OMRON

MVRC: Mark, Verify, Read and communicate

A better way to understand traceability in manufacturing

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Introduction

Traceability can seem staggeringly complex. Barcode reading stations need to be integrated into complex systems to enable the collection, storage and analysis of massive amounts of valuable tracking data on a daily basis. Unthinkable quantities of work-in-progress (WIP) parts need to bear markings that will withstand the tests of time and tough environments. For a single automobile, as many as 20,000 different parts need to be marked. Add powerful part tracking software that needs to be integrated into the manufacturing execution system (MES), and you have what appears to be a colossal endeavor just to keep track of things in accordance with industry standards like IPC-1782.

At Omron, one of our major goals is to make traceability as intuitive and accessible as possible. This allows manufacturers to implement workable systems and adhere to the standards with relative ease. We've found that simplifying the way we think about traceability can go a long way in making the traceability process easy. We call this concept MVRC: Mark, Verify, Read and Communicate. In this white paper, we'll discuss the four components of MVRC and the strategies and technologies to overcome the challenges at each step of the way.

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M is for Mark

The basis for traceability is the barcode. This machine-readable structure contains all relevant data about a particular WIP part and passes it to a database with every scan. You can think of barcodes as the glue connecting the physical world to the digital realm – each time a code is scanned, digital records are updated to reflect new information about the whereabouts and overall status of physical objects.

To ensure that the markings themselves are inseparable from the objects that carry them, manufacturers generally use what are known as direct part marks (DPMs) – barcodes that are etched, printed or otherwise marked directly on a given part. Printed labels are also used in many industries, but for the purposes of this white paper we will focus on DPMs.

There are several different direct part marking methods, and they vary in terms of durability, resolution, cost to implement and other factors. Manufacturers need to choose the marking method that works for them based upon the specific requirements of their industry.

The problem: some marks need to last forever, others must fit in tight spaces

Well, "forever" is a bit of an exaggeration. But there are some industries – particularly aerospace manufacturing – where certain DPMs need to last for several decades. No amount of wear and tear can be an excuse for the loss of information about a part's history as long as that part is still in service. This means that such long-lasting DPMs need to be applied using a highly durable marking method.

Another challenge in part marking is the fact that many parts – such as those in consumer electronics manufacturing – don't provide much room for adding barcodes. Manufacturers need to find ways to make DPMs smaller and sometimes even place them on surfaces that aren't completely flat.

Figure 1: MicroHAWK industrial barcode readers are an integral part of Omron's overarching traceability solutions.

The solution: advanced laser marking technology

Although ink jet printing is sometimes used for DPMs, those expected to last years or even decades should be applied using a more permanent method. Some industries that require extremely long-lasting marks use a method known as dot peening, in which a pattern of dots is hammered into the metal surface of a part. However, dot peening has a low resolution and doesn't work well for parts that are delicate or space-constrained. It's also rather slow.

Laser marking is a method that combines high resolution with high permanence. Essentially, the focused light coming from a laser interacts with the surface material of a part to create a mark that is both durable enough to resist abrasion, heat and acidity and delicate enough to produce legible letters in 1-point font. It's also one of the fastest marking methods available, and it doesn't use consumables (such as the ink in ink jet printing and the electrolytic solution in electrochemical etching). These qualities make laser marking relatively cost-effective.

Omron's MX-Z family of laser markers offers the kind of high-quality, permanent part identification that industrial traceability demands. It marks a variety of materials, including stainless steel, iron, copper, gold, silver, aluminum and plastics, with the option to employ color marking on stainless steel. Its exceptionally high resolution of 2µm allows it to mark characters as small as 0.1mm (100µm). It also provides the benefit of connectivity and integrates easily with other systems and controls.

Figure 2:
Omron's MX-Z laser marking machine produces durable, high-resolution symbols.

DPM types

Ink Jet: A mark created using an ink jet printing process.

Dot Peen: A pattern of dots hammered into the metal of surface of a part.

Laser Mark: Focus laser light that interacts with the surface material of a part to create a mark that is both durable and legible.

V is for Verify

As discussed above, many DPMs need to stay readable for extensive periods of time. But how do manufacturers know that their markings are going to hold up under the pressures of the factory floor and the unpredictable challenges of the supply chain? In many industries – including automotive, consumer electronics and medical device manufacturing – barcodes need to remain readable throughout the entire product lifecycle. To make sure these codes start off with a sufficiently high level of quality, it's necessary to verify them thoroughly according to standards developed by the International Organization for Standardization (ISO).

Barcode verification is more than simply validating that your scanners and images can read a code. It's a complex process that grades each individual code against several key ISO standards – such as ISO/IEC TR 29158 for direct part marks. A few of the many criteria for grading two-dimensional barcodes are symbol contrast (the intensity difference between light and dark cells), modulation (the degree to which contrast varies throughout the symbol), and print growth (the degree to which one cell type is larger or smaller than the other).

Production materials often place a limit on the grade that a DPM can achieve. For example, slight changes in the color of a printed circuit board (PCB) can make it impossible to apply a laser marking that gets a perfect score for contrast. Applying DPMs to shiny or curved surfaces will also be unlikely to get a high grade. Sometimes, however, that's the best you can do.

The problem: some codes are very, very extraordinarily small

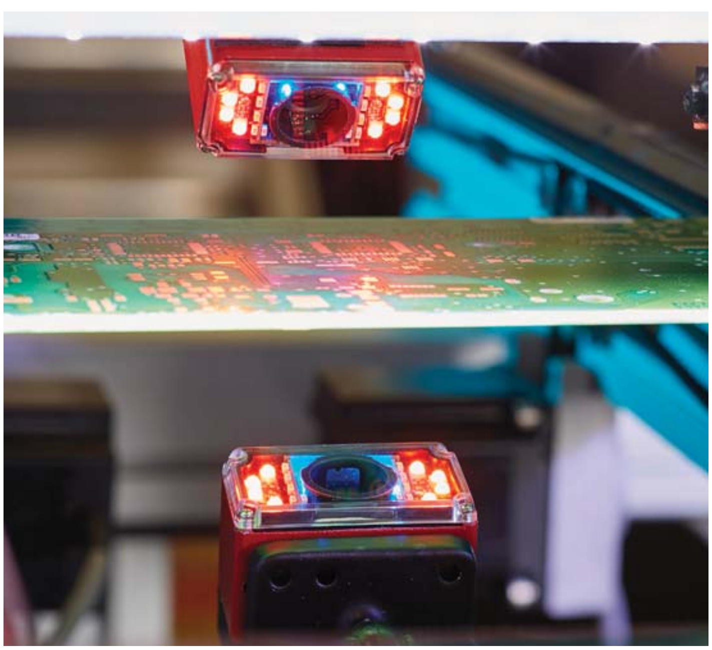

Figure 3: A MicroHAWK gathers data from miniscule codes placed on a printed circuit board.

Thanks to the awe-inspiring capabilities of today's laser marking technology with resolutions of just a couple micrometers, manufacturers have far more options for code placement than they used to. However, this creates a new challenge when it comes to reading and verifying these codes. Since the verification process is much more involved than the simple act of reading a code, it can be quite difficult to find verification systems that work properly on such tiny codes.

For products like certain medical devices that are legally required to bear fully readable DPMs throughout their lifetime, the international standards organization defines the minimum code size as 3.9 mil. Codes on PCBs and some of the electronic components affixed to them can be even smaller.

The solution: extremely high-density verifiers

Fortunately, Omron realized that the need to verify extremely small codes would only continue to grow, and its engineers actively worked towards designing a solution. A recent upgrade to the LVS-9580 and LVS-9585 handheld barcode verifiers perform ultra-high-density inspection and grading of codes with cells as small as 2 mil (or two thousandths of an inch). This is almost twice as small as the GS1 minimum.

Figure 4:
Omron's LVS-9585 handheld barcode verifier is equipped with a special high-density lens that can comprehensively verify extremely small codes and DPMs.

R is for Read

Once WIP parts are marked and their codes are verified to be of good quality, manufacturers need to make sure their systems read these codes at key points throughout the production line. The benefits provided by this process are immense. Code capture and subsequent data analysis helps optimize manufacturing, identify problems with specific machines, and ensure that all parts have gone through each manufacturing step. More code reading means more comprehensive, real-time traceability and more data to use in optimizing processes. In some industries, assembly information is included in DPMs, so barcode reading technology becomes an essential component of the overall manufacturing process.

Did you know?

International standards organizations defines the minimum code size as 3.9 mil.

The problem: manufacturing environments can damage codes

Even when codes start out with a good grade, the sheer harshness of some manufacturing environments can wreak havoc on their readability. Since no-reads can delay or even shut down the production line, it's essential to minimize their occurrence in whatever way possible. The combination of choosing a durable marking method and verifying that barcode quality is high at application goes a long way in ensuring that codes are readable. Unfortunately, problems can still arise down the line, especially in the automotive industry where high heat and chemical spray-downs are the norm.

The solution: code readers with advanced decoding algorithms

"Many damaged codes are still perfectly readable thanks to redundancy in the symbols themselves "

When part of a DPM gets damaged, that doesn't mean that all the data contained in the code is lost forever. In fact, many damaged codes are still perfectly readable thanks to redundancy in the symbols themselves and highly advanced decoding algorithms that can reconstruct codes from what's left of them. Omron's X-Mode decoding algorithms are exceptionally good at extracting the data from a wide variety of hard-to-read codes, including Data Matrix codes that are missing almost half their pattern. X-Mode is a key feature in several of Omron's industrial code readers, including the MicroHAWK line and the ultra-rugged HS-360X handheld.

Successful reading is also made more difficult by the fact that not all parts have flat spaces available for DPM placement. In these cases, DPMs might be placed on curved surfaces or within recessed cavities. In order to read these marks, the MicroHAWK line uses a special liquid lens autofocus technology combined with advanced on-board lighting to work reliably with various part geometries and sub-par factory lighting.

C is for Communicate

Just collecting traceability data isn't enough – it needs to be communicated. Otherwise there would be no way to draw upon the data to discover process bottlenecks, determine the source of production failures and implement targeted recalls. Controllers on the production floor can work as data aggregators, sending traceability data to the manufacturing execution system. It's important for the MES to have the proper interface for capturing and integrating this information.

The problem: traceability data processing can increase production cycle time

To meet high-level quality standards, traceability is essential, and the more data, the better. However, the time required to process all this data can dramatically lengthen the production cycle. This creates a difficult trade-off between gathering and utilizing valuable data on the one hand and trying to keep an optimal cycle time on the other.

The solution: controllers that are designed to increase productivity

As it turns out, traceability data processing doesn't have to make production cycles longer. Intelligently designed controllers like those in Omron's NX/NJ series can directly transfer traceability information to a SQL database without hampering machine control performance thanks to embedded SQL clients. By making secure data transfer easily available at the machine level, the NX/NJ controllers help manufacturers get the information they need to make significant

Figure 5:

Omron's NX1 controller is designed to ensure that a traceability system can collect large amounts of data without slowing down the production cycle.

Summary

Traceability becomes much more straightforward when broken down into the four concepts of "Mark, Verify, Read and Communicate." Each part of MVRC represents a concrete requirement of any good traceability system, and each comes with its own set of challenges and strategies for overcoming them.

There are plenty of traceability-related issues that are beyond the scope of this white paper, but no matter the challenge, it could most likely be assigned to a particular part of MVRC and understood more clearly that way.

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