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METALLIC PIGMENTS AND SOME ASPECTS OF THEIR USE IN PRINTING INDUSTRY

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One of the effective ways to design products is currently metallization. Owing to extraordinary bright effects that can be obtained using different combinations of metallization, this method is effectively used in the manufacture of various products advertising printing, labels and packing. "Metallization" effect of products scrutinizes manufacturing companies, which in turn tend to increase consumer demand for goods in this category.

There are three methods of manufacturing metallic pigments: vacuum deposition method, a traditional method (mechanical grinding), processing metal scrap. Given the increasing consumer demand for metalized products, research questions of technological possibilities of using such materials in economic indicators are relevant and very important for modern printing companies. The introduction of metallic pigments from the shaving waste opens a new stage in the evolution of production, safer in terms of ecology. The present analysis of economic and organizational features of the use metal waste emphasizes the usefulness of latest in modern printing processes.

Keywords: *metallic pigments, shaving waste, powder for bronzing, the life cycle, metallic ink, container and packaging materials, printing products, processing packages, technological system.*

Problem statement. Metallized surfaces have a number of valuable properties that can be used for different functional purposes. They are antifrictional, that is, they have a low coefficient of friction; one of the properties of metallized surfaces is that they are conductor and abrasive. Metallized coating makes products more durable, resistant to damage, protects against moisture and sunlight. One of the simplest and cheaper methods of achieving metallization effects is printing with metallized inks. At the same time, metallized inks are added to ordinary inks that can convey the color of gold, bronze and silver [1-7].

In the manufacture of metallized inks, metallic pigments obtained by mechanical grinding of metals and their alloys are used. Aluminium pigments are used to imitate silver, aluminium pigments are used to imitate gold and bronze, which are tinted with transparent colored varnish, as well as copper or brass pigments.

The presence of metallic particles of aluminium or copper powders in conventional printing inks changes their physicochemical properties. The main factor determining their kinetic resistance is the degree of sedimentation of colloidal solutions. The effect on the sedimentation resistance of the system depends on the concentration and dispersion of the particles of the metal filler [8].

Economic aspects of the use of metal pigments from waste. In the current conditions of the development of printing products, an important economic and ecological lever is the use of metal pigments from chip waste, which is confirmed by the data shown in the diagram (Fig. 1).

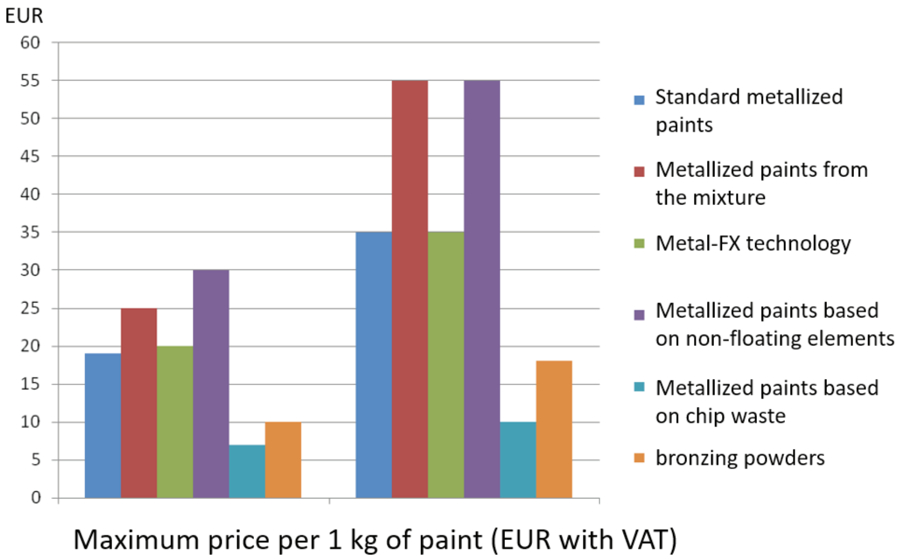

Fig. 1. Diagram comparing technical and economic indicators of various metallization technologies

As an alternative to metallized inks, bronzing technology is used in the finishing of labels and packaging products in the operational and protective printing [3]. The packaging design using metallized ink gives it a higher status, and ennobles an inexpensive range of printing products. Due to the fact that the particle size of the bronzing powder is much larger than in pigments of conventional printing inks, the image on the sealed surface is formed bright, original, with the effect of a three-dimensional figure. Despite the amount of the dispersion of the bronze powder, it is possible to reproduce even thin lines and patterns, which allows you to actively use this method for various design solutions. This method is quite cheap and effective, which makes bronzing very popular in the market of printing services. A unique bright effect is caused by the size of bronzing powder (12-14 μm), while in offset it is (3-5 μm), and distribution of powder on the surface of the primer.

Comparing the prices of powders and waste and taking into account the cost of metallurgical processing, it is possible to predict the economic efficiency of powder production from waste. The results of the projected accounts are given to one tone of powder products for the various metal wastes presented in Table 1 [9].

Table 1

The results of the projected accounts given to one ton of powder products for various metal wastes

Metal or alloy	Waste price, $/ton	Recycling cost, $/ton	Powder cost, $/ton	Powder price, $/ton	Expected profit, $/ton
Aluminium	990	400	1390	4070	2680
Copper	1640	450	2090	3600	1610
Cast iron (chips)	20	300	320	650	330
Stainless steel	475	900	1375	4180	2805
High-speed steel	390	1500	1890	6000	4110
Titanium (chips)	900	2500	3400	20000	16600
Hard alloys	4500	2000	6500	16000	9500

The analysis of tabular data indicates a high economic efficiency of powder production from metal waste. A number of business projects have been worked out on the creation of production of powders from copper shavings and lump wastes of solid alloys, as well as the production of pulverized powders from titanium, tool steel.

Even when it comes to recycling used printing products, metallized pigments in ink have their advantages. Packaging processing is quite profitable not only from an environmental point of view, but also with an economical for the manufacturer itself, as due to its sufficiently long-lasting stability pigment does not lose its main properties, and so it can be reused in the production of printing inks. Therefore, the priority of recycling (metal reuse) is important for optimizing the modern production of metallized inks.

Organizational aspects of the use of pigments in the manufacture of packaging. As noted above, one way of recycling metal chips is through their use in the printing industry as pigments for printing inks, which are widely used in the packaging industry. Usually, glass, plastic, polymer film, various metals are printed material in the manufacture of packages. The most important feature of the group of these materials is the relatively short life cycle (from the manufacturing of packages to their removal before the main product is put into use). The life cycle of packaging materials is directly dependent on the liquidity of the main product and is measured by the time taken to pack the main product (t_1) and the time taken to store the main product in stock during the pre-sale period (t_2) the time taken to transport the product to the place of use (t_3) and the period of time before the main product is unpacked from the consumer (t_4) [10].

$$T^{жц=\sum_{i=1}^{4} ti} \quad (1)$$

Figure 2 shows the distribution of the costs and efficiencies of each Life Cycle Stage (LCS) of a technological system regardless of its purpose. The theoretical and methodological value of the HVP accounting of the technological system offers great real possibilities for improving the management of the set of stages formed in a single organizational model.

Through a single LCS system, there are viable ways to improve the management of the national economy, in particular by redistributing the length of the cycle stages. Research, design, technology, production and disposal phases need to be shortened through cycle optimization and longer operation.

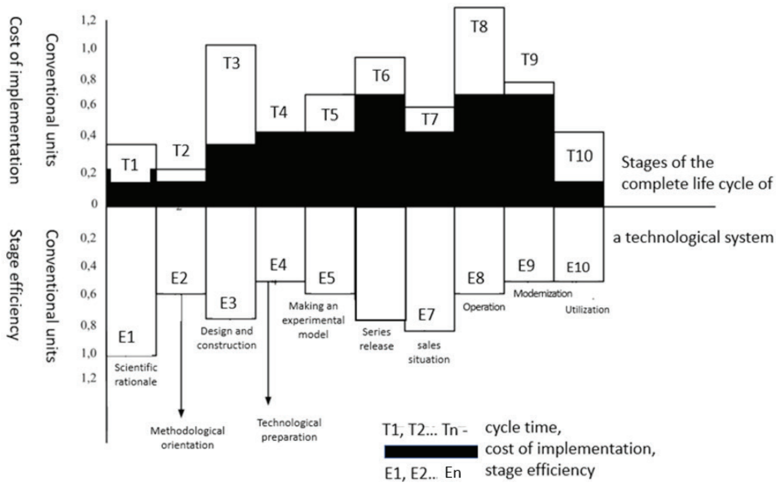

Fig. 2. Qualitative Diagram of Milestones of the Metal Waste Recovery Process System Stages (in Standard Units)

Figure 3 shows a block diagram of the criteria for joining and compatibility of individual stages of the LCS technological system (TS) for metal waste disposal. Presenting the stages of the LCS as an integrating methodological tool ensures the stability of scientific creativity and management from the unified standpoint of the newly created organizational system. New organizational system (integrity of the LCS stage) provides a single continuous process and the ability at each stage to achieve maximum social economic efficiency at a fixed cost or set efficiency with minimal resource-efficient investments. However, by now in the theory and practice of creation, in particular metallurgical equipment, at best optimized only some stages of incomplete «life» machine cycle. At the same time, it is known that the step-by-step optimization of the technological system as a whole, the lack of a systematic approach to the analysis of stages of technological machines leads to big mistakes, especially in calculating their cost, as well as forecasting the timing of physical and obsolescence. At the same time, it is known that the step-by-step optimization of the technological system as a whole, the lack of a systematic approach to the analysis of the stages of the life cycle of technological machines leads to big errors, especially when calculating their cost, as well as predicting the terms of physical and moral wear.

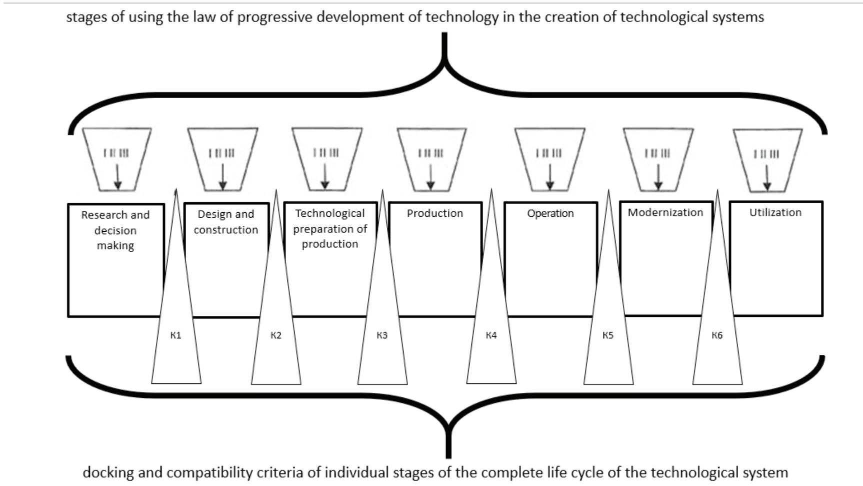

Fig. 3. Block diagram of quality management in the formation of stages of the LCS technological system as a whole

The authors would like to draw attention to a significant contradiction in the fact that packaging materials are initially oriented to an increased consumption mechanism, but, unlike the main products, their useful life is less, the more effective they are (Fig.4).

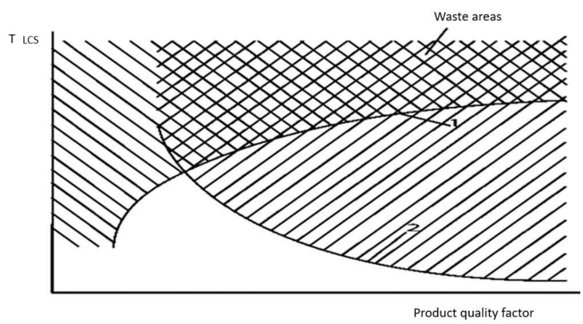

Fig. 4. The influence of product quality on the duration of its life cycle: 1 – for main products; 2 – for packaging materials

Since the manufacturer is interested in the product having a «commercial appearance», was not damaged in the pre-sale period, was sold faster and at a higher price, he sets the task — to provide packaging materials of high quality (even if this requires additional labour), pre-emptively or at least without lowering the cost of the main product, and as a result contribute to its liquidity. However, even the high liquidity of the product itself is not a guarantee of an ideal condition for the manufacturer $t_2 \to 0$. The main problem in terms of waste for this type of product is that the circumstances of the nature of this phenomenon are ideal for the implementation of previously planned mechanisms of waste generation. They are built on terms advantageous to the main manufacturer, but not favourable to the environment.

As a result, one has in waste a large amount (both by mass and by nomenclature) of packaging materials. Polymeric materials (packs, packaging of all kinds, rotating materials, fixtures, supporting elements, necessary for transportation, forming and protective materials, etc.) are of particular interest. Typically, these polymeric materials, in large quantities and with a short life span in the waste, have a very long natural decay period, which means that they are constantly accumulated and stored sometimes for decades without any processing.

However, packaging processing is not only profitable from an environmental point of view, but also economical for the manufacturer itself, as due to its sufficiently long-lasting resistance, the metal pigment does not lose its main properties, and so it can be reused in the production of printing inks. This stability is ensured precisely by the fact that the pigment is formed from metal chips and, due to its preliminary processing and introduction into the dispersion medium of the printing ink, it can adhere well to the printed material and exfoliate from it without being damaged during processing. Figure 5 shows the algorithm for recycling metal raw materials from the processing of used packaging to the reuse of metal pigments in printing inks.

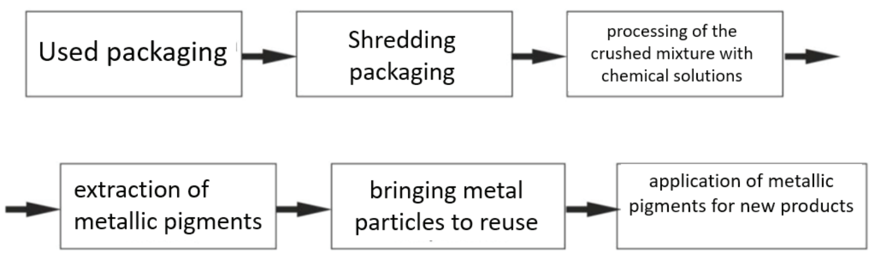

Fig. 5. Circuit diagram of metal pigments

Thus, metal waste in the form of chips can be used in printing metal ink, which is very attractive for applying it to the package, and further metal particles when recycling packages can be restored for further operation [11-12].

Conclusions. Metal-plated inks can be used to produce printing products for various purposes, depending on production and consumption needs. Metallized gloss, which has many applications and opens up new opportunities in the manufacture and promotion of packaging materials is gaining popularity. A positive development is the economic aspect of the life cycle of metallized pigments. They are available at different levels for printing, and the introduction of recycled particle metal pigments opens a new phase in the evolution of production — a more environmentally friendly one. Due to sufficient long-term stability, the pigment does not lose its main properties, and therefore it can be reused in the production of printing inks.

СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

1. 3D printing of high -strength aluminium alloys / Martin J. H., Yahata B. D., Hundley J. M., Mayer J. A., Schaedler T. A., Pollock T. M. *Nature.* 2017. Vol. 549. Issue 7672. Pp. 365−369. doi: http://doi.org/10.1038nature23894.

2. Ishida Y., Nakagawa G., Asano T. Inkjet Printing of Nickel Nanosized Particles for Metal-Induced Crystallization of Amorphous Silicon. *Japanese Journal of Applied Physics*. 2007. 46 (9B). 6437–6443. doi: http://doi.org/10.1143/jjap.46.6437/
3. Babaei V., Hersch R. D. Color Reproduction of Metallic-Ink Images. *Journal of Imaging Science and Technology*. 2016. 60 (3). 305031–3050310. doi: http://doi.org/10.2352/j.imagingsci.technol.2016.60.3.030503.
4. Recent advances in inkjet printing synthesis of functional metal oxides / Liu X., Tarn T.-J., Huang F., Fan J. *Particuology*. 2015. 19. 1–13. doi: http://doi.org/10.1016/j.partic.2014.05.001.
5. 3D printing of high-strength aluminium alloys / Martin J. H., Yahata B. D., Hundley J. M., Mayer J. A., Schaedler T. A., Pollock T. M. *Nature*. 2017. 549 (7672). 365–369. doi: http://doi.org/10.1038/nature23894.
6. Zhang Y., Ye H., Liu H. Preparation and characterization of blue color aluminum pigments Al/SiO2/PB with double-layer structure. *Powder Technology*. 2012. 217. 614–618. doi: http://doi.org/10.1016/j.powtec.2011.11.035.
7. Kitsomboonloha R., Bera T., Dutta J. Direct Synthesis of Anisotropic Metal Particles by Ink Jet Printing Technique. *Advanced Materials Research*. 2008. 55-57. 585–588. doi: http://doi.org/10.4028/www.scientific.net/amr.55-57.585.
8. Ogura K. Technology for Powder Production and Evaluation of Powders. *Journal of the Japan Society of Powder and Powder Metallurgy*. 2006. 53 (4). 340. doi: http://doi.org/10.2497/jjspm.53.340.
9. Solid State Sintered 3-D Printing Component by Using Inkjet (Binder) Method / Frykholm R., Takeda Y., Andersson B.-G., Carlström R. *Journal of the Japan Society of Powder and Powder Metallurgy*. 2016. 63 (7). 421–426. doi: http://doi.org/10.2497/jjspm.63.421.
10. Kronberger R., Wienstroer V. 3-D printer FSS using printing filaments with enclosed metal particals. Progress in Electromagnetics Research Symposium-Fall (PIERS-FALL). Singapore, 2017. doi: http://doi.org/10.1109/piers-fall.2017.8293245.
11. Morozov A. S. Collective monographic series " European science" Chapter 1 "Resource-saving aspects in modern technologies" Book 7, part 3, October 2021, Pp. 8–31. Karfsrufie. DOI: 10.21893/2709-2313. 2021-07-03-015.
12. Morozov A. S. Feature of chip formation mechanism, morfological and structural properties of shaving and powder from aluminum bronze Modern engineering and innovating technologies. Issue № 18, part 1, December 2021, Pp. 6–12. DOI: 10.308902567-5273.2021-18-01-05.

REFERENCES

1. Martin, J. H., Yahata, B. D., Hundley, J. M., Mayer, J. A., Schaedler, T. A., & Pollock, T. M. (2017). 3D printing of high -strength aluminium alloys: Nature, 549, Issue 7672, 365–369. doi: http://doi.org/10.1038nature23894 (in English).
2. Ishida, Y., Nakagawa, G., & Asano, T. (2007). Inkjet Printing of Nickel Nanosized Particles for Metal-Induced Crystallization of Amorphous Silicon: Japanese Journal of Applied Physics, 46 (9B), 6437–6443. doi: http://doi.org/10.1143/jjap.46.6437/ (in English).
3. Babaei, V., & Hersch, R. D. (2016). Color Reproduction of Metallic-Ink Images: Journal of Imaging Science and Technology, 60 (3), 305031–3050310. doi: http://doi.org/10.2352/j.imagingsci.technol.2016.60.3.030503 (in English).

4. Liu, X., Tarn, T.-J., Huang, F., & Fan, J. (2015). Recent advances in inkjet printing synthesis of functional metal oxides: Particuology, 19, 1–13. doi: http://doi.org/10.1016/j.partic.2014.05.001 (in English).
5. Martin, J. H., Yahata, B. D., Hundley, J. M., Mayer, J. A., Schaedler, T. A., & Pollock, T. M. (2017). 3D printing of high-strength aluminium alloys: Nature, 549 (7672), 365–369. doi: http://doi.org/10.1038/nature23894 (in English).
6. Zhang, Y., Ye, H., & Liu, H. (2012). Preparation and characterization of blue color aluminum pigments Al/SiO2/PB with double-layer structure: Powder Technology, 217, 614–618. doi: http://doi.org/10.1016/j.powtec.2011.11.035 (in English).
7. Kitsomboonloha, R., Bera, T., & Dutta, J. (2008). Direct Synthesis of Anisotropic Metal Particles by Ink Jet Printing Technique: Advanced Materials Research, 55-57, 585–588. doi: http://doi.org/10.4028/www.scientific.net/amr.55-57.585 (in English).
8. Ogura, K. (2006). Technology for Powder Production and Evaluation of Powders: Journal of the Japan Society of Powder and Powder Metallurgy, 53 (4), 340. doi: http://doi.org/10.2497/jjspm.53.340 (in English).
9. Frykholm, R., Takeda, Y., Andersson, B.-G., & Carlström, R. (2016). Solid State Sintered 3-D Printing Component by Using Inkjet (Binder) Method: Journal of the Japan Society of Powder and Powder Metallurgy, 63 (7), 421–426. doi: http://doi.org/10.2497/jjspm.63.421 (in English).
10. Kronberger, R., & Wienstroer, V. (2017). 3-D printer FSS using printing filaments with enclosed metal particals. Progress in Electromagnetics Research Symposium-Fall (PIERS-FALL). Singapore. doi: http://doi.org/10.1109/piers-fall.2017.8293245 (in English).
11. Morozov, A. S. (October, 2021). Collective monographic series " European science" Chapter 1 "Resource-saving aspects in modern technologies" Book 7, part 3, 8–31. Karfsrufie. DOI: 10.21893/2709-2313. 2021-07-03-015 (in English).
12. Morozov, A. S. (December, 2021). Feature of chip formation mechanism, morfological and structural properties of shaving and powder from aluminum bronze Modern engineering and innovating technologies. Issue 18, part 1, 6–12. DOI: 10.308902567-5273.2021-18-01-05 (in English).

doi: 10.32403/1998-6912-2023-1-66-146-154

МЕТАЛЕВІ ПІГМЕНТИ ТА ДЕЯКІ АСПЕКТИ ЇХ ВИКОРИСТАННЯ В ПОЛІГРАФІЇ

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Одним з найефективніших способів декорування виробу на сьогодні є металізація. Завдяки неймовірно яскравим ефектам, які можна отримати за допомогою різних прийомів металізації, цей метод ефективно використовується при виготовленні різних виробів рекламної поліграфії, етикеток і упаковки. Ефект «металізації» продукції та його психологічні фактори впливу на вибір споживача досить ретельно досліджуються компаніями-виробниками, які в свою чергу прагнуть підвищити споживчий попит товару.

На сьогоднішній день існує три методи виготовлення металевих пігментів: метод вакуумної металізації, традиційний метод, переробка металевих відходів. Вдосконалення технологій відкриває металізованим фарбам нові перспективи, і зараз їх використовують не лише для традиційної упаковки , але й у високоякісних буклетах, рекламних матеріалах та продукції іміджевого характеру. Одне з останніх застосувань - як дизайн елементів захисту при виготовленні цінних паперів. Зважаючи на специфіку продукції, захист цінних паперів від підробок та фальсифікації займає чільне місце. Використання металізованих фарб для більшості елементів і способів захисту закладаються на стадії дизайну, вони дають гарантію неможливості точного відтворення друкованого зображення при фальсифікації, як за допомогою копіювальних пристроїв, так і друкарського типографського обладнання. Враховуючи збільшення споживчого попиту на металізовану продукцію, питання щодо дослідження технологій застосування подібних матеріалів на економічні показники є актуальним і важливим для сучасних поліграфічних компаній. Впровадження металевих пігментів із стружкових відходів відкриває новий етап в еволюції виробництва – більш безпечний з точки зору екології. Наданий аналіз економічних та організаційних особливостей використання металевих відходів підкреслює доцільність останніх в сучасних поліграфічних процесах.

Ключові слова: *металеві пігменти, стружкові відходи, бронзувальний порошок, період життєвого циклу, металізована фарба, тарно-пакувальні матеріали, поліграфічна продукція, переробка пакувань, технологічна система.*

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