

INVESTIGATION OF ADHESIVE LAYER THICKNESS DISTRIBUTION OF PERFECT BOUNDED BROCHURES

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Abstract

Perfect binding has become an economically attractive binding method in the last decades, primarily because of its suitability for mass production of low- and mid-range graphic products, but nowadays, due to the constant development of new adhesives, it is gaining on importance in the field of high quality, short-run products too. There are many influencing factors of perfect binding technique regarding the raw materials' basic properties and the application procedure, as well. Besides the paper and its preparation, the used adhesive and its application directly affect the paper/adhesive interface and the adhesive bond strength of the finished products. In this paper, the uniformity of glue application has been analysed to investigate the effect of book block thickness and gluing system set-up (nominal thickness and length) on the adhesive layer thickness distribution along the spine. The obtained results showed that the adhesive layer became more evenly applied to the block spine by increasing the book block thickness and the nominal adhesive thickness too. In the case of glue length set-up, results showed similar tendency of uniform application, but only for the lower set-up values, i.e. by shortening the glue length.

Keywords: *perfect binding, adhesive layer, book block spine*

Introduction

Perfect binding is today one of the major binding techniques for the low- and mid-range graphic products, but by the application of new adhesives, its present on the field of high quality and short-run products is more and more prominent (Liebau and Heinze, 2001; Pasanec Preprotić et al, 2012).

There are numerous influencing factors of the quality of perfect binding, such as the quality of the used materials (paper, cardboard, adhesive), type, temperature, viscosity of the applied adhesive, book spine preparation techniques, adhesive application techniques, etc. (Kipphan, 2001). These factors could be roughly divided into two broad areas: the paper and its preparation, and the adhesive and its application (Gross, 1981).

For adequate perfect binding strength and stability of the book spine shape, the thickness of the adhesive layer has particular importance. The desirable amount of adhesive layer thickness mostly depends on the size of the book block. Larger, i.e. thicker book blocks require a thicker adhesive layer and vice versa, for thinner book blocks smaller amount of adhesive is sufficient to obtain the expected binding strength and spine shape stability. By applying adhesive in a thicker layer than recommended, the book spine flexibility will be reduced, making it more difficult to open a book and lay down flat without cracking the spine shape, while the adhesive consumption and overall production costs will increase. Lower adhesive thickness than recommended will result in insufficient adhesion, decreased book block integrity and reduced adhesive open-time (Lauren, 2017). Also, the uniform adhesive application over the book spine is also fundamental in achieving high binding quality. The uneven distribution of adhesive layer could directly affect the overall adhesive bond strength, but also the aesthetic feature of the finished brochure (wavy shape of the book block due to the unwanted local glue accumulation).

The scope of this investigation is limited to the adhesive layer distribution on the book block spine in a function of book block thickness and two gluing system set-up parameters, nominal adhesive layer thickness and gluing length.

Materials and methods

For the purpose of this investigation, a commercially available uncoated, wood-free, offset paper was selected (IQ Print, Mondi) with a basis weight of 80 g/m² to prepare the book block samples. The excellent surface properties and smoothness made this paper ideal for both, sheet-fed or web offset printing of diverse graphic products such as annual reports, magazines, books and brochures (Mondigroup, 2016). The brochure covers were prepared from glossy coated cardboard (Nevia CS2, Hainan Jinhai Pulp & Paper and Gold East Paper) with a basis weight of 300 g/m² (Nevia, n.d.). The perfect binding operation was done with hot-melt adhesive Mitol-Termokol Ultra 2410/05 (Grafino, 2017), at working temperature of 170°C using an automated, single-clamp perfect binding machine, Horizon BQ-270 equipped with a double rollers gluing unit and a milling section for block spine processing (Xerox Corporation, 2018). The width and height of sample brochures were 176mm x 250mm, while the book block thickness (number of sheets, i. e. the volume) was varied from 50 sheets up to 250 sheets. In a perspicuous manner, all the specifications for the perfect binding process (book block thickness, nominal adhesive layer thickness and gluing length) are presented in Table 1. In order to investigate the adhesive layer thickness

distribution along the book block spine, each sample was 3-side trimmed (Figure 1a) and cut into 24 segments (Figure 1b) using high-speed cutting machine Perfecta 72 TVC. The thickness measurement was carried out using a measuring magnifier with metric scale (field of view: 0 to 10 mm, minimum scale division: 0.1mm). Five brochure samples were prepared for each parameter settings and the thickness measurement was repeated three times on one segment, hence 15 measurements were carried out for each segment or altogether 360 measurements for each parameter.

Table 1 – Sample group specifications for the perfect binding process

Group number	Book block thickness (volume)	Book block thickness [mm]	Nominal adhesive layer thickness [mm]	Glue line length [mm]	
1.	50 sheets	5	1.8 mm	-1.5 mm	
2.	100 sheets	10			
3.	150 sheets	15			
4.	200 sheets	20			
5.	250 sheets	25			
6.	150 sheets	15	1.4 mm	0 mm	
7.	150 sheets		2.2 mm		
8.	150 sheets		1.8 mm		-3 mm
9.	150 sheets				

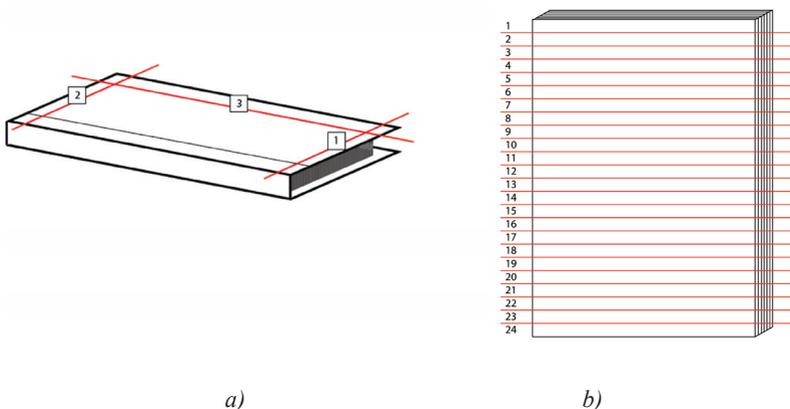


Figure 1 – Cutting sequences for book block 3-side trimming (a) and measurement segments preparing (b)

Results and discussion

The mean values of adhesive layer thickness, their standard deviations and corresponding coefficient of variations were calculated for each brochure segment and parameter group. The obtained results for book block thicknesses are presented graphically in Figure 2, while the results of two gluing system set-up parameters, the nominal adhesive layer thickness and gluing length, are shown in Figure 3 and 4, respectively.

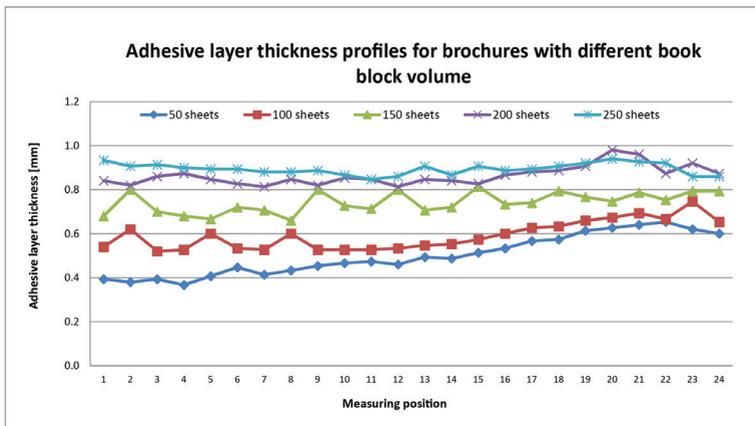


Figure 2 – Adhesive layer thickness profiles for brochures with different book block volume

As it can be noticed in the presented graph, the adhesive layer thickness values show increasing tendency by increasing the brochures volume (the range was from 0.37mm to 0.65mm for the thinnest brochures, while ranges of 0.52mm ÷ 0.75mm, 0.66 mm ÷ 0.81mm, 0.82 mm ÷ 0.98mm and 0.85 mm ÷ 0.94mm were delivered for brochures made of 100, 150, 200 and 250 sheets, respectively). Additionally, it can be seen that for lower brochure volumes (especially for 50 sheets) the adhesive layer thickness has increasing tendency along the measuring positions. These results could indicate the unwanted glue accumulation over the book spine at the end of the glue applying process, since the position 1 refers brochure's upper part, where the gluing process begins, while position 24 corresponds to the brochure's bottom part where the gluing process was stopped. For higher book block volumes this uneven adhesive application is not that apparent. Regarding the overall adhesive layer thickness, it can be observed that although the nominal adhesive layer thickness was set-up as 1.8mm for all brochures with

different volume, none of the prepared samples had thicker adhesive layer than 1 mm. The reason for that is the nominal adhesive thickness on the book block spine represents the maximum quantity of the adhesive on the gluing roller, which rarely can be transferred completely on the book block. The moderately low values of standard deviation indicate high consistency of the measured values (the ranges of corresponding coefficient of variations were: 9.27% ÷ 22.15%, 10.79% ÷ 29.55%, 8.24% ÷ 26.75%, 7.52% ÷ 16.79% and 7.84% ÷ 16.02%, for samples made of 50, 100, 150, 200 and 250 sheets, respectively).

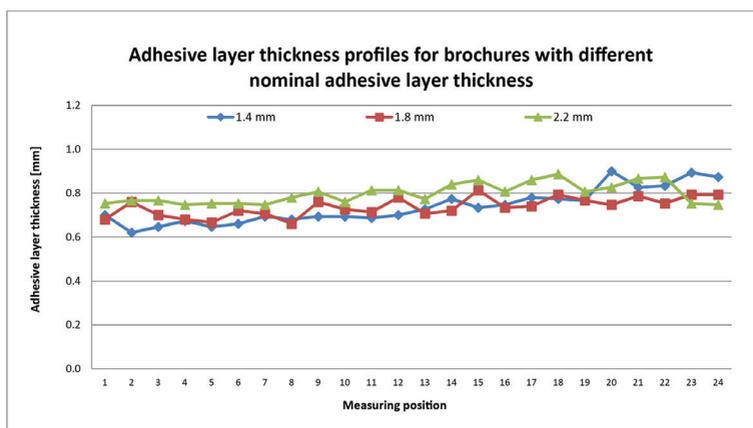


Figure 3 – Adhesive layer thickness profiles for brochures with different nominal adhesive layer thicknesses

By analysing the results regarding nominal adhesive layer thickness it can be observed that all the obtained values of measured adhesive layer thickness were similar (ranges were 0.62mm ÷ 0.90mm, 0.66mm ÷ 0.81mm and 0.75mm ÷ 0.89mm for nominal adhesive thicknesses of 1.4mm, 1.8mm and 2.2mm, respectively) and none of them exceeded the maximum value of 0.9mm. Additionally, a mild increasing tendency could be noticed along the measuring positions (from position 1 to position 24), which is more emphasised for the lowest nominal adhesive layer thickness value (1.4mm).

Comparing the obtained results for different gluing length values (Figure 4) it can be seen that without gluing line shortening (set-up value of 0 mm) there was too much adhesive application on the spine, especially at the beginning of the gluing process, resulting in apparent waviness of the adhesive layer. For the shortening of 1.5 mm on both ends of the brochures, the applied adhesive layer was more evenly spread, but the most uniform ad-

hesive application was achieved with the shortest gluing length since there were no excess adhesives at the ends of the brochures. The measured thickness values for both sample groups with shortened gluing line were in very similar range (0.66 mm ÷ 0.81 mm for -1.5 mm, and 0.67 mm ÷ 0.8 mm for -3 mm), while samples without gluing length modifications had higher maximum values (range 0.67 mm ÷ 0.96 mm).

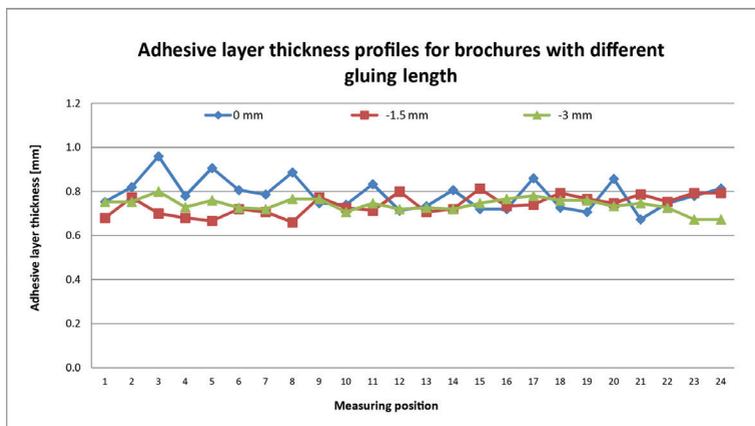


Figure 4 – Adhesive layer thickness profiles for brochures with different gluing length

Conclusions

This paper analysed the influence of the book block thickness and two gluing system set-up parameters (nominal adhesive layer thickness and gluing length) on the adhesive layer distribution. The obtained results showed that the adhesive layer became more uniformly applied to the book block spine by increasing the book block volume. In the case of increasing the nominal value of adhesive layer thickness, results showed similar tendency of more uniform application. The analysis of the influence of gluing length pointed out that by reducing the gluing length, not only the adhesive layer thickness will be evenly distributed, but the adhesive consumption and therefore the production costs will also be reduced.

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