PERFECT BINDING TECHNIQUE AFFECTS
THE PAPERBACK ADHESIVE BINDING STRENGTH

Suzana Pasanec Preprotić, Branka Lajić, Denis Jurečić
Grafički fakultet Sveučilišta u Zagrebu, Getaldićeva 2, Zagreb, Hrvatska
E-mail: spasanec@grf.hr, blajic@grf.hr, denis.jurecic@grf.hr

ABSTRACT

Bindability aspect of the perfect binding technique is presented in this work. Paperback production process involves two main technologies apart: text block spine treatment process and hot-melt gluing process. Furthermore, paperback adhesive binding strength mostly depends on material properties (substrate, adhesive). Hot-melt adhesive gives almost instantaneous adhesion due to its thermoplastics melt properties. Text block spine form never allows to lay open flat and loose leaves binding edges transfer tensile stress. Hence inter phase region (adhesive-adherend) can only improve adhesive bond strength. This mechanical interlocking adhesion is more dependent on substrate morphology (paper surface roughness characteristics).

Key words: paper properties, text block spine roughness, adhesive binding strength control, adhesive joint strength

SAŽETAK


Ključne riječi: svojstva papira, hrapavost hrpta knjižnog bloka, kontrola lijepljenog uveza, čvrstoća slijepljenog spoja
1 INTRODUCTION

The success of perfect binding in recent years has been due to the availability of wide range of adhesives suitable for binding most types of paper. The development of machinery to make this method a quick, reliable and profitable activity for printers and trade finishers, and of course its continued cost advantages over traditional sewn books. Furthermore, the use of thermoplastic adhesive (hot-melt) means that books can be teemed almost immediately, rather than waiting for a day as was necessary with cold adhesive (PVAc). A perfect bound book or paperback has a square text block spine. Loose leaves are mostly equally strong dependence on their position. Hence paperback is a “prestige” product, chosen by publishers of quality magazines, financial reports and house manuals. Perfect binding technique is also far cheaper than mechanical bindings, basically due to the fact, that binding is labor oriented and maintaining large work area and work force is expensive. Paperback is easier to handle, looks attractive and a far greater range of paperback volumes and formats are available. Machinery minimal set-up requirements, no special machine operator skills and high product output due to adhesive rapid set-up time are main advantages of this binding technique.

2 THEORETICAL PART

Perfect binding uses initially for paperback mass production, thermoplastic adhesive (hot melt) involves only. Binding process is more cost-effective, it widely used in relation to other adhesive technique (PUR or two shot adhesive PVA/EVA). Adhesive allowed much faster setting, a few seconds after leaving the adhesive tank. Generally, hot melt adhesive is permitted high speed paperback production. Furthermore, perfect binding technique becomes more specialized in materials handling aspects, in order to satisfy definite markets. Magazines, text blocks, periodicals, telephone directories, note books, technical reports, internal reports and short run works in plant printing units present paperback products. Adhesive binding grows with the continual improvements in adhesive formulation, the means of applying the adhesive and text block spine preparations.[1] The most critical factor is paper bind ability. Paper surface and mechanical properties are impact factors of paperback adhesive joint strength. Paper properties have strong influence on determination the bond quality on adherend layer. The adherend layer distinctiveness depends on text block spine roughness characteristics. Adherend properties are main contributor to adhesive binding strength enhancement.[2] Loose paper dust on adherend layer causes adhesive joint strength reduction. Furthermore, the mechanical interlocking adhesion mechanism is
reduced due to adhesive kinetic wetting reduction. [3,4] Therefore, the adherend properties promote mechanical interlock intensity [5] and adhesive viscosity properties contribute adhesive bond strength.[6] Thermoplastic adhesive immobilizes the paperback spine due to its rigidity. [7] The loose leaves binding edges take over too much stress is placed on adhesive bond layer. Therefore, the paperback binding quality depends on adhesive bond layer strength. On the other hand, high grades coated papers tend to adhesive layer failure. This problem involves paper surface coating properties analysis. Paper surface coating cohesive failure causes paperback adhesive binding strength reduction. Generally, high grades papers bindability differences suggest alternative adhesive binding technique. Contrary paper mechanical property as strain rate always has positive impact on paperback quality. High paper grades tend to stretch in cross direction during the tensile stress force loading.

3 EXPERIMENTAL

In this study was used high grade papers (HRN EN 643:2002) different properties depend on fiber choice and paper furnishes. Paper bindability determination (ISO 534, ISO 536, ISO 2494, ISO 5636-3, ISO 535, ISO 1974, ISO 1924-2, TAPPI 413) includes papers presented in Table 1. Bulky paper contains wood-free pulp and mechanical pulp more than 10%.

Table 1: Paper specification

<table>
<thead>
<tr>
<th>Paper nomenclature</th>
<th>Trade name</th>
<th>Basic weight (gm⁻²)</th>
<th>Sample name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncoated, wood free</td>
<td>Amber graphic</td>
<td>80</td>
<td>U_80</td>
</tr>
<tr>
<td>Uncoated, wood free</td>
<td>Amber graphic</td>
<td>100</td>
<td>U_100</td>
</tr>
<tr>
<td>Triple coated, wood free</td>
<td>Maxi gloss</td>
<td>115</td>
<td>Cg_115</td>
</tr>
<tr>
<td>Triple coated, wood free</td>
<td>Maxi matt</td>
<td>150</td>
<td>Cm_150</td>
</tr>
<tr>
<td>Bulky</td>
<td>Munken White Print, 15</td>
<td>80</td>
<td>W_80</td>
</tr>
</tbody>
</table>

Ten paperback samples with identical text block spine treatment condition were made according to preliminary test (HRN EN 12092:2003 i ISO 8962:1987). Optimum adhesive bond includes test adjustment result in order roughening type. The binding process was performed under standard conditions (ISO 187). The ingredients combination, ethylene vinyl
acetate copolymer [8] grades and tackifying resin have influence on the adhesive melting point. Adhesive type Planatol HM 6010, temperature 130°C (adhesive film layer on spine roller), viscosity 2165 mPa·s, adhesive film layer thickness 0.80 mm; and adhesive open dry time 600 books/hour (Type: Muller Martini Pony 5) with strong clamping effect were included. Adhesive viscosity was determined in accordance with standard (ISO 3219:1993) by ISO-Viscometer 550 with Plate Cone. Three measurements were used to calculate adhesive viscosity. The paperback unprinted sample specification is 15cm (width) x 21cm (height) x 64 loose leaves (volume). Arithmetic mean is calculated on the base of ten measurements, each paperback sample separately. A binding endurance test or pull test determines the force required to pull a loose leaf from text block spine. The disposition of ten loose leaves in relation to each other is identical. Its purpose is to determine the adhesive joint strength of the method used to secure the loose leaf. The loose leaf (A-J) is pulled with uniform force along the binding edge. The total load force is divided by the loose leaf height in centimeter to give the loose leaf pull unit of measurement as Ncm⁻¹.[9,10] The result was compared with a rating of adhesive joint strength (bad, sufficient, good and very good binding strength) according to FOGRA guidelines for page pull test. [11,12,13]

4 RESULTS AND DISCUSSION

In the first part, measurement paper properties results are presented in Figure 1-4. The paper samples conditioning were performed in compliance with Standard HRN ISO 187, over 24 hours. Arithmetic mean is calculated on the base of ten measurements; paper lower (B) and upper (A) side separately and paper machine (MD) and cross direction (CD).

[Graph and Table]

Figure 1: Comparison of high grades papers properties
Figure 2a: Comparison of high grades papers absorbency properties (A/MD)

Figure 2b: Comparison of high grades papers absorbency properties (B/CD)

Figure 3: Comparison of high grades papers mechanical properties (CD)
Figure 4: Comparison of high grades papers bindability

Generally, enhancement of paper surface roughness result is main contributor of adherend enhancement and higher bonding degree by mechanical interlocking adhesion (Fig.2a-b).[14] Paper roughness property increasing depends on paper fibers type and furnishes choice. Bulky paper surface roughness result enhancement is consequence of long fiber in mechanical wood pulp. Increasing of fiber mass causes its coarase [15] and paper bulk property increasing. Furthermore, paper surface roughness is main contributor to adhesive kinetic wetting. [16,17] Adhesive fillers paper cavities volume and makes bond form due to adherend thickness enhancement. Also paper thickness increasing has positive impact on adhesive kinetic wetting. On the other hand, ash content, CaCO$_3$ content, surface water absorbency and capillary absorbency results reduction don’t establish ultimate adhesive joint strength enhancement.[18] Furthermore, lignin content to the wood pulp stock has potential to develop hydrophobicity (low surface energy)[19], but papers resistance hasn’t influence on thermoplastic adhesive penetration[20]. The confirmation of mechanical interlocking adhesion reduction is paper dust creation on adherend. There are inorganic compounds cause cavities volume reductions. Triple coated wood free paper (Cg_115 and Cm_150) ash content and CaCO$_3$ content result enhancement directly confirms binding strength result reduction. Therefore coated paper bindability reduction can be explained by paper inorganic compounds increasing. Also coated paper surface absorptiveness result enhancement is a consequence of CaCO$_3$ porous structure. The water directly penetrates into surface coating layer only. High grades papers mechanical properties in lateral direction (CD) are point of
interest (Fig.3). Bulky paper results reduction explains paper poor formation as consequence of containing the cellulose, hemicelluloses and lignin. Wood free paper increasing explains paper higher bonding degree of the fiber network, fibers and inter-fibers bonds including. Unfortunately, triple coated wood free papers enhancement have negative impact on paper bindability as consequence of surface coating layer. Furthermore, uncoated wood free paper results tend to its bindability especially as results of paper in-plane tensile properties and its surface characteristics. Generally, papers bindability result directly explains paperback binding strength result. It calculated from loose leaves adhesive joint strength mean value. Furthermore, FOGRA Standard recommendation rating directly describes paperback binding quality. Comparing of high grades papers bindability includes all adherend relevant parameters. Therefore the loose leaf adhesive joint strength determination accurately explains paper bindability impact factors. Adherend properties of text block spine have strong impact on paperback binding quality. High grades papers bindability level with regard to FOGRA Standard recommendation is presented in Figure 4. . Paper U_100, Paper W_80 and Paper U_100 Tensile Index results enhancement tend to significantly paperback binding quality by FOGRA recommendation. On the other hand, Paper Cm_115 and Paper Cg_150 Tensile Index results reduction cause sufficiently decrease of paperback binding quality.

5 CONCLUSION

This research focuses on the high grades papers bindability using the perfect binding technique with thermoplastic EVA copolymer adhesive. Generally paper bindability impact factors directly determine paperback binding quality. Adherend properties of text block spine are main contributor of intensity of mechanical interlocking adhesion. Therefore loose leaf adhesive joint strength results mostly depends on adherend properties. Chemical, surface and mechanical properties of paper directly explain adherend characteristics. Adherend roughness increasing contributes paper bindability. This statement is verified after adhesive joint strength measurement by static pull-test method. Furthermore, uncoated wood free paper and bulky papers are appropriate for perfect binding technique due to paper surface roughness increasing. Unfortunately, triple coated wood free paper tends to loose leaf adhesive joint strength result reduction. Less papers bindability explains its surface coating layer and reduction of mechanical interlocking adhesion on adherend. Accordingly, paper fiber network layered structure interface with thermoplastic layered adhesive is main contributor of paper bindability. These preliminary results can be used in future. Perfect
binding technique optimization will include high grades paper (uncoated, bulky) different paper thickness and adhesive thickness film with same adhesion surface tension, heat adhesiveness initial tack, open and setting adhesive time.

6 REFERENCE


