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THE DEVICE DESIGN AND THE MEASURING TECHNIQUE OF THE RIGIDITY OF BINDING MATERIALS FOR THE MANUFACTURE OF INTEGRAL AND SEMI-RIGID COVERS

© O. O. Paliukh, Ph.D., Associate Professor, Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine

The proposed measuring technique and measuring device, in comparison with prototypes, allows to obtain the objective indicators of measurements of destructive pressure, in the longitudinal and transverse directions, in materials with a heterogeneous structure such as cardboard, chrome ersatz and dense types of coated papers, from which integral and semi-rigid covers for book and magazine products are made, in contrast to measuring devices that record indirect indicators of destructive pressure, without taking into account the internal structure of test materials.

Keywords: cover; machine direction; clamping mechanism; impression element; destructive forces; material rigidity.

Statement of the problem

The task of studying the technological features of measuring the rigidity of binding materials for the manufacture of integral and semi-rigid covers is the need to determine objective indicators of measuring destructive pressure in the longitudinal and transverse directions in materials with an inhomogeneous structure such as cardboard, chrome ersatz and dense types of coated paper with a mass of more than 200 g/m^2.

Scans of integral and semi-rigid covers are cut from one sheet of material and, subsequently, are stored in spatial structures with edges or valves, which are fixed with adhesive polymer compositions to the main plane of the covers, forming a strong solid structure [1].

The determination, when designing, of the components of the book, of the location of the directions of the folds of the first or second pages of covers, in the longitudinal or transverse directions of the materials from which the covers will be made, significantly affects the operational durability of the covers and, accordingly, of book products in general.

The design of the measuring device shall take into account the possibility of obtaining objective indicators of the burst strength and destruction of experimental samples of covers that have a single thickness of the manufacturing material, double without glueing-off, and also double glued along the internal plane of the spatial double structure.

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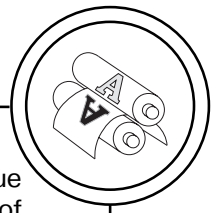

An analysis of previous research

The known clamping mechanism UGT-7013-MD for determining the burst strength of cardboard and corrugated cardboard, which consists of two elements of the sample clamp, made in the form of rings, rubber diaphragm mounted on the upper clamping element, and the load mechanism, that contains hydraulic cylinders, manometer, pressure gauge [2].

The measurement technique consists in creating a smoothly increasing hydraulic pressure effecting through the rubber diaphragm on the surface on one side of the sample compressed along the ring, in determining the pressure value at which the sample is destroyed.

The disadvantage of this device is the uneven growth of hydraulic pressure, which through the rubber diaphragm affects only one surface of the sample compressed along the ring; the use of distilled glycerin in the hydraulic system and the need for periodic change of the rubber diaphragm negatively affects the duration of the research process.

A clamping mechanism for determining the burst strength of cardboard and corrugated cardboard is also known, consisting of upper and lower clamping elements in the form of rings, the upper of which is equipped with a bursting element with hydraulic means for creating pressure, and the bursting element is made in the form of carbolite ball [3].

The internal structure of most part of the binding materials for the manufacture of covers for book and magazine products, in the process of their physicochemical creation, is heterogeneous — due to the directivity of the fibers of these materials in the longitudinal direction, which is determined by the feature of the technological process of their manufacture.

Because of this, the resistance to operational destructive forces will depend on the spatial positioning of the cover scan on the material in the machine or transverse machine directions.

Accordingly, the destructive strength in the longitudinal direction is greater than in the transverse direction, therefore, the disadvantage of such a device is that the pressing of carbolite ball into materials with an inhomogeneous structure does not determine objective indicators of destructive pressure in the longitudinal and transverse directions [4].

The aforementioned tools and the technology for measuring the destructive forces of bursting the materials with a heterogeneous structure, such as cardboard, chrome ersatz and dense coated papers, allow only indirect indicators to be recorded, through the round design of the bursting elements, the effect of which on the materials under study does not distinguish the heterogeneity of the structure of these materials in machine and transverse machine directions.

Accordingly, the minimum indicators of destructive forces in one of the directions of the existing structure of the material, which will negatively affect further performance and premature destruction of book products during using, will not be taken into account when designing the manufacture of covers and forming slopes for printing, further cutting and folding of the edges, or valves.

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Also, the method for determining the fracture strength of paper and cardboard with repeated bends is known [5]. Measurement of the fracture strength of paper and cardboard samples up to 1.4 mm thick shall be carried out with their multiple bends at an angle of 900, in each direction, from the vertical position to the fracture of the sample, under a constant load. Measurements are carried out on a UGT-6014 bending strength tester.

Unlike previous tests, the determination of the strength at multiple bends is possible, both in the longitudinal and transverse directions of the samples, that are fixed in the device one by one, changing the position in the clamps by an angle of 90° with each new sample and new test.

But a significant factor in limiting the widespread use of the methodology for determining the strength of materials with an inhomogeneous structure for scrap is the length of the process of multiple bends, which complicates the measurement process, as well as the unit of measurement, in the form of the number of bending cycles to complete destruction of the sample, has a relatively trustworthy nature of the test results.

One of the technological operations in the manufacture of simplified covers of increased rigidity is the formation of fold lines for the first and second pages of covers, which are formed by scoring during cutting of the scan, simultaneously with cutting, or folding a double spatial design of the cover, gluing edges and valves, by hatching or rolling a sealing disk, the thickness of the forming oval surface of which is equal to the width of the scoring grooves [6].

The determination of the relationship between the rigidity of cardboard and the rigidity of scoring lines, in accordance with the requirements of the BS 6965 standard, is determined by the resistance of the sample with a length of 50 mm of bending with 15 degrees [7]. The rigidity of the scoring line is determined by the strength of the residual elasticity after keeping the prepared sample bent at an angle of 90 degrees for 15 seconds. The UHA-CBT1 device contains a measuring channel designed to measure the force required to bend a sample of a given length and shape at certain angles.

The determination of the relationship between the rigidity of cardboard and the rigidity of scoring lines, according to this technique, is static in nature and, due to the scoring line deformed by the seal, regardless of the direction of its location on binding materials, also does not provide reliable indicators of ratios in the machine and transverse machine directions.

The aim of the work

Considering the peculiarities of the internal structure of part of binding materials such as cardboard, chrome ersatz and dense types of coated paper in machine and transverse machine directions, as well as differences in the processes of operational destruction of materials, as components in integral and semi-rigid covers of book products, the determination of the minimum and maximum indicators of the destructive forces of such materials, before the start of the manufacture of covers, the blanks of which are cut from one sheet of

material and formed into various spatial structures, is an important task of design and technological preparation of a book publication for production.

The possibility of creating a measuring device and developing a technology for measuring the rigidity of binding materials for the manufacture of integral and semi-rigid covers in the machine and transverse machine directions is also subject to study.

The results of the research conducted

The rigidity of binding materials such as cardboard, chrome ersatz and dense types of coated papers used for the manufacture of edged, integral and semi-rigid covers is one of the main measurement indicators that are determined during the incoming inspection of materials before starting the process [8].

Since the covers and materials from which they are made, in the first place, perform protective functions in relation to book and magazine blocks, in terms of wear resistance, operational strength, preservation of the structural and artistic form, and only then aesthetic, design, organoleptic, etc. functions, then such mechanical characteristics as burst strength, fixed between the clamping plates of cardboard or other binding material with a heterogeneous structure, help to identify weaknesses of materials and their orientation during prototyping, printing, cutting, die cutting, folding, gluing and further operation [9].

The objective of the study was to create the design of a measuring device for determining the burst strength of certain types of binding materials such as cardboard, chrome ersatz, coated paper, for the objective determination of pressure indicators at which samples are destroyed in the longitudinal and transverse directions.

The assigned task is solved in such a way that the design of the measuring device proposed by the author for determining the burst strength of cardboard, chrome ersatz, coated paper consists of upper and lower clamping elements, the upper of which is equipped with a bursting element with hydraulic means for creating pressure [10].

However, to measure the destructive pressure in the longitudinal and transverse directions, the clamping elements are made in the form of two rectangular plates with the same rectangular holes in the center of each plate; in the lower base plate, the six threaded holes are cut into, in which four cylindrical guides are screwed in for positioning the upper plate in relation to the lower plate, and two threaded rods with washers and nuts, with the help of which a sample of the studied binding material is pressed by the upper plate to the lower plate.

And the bursting mechanism with a hydraulic means of creating pressure is equipped with a bursting element in the form of a parallelepiped, the lower part of which is made as a half of cylinder, divided into two parts along the axis of the cylinder and the diameter of which is equal to the width of the parallelepiped and the length of the bursting element is four times greater than its width.

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The bursting element creates destructive pressure on the measuring samples of cardboard and chrome ersatz located in the clamping device, first one sample in the longitudinal and then the next sample in the transverse directions.

In this technical solution, the design features of the measuring device for determining the burst strength of cardboard chrome ersatz, coated paper — materials with a heterogeneous structure, allow to obtain objective indicators of destructive pressure measurements in the longitudinal and transverse directions.

A comparative analysis of the proposed technical solution with the prototypes allows to conclude that the proposed technical solution has significant features that distinguish it from prototypes and known technical solutions and determines the achievement of the task due to the ability to create destructive pressure on the experimental samples of binding materials for the manufacture of integral and semi-rigid covers, using a bursting element, in the form of a parallelepiped, the lower part of which is made as a half of cylinder, divided into two parts along the axis of the cylinder and the diameter of which is equal to the width of the parallelepiped. The bursting element carries out movement through the rectangular openings of the clamping plates, between which a meas-

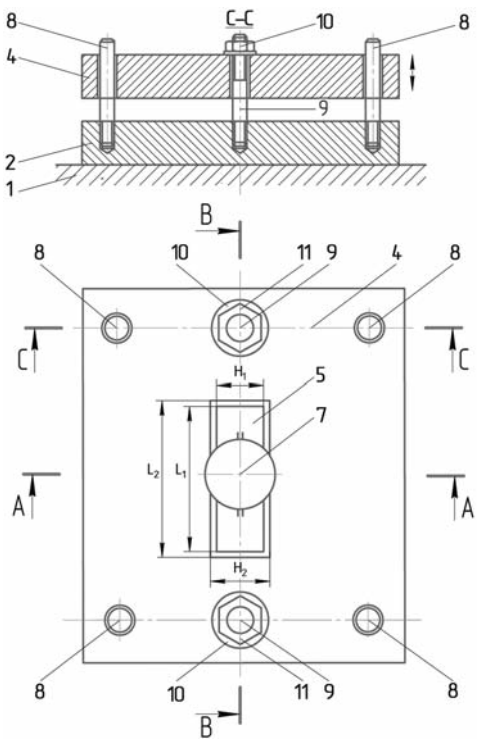

Fig. 1. Testing device for determining the burst strength of binding materials: cardboard, chrome ersatz, coated paper (top view, section C-C)

uring sample of cardboard or chrome ersatz is clamped, first one sample in the longitudinal direction, and then the next sample in the transverse directions.

The essence and principle of operation of the proposed technical solution are explained by the drawings presented in Fig. 1–3, where the structural diagrams of the measuring device are presented and the blanks of cardboard, chrome-ersatz, thick coated paper, or other binding material with a fiber structure in longitudinal and transverse directions are shown.

The measuring device (Fig. 1, 2) includes: a bed (1) with a lower rectangular pressure plate on which the test sample (3) is mounted, an upper rectangular pressure plate (4), bursting element (5), in the form of a parallelepiped, the lower part of which is made as a half of cylinder, divided into two parts along the axis of the cylinder and the diameter of which is equal to the width of the parallelepiped (s_1 = = D), hydraulic pressure generating tool (7) to which the bursting element is attached; 4 (four) cylindrical guides (8) positioning the upper pressure plate in relation to the lower pressure plate, 2 (two) threaded rods (9) with washers (10) and nuts (11), with the help of

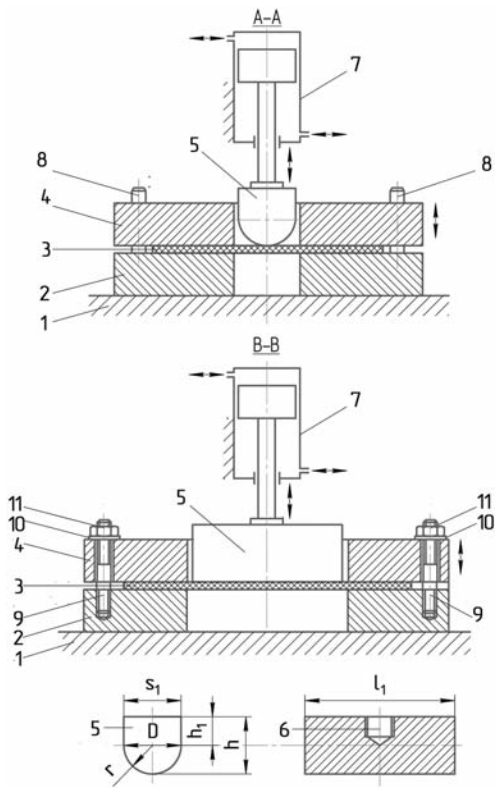

Fig. 2. Testing device for determining the burst strength of binding materials: cardboard, chrome ersatz, coated paper (sections A-A, B-B)

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which a sample of the testes cardboard or chrome ersatz is pressed with the upper plate to the lower plate.

The upper pressure plate (4) has 6 (six) cylindrical through holes (12) for passing the cylindrical guides (8) and threaded rods (9), and the lower plate (2) has 6 (six) threaded holes (13) into which cylindrical guides and threaded rods are screwed in.

The bursting element is attached to the hydraulic means for creating pressure (7) using a threaded hole (6). The overall dimensions (width and length) of the bursting element $s_1 \times l_1$ for 3 mm, on each side, are smaller than the overall dimensions $s_2 \times l_2$ of rectangular holes in the upper and lower pressure plates.

The length of the bursting element l_1 is four times ($l_1 = 4s_1$) greater than the width s_1. The height of the bursting element h consists of the height of the parallelepiped h_1 and the radius r of half the cylinder from which the lower part of the bursting element is formed ($h = h_1 + r$).

The test sample (3) of cardboard or chrome ersatz has transverse (14) and longitudinal (15) fibers.

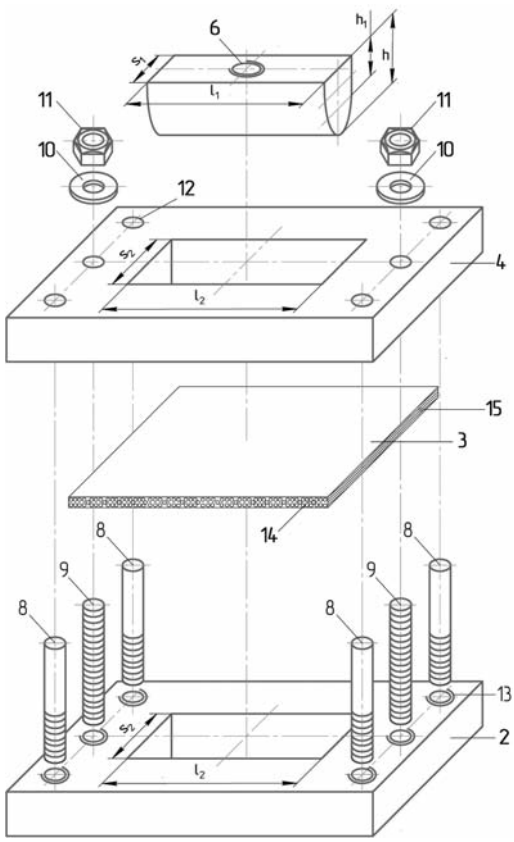

Fig. 3. Testing device for determining the burst strength of binding materials: cardboard, chrome ersatz, coated paper (assembly drawing)

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The measuring device is used to determine the burst strength of cardboard, chrome-ersatz and dense types of coated paper in machine and transverse machine directions in order to obtain objective indicators of destructive pressure, which must be taken into account when designing spatial structures of integral and semi-rigid book and magazine covers, as well as places of their bends during operational use.

A measuring device for determining the burst strength of cardboard, chrome ersatz, thick coated paper, or other binding material in the longitudinal and transverse directions works as follows.

The sample 3, with a longitudinal placement of fibers in the structure of the test cardboard or chrome ersatz, is placed on the lower pressure plate *2*, into the threaded holes *13* of which the cylindrical guides *8* and the threaded rods *9* are screwed, so that the entire surface of the plate is overlapped with the sample.

The upper pressure plate *4* through holes *12* along cylindrical guides and threaded rods is positioned on the upper part of the test sample. Using washers *10* and nuts *11* twisted onto threaded studs with an interference fit, the upper pressure plate tightly fixes a sample of the test cardboard or chrome ersatz.

Due to the gradual increase of pressure in the hydraulic device *7*, the bursting element *5* drops down, passes through the first rectangular hole in the upper pressure plate *4*, comes into contact with the sample *3*, continues to lower down through the rectangular hole in the lower pressure plate *2* and destroys the structure of the sample 3. Force of the destruction of sample placed in the measuring device in the longitudinal direction is fixed using measuring equipment.

The next stage of measuring the destructive force is carried out in the same sequence for a sample placed in the measuring device in the transverse direction.

The conclusions

The proposed measuring technique and measuring device, in comparison with prototypes, allows to obtain the objective indicators of measurements of destructive pressure, in the longitudinal and transverse directions, in materials with a heterogeneous structure such as cardboard, chrome ersatz and dense types of coated papers, from which integral and semi-rigid covers for book and magazine products are made, in contrast to measuring devices that record indirect indicators of destructive pressure, without taking into account the internal structure of test materials.

A special feature of the proposed measuring device is the design of the element of impression into the test material in the form of a parallelepiped, the lower part of which is made as a half of cylinder, divided into two parts along the axis of the cylinder and the diameter of which is equal to the width of the parallelepiped, which provides not intermediated, but a different nature of the obtained measurement results, larger in the longitudinal direction, smaller in the transverse direction.

The obtained indicators of the destructive forces of impression into materials with a heterogeneous

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structure in the machine and transverse machine directions contribute to the determination of the minimum and maximum measurement components, that should be used in designing of placement of covers scans on printed sheets, taking into account further operational bends of the pages of covers attached to the book-magazine blocks by non-sewed method, or using book sewing with thread.

The punching element moves through rectangular openings of the clamping plates, between which is clamped the measuring sample of the binding material, first one sample in the longitudinal and then the next sample in the transverse directions.

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Запропоновано технологію вимірювання та вимірювальний пристрій, що порівняно з прототипами, дозволяє отримувати об'єктивні показники вимірювань руйнівного тиску, в поздовжньому і поперечному напрямках, у матеріалах із неоднорідною структурою таких, як картон, хром-ерзац і щільні види крейдованих паперів, із яких виготовляють інтегральні та півжорсткі обкладинки для книжково-журнальної продукції, на відміну від вимірювальних пристроїв, що фіксують опосередковані показники руйнівного тиску, без врахування внутрішньої структури досліджуваних матеріалів.

Ключові слова: обкладинка; машинний напрямок; затискний механізм; елемент вдавлювання; руйнівні зусилля; жорсткість матеріалу.

Предложена технология измерения и измерительное устройство, которое по сравнению с прототипами, позволяет получать объективные показатели измерений разрушительного давления, в продольном и поперечном направлениях, в материалах с неоднородной структурой таких, как картон, хром-эрзац и плотные виды мелованных бумаг, из которых изготавливают интегральные

полужерсткие обложки для книжно-журнальной продукции, в отличие от измерительных устройств, фиксирующих косвенные показатели разрушительного давления, без учета внутренней структуры исследованных материалов.

Ключевые слова: обложка; машинное направление; зажимной механизм; элемент вдавливания; разрушительные усилия; жесткость материала.

Рецензент — Ю. О. Шостачук, канд. техн. наук, доцент, КПІ ім. Ігоря Сікорського

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