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## ANALYSIS OF MODERN PROTECTIVE SIGNS OF PRINTED AND PACKAGING PRODUCTS

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*Prevention of falsification and counterfeiting of printing and packaging products is implemented with a high degree of success thanks to the use of traditional, modern and the latest methods of protected printing, which cover the entire technological cycle of production of such products – from the paper manufacturing process to the stages of post-press processing and decoration. The use of specific technologies for making paper with special additives, technologies and styles of graphic design, special methods of printing and post-printing processing, holographic (glued or pressed kinegrams and holograms) and information (embedded chips, RFID tags) technologies, unique equipment and materials is aimed at complicating the possibility of copying the original printed product not only with the help of traditional technological methods of general printing, but especially with the use of modern digital methods of reproduction, as it is well known that the industry of secure printing has undergone significant changes in recent decades due to technological complexity and the ever-increasing challenges of the digital age. A detailed review of these specific technologies is the main task of the conducted analytical studies.*

*As practice shows, in the vast majority of counterfeits, the protective elements are not reproduced, but only imitated using other simplified methods, as of which digital technologies are increasingly used recently. Over the past decades, the printing industry has undergone drastic changes thanks to the application of new technologies and materials, especially in the pre- and post-print processing sector, and continues to change constantly, thus demonstrating the dynamic development of the industry.*

**Keywords:** *protective signs, protected printing, falsification, printing products, paper, watermark, Orlov's printing, iris printing, metallography.*

**Problem statement.** Protective printing is one of the methods that many companies and manufacturers use to protect their brand, printing and packaging products from counterfeiting or falsification. A distinctive feature of protected printing is the use of special technological methods, materials and equipment that prevent copying of the brand. Sometimes this is explained by the complexity and high cost of the used technologies, which become profitable only with huge circulations of a given type of product (excise stamps or banknotes, etc.). Such technologies include, for example, the production of special paper with additives, special dyes, guilloche signs, metallographic and Orlov's printing methods. Increasing the protective properties of

products that are manufactured using these technologies is facilitated by appropriate measures of governments and manufacturers of protected products, which prevent the spread of these specific technologies. This is especially relevant in the production of banknotes, which are the main target of attacks by counterfeiters. To protect their national currencies from counterfeiting, banknote manufacturers keep the presence and essence of most of the banknote's security features in the state secret regime. In order to choose the right methods and forms of product protection, it is necessary to accurately imagine what threats, methods and types of counterfeiting it needs to be protected against, that is, it is necessary to first of all take into account the purpose and order of use of protected printing products, the period and conditions of external circulation, sources of potential danger of abuse, it is possible to use types of protection based on the principle of maximum reliability and efficiency, as well as a complex of individual types of protection. As is known, there are declared, certified and hidden levels of printed products protection, which can be applied to printed products by providing them with protective features at all stages of the technological chain (Fig. 1). Therefore, the choice of the number and combination of different protective features depends on the purpose, term of circulation, conditions of use, level of damage in case of falsification and attractiveness of counterfeiting of a specific type of protected printing products [1-3].

**Analysis of recent research and publications.** Security signs, or as they are often called — protective elements, which are included in the composition of printed products in order to prevent their falsification or forgery, are hard-to-reproduce graphic or technological components of a printed product, created using special techniques. Modern protection degrees of printing and packaging products can be conditionally divided into three corresponding levels (table 1). The Swiss system for recognizing the originality of protected printing and packaging products developed by SICPA [4,5] works according to this principle of three-level classification of protective features.

In addition, protective signs are also divided into 2 categories: open (overt) and closed (covert). Public and instrument (cash register) signs are classified as open, and all others are classified as closed. Another level of protection is also known — the so-called dormant protection, which involves the use of a special class of protective features, which, as a rule, are introduced into the document with the aim not to prevent falsification or forgery, but, on the contrary, to confirm the authenticity of the document in those cases where unequivocal proof of authenticity is required. Such signs are present on the banknotes of some currencies of the world.

Also, protective signs can be conventionally divided into traditional and new ones. For example, until the second half of the last century, the main and often the only elements of protection were protected paper and metallographic printing. However, the improvement of falsification methods requires, accordingly, the constant improvement of technological methods of protection of printing and packaging products. The accelerated development and application of new protection technologies is facilitated by the development and wide spread of copying equipment, hardware and software image processing tools [6,7].

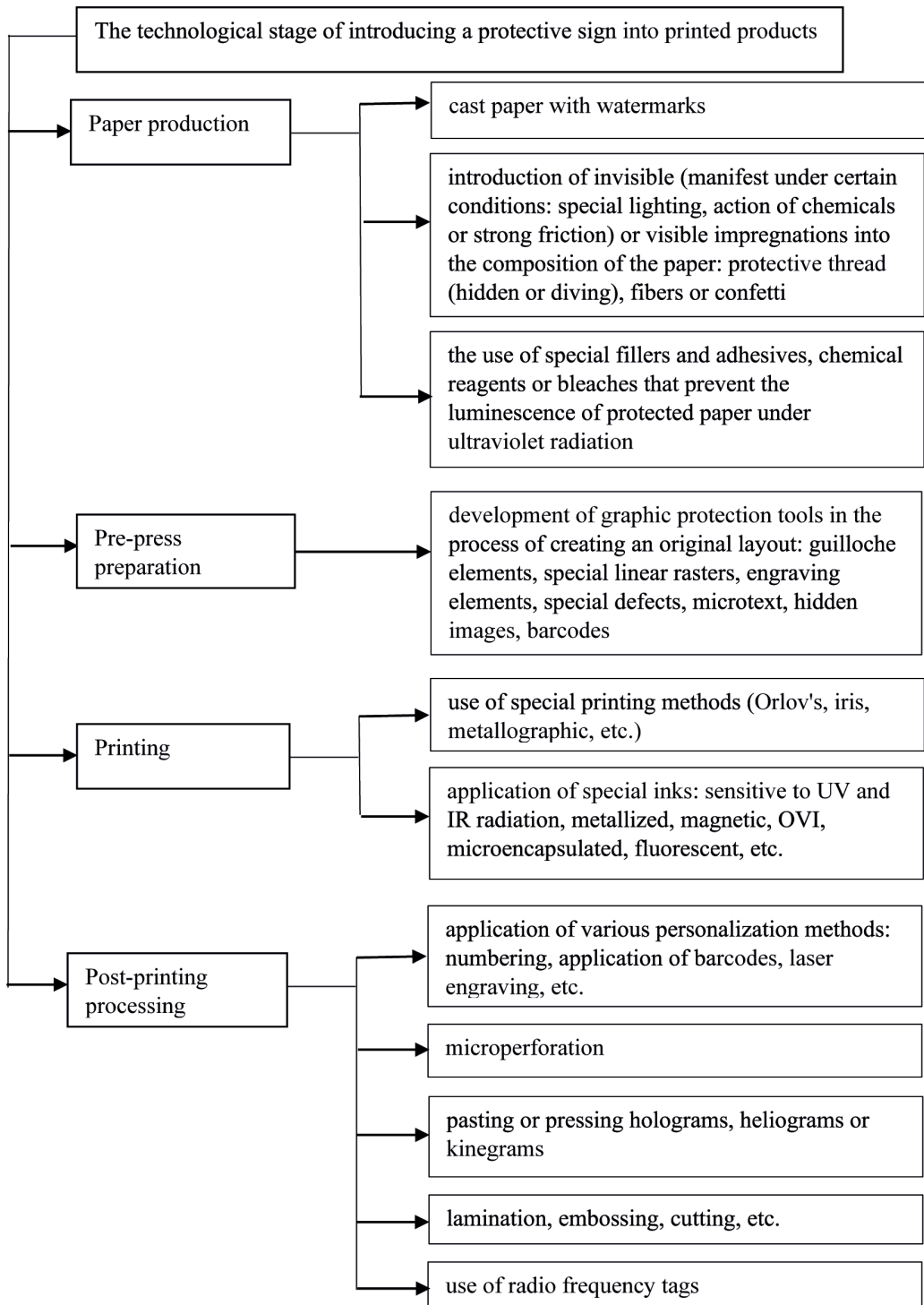


Fig. 1. Stages of the technological chain of protective signs introduction into printing and packaging products

Table 1

**Modern protection levels of printing and packaging products**

Protection level	Protection level name	Characteristic features
I	organoleptic	protection can be recognized by an unqualified user of products (banknotes, securities, packaging, etc.): the presence of numbering, watermarks, security threads, holograms and other signs that are detected and determined organoleptically
II	instrumental	involves the use of simpler detector equipment that determines, for example, the presence of fluorescent or metameric inks, etc
III	expert	protective signs are diagnosed by expert organizations and banks by conducting special studies on more complex equipment: determining the presence of special inks, hidden images, coded magnetic marks and other similar signs.

But for reliable protection, it is not enough to saturate printed products with protective signs, it is necessary to bring information about them to the interested user so that he can judge its authenticity within the limits of his competence. According to the results of surveys conducted by the Bank of the Netherlands regarding the awareness of the population of different countries of the world about the security features of their national currency, the average user remembers no more than four security features (Fig. 2). In addition, there is a positive correlation between the visual assessment of the banknote design and the knowledge of its security features [8].

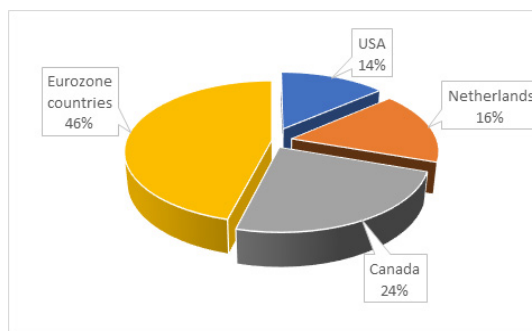


Fig. 2. Diagram of the state of population not awareness of different countries in the protective features of the national currency

Manufacturers of protected printing products understand that there are no absolute protections and no protective feature can be universal and guarantee protection against several foreseeable types of forgery, therefore, the manufacturer must use such a balanced set of protections that its reproduction for this type of product is at least economically unprofitable.

The industry of protected printing is developing at a rapid pace, manufacturers of protected printing and packaging products are constantly introducing a huge number of new developments to the market, which in the future can become new protective elements of banknotes and other printed products.

**The aim of the research.** The purpose of these studies was to carry out a detailed analysis of known modern protective signs of printing and packaging products, their classification and technological features; to highlight methodical approaches to identifying the problem of ensuring a high level of security of printed products by establishing cause-and-effect relationships and finding a number of effective solutions.

**Presentation of the main research material.** Ishikawa's diagram was used to study the cause-and-effect relationships between parameters and consequences in the process of obtaining a high-quality protected printing product, which makes it possible to identify the key relationships between various factors and to better understand the researched process (Fig. 3). In general, it can be said that the main factors affecting the quality of the protected product are the use of modern equipment, materials and the latest technological developments.

Thus, traditional technologies of printed products protection usually include:

- *protective elements introduced into the paper during its production:*
  - watermarks (one-, two-tone, and multi-tone) — an image inside the paper that occurs due to the uneven density of the paper in different areas during its production and which is visible only through the light. Dark areas are a local increase in the density of fiber distribution on a sheet of paper, and light areas are a decrease;
  - protective fibers are thin multi-colored hairs inserted into the surface layer of paper during its manufacture. These can be of different nature (natural and synthetic) and have different properties in different optical ranges of the spectrum;
  - protective threads are, as a rule, polymer strips of different widths. A distinction is made between hidden (completely inserted into the thickness of the paper) and diving (emerging on the surface of the paper in steps of about 1 cm) protective threads;
- *images made with special materials, printing and post-printing technologies:*
  - metallographic printing provides a characteristic saturated color and glossy shine of imprints, clarity of lines of guilloche elements and a strong relief, which is easily recognized by touch;
  - iris printing is characterized by smooth transitions of colors, which are difficult to reproduce even with modern means of digital printing;
  - Orlov's printing allows to get a sharp change of several different colors on the image without transition zones. This feature is practically impossible to reproduce either with modern digital printing methods or general printing methods;
  - images made with Optically Variable Inks (OVI) and iridescent inks of various shades with a characteristic pearly shine;
  - various types of hidden images (kip effect, etc.), which are revealed when changing the viewing angle of the document surface;
  - MVC (Moire Variable Color) — a hidden moiré pattern that appears as a series of colored iridescent bands when viewed at an angle to the plane of the banknote.

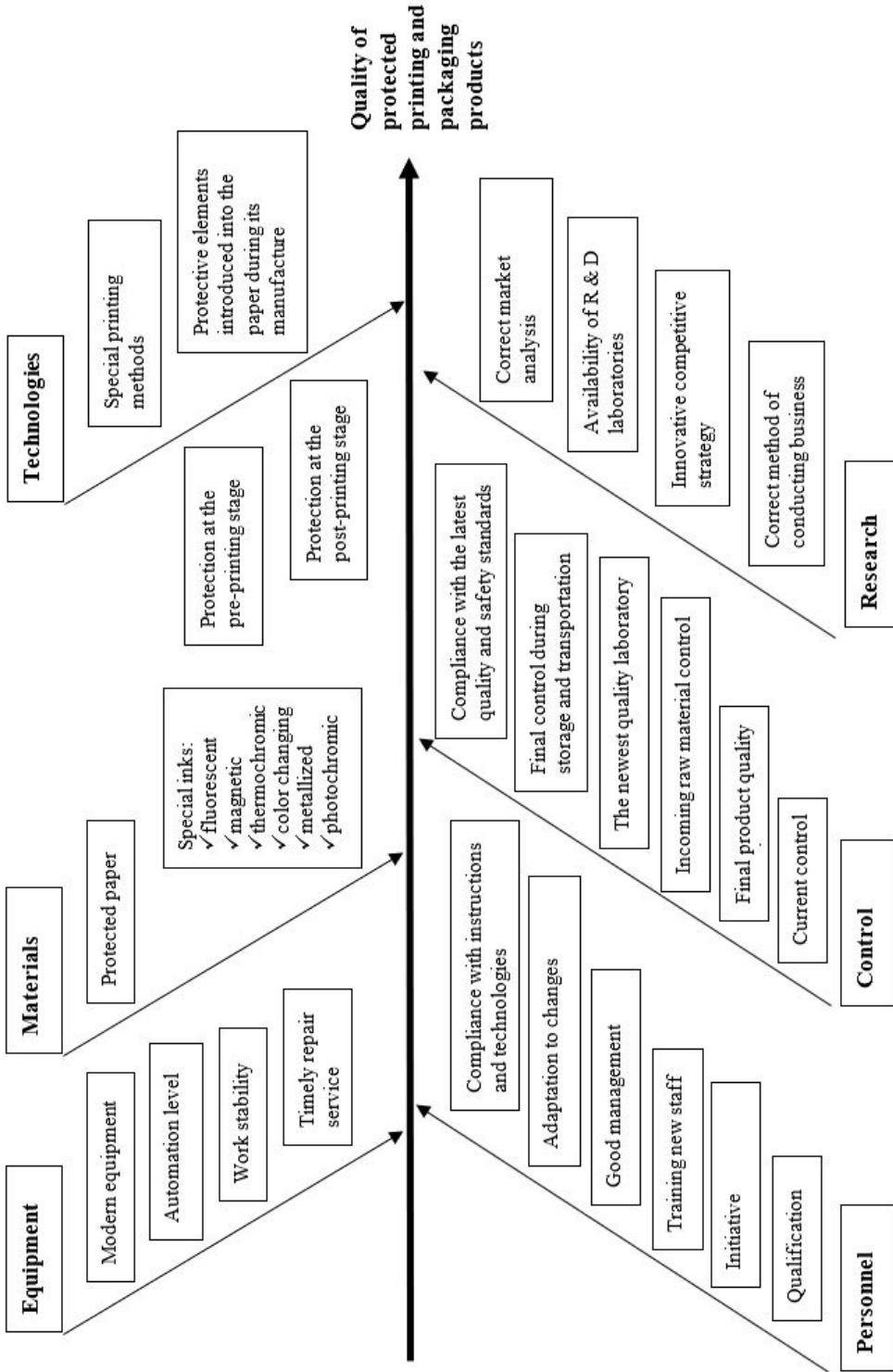


Fig. 3. Ishikawa diagram of the key indicator "Quality of protected printing and packaging products"

- holograms, kinegrams, heliograms are metallized films glued or pressed to a protected document with iridescent colors and changing graphic plots. In connection with the active development of digital technologies, the production of holograms has become available to a wide range of manufacturers in recent years, because of this, the protective properties of this element are gradually decreasing.
- microperforation — the protective effect of this technology is based on the fact that an attempt to imitate laser microperforation by mechanical punctures with thin needles is easily detected, as it inevitably leads to the appearance of almost irresistible bulges of paper in the places of the puncture.

In recent years, a number of new developments have been added to these traditional public security elements, which have come to be used to protect certain types of printing and packaging products. Among them, it is necessary to highlight the technological development MOTION™ of the American company Crane & Co., Inc. with premium safety function, which is made as a system of microlenses applied to microimages. The image under the lens is actually smaller than any microprint, but is visually magnified hundreds of times thanks to the existing micro-optical matrix of lenses, and when the banknote is tilted, the effect of smooth movement of the image is created. The images move perpendicular to the direction of the tilt, and it is easy to see in any lighting. An evolutionary solution to the MOTION mark was the development of the MOTION Switch, which allows to create an exciting visual effect of movement from two images. Thus, the MOTION element allows to combine protected printing, micro-optics and a substrate to provide a high level of protection for printed products [9].

Another protective feature with a similar effect was developed on the basis of micro-optical technologies. This is MOVE® (Micro Oriented Variable Effect) from the famous company Giesecke & Devrient, which provides dynamic, multi-colored and individual effects without the use of lenticular or holographic film with perfect integration into packaging products, because MOVE™ cannot be removed from the packaging without destroying it [10].

A barrier against counterfeiters was Louisenthal's development called Magic™, which serves as a simple authentication test for the general public: the detection of the movement of a three-dimensional object when the banknote is tilted due to the magnification of the microstructure by micro-optical lenses [11].

Over the past few years, the direction of using machine-readable signs has been actively developing in the production of protected printing and packaging products. These include protective elements whose parameters are read by detectors of recognition and authentication devices. At the same time, existing control devices are being improved and new ones are being created, which are necessary for checking machine-readable signs. One example of the latest high-tech machine-readable features is a marker developed by SunChemical Security, which is introduced into ink to give it unique spectral characteristics. The detector identifies the signal as correct only if the emission spectrum profile and its intensity levels coincide with the reference ones. In addition, the company offers a wide range of innovative inks with different protective properties: the Helio<sup>NOTE</sup>, HELIO<sup>SEC</sup>, Helio<sup>MARK</sup> and Helio<sup>ID</sup> series, which have visible effects such as color change,

hidden functions (Infrared ASPECT series), or special forensic properties to protect banknotes at all levels [12].

The Swiss company SICPA also offers a full range of globally proven high-quality security inks (tactile, color-changing, with optical effects such as OVI® and SPARK®, fluorescent, etc.) and solutions for different levels of authentication by automated systems and devices [13].

The task of instrument recognition of the authenticity of printed products is complicated by the fact that a specific security feature requires certain appropriate detector equipment, focused only on its recognition. The development of such narrow-profile devices, which must necessarily have a specially created metrology and certification system, is extremely costly and time-consuming.

**Conclusions.** The problem of protecting goods from counterfeiting is becoming more and more relevant every day, because today there is practically no area in which it is not possible to encounter falsification of products. And the range of printing products that require protection against counterfeiting is steadily growing. Therefore, the methods of protected printing are beginning to be widely used in those industries in which they were not used before: packaging, various quality certificates, passports for technical products, etc. Such dynamic development of the industry inevitably causes the emergence of new materials, equipment and technologies for the protection of printing and packaging products. Therefore, conducting a detailed analysis of known traditional protective elements and the latest developments in the field of protected printing for the purpose of their systematization and classification is quite relevant.

The proposed methodical approaches make it possible to analyse the existing problem, to look at it from different points of view and to find non-standard and most appropriate solutions. Having constructed the Ishikawa diagram with the problem of the quality of protected printing and packaging products as the basis, we can see that such factors as the availability of modern equipment, quality control at all stages of the technological process of manufacturing such products, high level of personnel qualification, the use of quality materials and the latest technological developments lead to it. But it is worth noting that choosing only one option to solve the problem is impractical. It is important to understand that only a systematic and consistent approach to the problem of ensuring a high level of security of printed products will give the maximum result.

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## АНАЛІЗ СУЧАСНИХ ЗАХИСНИХ ОЗНАК ПОЛІГРАФІЧНОЇ ТА ПАКУВАЛЬНОЇ ПРОДУКЦІЇ

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*Запобігання фальсифікації та підробці поліграфічної та пакувальної продукції реалізується з високим ступенем успішності завдяки використанню традиційних, сучасних та новітніх методів захищеної поліграфії, які охоплюють весь технологічний цикл виробництва такої продукції – від процесу виготовлення паперу до стадій післядрукарської обробки та оздоблення. Використання специфічних технологій виготовлення паперу зі спеціальними добавками, особливих технологій та стилів графічного оформлення, спеціальних видів друку та післядрукарської обробки, голографічних (приклеїні або припресовані кінеграми та голограми) та інформаційних (вбудовувані чіпи, RFID-мітки) технологій, спеціального устаткування та матеріалів спрямоване на ускладнення можливості копіювання оригінального друкованого продукту не тільки за допомогою традиційних технологічних прийомів загальної поліграфії, але особливо й з використанням сучасних цифрових способів репродукування, оскільки, як відомо, галузь захищеного друку за останні десятиліття зазнала значних змін, пов'язаних із технологічною складністю та дедалі зростаючими проблемами цифрової епохи. Детальний огляд цих специфічних технологій і становить основне завдання проведених аналітичних досліджень.*

*Як свідчить практика, у більшості підробок захисні елементи не відтворюються, а лише імітуються з використанням інших спрощених методик, якими останнім часом дедалі частіше є цифрові технології. За останні десятиріччя поліграфічна галузь зазнала кардинальних змін завдяки застосуванню нових технологій і матеріалів, особливо в секторі pre- та post print обробки, і продовжує постійно змінюватись, демонструючи у такий спосіб динамічний розвиток галузі.*

**Ключові слова:** захисні ознаки, захищена поліграфія, фальсифікація, поліграфічна продукція, папір, водяний знак, орловський друк, ірисовий друк, металографія.

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