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RESEARCH OF THE BONDING STRENGTH OF LAMINATED MICRO-CORRUGATED CARDBOARD PACKAGING

S. F. Havenko, V. V. Bernatsek, M. T. Labetska

Ukrainian Academy of Printing,
19, Pid Holoskom St., Lviv, 79020, Ukraine

Laminating technology is widely used in packaging production, because today high-quality and presentable boxes of laminated cardboard are needed in various industries. In addition to paper, an important component of laminated micro corrugated cardboard is glue, which significantly affects the ultimate strength, and hence the final quality of the manufactured cardboard packaging. When laminating micro- and corrugated cardboard, as well as the manufacture of various products from them, different types of adhesives are used. The issue of choosing the optimal composition and the study of it physical and technical characteristics is given special attention by industry experts. The study of the quality of laminated micro corrugated cardboard packaging by determining their performance, namely the stratification effort and bond strength is carried out in this work.

Keywords: *lamination, packaging, micro corrugated cardboard, glue, operational indicators, quality.*

Problem statement. Nowadays, the world and in particular the Ukrainian market of printing materials shows a significant demand for packaging products from laminated corrugated cardboard. The technology of laminated cardboard and corrugated cardboard packaging production is in the center of attention, as the problems of high-quality application of glue (thickness, viscosity, type), drying modes (t ° C, time), the technological process of lamination (pressure, speed) on industrial and self-made installations remain unsolved at present. Laminating technology allows to obtain high-quality, attractive packaging, using cheap varieties of cardboard, which significantly increases the profitability of production. It should be noted that the main task in the implementation of the technological process of lamination is to obtain good adhesion of the coating to the substrate.

When laminating micro corrugated cardboard, adhesives with different properties and chemical auxiliaries are used: based on PVA, starch, silicate adhesives, synthetic adhesives (latex, polyvinyl alcohol, polyacrylic acetate, resins, etc.), which are able to penetrate the surface of solids and glue them together. Analysis of technological and operational characteristics of adhesives used for lamination shows that they must have: high adhesive capacity; a strong adhesive film with a deformation characteristic close to the materials to be glued; viscosity, depending on the application conditions; the ability to wet the surfaces to be glued; stability during storage and transportation; absence of odor and toxic components.

Modern adhesives used in the packaging industry, by their origin are divided into natural and synthetic, used in the form of hydrogen adhesives (solutions or dispersions).

The most common for laminating micro corrugated cardboard is an adhesive composition based on polyvinyl acetate dispersion due to a number of such important advantages as: fast setting; chemical resistance of the adhesive film; faint odor, white color; no foaming; readiness for use – does not require heating; required fluidity at low and high temperatures; mechanical stability; storage of properties after freezing – thawing; ability to stick together at ambient temperature; incombustibility; storage resistance; non-toxicity; ease of making various mixtures in order to improve certain indicators of glue; low cost; slight wear of tools during further processing of glued products [1-4].

Analysis of recent research and publications. Analysis of technological and operational characteristics of adhesives used for lamination shows that they must have: high adhesive capacity; a strong adhesive film with a deformation characteristic close to the materials to be glued; viscosity, depending on the application conditions; the ability to wet the surfaces to be glued; stability during storage and transportation; absence of odor and toxic components. Different types of adhesives are used in the production of laminated micro-corrugated packaging, which can be divided according to the composition of the binding components into natural, synthetic and combined.

The printing market offers a wide range of laminating adhesives from world-renowned companies with branches in many countries: National Starch & Chemical (USA), Henkel, Geresan GmbH Markranstabt, Emsland - Starke GmbH, Planatol Adhesiv GmbH (Germany), Kiilto OY (Finland), CR, CR / S (Poland), Helios (Slovenia). The choice of an adhesive is made depending on the requirements for the final product. Thus, the analysis of scientific developments shows that the study of technological and operational characteristics of laminated micro corrugated cardboard, which is so widely used for the manufacture of packaging, is relevant today [5-7].

The aim of the research. Investigation of the process of manufacturing packaging from laminated micro corrugated cardboard were carried out in order to establish the strength of adhesive joints using a new type of adhesive apparatus to ensure high quality of finished products.

Presentation of the main research material. For conducting experimental studies of the quality of gluing packages were selected such materials:

– sample number 1 – cardboard “Arctica” with a weight of 200 g / m^2;
– sample number 2 – Kraft “Endura” striped 70 g / m^2;
– sample number 3 – food parchment 40 g / m^2;
– sample number 4 – Kraft packing 70 g / m^2;

as well as adhesives “Lux-R”:

– sample number 1 – Z-1F;
– sample number 2 – P-5;
– sample number 3 – ECO-34D;
– sample number 4 – S-90D.

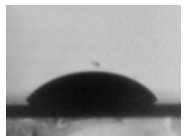
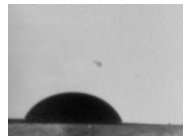
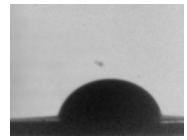
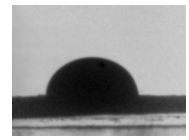
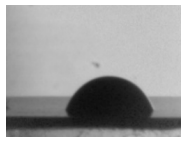
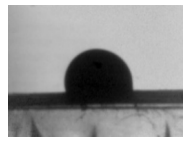
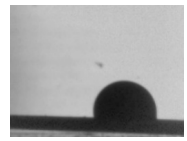
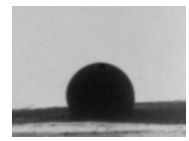
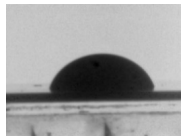
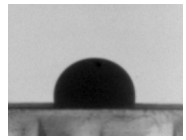
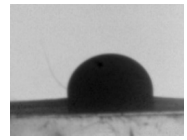
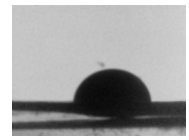
The process of laminating materials was carried out on the developed device (patent of Ukraine No83440) [8]. To measure the wetting angle the device and the program for automatic calculation of the cosine of the wetting angle “Angle Analyzer” were used. To determine the stratification force and bonding strength of the laminated micro corrugated cardboard a bursting machine of the RMB-30–2M brand was used [9].

For the reliability of the research results, 10 parallel measurements were provided. All materials were subjected to acclimatization before the experiments, the studies were performed at a temperature of 18-22 °C and a relative humidity of 65-75%. The results of experimental research were processed using the Microsoft Office Excel 2010 software package.

The average values of the cosines of the contact wetting angles of the corrugated cardboard surfaces with adhesives, determined using the program "Angle Analyzer" and micrographs of glue droplets are presented in table 1.

Table 1

The values of the cosines of the contact wetting angles of the paper surfaces with adhesives

Paper Adhesive	"Arctica" cardboard (200 g/m^2)	Kraft number 1 (70 rg/m^2)	Parchment (40 g/m^2)	Kraft number 2 (68 g/m^2)
number 1				
cos Θ	0,671	0,325	0,395	0,200
number 2				
cos Θ	0,267	-0,176	-0,164	-0,361
number 3				
cos Θ	0,429	-0,215	-0,101	-0,199
number 4	Does not spread			

As the analysis of microphotographs of glue drops and wetting edge angles showed that adhesives number 1, number 2, number 3 wet the surfaces of the studied papers and the smaller angle in the image of the program monitor "Angle Analyzer" - the greater cosine of the wetting edge angle, that is, the glue wets the surface better. Studies have shown that the glue №4 does not spread on the surface of the cardboard so it is impossible to determine the value and calculate its cosine of the wetting angle.

As can be seen from Table 1, the "Arctica" cardboard is best wetted with glue number 1, the glue number 3 shows a good result, the glue number 2 wets the surface worse. For the sample number 1, the best result was shown by the glue number 1, the worse

surface is wetted by the glue number 2. The investigated paper samples number 3 and number 4 (food parchment and Kraft number 2, respectively) are best wetted with glue number 1 and, as in the previous case, number 2 and number 3 adhesives showed the worst wetting results. Therefore, it can be argued that the selection of adhesives for gluing laminated cardboard should obviously take into account the surface structure of the substrates, the physico-chemical properties of the adhesive compositions.

As a result of research of operational characteristics of the laminated micro corrugated cardboard the diagram of values of breaking forces of glued surfaces (fig. 1.).

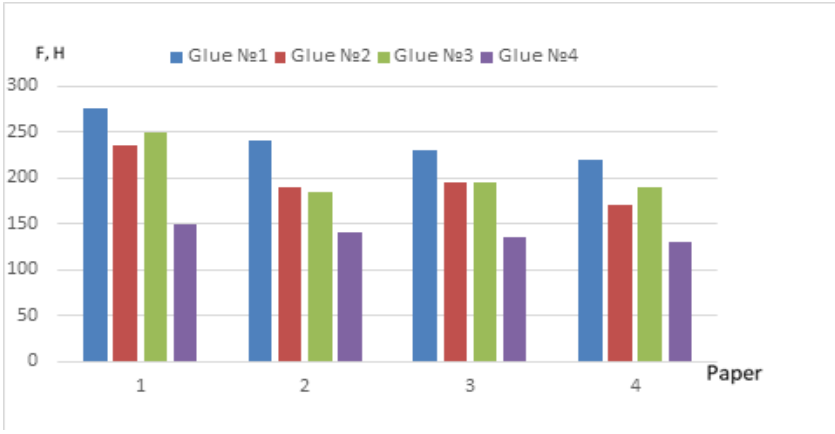


Fig. 1. Diagram of the average values of the breaking force of the studied samples

Considering the average value of the breaking force of the investigated samples of laminated micro corrugated cardboard, it can be stated that the greatest breaking force is required to break the bonds of adhesive joints of glue number 1: it is 275 N, 240 N, 230 N, 220 N for all investigated samples, respectively. Adhesives №2 and №3 have slightly worse, but similar strength characteristics, and the least strong connection is shown by adhesive №4 for all tested papers: 150, 140, 135 and 130 N, respectively.

Conclusions. The analysis of micrographs of glue and certain wetting edge angles of glued cardboards shows that adhesives LUX-R Z-1F, P-5 and ECO-34D have good adhesion to the investigated surfaces. S-90D glue is not recommended for use when gluing packages. The best wetting of all surfaces is demonstrated by glue №1. Studies of the performance characteristics of laminated micro corrugated cardboard packaging have also confirmed the feasibility of using adhesive "LUX-R" Z-1F, which has the best strength characteristics for all tested samples of paper.

СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

1. Raport marketingowy na temat runku opakowan i mashyn pakujacych w Polsce. Stan aktualny i prognoza po przystapienu kraju do Unii Europejskiej oraz 24 do roku 2010. *INCONA*. 2004. S. 184–185.
2. Jakowski S. Stan aktualu i perspektywy rozwoju branzy opakwan z papiru i tekturu. *Opakowanie*. 2006. № 7. S. 6–8.

3. New micro corrugated paper printing. URL: http://www.joyful-printing.com/info/new-micro-corrugated-paper-printing-28041375.html.
4. Bernatsek V., Labetska M. Prospects of the offset printing of environmental packaging for food products. Abstracts of the X international scientific-practical conference «Book Qualilogy» (September 12, 2019). Lviv : UAP, 2019. Pp. 51–54.
5. Features of the technology of adhesives manufacturing for corrugated cardboard / Boychuk N., Havenko S., Gevus O., Vuytsyk L. *Technology and technique of printing*. 2009. № 4. Pp. 138–141.
6. Top 8 best glue for cardboard. URL: https://gluefaq.com/best-glue-for-cardboard.
7. Investigation of quality of packaging made of laminated micro-corrugated cardboard / Havenko S., Bernatsek V., Ryvak P., Labetska M. *Technology and Technique of Typography*. № 4 (62). Kyiv, 2018. Pp. 18–26.
8. Pat. №83440 Ukraine. Glue apparatus of the laminating machine / Havenko S., Bernatsek V., Regey I.; applicant and patent owner Ukrainian Academy of Printing. Application. 26.02.2007; publ.10.07.2008, Bull. № 13.
9. Breaking machine for paper RMB - 30 - 2M. *Passport*. 1996. 10 p.

REFERENCES

1. Raport marketingowy na temat runku opakowan i mashyn pakujacych w Polsce. Stan aktualny i prognoza po przystapienu kraju do Unii Europejskiej oraz 24 do roku 2010: INCONA. (2004), 184–185 (in Polish).
2. Jakowski, S. (2006). Stan aktualu i perspektywy rozwoju branzy opakwan z papiru i tekturu: Opakowanie, 7, 6–8 (in Polish).
3. New micro corrugated paper printing. Retrieved from http://www.joyful-printing.com/info/-new-micro-corrugated-paper-printing-28041375.html (in English).
4. Bernatsek, V., & Labetska, M. (2019). Prospects of the offset printing of environmental packaging for food products. Abstracts of the X international scientific-practical conference «Book Qualilogy» (September 12, 2019). Lviv : UAP, 51–54 (in English).
5. Boychuk, N., Havenko, S., Gevus, O., & Vuytsyk, L. (2009). Features of the technology of adhesives manufacturing for corrugated cardboard: Technology and technique of printing, 4, 138–141 (in English).
6. Top 8 best glue for cardboard. Retrieved from https://gluefaq.com/best-glue-for-cardboard (in English).
7. Havenko, S., Bernatsek, V., Ryvak, P., & Labetska, M. (2018). Investigation of quality of packaging made of laminated micro-corrugated cardboard: Technology and Technique of Typography, 4 (62). Kyiv, 18–26 (in English).
8. Pat. №83440 Ukraine. Glue apparatus of the laminating machine / Havenko S., Bernatsek V., Regey I.; applicant and patent owner Ukrainian Academy of Printing. Application. 26.02.2007; publ.10.07.2008, Bull. № 13 (in English).
9. Breaking machine for paper RMB - 30 - 2M. Passport. (1996) (in English).

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ДОСЛІДЖЕННЯ МІЦНОСТІ СКЛЕЮВАННЯ ПАКОВАНЬ З КАШИРОВАНОГО МІКРОГОФРОКАРТОНУ

С. Ф. Гавенко, В. В. Бернацек, М. Т. Лабецька

Українська академія друкарства,
вул. Під Голоском, 19, Львів, 79020, Україна
martalabetska@gmail.com

Каширований гофрокартон є одним із найбільш широко використовуваних пакувальних матеріалів у світі. Гофроване паковання поєднує в собі жорсткість конструкції і амортизуючі властивості для надійного захисту важкого або крихкого вмісту від пошкоджень. Однією з причин такої багатофункціональності є особливості основної конструкції кашированого матеріалу, яка являє собою комбінацію кількох аркушів паперу з хвилеподібним шаром для поглинання ударних навантажень.

Окрім паперу, важливим компонентом кашированого мікрогофрокартону є клей, який суттєво впливає на граничну міцність, а значить і на кінцеву якість виготовленого картонного паковання. Тому питанню вибору оптимального складу та дослідженню фізико-технічних характеристик клейової композиції приділяється особлива увага фахівцями галузі. В роботі проведені дослідження якості паковань з кашированого мікрогофрокартону шляхом визначення їх експлуатаційних показників, а саме зусилля розшарування і міцності склеювання.

Ключові слова: *каширування, паковання, мікро гофрокартон, клей, експлуатаційні показники, якість.*

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