The Coding Industry:

A technological retrospective and technological forecast.

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Executive Summary

Coding is an integral part of manufacturing. In every country in the world, there are strict rules for individual marking for products. Every product sold in a marketplace requires a barcode, even if you make it yourself. These can be **sell-by dates**, **UPC** or **EAN** numbers.

A manufacturing company must have systems in place to individually mark items. These markings must have a level of visual fidelity to regional or international standards. And they should operate at a speed that doesnt slow doesnt production. As global demand has increased, the manufacturing industry has met the challenge with an increase in production (8.3percent in 2021). Marking technology has seen few improvements over the last 30 years and may soon become a bottleneck in production.

Most of the coding industry uses over-printers to complete coding, although conventional printing techniques are still used. Many commercially available manufacturing machines have hardpoint connections for the industry-leading coding printers.

The main coding printing technologies are Dot Matrix, Inkjet, Laser and Thermal printers. Dot matrix creates codes that can be difficult to scan. Laser printers can only print conventionally and cannot over-print, making them unusable in many scenarios. Inkjet also has limitations in how it can be placed and used. Printing at steep angles or inverted is not possible. The introduction of wet ink also can cause havoc on a production line. Direct thermal requires thermal material to print on, usually thermal paper. This can cause issues as it needs to be transferred to the product, usually for a sticker label. These labels can be removed from products which is a less effective solution.

By far the best and most used method of coding products is thermal transfer printing. Their printing method allows for the direct marking of many types of

packaging materials, with high speeds and quality at an adorable price.

Although these printing machines have slightly different techniques, they all suffer from essentially the same limitations.

- Reliability/Durability
- High cost of consumables Ink, printheads

The mechanical nature of transferring ink to the material's surface means that these printers have many parts that can become worn over time, as well as physical limits to their achievable speed. As factory production speeds increase the prints per minute of the printerPPM increase and their consumable parts reach the end of their life much faster. This means partially stopping production by swapping the ink medium or a printhead.

Ink can also come in many forms but generally is shipped in small packets, where a large portion of the mass of the cartridge is plastic packaging. The most used technology currently (thermal transfer printing) has a 60-80percent ink transfer efficiency. These factors can have a significant effect on product margins.

High-frequency UV laser marking is an advancing technology that addresses many of these issues. Laser making is a robust technology that has been used to mark packaging and products for over 30 years. It is an inkless technology that burns irremovable marks into the item. Its main limitation is that it can only be used on certain materials due to the high play nature of the laser?

UV lasers have less energy and work well on plastics. Also with High-frequency pulsing, there is greater control of the laser power, allowing for annealing effects on plastics. This inkless process doesn't require contact, reducing cost and dramatically increasing reliability. It is also faster than traditional printing with the slow machine being capable of 600/m/s, which is at the top end for overprinting. It is also far more accurate allowing for double the dpi (dots per inch) of a traditional over-printer.

1 Introduction

Coding machines are an integral part of the manufacturing industry and are an important part of how governments regulate products. The manufacturing industry grew by 8.3% and is predicted to increase in the coming years. As production output increases, overall production speeds will increase to meet the demand. This is directly proportional to the coding industry growth. Whether it be a sell-by date, barcode or an EAN number, products are legally required to be marked either in batches or individually.

This job has traditionally been done by **over-printers**.

1.1 What is an over-printer?

Rather than a classic printer that feeds the material into its system, an over-printer is a machine designed to print directly on the material, from above (or other angles). The main benefit of this is the ability to mark products at different points with little interference in the assembly line.

1.1.1 Intermittent and continuous printers?

There are two main types of operation for over-printers, intermittent and continuous. They refer to the operation of the parent machine (the machine the printer is attached to). Some production lines operate in a stop-start fashion giving time to complete batch tasks before moving products to the next position. Other production lines work without stopping.

- **Intermittent** printers are required if the production line stops and starts. They print on the substrate(material to be printed on) when it is stationary. They print on a flat surface with a mechanical arm in the printer that moves the printhead across the substrate.
- **Continuous** printers are used when the substrate does not stop. They print on the substrate as it is traveling. They usually print on a roller (see below). The substrate is moved by the parent machine (the machine the printer is attached to). The printing speed is also synchronized with the parent machine.

1.1.2 Prints per minutes (PPM) Vs Print speed(mm/s)?

A few values are used to show the speed of a printer. The most common are PPM and Print speed. The PPM is the maximum number of prints the machine can do in a minute. The print speed is the speed at which ink is transferred to the substrate. It is hard to draw any meaning from PPM as manufacturers do not refer to the size of the printed image. Print speed better represents the printer's capability for high production as PPM can be calculated situationally.

1.1.3 Left and right-hand printers?

Most continuous over printers only print on the substrate in a given direction. Due to the variety of parent machines and the fact that cartridges need to be easy accesses, some companies produce mirror printers that operation the opposite direction.

2 Current Technology

There are two main over-printing technologies:

- Thermal transfer
- Inkjet

2.1 Inkjet

Inkjet printers use liquid ink in cartridges, and a mechanical mechanism to move the nozzle across the substrate whiles the substrate is moved perpendicularly underneath. As such, Ink-jets are mostly continuous printers, although there are some intermittent variations.

The main issue with ink-jets is the use of expensive liquid ink, which needs to be replaced often and can leak, causing massive production line issues. The quality can be mixed as time is needed for the ink to dry and smudging can occur. The level of smudging depends on the material printed on with less porous materials being worse. Also, printing must be done in a flat position, machines cant print inverted or at a steep angle. This creates limitations when installing the machines.

2.2 Thermal transfer

Thermal transfer printers use ink with wax on a roll of thin plastic ribbon. The machine unrolls this as ink is needed. To deposit the ink, the printhead presses the ribbon against the substrate and uses heater elements to melt and transfer the ink-wax mixture. The printhead contains hundreds of heater elements in a horizontal line, each corresponding to a pixel of information. In intermittent printing,

the printhead moves across the substrate using a mechanical mechanism activating different heater elements across the ribbon to transfer ink. In continuous operation, the printhead synchronises its elements with the moving substrate underneath to deliver ink. This allows for print while inverted and at steep angles. There is very good ink adhesion with plastic materials.

2.3 Hot Foil

Before thermal transfer in ink-jet, hot foil machines were the majority and they are still used today. The machine uses a similar process as a thermal transfer printer but uses a heated stamp instead of the elements. Every printed image used a different stamp configuration.

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3 Technological Limitations

3.1 Speed Limitations

The speed limitation of an over-printer is determined by its mechanical design, the properties of the substrate and the ink used. The limitations with mechanical design can mostly be overcome without limit, but the chemical properties of currently available inks seem to be the industry's major limiting factor. There are over-printers that boast speeds of around 1m/s and a few special examples of even faster speeds of 1500m/s that require a particular substrate and ink combination, but in a future where production lines will have certain elements working 2-4m/s, the over-printer will become a bottleneck that can only be alleviated by buying multiple machines.

3.2 Durability

Over-printers have many mechanical elements. As production speed increases, over-printers will have to become larger and bulker. The Mechanics that move the printhead at higher speeds will need to be more robust to counteract the momentum generated. They will use ink faster so they will need larger body sizes for ink storage. Printheads can also be considered consumable they have a limited life and will need to be changed more often with increased production. Every time A printer ink needs to be changed the production line must stop (in that area). These machines will reach a point where their size, cost and amount of human maintenance needed will make them an ineffective solution.

3.3 Consumables

As production speed increases so do the use of consumables. Most over-printer have warranties that require you to buy a particular brand of ink much like home printers. Unlike home printers, Industrial printers print continuously for up to 7 days a week. This generates a massive amount of usage that dwarfs the cost of the over-printer. An over-printer that is being used moderately can use £100,000 of ink in a year. As production speed increases, this cost will increase proportionally. This cost is exacerbated by the fact that the machines don't use 100Most inks are also sold on a transmission medium with a large amount of unrecyclable plastic, this also increases proportionally with production as well as shipping costs.

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4 Future Technologies

4.1 Laser markers and engravers

Laser engraving/cutting and marking technology have been around for over 50 years. Generally, it is used on ceramics, wood and metals. They work by moving a high-powered laser over the surface of the substrate. The surface is burnt leaving an irremovable mark.

4.2 Scanning lasers

A scanning laser uses a set of small mirrors on rotating arms, known as a galvo, to direct its beam. Due to the mirrors' low mass, extremely fast movement can be attained.

4.3 High-frequency UV Laser Markers

UV laser uses a different wavelength than standard laser markers and can be used on plastic materials. By modifying the pulse width and frequency, their burn effect can be minimised and instead activates annealing effects on the substrate, causing different contrast effects.

4.4 Subtractive marking

When dealing with thin, delicate materials etching the surface may cause excessive deformation. Subtractive marking is then used. The laser is configured to remove

the ink from a darkened area on the packaging. All packaging is pre-printed with logos and general information externally before it reaches the production line. Adding a darkened square on each pack results in a minimal cost increase(If any), as the machines used in this printing process are more ink efficient.

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