roll papers were printed with Goss M600 web offset printing machine. All roll papers were conditioned 24 hours at 23±1°C and 55±2% of RH before printing and all tests were applied with the same conditions. The oven drying temperature was measured in average of 139°C during printing and drying process. After drying, “Flint Group Varn Pro-Web Plus” silicon oil was used for silicon coating. All measurements on the papers were performed completely on silicone and non-silicon areas. The whiteness values of the papers were measured in accordance with the “ISO 11475, D65/10 degrees “; the gloss values were measured in accordance with the “TAPPI-T 480” and CIE a * and CIE b * values were measured in accordance with the “DIN 6174”; Tearing values were measured in accordance with the “ISO 776”; Ash values were measured in accordance with the “TAPPI-T 211”; Tensile values were measured in accordance with the “ISO 1924-2” standards. The study parameters for all three different types of paper: non-oven- non-silicone, ovened- non-silicone and ovened- siliconed are used to determine how the papers are affected by the oven and silicone oil. All printed papers were compared to only their own kind, not the other type of papers.

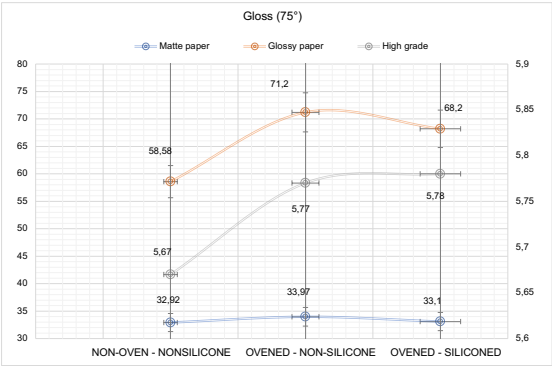
Results and Discussion

The optical changes and physical strengths of the papers (high-grade, matte coated and glossy coated papers) were measured separately for each stage (non-oven - non-silicone, ovened- non-silicone and ovened- siliconed). For optical changes: whiteness, gloss, CIE a * and CIE b * measuring tests, for physical strength: tearing, ash and tensile tests were applied. All measurements are shown in graphs below. In addition, explanations have been made for all of the obtained values.



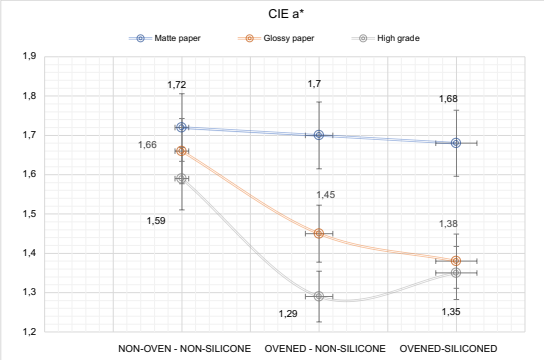
» **Figure 2:** *Whiteness values*

It has been determined that there is no serious change in none of the three types of paper whiteness values.



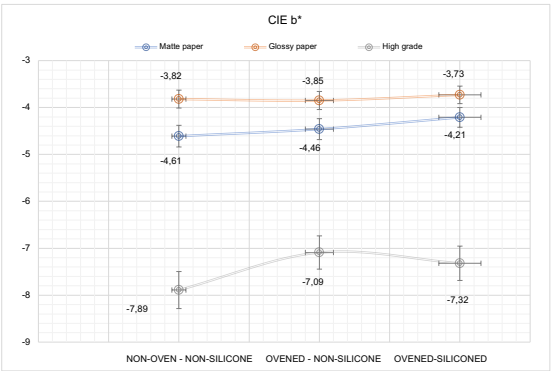
» **Figure 3:** *Gloss values*

In the comparison of gloss values, it has been determined that the values of all three paper types rose in the ovened – non-siliconed values, and then the values were slightly lowered by the silicone oil application, but just glossy paper values increased sufficiently. Glossy paper, ovened- non-siliconed gloss values first significantly increased 21.5% then decreased by 16.4% in the ovened - siliconed section.



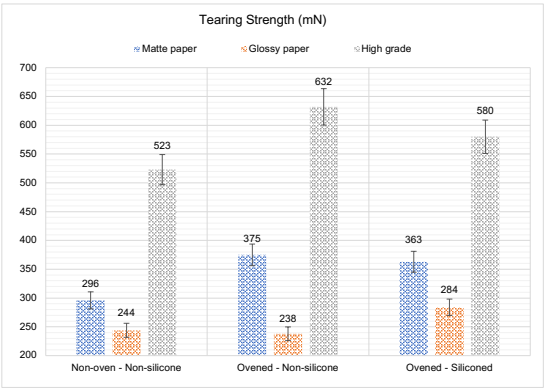
» **Figure 4:** *CIE a* values*

In the comparison of CIE a* values, it has been determined that there is no significant change in matte paper. Glossy paper values decreased not only ovened- nonsilicon but also decreased ovened- siliconed section. The change for ovened- non-silicon was 13% and ovened-siliconed was 17%. High-grade paper values first decreased 18.9% in the ovened- non-silicon section then increased by 15.1% in the ovened- siliconed section.



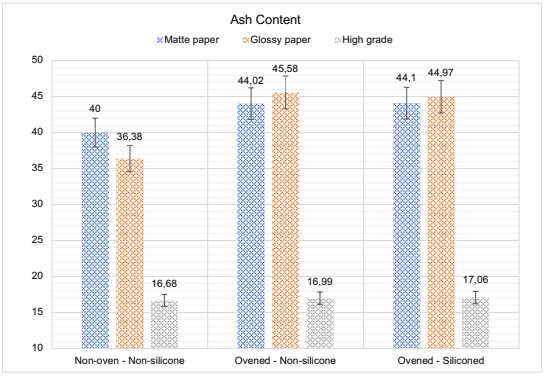
» **Figure 5:** *CIE b* values*

In the comparison of CIE b* values, there is no significant change in glossy paper. Matte paper increased 8,7% significantly just in the ovened- siliconed section. High-grade paper values first increased 10,2% in the ovened - non-siliconed section then decreased by 7,3% in the ovened- siliconed section



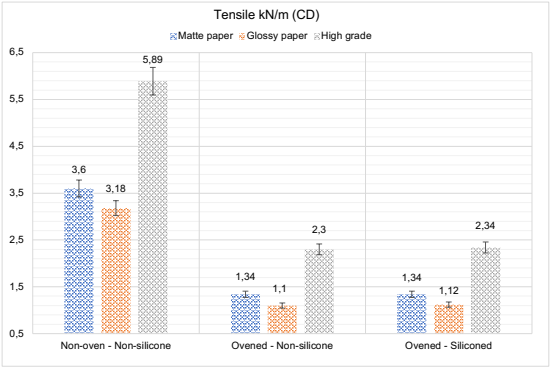
» **Figure 6:** *Tearing strength values*

In the comparison of tearing strength values, it has been determined that high-grade paper values first increased 20,8% in the ovened- non-silicon then a little bit decreased by 10,8% at ovened- siliconed section. Glossy paper values just increase 16,3% in the ovened- siliconed section. Matte paper values first increased 26,6% then decreased by 22,6% in the ovened-siliconed section.

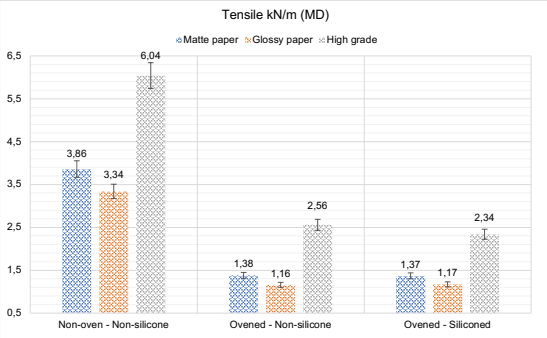


» **Figure 7:** *Ash content values*

In the comparison of ash content values, an increase in both ovened and silicone coated values for high-grade paper has been determined. For coated papers, it first increased slightly and then decreased again. But there are no sufficient changes for ash content values for all paper types.



» **Figure 8 (part 1):** *Tensile values*



» **Figure 8 (part 2):** *Tensile values*

In the comparison of tensile values, it has been determined that not only CD (Cross Direction) but also MD (Machine Direction) values decreased after the ovened- non-siliconed section for all three kinds of paper. However, there are no significant changes at the ovened- siliconed section after ovened- non-siliconed section. It has been found out that using siliconize process after the oven process provides an insignificant increase in paper tensile properties.

Conclusion

When optical values are compared, it has been determined that there is no significant change in whiteness values for all three kinds of paper. The gloss value was increased after the drying oven process for all of paper but decreased after siliconize process. However, contrary to popular belief, silicon oil doesn't affect to paper glossy.

CIE a* values decreased for coated papers (matte and glossy) after both the drying oven and siliconize process. High-grade paper CIE a* values decreased after the drying oven process but, increased after the siliconize process. When looking at the CIE b* values, all three kinds of papers' CIE b* values increased after the drying oven process and siliconize process.

When physical values are compared, it has been determined that high-grade and matte coated paper showed the same behavior for tearing resistance. Their tearing resistance values increased after drying oven process, then slightly reduced with the siliconize process. On the contrary of matte coated and high-grade papers, glossy paper tearing resistance values decreased after the dryer oven process and then increased with the siliconized process.

When comparing tensile values, it has been observed that all three kind of papers showed similar behavior for tensile test. When they were ovened and covered with silicone oil, their values were reduced significantly because of the change of their internal structure.

All the obtained results showed that, not only the drying oven process for quickly drying the ink but also silicon oil application affected optical and physical properties of paper.

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