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STUDY OF OPERATIONAL (CONSUMER) PROPERTIES OF PAPER NAPKINS

BADANIE WŁAŚCIWOŚCI UŻYTKOWYCH (KONSUMENCKICH) SERWETEK PAPIEROWYCH

ABSTRACT: In the present article, the studies of the operational properties of paper napkins printed by the flexographic method have been discussed. The classification of napkins made of tissue paper according to consumer characteristics has been given. The physical and mechanical parameters of one-, two-, and three-layer napkins were studied, in particular: capillary absorption of water, aqueous solutions, and liquid food products, as well as the resistance to deformation during compression. Densitometric indicators were determined according to the printed test scale. It has been confirmed that the optical density is changed depending on the colour percentage of the print area. The conducted test for smearing of printed images showed a negative result, which ensures the satisfactory quality of the napkins when used.
Key words: issue products, paper napkins, consumer properties, flexographic printing, quality

STRESZCZENIE: Artykuł ten przedstawia badania właściwości użytkowych serwetek papierowych zadrukowanych metodą fleksograficzną. Podano klasyfikację serwetek wykonanych z papieru cisowego według cech konsumenckich. Przeprowadzono badania parametrów fizyko-mechanicznych serwetek jedno-, dwu- i trójwarstwowych, w szczególności kapilarną absorpcję wody, roztworów wodnych i płynnych produktów spożywczych oraz odporność na odkształcenia podczas ściskania. Wskaźniki densytometryczne wyznaczane są według wydrukowanej skali testowej. Potwierdzono, że gęstość optyczna zmienia się w zależności od procentowego udziału koloru w obszarze zadruku. Przeprowadzony test usuwania farby z nadruków dał wynik negatywny, co zapewnia zadowalającą jakość serwetek podczas ich użytkowania.
Słowa kluczowe: produkty tissu, serwetki papierowe, właściwości konsumenckie, druk fleksograficzny, jakość

INTRODUCTION

In today's world, it is impossible to imagine a person who would not use products made of tissue materials. Humanity uses various sanitary and hygienic products every day.

Depending on the scope of application, sanitary and hygienic products should be divided into two groups: personal (consumer tissue/ at home (AH)) and commercial use (tissue for bulk consumers/ away from home (AFH)). The first group includes toilet paper, paper towels, napkins, handkerchiefs, tablecloths, etc. The second one – is toilet paper and paper towels for offices, public catering enterprises, and schools. By volume of use in the world, the tissue segment for personal consumption dominates (almost 82%) compared to the products for commercial use (18%) [1-4].

A napkin is a small indispensable thing that may be needed in various life situations. The very word "napkin" comes from the Latin "salve" – "be healthy". Ordinary paper napkins in the form we are used to seeing them appeared recently - a little more than 100 years ago when the English entrepreneur John Dickinson in 1887 constructed a machine that produces napkins from cellulose.

FIG. 1. GENERAL APPEARANCE OF NAPKINS; 1 – UNPRINTED WHITE, 2 – COLOURED, 3 – WITH PRINTING AND EMBOSSING

However, the interest in tissue products and the relevance of these products is dictated by the daily needs of people around the world. Moreover, July 9 is marked in the calendar as the World Paper Napkin Day [5].

With the growth of the market of paper napkins, the demand for them and consumer requirements for such products is steadily growing. As is well known, high-quality paper napkins are usually made from cellulose and wood fibres. The quality of raw materials, the manufacturing technology of tissue products and their purpose – all determine the structure of product consumption by price segments and are formed by the level of the population's welfare.

According to economic criteria, tissue products are divided into three main categories: "Economy", "Standard" and "De Luxe", or "Premium" (high-quality, expensive products):

- economy-class napkins, intended for inexpensive cafes, canteens, and fast-food establishments, usually of standard sizes – 24×24 cm or 25×25 cm;
- standard napkins used at home are single-layer paper napkins, stronger than their counterparts in the economy segment, made in white or multi-coloured;
- luxury napkins, which are the densest among all the napkins mentioned above. Their sizes are larger than usual – 33×33 cm or 41×41 cm. They are used for serving the festive table, in the work of expensive cafes and restaurants. Such napkins are used to create work in the decoupage technique, while the top layer with a pattern plays an important role. They are made of high-quality raw materials, and the full-colour images on them are bright and clear [2].

According to the number of paper layers, napkins are divided into single- and multi-layered. According to the availability of crepe, creped and non-creped napkins can also be classified according to absorbency (excellent, high, medium and low absorbency) into dry or wet. Today, there are many types of wet napkins on the market: universal, for personal hygiene, medical, household wipes, etc. Each group, in turn, is divided into categories according to its scope of application. On the world market, universal wet napkins are in the greatest demand – 45%. Baby wipes account for 29%, wipes for removing make-up and masks – 10%, wipes for intimate hygiene – 5% and deodorant wipes for 1%. Napkins are divided by colour – white/bleached, natural colour and dyed in different colours; according to the presence of flavourings – flavoured and unflavoured. According to the type of packaging, napkins should be divided into single and packed in several pieces. A special part of the market is napkins that are used in medical practice and belong to both the first (baby care napkins) and the second group (sterile obstetric and surgical, antiseptic, prophylactic, therapeutic, etc.). By raw material, products are classified into those made from primary raw material – cellulose, and from secondary raw material – waste paper [3].

All these classification features of napkins are expedient, meaningful and complete from a merchandising point of view [4].

However, their classification according to decoration technologies is also important: with printed images (single or multi-coloured), with embossing or without it (Fig. 1).

The quality of decoration and marking of napkins depends on their purpose and the selected printing technologies used for this purpose. In the recent years, printed advertising on napkins has become more and more widespread: logos, corporate symbols, slogans, and advertising images. The main requirements for all types of napkins are that they should not crumble into small pieces when wet, not dirty your hands and absorb moisture and fat well.

Therefore, the improvement of printing technology on tissue materials, the selection of ecological inks, technological regimes and finishing methods using the latest printing technologies is an urgent task [6-10].

MATERIALS AND METHODS

The object of the research was one-, two-, and three-layer napkins with a size of 24×24 cm. The napkins had the following technical characteristics: degree of crepe – 12%, weight of 1m^2 – 37g. For the manufacture of napkins, paper from the cellulose fibre of the Huchtemeier Papier Gmbh company was used, and printing was carried out with USOPO1 NEO INK (AQUA FLEX plus – Ukraine) in full-colour printing on an OMET TV 503 Lecco flexographic printing machine.

The task of the research included determining the quality of printed images (densitometric and colorimetric indicators) and capillary absorption of water and fat, that is, the absorbent capacity of the napkin in two directions. Assessment of the absorbent capacity of napkins was determined by the Klemm method based on capillary absorption (ISO 8787-86) (Fig. 2).

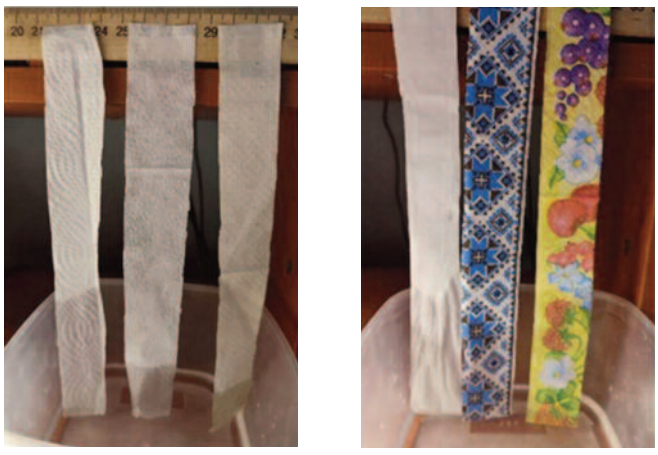


FIG. 2. DETERMINATION OF CAPILLARY ABSORPTION OF LIQUIDS BY NAPKINS

The value of the tensile strength was determined by the destructive force averaged in two directions in the dry and wet states of the napkins. To determine the destructive force in the wet state, three samples for testing single-layer products and one sample for testing multilayer products were cut out of ten randomly selected products in machine and transverse directions. The time of keeping the samples in water is (30±2) s. Three wet test samples of single-layer products are attached to the clamps of the tearing machine at the same time. For testing multilayer products, one wet test sample is attached to the clamps of the tearing machine. The arithmetic mean value of all determinations is taken as the result of the test.

To determine the deformation of the compression of napkins, a pressing device based on the UK25-1.6M unit was used.

The quality of the printed image and the absence of smearing of the colour image are important for the operational properties of printed napkins. The method of determining ink smearing involved the selection of 10 napkins. The samples are cut into pieces with a size of 10×10 mm with size deviations of no more than ±5 mm. The pieces are thoroughly mixed. From the obtained pieces, take a weight of about 2 grams, weighed with an error of no more than 0.01 grams. Next, the resulting sample is placed in a flask with a capacity of at least 200 cm^3. The sample is poured with 100 ml of distilled water at a temperature of 15-25°C. The sample is left to stand for one hour, stirring every 10-15 minutes. Then the aqueous extract is poured into glasses made of chemical glass. The water extract should be colourless. Distilled water is used as a standard for comparison.

Optical density measurements of printed images were determined using a GRETAG SPM50 spectrophotometer.

RESEARCH RESULTS

The absorbent capacity of napkins for water, water solutions and liquid food products (milk, oil, vinegar, etc.) is one of the main physical and mechanical indicators characterizing their properties. The absorbent capacity of the napkin depends both

TABLE 1. RESULTS OF STUDIES OF CAPILLARY AND SURFACE ABSORPTION OF LIQUIDS BY PAPER NAPKINS*

Napkin samples	Composition component					
	Water		Water + glycerine		Oil	
	Absorption rate, min	Height, mm	Absorption rate, min	Height, mm	Absorption rate, min	Height, mm
1-layer	0.22	33	0.22	27	1.4	21
2-layer	0.25	38	0.34	29	2.2	23
3-layer	0.27	42	0.42	30	2.4	26

* average values

on the viscosity of the liquid and on the properties of the tissue paper itself, in particular its micro and macrostructure. To achieve a high absorption capacity, the paper should have a loose structure and high porosity. This is achieved due to the use of fibrous semi-fibres, such as fine grinding, mechanical destruction of the structure of the paper web (creping, embossing), intensive drying and increasing the hydrophilicity of the fibres with the help of chemical additives.

Comparative studies of the structural characteristics of napkins made from cellulose and secondary raw materials were conducted. Napkins with different numbers of layers (one, two and three layers) were studied, six identical samples each. The absorption capacity was evaluated by measuring capillary absorption, which reflects a certain aspect of the paper's absorption capacity: capillary absorption – absorption rate, and also by surface absorption – the paper's wetting ability (Table 1).

The results of the research showed that the indicator of surface absorption of water and composition (water and glycerine) for all samples of paper napkins meets the standard requirements (more than 22 mm). The rate of capillary absorption of oil into the structure of single-layer napkins increases by 6 times, and in two- and three-layer napkins – by 8 times. The height of absorption of water solutions in 2-3 layers of napkins increases and is achieved by applying several layers of paper.

If the paper has high absorption, it is also important that it has the required mechanical strength. The conducted studies have determined that the tensile force indicators of napkins with printing and embossing by the Steel-t-Rubber method - in the machine direction are placed in a series:

Napkins: one layer → two layer → three layer

Resistance:

Machine direction: 3.2H → 3.8H → 4.3H

Transverse direction: 1.8H → 2.0H → 2.5H

Based on the experimental studies and their mathematical and statistical processing, a diagram of changes in the resistance of paper napkins to compression was constructed (Fig. 3).

Analysis of the diagrams showed that the maximum amount of napkin deformation characteristic of 3-layer samples with printing and embossing using the Steel-t-Rubber method is on average 15.8 kPa, and the sample without printing withstands a resistance of 14.6 kPa. Single-layer napkins have the lowest resistance - 10 kPa (without printing) and 10.7 kPa (printed and with embossing). An intermediate place is occupied by

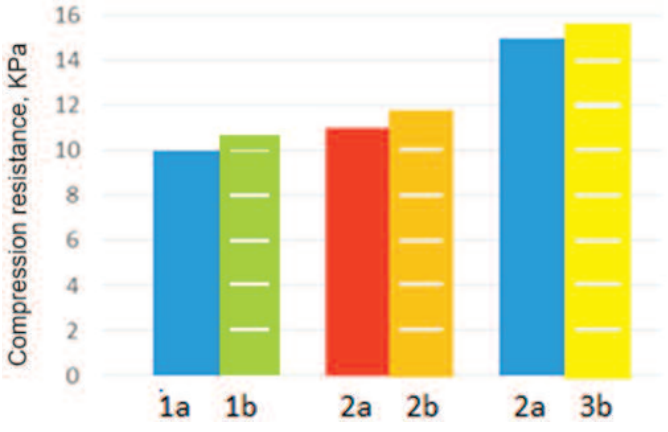


FIG. 3. RESISTANCE OF PAPER NAPKINS TO COMPRESSION:

1 – ONE-LAYER, 2 – TWO-LAYER, 3 – THREE-LAYER NAPKINS;

A – WITHOUT PRINTING; B – WITH PRINTING AND EMBOSSING

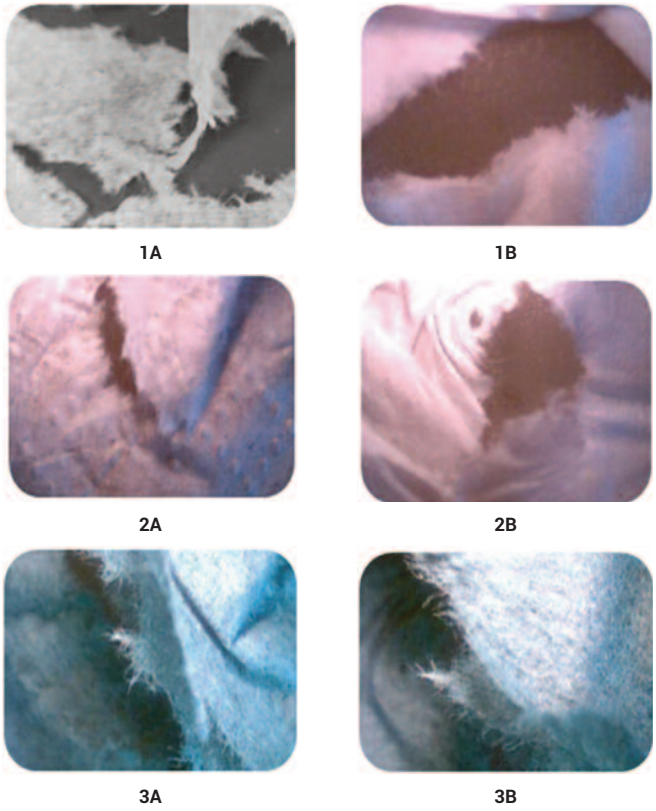


FIG. 4. MICROPHOTOGRAPHS OF NAPKINS IN PLACES OF COMPRESSION: 1 – ONE LAYER; 2 – TWO-LAYER; 3 – THREE-LAYER; 1 – WITHOUT PRINTING; 2 – WITH PRINTING AND EMBOSSING

two-layer napkins. Fig. 4 shows microphotographs of napkins after compression.

The values of the optical densities of the printed test scales (Fig. 5) are presented in Table 2.

The analysis of tabular data showed that the values of the optical density of inks depend on the tonal transfer. A stable gradation colour rendering is observed in light areas. Colour rendering in light areas within the range of 0-5% gradually increases. In the halftone and dark areas from 30-70% and 80-100%, there is a significant increase and deviation of these colours among themselves, and it is especially noticeable when printing with black ink (contour). The analysis of the diagrams shows that the imprint changes depending on the colour of the image and its saturation. For CMYK inks, the optical density changes depending on the percentage filling with the colour of the imprint area. Thus, in the range from 2% to 100%, the optical density increases almost 7 times for Cyan, 5.6 times for Magenta, 3,7 times for yellow ink, and 6 times for black ink.

FIG. 5. TEST OBJECTS PRINTED ON A NAPKIN TO DETERMINE DENSITOMETRIC INDICATORS

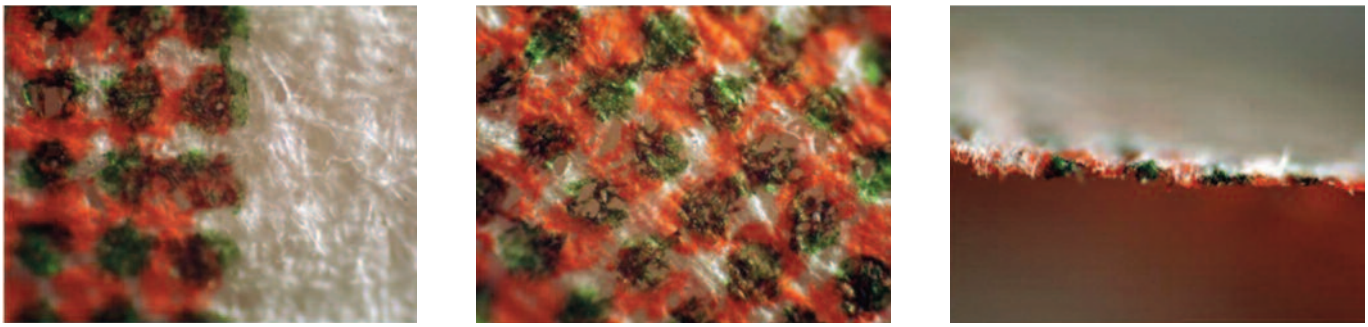
The aesthetic properties of paper napkins are determined by their appearance and are characterized by the quality of printed images.

As can be seen from the microphotographs (Fig. 6) of the napkin appearance with the printed image, the flexographic ink is evenly distributed on the surface of the fibres, which indicates a close relationship between the ink particles and the cellulose fibres.

The conducted test for smearing printed images on napkins showed a negative result, that is, the inks do not leave a mark on the consumer.

TABLE 2. THE RESULTS OF MEASURING THE VALUE OF THE OPTICAL DENSITY OF THE PRINTED TEST SCALES

The value of the optical density of the image															
%	0,4	0,8	1	2	5	10	50	75	80	85	90	95	98	99	100
C	0,22	0,24	0,27	0,27	0,34	0,36	0,58	0,92	1,03	1,05	1,1	1,14	1,18	1,19	1,6
M	0,22	0,25	0,25	0,3	0,43	0,48	0,73	1,09	1,13	1,18	1,18	1,21	1,2	1,22	1,24
Y	0,32	0,33	0,34	0,37	0,41	0,43	0,63	0,89	0,94	1,05	1,1	1,14	1,19	1,21	1,21
K	0,23	0,26	0,28	0,29	0,32	0,96	0,72	1,07	1,11	1,2	1,31	1,3	1,34	1,42	1,4



A B

FIG. 6. MICROPHOTOGRAPH OF THE SURFACE (A) AND CROSS-SECTION (B) OF THE PRINTED IMAGE ON A NAPKIN (MAGNIFIED ×200 TIME)

CONCLUSIONS

Despite the fact that the requirements for performance indicators of paper napkins are regulated by standards, consumers also put forward their own standards that ensure ease of use. Among them, such as softness (which is determined by the thickness, looseness, macrostructure of the paper web), looseness (which mainly depends on the degree of grinding of the paper mass: with an increase in the degree of grinding, the looseness of the paper increases), the degree of crepe (giving the paper a wrinkled structure, in order to increase elongation to break), absorption capacity, degree of embossing, number of layers, presence of perforations, presence of coloring and flavoring or impregnation with special solutions.

The conducted expert surveys made it possible to form consumer requirements for the appearance of napkins and provide the following list:

- absence of mechanical damage and stripes, folds, holes, stains, foreign inclusions;
- even cut of the edges of the napkin;
- the printed image on the products must be clear, without distortions and gaps. Traces of plucking fibres from the surface of the product and smearing of ink are not allowed;
- the colour tone and saturation of images should be uniform;
- the embossing relief should be even, clear, visible to the naked eye, without gaps;
- the layers of paper in multi-layer napkins must be fastened together, which ensures a tight fit over the entire area.

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