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Enhancing Efficiency and Accuracy in Food Packaging and Pharmaceutical Labeling: An Analysis of UV Laser Printing Technology

Animek Shaurya

59 Birchview Drive, Piscataway, New Jersey, 08854, USA
shaurya.mekki@gmail.com

Abstract: ***This study uses a data-driven approach to analyze the advantages and impacts of ultraviolet UV coding technology in food packaging and pharmaceutical industries utilizing vertical pillow-type packaging machines. The context of this paper helps in understanding the logic behind needing to follow a strict labeling standard to meet dietary and medical regulations on the products produced and the science behind the principles, techniques, and methodologies of the correct coding or marking processes used to achieve these requirements. The challenge of matching the high speed of a packaging machine, married with the high accuracy of applying data codes on the packaging material, is a critical aspect of these industries. In today's world, industries use various innovative methods for coding and marking solutions, evolving daily to improve productivity while maintaining high product quality standards. This paper compares the data collected from running a thermal printing solution in the food packaging industry against using an ultraviolet laser printing solution. It analyses this data to compare both techniques on the cost of maintenance, spare parts, consumables, machine reliability, production rate, accuracy of printing, and traceability for product recalls.***

Keywords: Ultraviolet Laser Printing,Data Coder, Food Packaging,Pharmaceutical Labeling, Operational Efficiency, Product Traceability

1. Introduction

The concept of process involving the packaging of products in food and pharmaceutical industries has grown tremendously in the past few years using various techniques and solutions offered by multiple coding and marking specialists available in the market to provide important information about a product through printing them on the packaging material. The need to match dietary and regulatory demands set up by the governmental organization and to match strict labeling standards to contain critical information related to nutritional data, expiration date, best-by date, batch or lot information, data and time of manufacturing, instruction for use (IFUs) has challenged the innovative thinkers and decision-makers in a company to look for solutions to match these requirements in additional to business demand of increasing productivity without affecting product quality and reducing cost of operation spent on labor, maintenance, spare parts etc. The packaging material of a product serves as a data carrier that connects the product's origin to its consumer. The customer can get information about their expiry, ingredients, etc. This information is also helpful in managing customer recalls and complaints. It helps track and run traceability methods to gather detailed information about the product per the standards laid out by food and medicine governing bodies. [1] According to the research study on "Powering the Future of Retail," from information standards organization GS1 US has revealed that 82% of retailers and 92% of brand owners support transitioning from the UPC to a data-rich 2D barcode (e.g., QR code, GS1 data matrix), a digital watermark, and an RFID tag in the next one to five years. The study recognizes that an advanced data carrier must evolve retail and provide consumers with detailed product information and transparency. Various solutions are being offered in the current market to satisfy the need for printing on packaging material, which uses different technologies like ultraviolet laser, thermal transfer printing, CO2 laser, etc.The purpose of this study is to analyze and compare the effectiveness of UV laser printing technology against traditional thermal printing methods in the food packaging and pharmaceutical sectors, focusing on operational efficiency, cost reduction, and compliance with regulatory standards

2. Current technologies for marking and printing solution

There are various technologies out there in the market that offer solutions to industries in the packaging sector to help fulfill the needs of marking and label requirements. With the information related to the batch number, lot codes, and other traceable markings, companies can easily connect them with data like sources of product ingredients, trace the supply chain route of each ingredient, track distribution, logistics, and supply chain of the product once it leaves the facility and reaches the consumer, accurate traceability in events of customer recall. The coding and marking solution used by every company in these sectors must have the correct hardware and technology to print permanent, clearly visible, and readable information related to the products. Several factors should be considered while selecting a technology to meet these labeling standards, like line setup for printing information on packaging material and the environment in which the production is carried out. The selection of the marking solution varies based on the temperature of the products that are being packaged. For example, cold products can cause condensation outside a bag, while hot products may cause ink transfer issues.

[2] Some of the best available coding and marking solutions available in the market are as follows-

2.1 Thermal Transfer Over Printer

This technology uses heat to melt the ribbon and transfer the desired pre-defined information to the ribbon in the designated area. To print the code, the print head must be in complete contact with the print area. This coding technology transfers the printed content to the product packaging or label by direct contact.

2.2 Inkjet Coding

Continuous inkjet coding printers are used in various industries, including food, beverage, industrial, and manufacturing, and can print on multiple surfaces. Non-contact inkjet coders can print in high resolution at breakneck speeds. And its fast printing is also better suited for mass-coding drugs and medical devices with increasingly complex codes and information.

2.3 Laser Coding

For the beverage industry, printing batch codes on the bottoms of beer cans, wine, and water bottles requires machines capable of coding on foil seals, PET, and glass. The laser coding machine can focus the high-energy density laser on the surface of the marked object, vaporize the material by burning or etching, and accurately burn the required pattern by controlling the laser beam's or text's effective displacement. Laser markers can mark items and materials of various materials, including glass, plastic, foil, and metal.

3. Problem Statement

In this study, we considered a packaging line in the food and beverage industry, which comprised 32 thermal printers (2 on each machine) installed on 16 vertical pillow-type packaging machines. Many complaints from domestic and overseas customers related to missing, half, or smudged prints on the packaging material. Another common issue over the years was the capability of thermal printers to print multiple line codes on the packaging material. The other quality concern we have with the thermal printers is that the print can smudge off, causing pouches with missing prints. With the redesign of the graphics on the pouches, the print location was changed on some pouches, leading to the print location where the jaw seals the bags, causing the jaws to take some of the print off the pouch. The cost of consumables like ribbons, printheads, and cylinders contributed to the overhead cost of maintaining these thermal printers in the facility. During average production, each machine also must stop for about 3 minutes every day to change the ribbon, and the frequency of changing the ribbon increases when we run vertical multiple-line print codes.

4. Advantages of UV Laser printers

Table 1 shows the advantages of using a UV laser over a traditional thermal printer. Unlike conventional thermal printers that transfer ink to the film's surface, UV laser coders use a UV laser to mark only the marking layer of a film. This creates a permanent mark without damaging the film. It helps companies' sustainability projects by reducing CO2 emissions during ink ribbon disposal because it uses laser technology instead of thermal ribbons. The prints from a UV laser printer are not affected by oil, powder, heat, or any other environmental attributes that impact the traditional thermal printers. The prints are permanent, dust-free, and odor-free. The UV laser printers are reliable and long-lasting, with no need for periodic part replacement or maintenance activities. UV laser printers also reduce the film wastage and cost associated with it as there is no need to dispose of film during the ribbon change process, which is applicable for thermal printers. It eliminates the need for operational cleaning of printheads, as in thermal printers. It decreases production loss due to emergency breakdowns due to printer-related failures. No fumes are generated in UV laser printers compared to other laser printers like CO2 types.

Table 1: Comparison of Thermal printer vs UV laser printer

Area	*Thermal printers*	*UV Laser printer*
Spare parts and consumables	Consumables needed like Ribbon, Printheads, Cassettes, Printhead cylinder	No spare parts needed
Downtime in ribbon replacement	Downtime to change ribbon, print head or clean print head or maintenance	Does not need any replacement of parts for running production
Maintenance activities keep the printer in optimal condition	Print fades over time or rubs off	Prints are permanent
Consistency in printing	Skips print, or print is not consistently in the same position	Prints are consistent
Initial investment cost	Low initial cost	High initial investment
Storage cost of consumables	Shelf space need for consumables and spare parts	No shelf space is required to store consumables or spare parts

5. Data Collection and analysis

In this study, we collected data for 32 thermal printers and compared them against UV laser printers. Figure 1 shows the hours spent during the calendar year of 2021-2023 for replacing ribbons during each production run. When using a TTO printer, the ribbons must be replaced after a specific interval with a new one that requires the machine to be stopped. Typically, this is performed by the operator, who is usually responsible for more than one machine in his shift. This leads to 2-3 minutes spent on each printer replacing the ribbon. Adding all these minutes spent during an entire year, we can see that in 2021 and 2022, the number of pent was between 150 and 200. This is considered a loss in production time as it could have been used to package products and increase productivity. In 2023, with the introduction of laser printers, there was no need to change ribbons during production, contributing to zero downtime for changing ribbons compared to previous years. This increased productivity significantly.

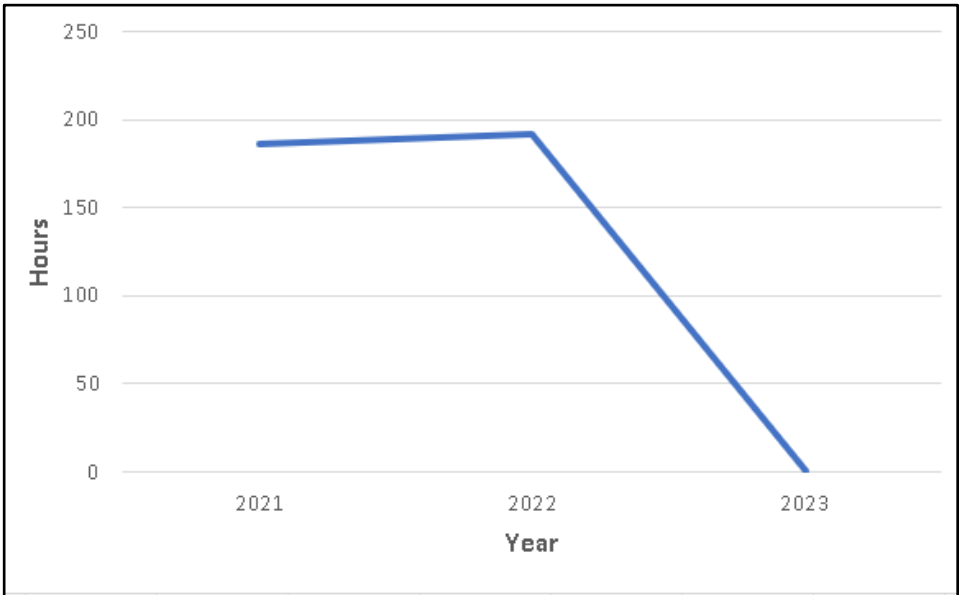

Figure 1: Downtime for ribbon change (hrs.)

Figure 2 shows the hours spent on repairs by the maintenance department to fix printer issues. In 2021 and 2023, these machines were equipped with TTO printers, frequently needing Maintenance attention to keep the printers operating. This included emergency repair and planned preventive Maintenance activities during the year. In 2023, with the introduction of laser printers, there was no need to allocate maintenance resources for repair and preventive maintenance activities, reducing the product's overhead cost. Occasionally, training sessions were scheduled through the Maintenance department to train operators and do refresher training courses on efficiently using these printers, adding a few hours of downtime.

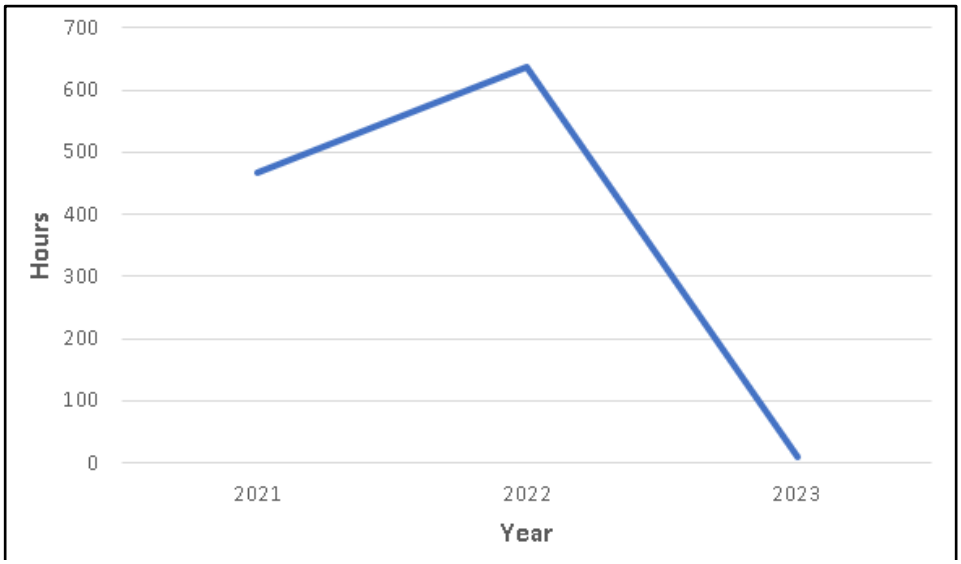

Figure 2: Downtime for printer failure (hrs.)

Figure 3 shows the amount spent on spare parts and consumables for printer maintenance between 2021 and 2023. In 2021 and 2022, when TTO printers were used in operation, it contributed to buying spare parts like printheads, printhead modules, cassette assembly, and consumables like thermal ribbons to continue using these printers for labeling on packaging material. This cost significantly went down in 2023 with the introduction of the UV laser printer, as there was no need to replace any spare parts or use ribbons for printing purposes.

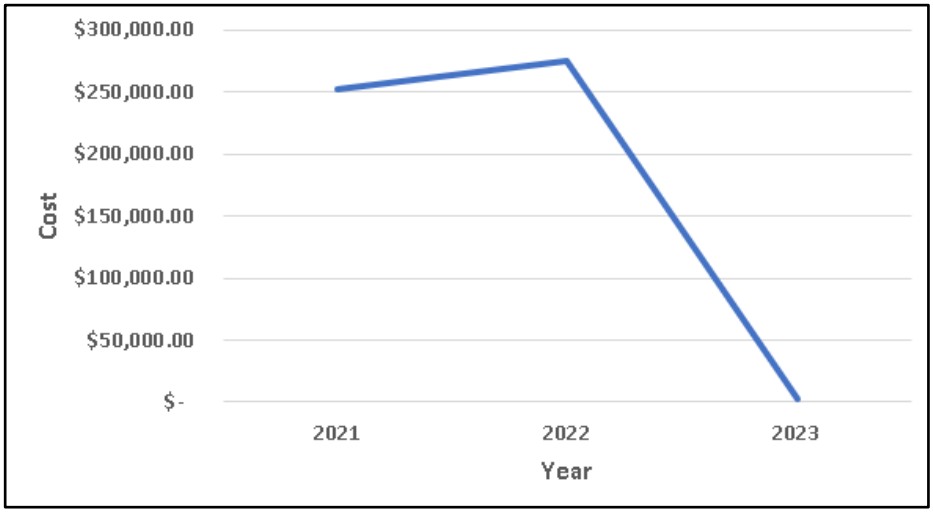

Figure 3: Cost of Maintenance and Spare Parts (Dollars)

Table 2: Gain in pouches when UV laser printer is used on 16 machines

Areas	*Vertical Pillow type packaging machine*
Packaging machine speed	30 packages/minute
Time Lost for Printer Ribbon Change	186 hours
Time Lost for Printer Failure	638 hours
Total Downtime	192 hours
Potential Pouches Gain with UV Laser	23 million pouches/year

Table 2 shows the gain in production regarding the number of pouches produced through all 126 vertical pillow-type machines together during a year.

6. Conclusions

Laser printing solutions are the future of printing technology that will help grow the packaging industry and support various companies in meeting the challenges of strict labeling standards as per government regulations. UV laser printing options are the most favorable and compatible solution among all the existing laser techniques for the packaging industry, which uses plastic film as the packaging material. It ensures public safety and mitigates issues related to food safety by giving proper traceability as per the regulations. It also helps companies reduce costs associated with spare parts, maintenance activities, and consumables to keep these printers in optimal working condition compared to other types. This significantly increases productivity without compromising the quality of the product.This research is significant as it provides empirical evidence of the benefits of adopting UV laser printing technology in critical industries, offering insights into improving regulatory compliance, enhancing product traceability, and achieving sustainable operational practices.

References

[1] A. Mohan,"Retail Industry, CPGs Support Switch from UPC to Data-Rich Barcode", Mar. 5, 2020. [Online]. Available: www.healthcarepackaging.com/home/article/21119790/retail-industry-cogs-support-switch-from-upc-to-data-rich-barcode
[2] Florence, "3 Types of Coding Machine Technology", Sep. 5, 2022. [Online]. Available: www.medium.com/@idprt888666_61468/3-types-of-oding-machine-technology-e8468adb97c3
[3] N. Verma, R. Kumar, V. Sharma, "Analysis of laser printer and photocopier toners by spectral properties and chemometrics," Journal of Spectrochimica Acta, Part A: Molecular and Biomolecular Spectroscopy (SAA), 2017.
[4] P.Chavan,R.Yadav,P.Sharma, A.Jaiswal, "Laser Light as an Emerging Method for Sustainable Food Processing, Packaging, and Testing," Journal of Foods, 2023.
[5] I. Shabir, S. Khan, A. Hussain, K. Dash, R. Shams, A. Altaf,A. Singh, U. Fayaz, T. Majeed, S. Ahmad, V. Pandey, "Laser beam technology interventions in processing, packaging, and quality evaluation of foods," Journal of Foods, 2022.
[6] T. Xiuxiu, Z. Min, M. Arun, "Potential application of laser technology in food processing," Journal of Trends in Food Science & Technology, 2021.

Author Profile

Animek Shaurya is a Planning and Reliability Engineer at a leading maker of brand-name snacks and confectionery. Instrumental in developing the Preventive Maintenance program and streamlining inventory management and procurement of spare parts. Goal-oriented and innovative professional with a broad-based background in production and manufacturing, new product development, and inventory monitoring. Aims to respond to new challenges, contribute to the industrial engineering sector, and effectively utilize Six Sigma methodologies to complete projects, meet objectives, and streamline operations. He holds a master's degree in industrial and systems Engineering from Rutgers University and a bachelor's in production and industrial engineering from the National Institute of Technology, Jamshedpur.