

MECHANICAL ENGINEERING

FINISHING METHODS FOR PACKAGING PRODUCTS

M.E. Khasanova¹, H.A. Babakhanova¹, D.I. Abdirakhmanova¹, I.G. Gromyko²

¹Tashkent Institute of Textile and Light Industry
Shohjaxon st., 5 100100, Tashkent, Uzbekistan

²Belarusian State Technological University,
Sverdlova st., 13^a, 220006, Minsk, Belarus

Abstract: *The article provides information about enhancing the competitiveness of a product on the market by means of surface treatment techniques and methods of creating a unique design which is one of the final processes in the preparation of packaging products. Packaging created using innovative ideas is a very important factor for expensive products. These include: cosmetics boxes as well as high-end packaging. Exclusive decoration of the packaging of such products serves to show the quality of the product and distinguish it from counterfeit products. Decorative and exclusive coatings are widely used for these processes. One type of finish is varnishing. This method protects products from external influences and helps to improve their appearance. The lacquering method gives a glossy effect when using UV-glossy varnishes and a metallic imitation when printing with metallic varnishes. For the production of multilayer packaging materials for liquid foodstuffs on various substrates, extrusion lamination is used, which protects against external influences and gives a glossy effect that enhances the product's appearance. Hot stamping with aluminium foil is proven to be the most common type of finish, due to the possibility of obtaining different textures and types of aluminium foil. The application of fine metallic powder only on smooth materials belongs to the bronzing process and is the most economical and profitable option in comparison with hot stamping with aluminium foil and printing with metallic inks. It is stated that twice as much effort is required to do hot stamping. The blanket process requires 4 times as much force than aluminium foil embossing. It follows that when choosing the type of finishing in order obtaining indelible and clear prints which are resistant to mechanical influences and whose aesthetics ensure recognisability of the corporate style for the packaging products, the labour input and cost of the process must be taken into consideration.*

Keywords: *Finishing techniques, packaging products, lacquering, laminating, foil stamping, bronzing, relief stamping*

INTRODUCTION. Nowadays, the range of packaging products is expanding, therefore, many manufacturing companies are creating packaging with unique designs using different printing materials to increase the originality of the packaging.

When designing packaging, it is important to respect not only the corporate identity but also a company's manner of 'holding its own' in the market. As product technology advances, new types of packaging appear. Packaging as a form of advertising is the most effective because the customer can see it at the point of sale at the very moment when he or she makes the final decision to purchase the product in question. Today, almost every product is packaged, and when a customer comes to a shop, the first thing he sees is the packaging. Any product will attract attention if it is packaged originally [1].

Design is important in the development of packaging. The size, shape, material, colour, text and positioning of the trademark have a direct impact on customers, creating a certain attitude

towards the product and the manufacturer [2]. To add to the originality of the product, packaging products are subjected to various finishing methods after printing, the purposes of which are shown in Figure 1.

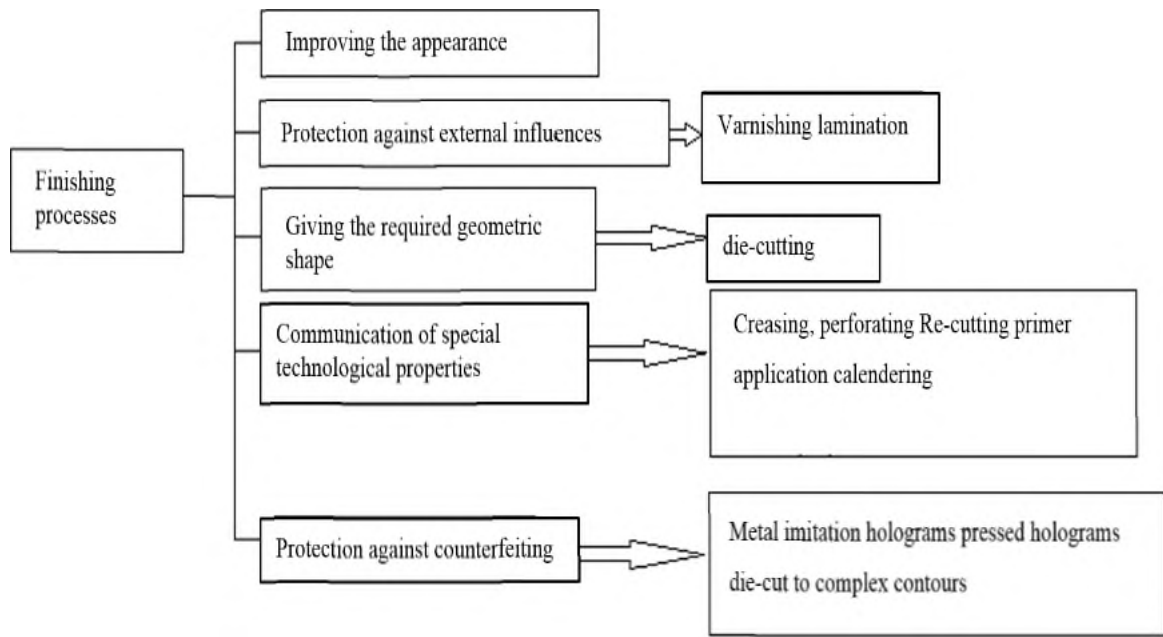


Fig 1. Assignment of finishing processes

Finishing processes are the last stage of product preparation. The main purpose of this process is to give an aesthetic appearance to the surface of the printed product.

MATERIALS AND METHODS. Reviewing and correctly selecting a finishing method for packaging products, taking into account the classification of the methods, the operations to be performed, the labour input and the cost of production is the aim of this work. Depending on the purpose of the finishing processes, different types of finishes are used [3]. It has been proven that the following finishes (Table 1) are used to improve the appearance of the package, which is one of the main purposes of the finishing operations (Fig. 1), in order to attract the attention of buyers to the product.

Table 1

Types of finishes to improve the appearance of the packaging

Type of finish	Manufacturing methods and technology
Glossy effect	
Varnishing	Filling in micro and macro surface irregularities with UV gloss lacquers
Excruciating lamination	Applying polymer melt
Laminating	Gluing a transparent plastic film to the surface of the material to be printed
Calendering	Mechanical smoothing of the surface of the printed material with a heated calender
Matte effect	
Varnishing	Filling in micro and macro irregularities with matt lacquer
Laminating	Laminating with matt foil

Imitation metal coating	
Aluminium foil embossing	Vacuum spraying a layer of fine metal particles onto the label surface
Bronzing	Spraying of aluminium powder on the adhesive layer previously applied to the material to be sealed
Varnishing with metallic lacquers	Metallised varnishes and paints are dispersions containing metallic pigments and have a high covering power
Printing with metallic lacquers	
Optical surface properties (holographic effect, luminescence, pearlescent sheen)	
Holographic effect	A method of obtaining a three-dimensional image of an object based on wave interference. Holograms are 2D (flat), 2D/3D (containing several different levels that create a volume image effect), 3D (three-dimensional images of objects). Holograms are applied by means of a pressing method.
Luminescent effect	Luminescence (from Latin <i>luminis</i> - light) is the luminescence of substances under certain conditions in excess of their thermal radiation at a given temperature. Luminescent varnishes and paints that contain special pigments with the property of glowing under the influence of radiation of a certain part of the spectrum, most often UV light.
Mother-of-pearl gloss	The reflection of light from special pigment particles. The reflection of light by the mica plates is accompanied by an interference pattern, resulting in a specific iridescent sheen of the coating. The lacquering with mother-of-pearl lacquers is used.

RESULTS AND DISCUSSION. Packaging created using innovative ideas is a very important factor for high-end products. These are: cosmetics boxes as well as high-end packaging. Exclusive decoration of the packaging of such goods serves to show the quality of the product and distinguish it from counterfeit products. Exclusive ornamental packaging for these products guarantees the quality of the product and protects against counterfeiting. Often, luxury goods cannot be separated from their packaging - the combination is so seamless.

As shown in Table 1, lacquering protects products from external influences and enhances their appearance by giving a glossy effect when using glossy UV lacquers, an imitation of a metallic coating when printing with metallic lacquers. It also protects printed materials from abrasion and scratching, increases image contrast and enhances surface gloss.

Four types of varnishes are used in the printing industry for finishing: water-based (WD), UV-curing, volatile solvent-based, vegetable oil-based varnishes. Numerous scientific works have been devoted to water-dispersible and UV-curing varnishes and to the determination of their application field in order to obtain efficient results. In [4] the influence of addition of oil varnish on optical properties of triad offset inks: spectral characteristics, coloristic characteristics and gloss level of prints was investigated. It has been found out that the addition of 20% of oil varnish before printing in black, yellow and magenta inks leads to increase of gloss level of prints and provides for reduction of prime cost by 38% in comparison with a traditional varnish coating.

The author of [5] studied the influence of water-based and UV-curing varnishes on the gloss values of offset and coated paper, as one of the main characteristics of the optical

properties of paper. Analyses have shown that water-dispersion lacquers do not affect the colour performance of the print, as they are colourless and have a high transparency. The UV curing varnish applied after the water-based varnish increases the gloss value by almost 8 times.

In the production of multilayer packaging materials for packaging liquid foodstuffs on various substrates, extrusion lamination is used, which protects products from external influences and gives a glossy effect that enhances their appearance. Hot foil embossing is proven to be the most common type of finish, due to the possibility of obtaining different textures and types of foil. Finishing processes in terms of technology are divided into two groups (Fig. 2).

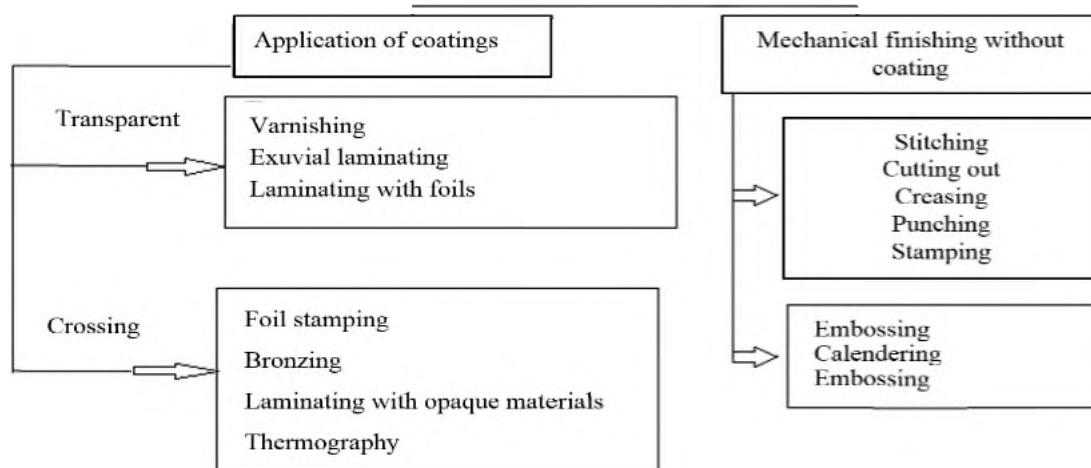


Fig 2. Classification of finishing processes

As can be seen in Fig. 2, lacquering, by forming transparent coatings, improves the appearance of packaging products, performs protective and barrier functions, including special technological functions, and is a cheaper method of finishing than laminating.

Laminating with adhesive is a fast process and strong bonding, the surface of the printed material is bonded together, then the substrate and the coating are bonded together, thus creating a multi-layer material. In the case of adhesive-free laminating the films used consist of a substrate and a thermoplastic layer, this material performs an adhesion function by melting to fill surface irregularities in the base material, so that the substrate and coating are bonded together.

In work [6] influence of heterogeneity of structure of paper surface and technological parameter of speed of process of wet laminating in the course of manufacture of cardboard package was investigated. It was found that with heterogeneous paper structures the processes connected with capillary absorption and filtering of glue into the pore space of the paper, when the paper sheet leaves the bonding zone in the laminating process [7-8].

Embossing was previously used mainly for bookbinding, but is now also used for paperbacks and sheet-fed products. In addition, it is also very popular for use in container and packaging production because it is more reflective than metallic inks and also prevents product counterfeiting [9].

With aluminium foil embossing, the fine metal particles are transferred from the aluminium foil backing to the material to be printed due to the high adhesive power of the adhesive. The main advantage of cold stamping compared to hot stamping is the absence of costly stamps, the use of which leads to an increase in the cost of printed matter in small print runs. The disadvantages of this type of embossing are the complexity of the technology and high requirements for the quality of the surface of the printed material. Authors of works [10-14] state that hot stamping with aluminium foil is the most common type of finishing due to the

possibility of obtaining different textures and types of aluminium foil. Aluminium foil embossing is an environmentally friendly process without the use of volatile organic substances [15]. This type of embossing has its disadvantages, the main one being the selection of embossing modes on new types of printed materials and new foil series. As a result of scientific research recommendations for improving embossing with aluminium foil on papers or paperboard with high roughness values have been elaborated. When embossing with thin adhesive layer (1 μm) of aluminium foil the optimum mode is the temperature - from 100° to 130° C, the embossing force - 17-18 kN; and with thick adhesive layer of aluminium foil (1.6 μm) the optimum mode is the temperature - from 100° to 130° C, the embossing force - 13-15 kN. It is stated that with increasing the drying time the hiding power increases from 65.4 % to 100 % and the image effect of the prints improves. The optimum drying time for the priming coat to achieve a high-quality impression is 6 seconds. High-quality prints with 100 % coverage and an admissible level of aluminium foil projection behind the printing elements are obtained on paper with an adhesive mass of 33-40 g/m^2 . The adhesive viscosity for this is 160 SP.

Bronzing is the application of a fine metallic powder only on smooth sealing materials, as it is difficult to remove the powder from the surface of a rough sealing material. The first powders for "bronzing" were produced from copper, i.e. genuine bronze. The shade of "gold" depends on the ratio of the two metals: the more pinkish-red copper in the alloy, the more reddish the shade is. This method is the most economical and advantageous option compared to hot stamping with aluminium foil and printing with metallic inks [16].

The thermography process involves applying a metallised polymer powder to an adhesive layer. After the powder is thermally bonded to the surface of the material to be printed, an embossed image is formed, characterised by a high gloss effect and resistance to moisture. For a metallic effect, powder with metallic pigments (gold or silver) is used in printing. Glitter thermal lift-glitters (small glitters) are mixed with the powder and applied to a clear or coloured paint. The result is a convex image with a glossy effect.

Embossing, which is part of the mechanical finishing process, is the result of the interaction between the stamp and the die (counter-stamp). The die is an embossed copy of the stamp made from an elastic material. The exact alignment of the stamp and die is essential to achieve a quality embossing result.

The following operations are carried out during shaping, shaping and forming of the structural elements of packaging products:

- die-cutting the contour of the packaging product to give the required shape;
- creasing the fold lines on the rear of packaging products as extruded grooves;
- perforation is the die-cutting of a chain of small holes to facilitate the folding of packaging products;
- notching-making an incision in the surface of the material at the bonding points of the packaging parts in order to increase the strength of the glue bond.

Whereas calendering is used to smooth and gloss the surface of the material to be printed, graining is used to change the texture or to create relief on the surface of the material to be printed in calendars where a relief image is created on one cylinder and a counter-relief image is created on the other.

The inventor of the spectacular and aesthetic used for high-end packaging is William Congreve (1772-1828), a resident of England - the "father" of missile weapons. The developed convex embossing technique produces minute details of embossed patterns and lettering on various types of surfaces: cardboard or paper (plain or design); plastic, or nitropolyamide-coated materials; natural or synthetic leather; linen or leatherette.

Dimensional, textured images, inscriptions, logos on boxes, bags, cases allow you to stand out from the competition and make your packaging:

- exclusive, memorable design that compares favourably with flat, one-dimensional images;
- the image component emphasises the status and respectability of the manufacturer, the brand and the brand;
- an effective tool to advertise, promote, sell a product or commodity.

Statistics confirm that aluminium foil packaging has a market share over plain packaging products. According to statistics from Achilles Group, demand for such packaging products increased by 45 % between 2012 and 2014. Convex technology is ordered 30% more and foil stamping 24% more. These packs are for chocolates, cosmetics, high-end spirits and merchandise. Fig. 3 shows packaging products made using hot stamping with aluminium foil and printing with metallic inks.



Fig 3. Hot stamping with aluminium foil and printing with metallised ink

It is proven that gradually metallised packaging, despite its high cost, is already popular in the packaging market. Producers and customers appreciate the effectiveness of this type of packaging product which attracts bright colour and a pleasant glossy effect. Additional finishing processes are needed to give special effects to the packaging products. These are hot or cold stamping methods with aluminium foil, hot stamping with aluminium foil as well as bronzing.

It is found that twice as much force is required to emboss with aluminium foil. With blind embossing, 4 times more force is required than with aluminium foil embossing. This means that when selecting the type of finish in order to achieve indelible and clear prints which are resistant to mechanical influences and whose aesthetics ensure a recognisable corporate identity for the packaging product, the labour intensity of the process must be taken into consideration.

CONCLUSION. In the production of packaging products the methods of metallisation are hot and cold stamping with aluminium foil, bronzing, lacquering and printing with metallised inks. In either method, the most inexpensive type of metallisation can make the packaging more effective and attractive, and the product's ability to withstand intense competition in the marketplace. When selecting the type of finish in order to obtain indelible and clear prints that are resistant to mechanical influences, the aesthetics of which provide brand identity recognition for packaging products, the labour intensity of the process must be taken into account.

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BLOCK DIAGRAM AND MATHEMATICAL MODEL OF AN INVARIANT SYSTEM

B. Kholhodjaev, B. Kuralov, K. Daminov

Tashkent State Technical University,
University st., 2 100095, Tashkent, Uzbekistan

Abstract: Recently, one of the modern directions of the theory of control, the theory of construction of state monitors of linear and nonlinear dynamic systems has significantly developed [2, 4, 10, 15]. The approach based on the expansion of the system dynamics based on the information of the input and output values due to the construction of a special dynamic system observer whose state converges quickly enough to the initial state of the system over time and the function of the state observer on the output, and the input of the initial system output variables and dynamic feedback can be applied spread out. In this case, the state observer at an arbitrary instant of time is considered as an estimate of the state of the system at a given instant of time [4]. Constructing an observer for a dynamic system is one of the ways to obtain an