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STUDY OF THE INFLUENCE OF THERMAL PLATES PROPERTIES ON THE QUALITY OF OFFSET IMPRINTS

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In today's conditions of rapid development in the printing industry, the quality of printed products is determined not only by design or functionality, but primarily by the accuracy of image reproduction following the author's original. One of the most important factors affecting the reproductive quality of offset printing is the stability and predictability of the colour transfer process, considering the characteristics of the printing plates used. In this regard, research aimed at studying the influence of thermal offset plate types on the accuracy and stability of tonal reproduction of inks, as well as on the conformity of imprints to colour proofs, becomes particularly significant. The article presents an experimental verification of imprint conformity to reference samples, analyses tonal reproduction and colour stability.

It has been established that plates with high resolution and screen ruling (up to 3200 dpi and 450 lpi respectively) provide the best quality reproduction of fine elements and gradations. A mathematical model has been developed which describes the influence of key plate characteristics on the printing result. The greatest positive contribution to reproduction quality is provided precisely by resolution and screen ruling. The results can be used for selecting optimal materials in prepress preparation and implementing quality control systems in offset production.

Keywords: *offset printing, thermal plates, reproduction and graphic characteristics, gradation transfer, optical density, printing quality.*

Problem statement. In today's conditions of the printing industry, where the majority of printed products are manufactured using offset technology, there is a growing need for high colour reproduction stability and image transfer accuracy. Printed products, particularly in the fields of packaging, advertising, publishing and branding, must meet increasing quality requirements, which include colour stability, detail sharpness and conformity to design solutions. Offset printing, whilst remaining the leading technology for mass printing, faces new challenges: variability in material batches, automation of quality control, and the influence of printing plate characteristics on imprint quality.

One of the key elements in the image reproduction system is thermal plates, whose physico-chemical properties determine not only image quality, but also the stability of the printing process as a whole (Fig. 1). In particular, parameters of such plates as resolution, energy sensitivity, tonal reproduction, optical contrast, and the ability for precise

exposure and processing, determine the level of detail, colour saturation and absence of defects on imprints. The availability of a wide range of plates from different manufacturers with varying characteristics necessitates a well-founded selection of materials for specific printing tasks.



Fig. 1. Thermal offset plate properties

However, in practice, such selection is often carried out based on the subjective experience of specialists or technical specifications, which do not account for the complex interaction between plate parameters and printing conditions. This creates risks of product quality instability, increased waste and material overconsumption. Despite the availability of individual empirical studies, there is a lack of mathematical models that allow predicting the influence of plate parameters on printing results in quantitative terms. For this reason, there arises a necessity for systematic research of this dependency using experimental data and formalised analysis methods [1-4].

Analysis of recent research and publications. Contemporary research in the field of offset printing is characterised by a comprehensive approach to studying the quality of printing plates and printing processes. Analysis of scientific publications from the last decade indicates active development of manufacturing technologies and quality control of offset printing plates. Fundamental aspects of the influence of surface characteristics

on printing plate quality were investigated by Novaković, Karlović and Gojo [5], who established correlational dependencies between the microgeometry of the plate surface and imprint quality. Their research laid the theoretical foundation for understanding the mechanisms of printing ink interaction with the plate surface and became the starting point for further research in this field.

A significant contribution to research on printing process stability was made by Skyba [6], who conducted a comprehensive analysis of offset printing plate stability throughout the print run. The results of his research demonstrated the critical importance of maintaining stable printing parameters to ensure high product quality and economic efficiency of production.

The development of environmentally oriented technologies was reflected in the work of Poljaček and co-authors [7], who conducted detailed research on the characteristics of processless offset printing plates. Their research demonstrated the advantages of new technologies in terms of reducing environmental impact and simplifying the technological process of plate manufacture, which corresponds to contemporary trends in sustainable development of the printing industry.

Pavlović and co-authors [8] proposed an innovative approach to assessing offset plate quality by combining digital image processing methods with traditional analytical methods. Their research established new standards in the methodology for evaluating printing plate quality and demonstrated the effectiveness of an interdisciplinary approach to solving technological tasks. A promising direction in quality control process automation is presented in the research by Zhang and co-authors [9], who developed an automatic defect detection system for web offset printing based on machine vision technologies. Their work demonstrates the potential for implementing artificial intelligence and computer vision in the printing industry, opening new opportunities for improving production efficiency and quality.

Comparative studies of different types of thermal offset plates, conducted by Jareb, Javoršek and Klančnik [10], made it possible to establish optimal parameters for using thermal decomposition plates and determine their operational characteristics. The results of this research have important practical significance for selecting optimal technological solutions in production conditions. Contemporary trends in the field of quality control of offset thermosensitive printing plates are reflected in the work of Sajek and Havenko [11], who developed a comprehensive quality assessment methodology taking into account the specificity of thermosensitive materials. Their research presents the most current methodology in this field and considers the latest achievements in printing plate materials science.

Analysis of the presented research indicates the presence of several key trends in the development of offset printing technologies: environmental orientation of production through the development of processless technologies, implementation of digital quality control methods, automation of production processes and an interdisciplinary approach to solving technological tasks. At the same time, despite significant achievements, issues of optimising technological parameters, standardising quality assessment methods and implementing innovative materials in printing plate production remain relevant. Particular

attention is required for comprehensive research into the influence of physico-chemical properties of offset plates on the quality of imprints, since these properties determine the efficiency of ink receptivity, plate durability and printing process stability throughout the entire production cycle.

The aim of the research. Establishment of regularities in the influence of physico-chemical properties of thermal offset plates on the reproductive-graphic characteristics of printed products and construction of a mathematical model for predicting the level of colour conformity of imprints to reference colour proofs based on printing plate parameters.

Presentation of the main research material. The research was conducted using three types of thermal plates, whose characteristics were analysed by constructing a radar chart (Fig. 2):

- 1. Arte IP-21 (Ipagsa Industrial S.L., Spain);
- 2. LTH-100 (Vela Verona Lastre srl, Italy);
- 3. Lastre Alloy™ Thermal Blue (China).

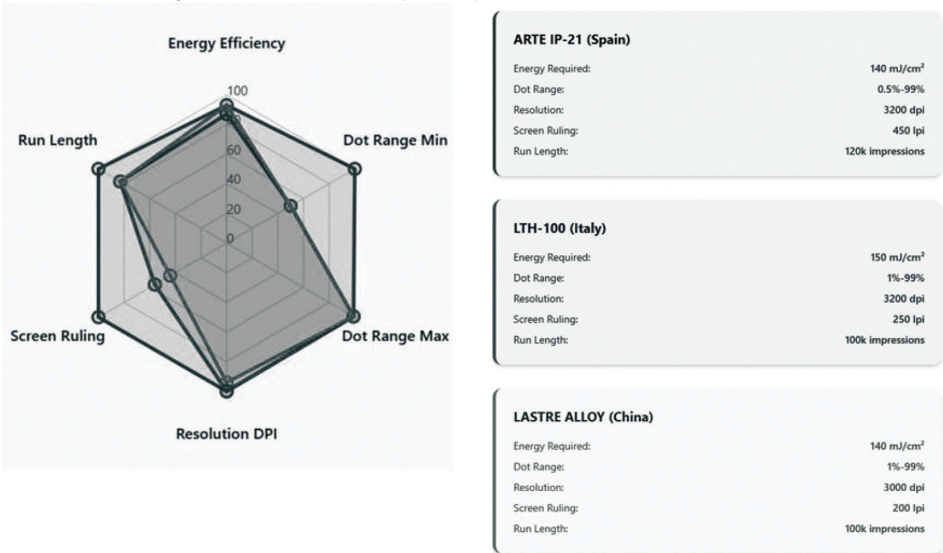


Fig. 2. The radar chart of thermal offset plates performance comparison

The radar chart compares six key performance parameters on a 0-100 scale. Larger areas indicate better overall performance. ARTE IP-21 excels in screen ruling and durability, has the best capability for reproducing small elements (0.5%), LTH-100 offers superior stochastic capabilities, while LASTRE ALLOY provides a balanced, cost-effective solution, although it has the lowest screen ruling values, which limits its capability for transferring small elements.

Plate exposure was carried out on a Screen PlateRite 8000II unit. Printing was performed on a Heidelberg Printmaster GTO 52-2P offset press using Huber Group MGA® Natura 5250 series inks and Vega Gloss paper with a grammage of 115 g/m². Imprints were produced according to ISO 12647-2:2008 standard [12] with subsequent

spectrophotometric analysis of colour reproduction parameters using a GRETAG SPM 50 spectrophotometer in the optical density range from 2% to 100% with a 10% step for each of the CMYK colours.

For quality assessment, indicators of tonal reproduction, correlation between digital colour proofs and actual imprints, as well as such reproductive-graphic characteristics as resolving power, screen ruling, and optical density were applied. Analysis of the obtained data showed significant differences in tonal reproduction characteristics between different types of plates (Table 1). It was established that one of the plates (Arte IP-21) provides the highest conformity to colour proofs.

Table 1

Results of the study of tonal reproduction of offset imprints

Colour Plate type	Cyan	Magenta	Yellow	Black
LTH-100	Satisfactory conformity to colour proofs in highlight areas, but significant density reduction in midtones and dark areas	Acceptable behaviour in high-light areas	The nature of tonal reproduction on imprints obtained from all plate types was approximately similar, with systematic density reduction observed relative to the colour proof. The greatest deviations were recorded in dark areas for plates No. 1 and No. 3.	Greatest deviations from the standard
Arte IP-21	Greatest conformity to reference colour proofs across the entire tonal range	The best conformity to colour proofs was recorded; acceptable behaviour in highlight areas; in midtones a slight increase in densities was observed		Best conformity to colour proofs
Lastre Alloy	Excessive density increase in midtones and dark areas	Acceptable behaviour in highlight areas; in midtones a slight increase in densities was observed; sharp density increase in dark areas		Significant deviations from the standard, particularly in dark areas

Detailed analysis of the characteristics of this plate showed that its key advantages are high resolution (up to 3200 dpi), low energy exposure threshold, which ensures precise formation of halftone elements, as well as stable screen ruling with reduced ink

spreading effect. Additionally, this plate has an increased level of image contrast after processing, which contributes to better ink transfer to the printed material and ensures preservation of small element sharpness. These parameters collectively result in better tonal reproduction, minimisation of optical density losses in printing and increased stability during long print runs.

With the aim of formalising the dependency of print quality on plate properties, a generalised mathematical model for prediction has been developed. The main purpose of the model (1) is to describe the influence of key plate characteristics (resolution R_p , energy sensitivity E_p , screen ruling L_p , contrast C_p) on the printing result (conformity coefficient K_q):

$$K_q = \alpha_1 R_p + \alpha_2 E_p + \alpha_3 L_p + \alpha_4 C_p + \varepsilon, \tag{1}$$

where α_i are the influence coefficients determined by multiple regression method; ε is the residual error.

To construct the model, a multifactor statistical analysis of experimental data obtained during the measurement of imprint conformity to digital colour proofs was conducted. The collected values of plate parameters (resolution, exposure sensitivity, screen ruling, contrast) became independent variables, whilst the correlation coefficient between the imprint and colour proof became the dependent variable. Using the least squares method [13], regression coefficients reflecting the strength of influence of each parameter on print quality were obtained (Table 2).

Table 2

Values of regression coefficients

Parameter (independent variable)	Coefficient (α)	Interpretation
Resolution (dpi)	0.0015	The biggest impact — raster detailing significantly improves K_q : increasing the resolution by 100 dpi gives an increase in K_q by 0.15
Screen ruling (lpi)	0.0012	Significant positive impact on the transmission of gradations: increasing the ruling by 100 lpi increases K_q by 0.12
Contrast	0.0004	Moderate impact: an increase in contrast by 1 conventional unit adds 0.0004 to the correspondence coefficient
Exposure energy (mJ/cm ²)	-0.0003	Overexposure reduces accuracy: increasing the exposure energy by 10 mJ/cm ² reduces K_q by 0.003

The obtained results can be used for automated selection of printing plates depending on product quality requirements. This will allow optimisation of the prepress process, reduction of material costs and decrease in waste under printing production conditions.

Conclusions. The conducted research confirms the significant influence of thermal offset plate properties on print quality. The greatest influence on colour proof conformity is exerted by such plate characteristics as resolution and screen ruling. The best

results were shown by Arte IP-21 plates (Ipagsa Industrial S.L., Spain), which provide the greatest conformity to digital colour proofs.

The proposed mathematical model based on multiple regression allows quantitative assessment of the influence of the specified parameters on print quality, which opens the possibility of its application for predicting and optimising the technological process, and its use as a tool for technical justification of printing plate selection. The obtained results should be considered when implementing automated quality control systems in printing production facilities. Prospects for further research include expanding the model through additional parameters, incorporating the influence of plate exposure and processing conditions, as well as developing software for integrating this model into prepress workflows, expanding the range of plates studied, investigating the influence of storage and operating conditions on imprint quality, and developing automated print quality control systems.

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ДОСЛІДЖЕННЯ ВПЛИВУ ВЛАСТИВОСТЕЙ ТЕРМАЛЬНИХ ПЛАСТИН НА ЯКІСТЬ ВІДБИТКІВ ОФСЕТНОГО ДРУКУ

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У статті висвітлено результати комплексного дослідження впливу властивостей термальних офсетних пластин на репродукційно-графічні характеристики друкованої продукції. Актуальність дослідження зумовлена необхідністю підвищення точності та стабільності передачі кольору в офсетному друці, що особливо важливо в умовах сучасного виробництва з високими вимогами до якості. В роботі проведено серію експериментів із виготовленням друкарських відбитків та здійснено спектрофотометричний аналіз точності передачі кольору.

У результаті встановлено, що пластини з вищою роздільною здатністю (до 3200 dpi), більшою лініатурою (до 450 lpi) та низьким порогом енергії експонування (140 мДж/см²) демонструють кращі результати у відтворенні дрібних деталей та забезпечують високу відповідність кольоропробі. Найкращі експериментальні показники досягнуто при використанні пластини, що має підвищений оптичний контраст і забезпечує відтворення растру у діапазоні 0,5–99%. Це дозволяє зменшити втрати градаційної передачі на світлих і темних ділянках зображення та забезпечити візуальну стабільність відбитків протягом тривалого накладу.

Для кількісної оцінки впливу кожного параметра пластини на якість друку розроблено математичну модель на основі методів множинної регресії. У моделі враховано ключові змінні: роздільну здатність, енергетичну чутливість, лініатуру та контраст. Проведено інтерпретацію отриманих коефіцієнтів, що дозволяє визначити відносну вагу кожного параметра у впливі на якість репродукції. Згідно з розрахунками, найбільший позитивний вплив на якість має лініатура та роздільна здатність, що підтверджує практичні висновки експериментів. Запропонована модель може бути інтегрована у системи автоматизованої підготовки форм до друку, а також використана для прогнозування якості продукції при виборі матеріалів і режимів експонування. Отримані висновки можуть бути корисними при створенні рекомендацій для закупівель пластин з урахуванням цільової якості продукції, оптимізації витрат матеріалів і підвищення ефективності виробничого процесу.

Ключові слова: офсетний друк, термальні пластини, репродукційно-графічні характеристики, градаційна передача, оптична щільність, якість друку.

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