

IMPORTANT FACTORS OF PAPERBACK BOOKS QUALITY OF ADHESION STRENGTH IN ADHESIVE BINDING

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Abstract: Major commercial bookbinding technique used today is perfect binding (or adhesive binding), originally used for paperback books. In perfect binding, adhesive is used to attach the pages of a book together and attach the book cover. One of most important criterion for adhesive binding is strength over the whole length of a book leaf. It is known that adhesion strength is function of the bond between the leaf and adhesive and total sum of material contact area. The subjects of research are physical properties of paper that have impact on different general sources of binding strength. The tests were performed with constant parameters of binding process and two chemically different types of paper. The measurements were performed by static pull test method.

Key words: softbound book, paper, adhesive, binding

1. INTRODUCTION

Perfect binding was originally used as economical and rapid binding method for paperback books, and it is the dominant binding process in industrial book and brochure production today (Tizzard & Thomas, 1988). Quick and efficient process of perfect binding was enabled by the use of hot melt adhesive (HMA). They are solid at ambient temperature, but at increased temperatures about 170°C is applied in molten form, then cooled and set rapidly. Block spine processing has strong influence on the strength of the binding (Kipphan, 2001). Also adhesive binding quality is determined by physical and chemical properties of the materials (paper, HMA). The importance of the binding strength is appropriateness of used paper for perfect binding.

2. EXPERIMENTAL

The quality analyses in adhesive binding relate in practice mainly to the book block strength. The strength of a paperback book in use means its mechanical durability. Quality of adhesive bindings is determined by measuring tearing strength of single leaf [F (N/cm)] value. The method for measuring tearing strength single leaf is called *pull test* (Kipphan, 2001). In this research, paperback books were made from two types of paper:

- Offset printing paper, AMBER GRAPHIC 80 g/m²
- Matt coated paper, MAXI SATIN 150 g/m²

Binding process was executed on Muller Martini, Pony 5 with constant technological parameters (block spine processing, block spine gluing, open time of adhesive, HMA type). The samples were 150 x 210mm and 64 single leaves (64x2=128 pages). Block spine processing includes the back edges cut off from the folded sheets, and roughening to increase the application surface of the spine. Finally, the adhesive area is cleared of paper dust and torn cellulose fibres by brushing and suction. HMA layer matched onto roughening the block spine and put on cover. Microscopic substrate roughness provides

mechanical locking for HMA and a larger surface area for bonding (Mital, 1977; Minford, 1981). HMA is mechanically linked with the porous substrate, technological means to obtain better adhesion strength. HMA are 100% non-volatile thermoplastic materials, composed of Ethylene-vinyl acetate copolymer, tack filers, plasticizers, waxes and antioxidants (Wake, 1982; Domine, 1977).

The pull test was performed on Martini Tester tensile device, Model VA. The single leaf is pulled down until the breaking occurs. All samples were tested in standard climate condition (50%RH, 23°C). There are no standards for adhesive binding quality of certain books category. After measuring all the samples, the average was calculated. Results were compared with internationally recognized attribute value of Institute of Adhesive Products from Illinois, USA (Kipphan, 2001).

VARIABLE PARAMETER		
<i>Types of paper</i>		
Matt coated paper	MAXI SATIN	150 g/m ²
Offset printing paper	AMBER GRAPHIC	80 g/m ²
CONSTANT PARAMETERS		
<i>Type of hot melt adhesive (HMA)</i>		
Process temperature HMA	Planatol HM 6010	
Thickness layer HMA on book spine	130°C	
Open time of HMA (speed of the machine)	0,80 mm	
Block spine processing	900 books/hour	
High back edges cut off the folded sheet	3,0 mm	
Depth of notched edge of book spine	0,4 mm	

Tab. 1. Parameters of book binding process

Rating of single leaf tearing strength [F (N/cm)]	Attribute value
less than 4,50	"Bad binding strength"
4,51 – 6,20	"Sufficient binding strength"
6,21 – 7,20	"Good binding strength"
more than 7,20	"Very good binding strength"

Tab. 2. Attribute value of advised Institute of Adhesive Products from Illinois, USA

2.1 Factors that influence adhesion strength

The mechanical theory of adhesion is associated with adhesion to rough and porous paper. Offset printing paper has high surface energy of atoms on an asperity surface. The roughness of an interface may be on any scale ranging from the macro (mechanical interlocking) to the molecular Van der Waals forces (Packham, 2003). A paper roughness affects the contact area of HMA. Increase of the total contact area results in increased adhesion strength of the leaf.

Matt coated paper has low surface energy, caused by non polar component on the top of surface paper. Therefore polymer allows for chemical bonding interaction with HMA. Adhesion

strength determines intensity of molecular forces in the adhesive binding. Adhesion primarily depends on the force in the transition region between the non-contacting areas (Avaja et al., 2009). It contains less macro pores than Offset printing paper. Surface macro porosity directly contributes to increased adhesion strength.

2. RESULTS AND DISCUSSION

3.1 Results

The main goal of this work is to compare the two different types of paper most frequently used for paperback books. The arithmetic value of distributing tearing strength of single leaf of book block is given in Fig. 1 and Fig. 2. The results of the experiments determine adhesion binding strength depending on the different position of single leaf into book block.

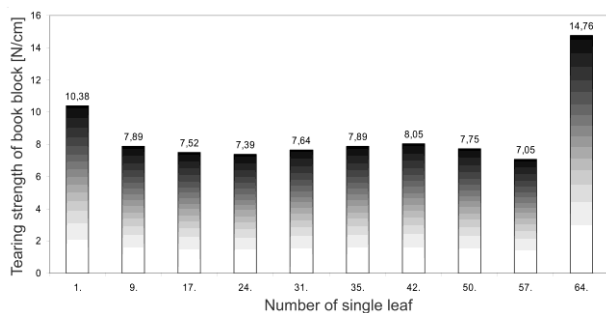


Fig. 1. Distribution of tearing strength single leaf for Offset printing paper

The pull test results were compared with attribute values from table 2. Offset printing paper showed significantly higher values (7,05 - 14,76 N/cm) than reference values. The 1st and the 64th single leaf of book block have significantly higher values of tearing strength, 10,38 N/cm and 14,76 N/cm. Also it could be noticed slight reduction on the 17th leaf (tearing strength 7,52 N/cm), on the 24th leaf (tearing strength 7,39 N/cm). More considerable reduction is noticed on the 57th leaf, where measured tearing strength is 7,05 N/cm.

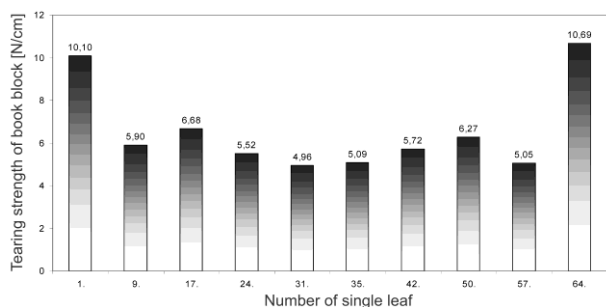


Fig. 2. Distribution of tearing strength of single leaf for Matt coated paper

Matt coated paper show noteworthy lower values (4,96 – 6,68 N/cm), except the 1st and the 64th single leaf of book block where measured values of tearing strength (10,10 N/cm and 10,69 N/cm) are considerable higher. Even more significant reduction is noted on the 24th leaf, (5,52 N/cm), the 31st leaf with tearing strength of 4,96 N/cm, and on the 35th leaf where tearing strength is 5,09 N/cm, and on the 57th leaf where tearing strength is 5,05 N/cm.

3.2 Discussion

In generally, the adhesion strength is significantly higher with Offset printing paper than Matt coated paper regardless where

single leaf is situated. Measurement of tearing strength of single leaf confirms significantly lower values in the middle of book block for Matt coated paper. Significantly higher values for the 1st and the 64th single leaf of book is caused by side gluing of book block, 1cm wide adhesive strip on the front and rear block surface in book binding process. The results confirm that Offset printing paper have outstandingly better binding characteristics than Matt coated paper. Tearing strength of single leaf for each type of paper has direct influence to adhesive bookbinding. Although considerably lower single leaf tearing strength is noted in the middle of the book block, the result are still in the range of sufficient binding strength (4,51 - 6,20 N/cm). “Sufficient binding strength” is described as attribute values. Offset printing paper has showed the best result given the distribution tearing strength of single leaf regardless on location single leaf within book block. Results are described as attribute values “very good binding strength” (tearing strength is measured more than 7,5 N/cm).

3. CONCLUSION

The increase in adhesion strength is caused by roughening spine of the book block and higher number of macro pores on surface of paper. Greater roughness contributes to more fibres bonding with HMA, as HMA penetrates between the single leaves. Therefore roughness has significant contribution to binding strength. Absorbency of Offset printing paper contributes to binding strength through mechanical interlocking contact between fibres and HMA. The total contact area, and number of fibres and quantity of HMA is higher than in case of Matt coated paper. It has low surface roughness because adhesive binding is often attributed to poor adhesion. Paper polymer coating structure has non polar characteristics as HMA. Their non polar characteristics are described as low surface energy or poor adhesion properties. It is concluded as adhesion strength dependant on the forces in the transition region between the non-contacting areas. Results of research confirm that of paperback book made from Offset printing paper have better qualities than paperback book made from Matt coated paper.

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