METHODS OF REFINING UV PRINTING ON REGULAR- AND IRREGULAR-SHAPED OBJECTS USING TEMPLATES AND MATRICES

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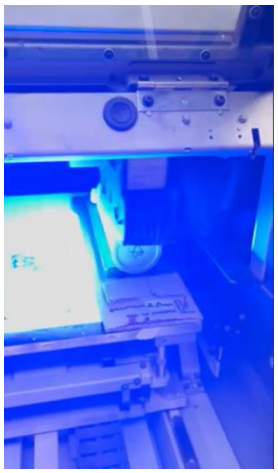
Abstract: UV printing is a technology for printing full-color images on flat surfaces. It is widely applicable to various materials, including wood, leather, plastic, silicone, metal, and others. The technology enables exceptionally detailed and high-quality printing. One of the key advantages of UV printing is its ability to be applied to a wide range of materials, making it exceptionally versatile. When it comes to printing on flat surfaces, this technology provides great freedom and flexibility in the manufacturing process. The maximum printing area that the machine can cover depends on the specific model and technical specifications, allowing for adaptation to different projects and requirements. One of the key aspects discussed in this article is the method of precision in printing on the object. The use of templates and minimizing deviations during positioning are crucial for achieving high accuracy in printing. Attention to detail and minimizing deviations play a crucial role in ensuring a quality and professional appearance of printed products. The article highlights the possibility of optimizing the manufacturing process through the application of templates and matrices. This approach can significantly increase work efficiency by allowing the simultaneous printing of multiple objects on the same plane with identical print positions. Such a method leads to increased profitability in mass production and underscores the flexibility and innovations that UV printing offers in the field of printing technologies. UV printing technology offers a wide range of applications across various industries. One of the primary areas of application is in advertising and marketing, where it can be used to create full-color advertising materials on different surfaces. In the manufacturing sector, UV printing is applied to personalize products. For example, it can be used for printing on wooden or metal items, leather accessories, plastic parts, and other products. This personalization contributes to increasing the value of products and enhancing the consumer experience. These are just some of the areas where UV printing technology can be successfully applied. With the development of technologies and the search for new creative uses, the possibilities for application continue to expand. The research support understanding of printing industry, showing practical experience that can enhance operational efficiency and product quality. By delving into the precision aspects of UV printing through the utilization of templates and matrices, the study provides a gain knowledge for stakeholders to optimize their manufacturing processes. Stakeholders, including manufacturers and printers, stand to benefit from increased work efficiency and reduced production costs, particularly in mass production scenarios where simultaneous printing on multiple objects with identical positions becomes feasible. The research underscores the adaptability of UV printing technology to diverse materials, reinforcing its applicability in various industries such as advertising, marketing, and personalized product manufacturing. As a result, stakeholders can leverage this experience to enhance the quality of their printed products, increase profitability through streamlined processes.
Keywords: UV printing, manufacturing process, application of templates

1. INTRODUCTION

UV printing is a technology that uses ultraviolet light to cure the ink immediately after its application on the material (Iftekar et. all, 2023, Jakopčević et. all, 2023). This process ensures the rapid and efficient creation of printed images with high resolution and color saturation (Fig. 1). The goal of this article is to explore the possibilities for optimizing printing processes by examining the use of matrices and templates. The purpose of the research is in accordance with the established standards of Industry 4 and the transition to Industry, in the context of human factors and collaboration with modern state-of-the-art technologies (Dovramadjiev et. all 2023, Maware and Parsley, 2023, Rupp et. all, 2021,). Industry 4.0, with its emphasis on automation, connectivity, and data exchange, underscores the importance of aligning technological innovations with human capabilities and comfort (Villalba-Diez and Ordieres-Meré, 2021). The strategic utilization of matrices and templates in UV printing not only streamlines production but also harmonizes with ergonomic principles, fostering a work environment that prioritizes worker health and productivity (Pagac et. all, 2021). Looking towards the emergence of Industry 5.0 (Alojaiman, 2023, Chivilò and Meneghetti, 2023, Pizoń and Gola, 2023, Zizic et. all 2022), which accentuates human-machine collaboration and cognitive technologies, underscores the significance of human factors in UV printing. The relationship between

humans and machines necessitates ergonomic design considerations that optimize human-machine interactions, mitigate fatigue, and enhance operational fluidity. By integrating ergonomic principles into UV printing processes, manufacturers can harness the full potential of Industry 5.0 while ensuring the well-being and satisfaction of their workforce. In this multifaceted context, the exploration of matrices and templates in UV printing extends technological enhancement applications (Liu et. all, 2023, Sang et. all, 2020). It approach that recognizes the symbiosis between technology, human factors, and industry evolution. Through a nuanced understanding of ergonomics and its integration into UV printing methodologies, manufacturers can optimize efficiency and quality while cultivating a work environment that fosters creativity, innovation, and human flourishing. Thus, this article seeks to delve into the intricate interplay between technology, human factors, and industry paradigms, offering perspectives that pave the way for a future where excellence in UV printing aligns seamlessly with sustainability, efficiency, and human-centric innovation.

Fig. 1. Example of UV Printing Process



2. MATERIALS AND METHODS

UV printing offers the capability for precise and detailed printing on various surfaces, providing resistance to wear and washing. It is highly versatile, as it can be applied to diverse materials, including wood, leather, plastic, silicone, metal, and more. This versatility makes the technology suitable for various industries and applications, fostering creativity and innovation. The ability to print on a variety of materials makes UV printing suitable for advertising, marketing, personalized product manufacturing, and other areas that require flexibility and high print quality.

UV printers can have different maximum print areas depending on the machine model. In this article, the Mimaki UJF 3042 model is used as an example, featuring a flatbed with a maximum print area in A3 format and a maximum object height of up to 153 mm. The maximum print resolution is 1200 dpi, allowing for detailed and precise printing of full-color images or graphics. UV printing supports both raster and vector graphics, expanding the technology's applicability for a variety of projects. There are several steps through which one needs to proceed timely in the process(Fig. 2)

Fig. 2. Methodology of UV printing process

The technology enables printing in white on the object, eliminating the need for a white base on the media. This allows for printing full-color images even on objects with a black or different-colored base without affecting the colors of the print itself. Flatbed printers print only in a single plane, with the highest point of the object being the determining factor. This non-rotational printing method limits the print area to the highest point of the object, for instance, when printing on a bottle, the print area closely follows the highest part of one of its sides (Fig. 2). An

additional feature of UV printing is the application of selective varnish. Selective varnishing in UV printing is a process where varnish is applied to specific parts of the printed surface, creating an accentuating effect or providing protection to particular elements. This method contributes to enhancing the visual impact of the print and delivering additional functionality (Nikolova and Murzova, 2015). The varnish is applied only to pre-defined areas of the surface, creating a selective effect. It is possible to adjust the intensity of the varnish based on desired visual and functional effects. Selective varnishing in UV printing offers opportunities for creativity and personalization, further emphasizing the visual aspect of printed products and providing protection to specific areas (Fig. 3).

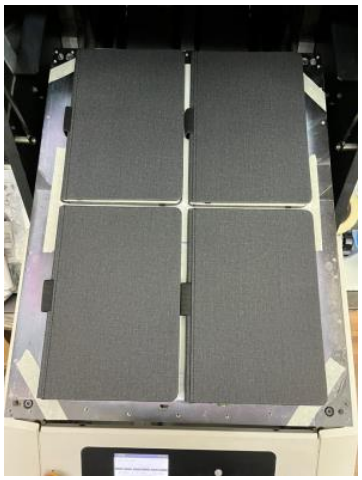
Fig. 3. Printing on a bottle with the print placed on the highest flat surface of the object

Fig. 4. Printing a logo on a silicone phone case by adding selective lacquer

3. RESULTS

The printing area can be significantly larger than the object's area, and if not utilized efficiently, this can lead to a waste of time and resources, consequently reducing the process's effectiveness and affecting its profitability. That's why, in this case, matrices and templates can be applied to enable mass printing of multiple objects simultaneously. This occurs by calculating the dimensional size of the object and how many times it fits into the printing area of the machine. Of course, the ratio of the number of objects that can be printed simultaneously is inversely proportional to their dimensional size. For example, a notepad with a standard A5 size fits four times into an A3-sized printing area, while a standard pen could fit 50 times in the same area with optimal distribution in the matrix (Fig. 5).

Figure 5. Arrangement of four notebooks with a standard A5 format for simultaneous branding within the maximum A3 printing area



In addition to optimizing the printing efficiency, matrices and templates enable precision in positioning the print concerning the object and specifying the printing field. They can be divided into two main types:
Graphic templates – graphic images incorporating the dimensional shape of the object, distributed over the object's printing area. These images determine the object's position on the machine table and, correspondingly, the position of the graphic element during pre-print preparation (Fig. 6). To apply this template, a graphic file with the required parameters is prepared, followed by printing it from the UV machine onto the plate. This stabilizes the exact location of the object without allowing deviations. The object can be positioned within the template outlines concerning its dimensional size with exceptional accuracy. The next step is to create a print file, using the initial template and positioning the graphic elements at desired locations based on the object outlines. This ensures the exact print placement concerning the objects. Templates can be reused for the same objects.

Fig. 6. Graphic template incorporating the dimensional shape of the object, distributed over the printing area of the machine

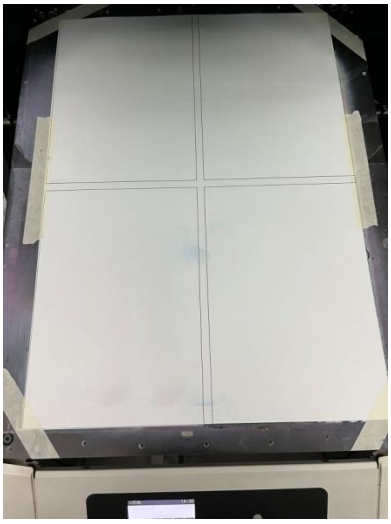


Fig. 7. Physical matrix for multiple use, made of plywood to optimize the process in printing pens

Physical matrices – these matrices are usually crafted from denser and more stable materials such as wood, plastic, etc., and are prepared in advance. Their role, aside from positioning, is to fixate the object. This is applied extensively for objects with an oval shape or those that are not stable enough to stand independently in a plane. Examples include pens, lighters, bottles, balls, etc. This allows the object to be fixed in a specific position without shifting during printing. Stabilizing objects for printing is of paramount importance in achieving a high-quality end result, as otherwise, the print may be displaced and of poor quality. A key advantage of matrices is that they are crafted from durable materials for multiple uses, making them much more wear-resistant (Fig. 7).
Also to technical advantages, is well visible that the use of innovative technologies economic benefits (Mohamed et. all 2022, Murzova and Panayotova, 2016, Xiao et. all 2022), as these processes play a crucial role in determining the cost of printing by reducing production costs. Factors influencing the cost of printing a product include the number of objects printed in one production cycle, the time required to prepare the objects, as well as the size of the print file and ink costs (Fig.7). UV printing technology not only offers opportunities for creative applications but is also exceptionally suitable for creating full-color advertising materials across various industries, especially in the fields of advertising and marketing. The outstanding versatility of UV printing makes it suitable for application on different surfaces, expanding possibilities for creative expression and visual representation. Among the materials onto which this type of printing can be successfully applied are wood, glass, plastic, leather, and metal.
In advertising and marketing, UV printing is used to create effective and exciting advertising campaigns where visual impact and image quality are crucial. The ability to print on various materials provides a unique opportunity for personalization of products and the creation of distinctive advertising materials that capture the attention of consumers. The adaptability of UV printing to diverse surfaces opens doors for innovation and creativity in the advertising industry. This technology offers opportunities for expression and differentiation, which are essential in the competitive world of advertising. Thus, the application of UV printing in the field of advertising and marketing not only delivers high-quality and impressive advertising materials but also upholds innovation standards in this dynamic industry.

4. DISCUSSIONS

Research in the field of UV printing plays a crucial role in the development of the printing industry, providing valuable scientific data and practical experience. This type of research focuses on various aspects of UV printing that significantly impact manufacturing processes and the applications of the technology. Emphasizing techniques to refine printing on different materials is of paramount importance, leading to improved accuracy and print details. This aspect positively affects the efficiency and quality of production, which is key to the competitiveness of the industry. The application of templates and matrices in the production process of UV printing has the potential to reduce costs, especially in mass production conditions. This provides an opportunity to enhance the profitability of manufacturers who can benefit from increased operational efficiency and reduced production costs. Research also highlights the adaptability of UV printing to different materials, expanding the potential applications of the

technology in various industries such as advertising, marketing, and product personalization. The ability to create impressive full-color advertising materials on diverse surfaces opens new perspectives in the field of visual representation and consumer interaction.

5. CONCLUSIONS

In summary, research in the field of UV printing represents a crucial foundation for the development and optimization of the printing industry. The obtained data and insights contribute to achieving higher quality, efficiency, and innovations in the sector. These results are of paramount importance to stakeholders as they help strengthen competitiveness and successful adaptation to ongoing technological challenges.

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